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Impacts of Land Use and Land Cover Changes on Migration and Food Security of North Central Region, Nigeria

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Abstract: Food security is adversely affected by challenges posed by changes in land use and land cover (LULC). LULC change impacts ecosystem functions and services, leading to migration of people, particularly rural dwellers. This paper uses multispectral satellite remote sensing, net migration data, household survey, stakeholders' meetings, Focus Group Discussions (FGD), expert interviews and yields and estimated land mass of maize, rice, groundnut, cassava, and yam to assess the extent of LULC in Niger, Kwara, and Benue states of North Central Region of Nigeria and their relevance for migration and food security. Remote sensing data for 1990, 2000, 2013, and 2020 were extracted from Landsat imageries to obtain LULC change. Household survey was conducted to validate the data obtained from Landsat imageries. The results of LULC between 1990 and 2020 show that most of the vegetation, agricultural land, and water body areas in Kwara and Benue States have been converted to built-up areas and barren land, while an increase in agricultural land and built-up areas was observed in Niger State. Our household survey, stakeholders' meetings, and interviews showed that there was a continuous massive migration of people, particularly young farmers, to cities leaving most of the existing agricultural lands uncultivated. This was due to the losses in agricultural land and conversion of some of the other LULC classes to barren land. We conclude that if this permanent migration remains uncontrolled, it will have significantly negative future impacts on food security of Nigeria. It is recommended that the government and its sub-ordinary administrative entities invest in more reliable infrastructure and attractive living environment for the rural dwellers to reduce the rate of rural-urban migration in the study areas.

Keywords: LULC; impacts migration; food security; farmers; Nigeria

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1. Introduction

Changes in land use have a lot of implications on the environment from local to global level. These significant changes lead to local, regional, and global loss of biodiversity, rise in soil erosion, and sediment loads and irregularities in water cycles [1]. Locally, changes in the use of land and its cover affect microclimatic resources, which have direct impacts on livelihoods of local communities [2]. Agriculture is responsible for about 25 per cent of all anthropogenic greenhouse gas emissions, that is about 15 per cent from the livestock sector and about 10 percent from land use change like deforestation, cropping, and conversion of vegetation to built-up areas [3]. Land degradation is one of the major contributors to low and decreasing agricultural production, which sequentially aggravates poverty [4,5]. Long-term undernourishment leads to stunted growth, slow cognitive development, and increase in susceptibility to illness [6]. In spite of the increase in the growth rate of urban slums over the last 10 years, approximately three-quarters of poor people in developing countries are living in rural areas [7]. Protection of soils and sustainable land use play a major role in climate, food security and human security [8].

Migration is seen as a growing and complicated global occurrence [9]. Between 2008 and 2015, nothing less than 26.4 million people were displaced annually across the globe due to hazards and disasters that are induced by nature and climate, and there is a continuous increase in this trend [10]. The present estimated total number of international migrants, together with those displaced by natural disasters related to climate, is 40 percent higher than that of 2000, and this is anticipated to be more than 400 million by the year 2050 [4]. Rural-urban migration patterns in Sub-Saharan Africa are multifaceted. People may be forced to migrate due to environmental, political, cultural, demographic, or socio-economic factors. In most cases, the decision to move is influenced by a mixture of a number of aforementioned factors [11]. Migration to urban centers places pressure on limited available housing resulting in a large number of urban residents living in informal housing [12]. Migration can be regarded as a means of adapting to climate change [13]. International Organization for Migration (IOM) [14] found out that migration that is well organized, safe, and regular can contribute to the growth and development of agriculture, economics, livelihoods of rural dwellers, and food security.

Nigeria and indeed Northern Nigeria, which was known for blossoming agricultural productivity before is now heavily affected by climate change and land degradation in the form of prevalent drought and flood [15]. Most of the crops are less productive due to the overdependence on rainfed agricultural practices and high poverty level of the residents [15]. The degradation of agricultural assets exacerbated by climate change is leading to a decline in production, drastically reducing livelihood opportunities in rural areas [16].

The combination of food insecurity and poverty contributes to rural-urban migration [13]. Increases in the frequency and intensity of weather and climate-induced risks, including sudden and slow-onset events, are potential pathways from climate change to migration [3]. Extreme meteorological events, which are sudden-onset events, tend to have an immediate impact and direct linkages between climate change and migration [3]. Rural populations are often displaced as a result of damage done to their assets and/or production because of natural disasters attributed to these sudden-onset events [17,18]. Some of the major factors that determine rural-urban migration include poor health care system, low agricultural yield, limited access to quality education, poverty, among others [13]. Although many scholars described migration climate change adaptation strategy [19], it is also described as the failure to adaptation or mitigation [20]. In North Central Nigeria, the majority of the farming households have between one and four members that migrate every year as a result of land use changes and climate-related disasters, thereby reducing their ability to be food secure [21]. Our paper aims to identify the extent of LULC change in the selected states in the North Central Region of Nigeria, analyzing the impacts of LULC change on migration, and evaluating the resultant effects of LULC change and migration on the food security of the selected states.

Most of the previous studies on changes in LULC in North Central Nigeria used remote sensing to evaluate the dynamics of changes in LULC, but explanations on the opinions of the local people on the drivers of changes in LULC were not included [22–25]. This study will fill the gap. The structure of this paper includes the material and methods used for this study, presentation, and discussion of findings of this study, which include a description of the extent of changes in LULC and the resultant effects of changes in LULC on migration and crop production. Conclusions were drawn and related recommendations were made.

2. Material and Methods

This study adopted a mixed-method approach in which quantitative and qualitative data were collected. This approach was adopted in order to fully explore the objectives of this study.

2.1. Study Area

The study was carried out in the North Central Region of Nigeria with Longitude 4°00′–11°00′ East of the Greenwich Meridian and Latitude 7°00′–11°30′ North of the equator (Figure 1). It spans from the west, around the confluence of the River Niger and the River Benue. The region has a land area of about 296,898 km^2 representing about 32 percent of the country's total land area [26]. The region has six States and the Federal Capital Territory, Abuja. The States are Benue, Kogi, Kwara, Nasarawa, Niger, and Plateau. The region is located in the central part of Nigeria and in the sub-humid region of the country, and bounded to Bauchi, Kaduna, Zamfara, and Kebbi States to the north; Cross-River, Ebonyi, Edo, Ekiti, Enugu, Ondo, Osun, and Oyo States to the south; Taraba State and Republic of Cameroon to the east and the Republic of Benin to the west [27]. The area experiences tropical continental climate characterized by rainy and dry seasons. The planting of crops is mostly done in the rainy season because rainfed agriculture is mostly practiced in the region. The mean annual rainfall ranges between 1200 and 1500 mm, and the air temperature ranges from 22.55 to 33.54 °C. The air temperature is high almost throughout the year except during the period of harmattan which begins in November and lasts until February. This is a period of the year in which the weather is dry and cold, in addition to a hazy atmosphere and dust particles that flow around. The region is susceptible to negative impacts of climate change [28,29]. The vegetation of the North Central Nigeria cuts across the three savannah belts (Guinea, Sudan, and Sahel) [28,29]. The Guinea savanna receives annual rainfall ranging from 1000–1500 mm with about 6–8 months of rainfall. The existing vegetation is an open woodland with tall grasses of 1 to 3 m high in open areas and trees about 15 m high, usually with short boles and broad leaves. Furthermore, the Sudan savanna has annual rainfall, which ranges from about 600–1000 mm. The area experiences a dry season of about 4–6 months. The landscape is more of Guinea savanna than vegetation. The typical vegetation consists mainly of short grasses of about 1–2 m high and some stunted tree species. The Sahel savanna receives annual rainfall that is less than 600 mm and with dry seasons exceeding 8 months. The typical vegetation consists of grasses, open thorn shrub savanna with scattered trees, extensive sparse grasses, and 4 to 9 m in height, most of which are thorny [30].

Furthermore, the region is drained by River Niger and River Benue and their tributaries. The areas which are close to the river levees have clayey soils, while areas that are far from the river levees positions have variable and sandy soils [31]. The region has an estimated population of 29,252,408 as of 2016, according to United Nations, with about 77 percent as rural dwellers. It is the third largest region in Nigeria in terms of population after North West and South West. It is dominated by Nupe, Igala, Gbagyi, Idoma, Fulani, Hausa, Gwandara, Yoruba, Eggon, Tiv, Berom, among others. The area is endowed with an expanse of land suitable for cultivation of yam, cassava, millet, cowpea, Irish potato, rice, and rearing of animals like poultry, cattle, sheep, and goat. The region serves as the food basket of Nigeria [27,28,32]. In this study, Niger, Kwara, and Benue States in the North Central Region of Nigeria were purposively selected out of the six states and FCT that make up the North Central Region of Nigeria. They are selected because they are the three largest states (land mass) in the region.

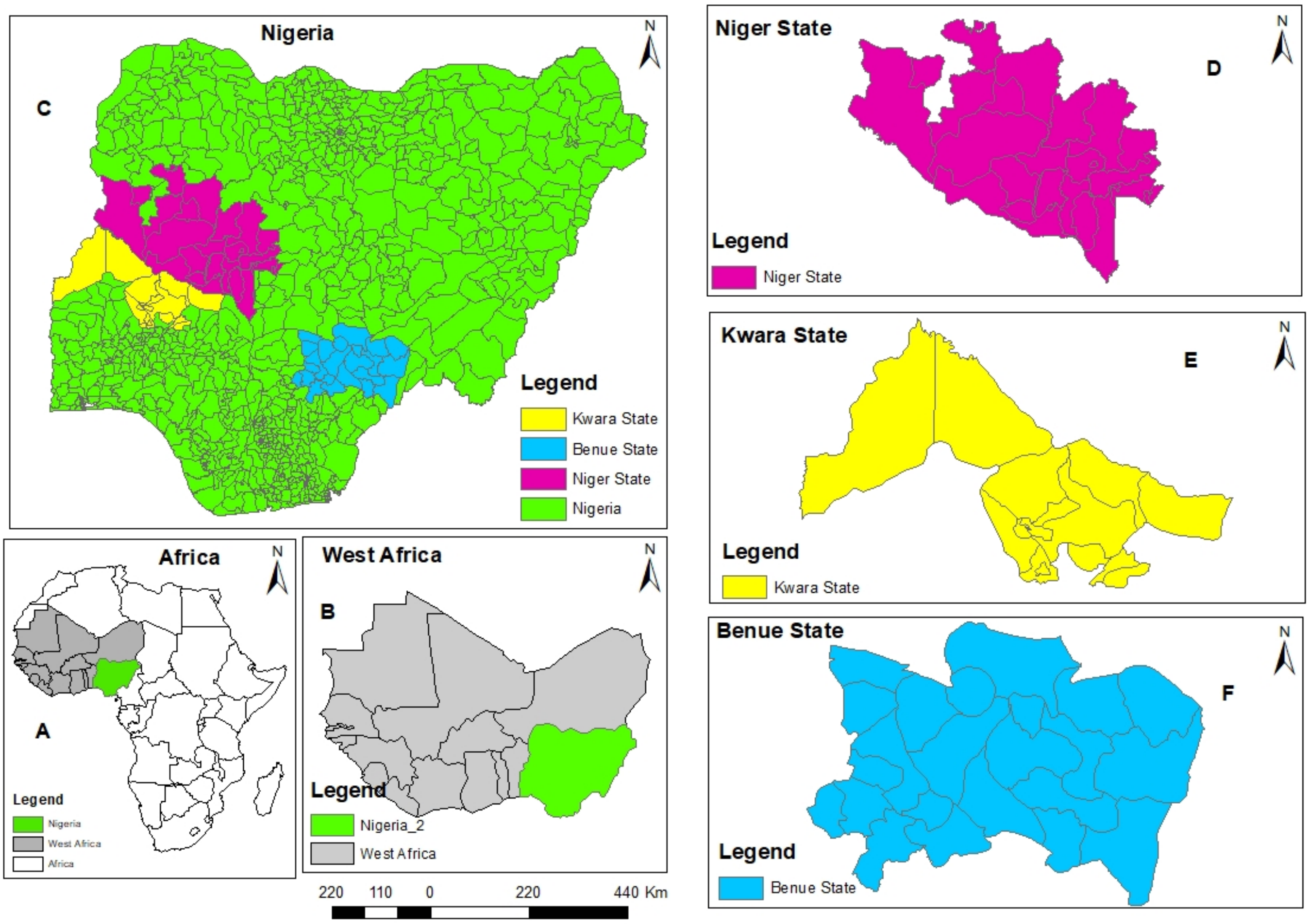


Figure 1. Location and map of the study area. Source: Author. (**A**) Map of Africa, (**B**) Map of West Africa, (**C**) Map of Nigeria, (**D**) Map of Niger State, (**E**) Map of Kwara State, (**F**) Map of Benue State.

2.2. Household Sampling and Data Collection

2.2.1. GIS and Remote Sensing

Portable Global Positioning System (GPS) was used to take all the coordinates needed, and Landsat 5 TM, Landsat 7 TM+, and Landsat 8 remote sensing images covering 1990–2020 were used to analyze LULC. Satellite images from 1990 and 2000 were downloaded from Landsat 7 TM+, while satellite images from 2013 and 2019 were downloaded from Landsat 8 for the three sampled States: Niger, Kwara, and Benue), all from the United States Geological Survey (USGS) website (earthexplorer.usgs.gov, accessed on 17 January 2022). Digital topographic maps produced in 1990, 2000, 2013, and 2020 were geo-referenced to a common UTM coordinate system and used as base maps to geo-reference the Landsat images acquired in these years. Many ground control points, like intersections of roads and agricultural plots, river channels, and utility infrastructure, were examined and matched with all the images. Ground truthing exercises in the form of a collection of geographical coordinates via the use of Global Positioning Receiver (GARMIN GPS) and direct observation through transect walk were used to collect primary data on LULC. Locations of the satellite imageries in the GIS analysis were represented by the coordinates which served as the reference system. This was conducted to provide ground truth of vegetation and land use, which was used as a reference tool to ensure and verify the accuracy of the satellite image interpretation and to also determine the dynamics of migration in the study area.

2.2.2. Surveys

Primary data to validate the results of the analyses of the GIS and satellite imageries were collected using a semi-structured questionnaire, expert interviews, focus group discussions, reconnaissance, stakeholder's meetings, and reconnaissance. All these activities took place between June 2021 and December 2021. A multi-stage random sampling technique was used to select a sample size of 600 respondents. This sample size was used as a result of limitations in accessibility and availability of the respondents. In the first stage, a purposive selection of three states from North-central Nigeria, which have the highest land masses in the region was made. Hence, Niger State, Kwara State, and Benue State were selected. Secondly, two agricultural zones that are mostly affected by land use change and migration from each state selected were sampled (based on the recommendations of the experts interviewed) for the study making six agricultural zones. Thirdly, two local government areas were selected from each agricultural zone, giving a total of twelve local government areas. In the fourth stage, two farming communities were randomly selected from each local government area, making a total of twenty-four farming communities. Lastly, twenty-five farmers were randomly selected from each farming community, giving a sample size of 600 farmers (i.e., 200 respondents from each state). The list of the selected communities is indicated in Table 1. The information was collected using a well-structured interview schedule prepared in English language but mostly interpreted in Hausa or Yoruba (languages understood and spoken by the respondents) during interview. Joint interview was sometimes used in order to get inputs from as many respondents as possible and to save the respondents from the fatigue of being interviewed. In addition, the experts interviewed included the officials of Ministry of Agriculture, Agricultural Development Project (ADP), and International Fund for Agricultural Development (IFAD) in Niger, Kwara and Benue States. The participants included in the stakeholders' meetings held in the three states were traditional rulers, community leaders, and farmers' leaders. They were selected based on their familiarity with the study area. Each of the states was represented by ten members, making a total of 30 members in the three states. During the focus group discussion held at each of the ADP zones, attendees included representatives of men, women, and youth farmers. Ten participants were drawn from each ADP zone, making a total of 60 representatives across the three states, and they were selected because they represented groups that are mostly affected by the negative impacts of land use change on migration and food security.

Table 1. List of the Selected Communities in the Study Area.

NIGER STATE							
NIGER ADP ZONE 1				**NIGER ADP ZONE 2**			
Katcha LGA		**Bida LGA**		**Bosso LGA**		**Suleja LGA**	
Badeggi Community	Shaba-Woshi Community	Batavovogi Community	Debarako Community	Shata Shiqmar Community	Lokoto Community	Chaza Community	Rafinseyi Community
KWARA STATE							
KWARA ADP ZONE C				**KWARA ADP ZONE D**			
Asa LGA		**Moro LGA**		**Oke-Ero LGA**		**Irepodun LGA**	
Alapa Community	Ballah Community	Olooru Community	Shao Community	Imode Community	Ayedun Community	Araromi-Ipo Community	Okeya-Ipo Community
BENUE STATE							
BENUE ADP ZONE B OR NORTHERN ZONE				**BENUE ADP ZONE C OR CENTRAL ZONE**			
Makurdi LGA		**Gwer East LGA**		**Obi LGA**		**Otukpo LGA**	
Tse-Ayihe Community	Agan Communities	Ikapayongo Community	Taraku Community	Ijegwu Community	Okpokwu-Ito Community	Otobi Community	Asa-Otukpo Community

ADP: Agricultural Development Project; LGA: Local Government Area.

2.2.3. Migration Data

Net migration data by the United Nations for Nigeria for the period of 2005–2020 were downloaded from the World Bank's website (http://data.worldbank.org). These data were accessed on 29 November 2022. Net migration data for Nigeria were used for the three states due to the unavailability of state-by-state net migration data. The period of 2005–2020 was purposively used to equate the period of available crop yield data in order to ensure accurate statistical analyses. The analyses of these data were used to evaluate the resultant effects of changes in LULC on migration and crop production.

2.2.4. Crop Yields

Crops yields and estimated cultivated landmass data of maize, yam, cassava, rice, and groundnut for 2005–2020 were extracted from National Reports on Wet Season Agricultural Performance in Nigeria published by National Agricultural Extension and Research Liaison Services (NAERLS), Ahmadu Bello University, Zaria, Kaduna State, Nigeria. These crops were selected because they are very common staple crops in North Central Region of Nigeria.

2.3. Data Analysis

ARC GIS 10.1 was used to create a composite band image with bands applicable to land-use changes investigation. These bands were bands 4, 3, and 2 representing near-infrared, red, and green colors, respectively, of the Landsat 5 TM, 7 TM+, and 8 datasets. This gives a single-layer multiband image, which is suitable for land-use and vegetation cover studies. The images were then extracted for analysis. The processed satellite imageries were analyzed using maximum likelihood classification into five Land Use and Land Cover (LULC) classes, as shown in Table 2. The obtained classes were assessed for accuracy using a scale range of -0.1 to 1, any scale above 0.5 to 1 indicates an accurate assessment, while a scale below 0.5 was considered not accurate. To determine the trend patterns in land use changes and migration, Landsat 5 TM, Landsat 7 TM+, and Landsat 8 images (1990–2020) were obtained for the study. These satellite data for time interval of 30 years allowed a meaningful analysis of change detection in land use and land cover in the area. Satellite image datasets were analyzed using remote sensing and GIS techniques, and data were extracted for descriptive quantitative analysis. Crop yields and estimated cultivated landmass of the five crops (maize, rice, groundnut, cassava, and yam) coupled with LULC classes and net migration data were analyzed using regression analyses. All the survey data were first scanned for their statistical distribution by using SPSS and Excel software. After comparing the means of several variables with regard to different groups of households, specific statistical tests were used and cross-tabulated to check if there are significant relationships among various variables.

Table 2. Classification of Land Use and Land Cover.

LULC Classes	Description	Color
Vegetation	Grasslands, trees, shrubs, gardens, palms, orchids, forests, and herbs.	Light green
Waterbody	Rivers, streams, ponds, wetlands, reservoirs, swamps, and marshy areas.	Blue
Barren Land	Empty lands without grasslands, shrubs, or trees.	Yellow
Agricultural Land	Cropland, orchards, pasture, nurseries, groves, horticultural land, confined feeding operations lands, ornamental lands, groves, and livestock pens.	Dark green
Built up Area	Commercial, industrial, and residential areas, transportation infrastructure and village settlement.	Red

2.4. Statistical Treatment

2.4.1. Accuracy Assessment

Accuracy assessment is the process in which an estimated remote sensing dataset is quantified [33]. It can be defined as the degree to which produced maps and reference maps are similar, and it is one of the final steps that are important in the classification of images [34]. Kappa coefficient and overall classified accuracy are mostly used to determine the degree of accuracy. Kappa coefficient is used to determine the proportion of improvement by the classifier classes that are purely assigned randomly [35,36], while the producer and user accuracies are used to determine the proportion of the map that is correctly classified from the points of view of producer and user, respectively [35]. The Kappa coefficient ranges between −1 and 1. According to Monserud and Leemans [37] and Amini et al. [30], a value of 0 indicates that there is no degree of agreement, while a value close to 1 shows an excellent degree of agreement, and a negative value indicates a very poor degree of agreement.

$$\mathrm{Accuracy} = \frac{\mathrm{Tp} + \mathrm{Tn}}{\mathrm{Tp} + \mathrm{Tn} + \mathrm{Fp} + \mathrm{Fn}} \tag{1}$$

where Tp, Tn, Fp, and Fn are the number of true positive, true negative, false positive, and false negative, respectively.

$$\mathrm{Pa} = \sum_{i=1}^{c} pii \tag{2}$$

Pa is the simplest and most used level of agreement

$$\mathrm{Pb} = \sum_{i=1}^{c} pi.pi \tag{3}$$

$$\mathrm{K} = \frac{\mathrm{Pa} - \mathrm{Pb}}{1 - \mathrm{Pb}} \tag{4}$$

where Pa, Pb, and K are relatively observed agreement, probability that agreement due to chance, and Kappa coefficient, respectively.

2.4.2. Annual Percentage Change and Annual Rate of Change

A negative value indicates a decrease, while a positive value indicates an increase

$$\mathrm{Mc} = \mathrm{A2} - \mathrm{A1} \tag{5}$$

$$\mathrm{Ac} = \frac{\mathrm{Mc}}{\sum \mathrm{LULC}} \times 100 \tag{6}$$

$$\mathrm{Ar} = \mathrm{Ac} \div \frac{100}{\mathrm{Y2} - \mathrm{Y1}} \tag{7}$$

where Mc, Ac, Ar, and LULC are values of magnitude of change, annual percentage change, annual rate of change, and Land Use and Land Cover classes, respectively, while Ac is the annual percentage change, A1 is the extent of initial area of each of the LULC classes at initial year (Y1), and A2 is the extent of the final area of each of the LULC classes at final year (Y2).

2.4.3. Impacts of LULC on Migration

Univariate regression analysis was used to show the impacts of changes in LULC on migration in Niger, Kwara, and Benue States. We made use of Statistical Package for Social Sciences (SPSS)-IBM SPSS Statistics 25 version for the statistical analysis.

$$\Delta \mathrm{NetMig} = \mathrm{constant} + (\beta \times \Delta \mathrm{VG}) + (\gamma \times \Delta \mathrm{WB}) + (\mu \times \Delta \mathrm{AL}) + (\lambda \times \Delta \mathrm{BL}) + (\phi \times \Delta \mathrm{BA}) \tag{8}$$

where ΔNetMig is the observed change in Net Migration due to changes in vegetation (VG), water body (WB), agricultural land (AL), barren land (BL), and built-up area (BA).

Similarly, β, γ, μ, λ, and ϕ are coefficients of vegetation, water body, agricultural land, barren land and built-up area respectively. Furthermore, ΔVG, ΔWB, ΔAL, ΔBL, and ΔBA are observed changes in vegetation, water body, agricultural land, barren land, and built-up area, respectively. Significance level (alpha) of 0.05 was used.

2.4.4. Migration, LULC and Food Crop Yields Relationship

We used multivariate regression analysis to show how migration and changes in LULC classes influenced the yields of maize, rice, groundnut, cassava, and yam in Niger, Kwara, and Benue states. This statistics was performed using Statistical Package for Social Sciences (SPSS)-IBM SPSS Statistics 25 version.

$$\Delta Y = \text{constant} + (\alpha \times \Delta \text{NetMig}) + (\beta \times \Delta \text{VG}) + (\gamma \times \Delta \text{WB}) + (\mu \times \Delta \text{AL}) + (\lambda \times \Delta \text{BL}) + (\phi \times \Delta \text{BA}) \quad (9)$$

where ΔY is the observed change in the crop yield due to changes in net migration (NetMig), vegetation (VG), water body (WB), agricultural land (AL), barren land (BL), and built-up area (BA). Similarly, α, β, γ, μ, λ, and ϕ are coefficients of net migration, vegetation, water body, agricultural land, barren land and built-up area respectively. ΔNetMig, ΔVG, ΔWB, ΔAL, ΔBL and ΔBA are observed changes in net migration, vegetation, water body, agricultural land, barren land, and built-up area respectively. Significance level (alpha) of 0.05 was used for this study.

3. Results

This section presents the findings of the study by describing the extent of LULC, its influence on migration, and consequent impacts on food security in Niger, Kwara, and Benue states of Nigeria.

3.1. Accuracy Assessment of LULC Classification

To ensure the reliability of the results of LULC, efforts were made to determine its accuracy assessment using Equations (1)–(4). Global Positioning System was used to do the ground truthing. This was done to obtain the ground reference data for the different years from 1990 to 2020. The results presented in Tables 3 and 4 indicate that LULC classification of the three states has a great significant alignment with ground observation of the various land cover classes.

Table 3. LULC Accuracy Assessment (Overall Classified Accuracy and Overall Statistic Kappa) for Niger, Kwara, and Benue States for the years 1990, 2000, 2013, and 2020.

	Niger State		Kwara State		Benue State	
Year	**Overall Classified Accuracy**	**Overall Statistic Kappa**	**Overall Classified Accuracy**	**Overall Statistic Kappa**	**Overall Classified Accuracy**	**Overall Statistic Kappa**
1990	80%	0.75	80%	0.75	98%	0.975
2000	81%	0.7625	76%	0.7	76%	0.7
2013	61%	0.5125	80%	0.75	95%	0.9375
2020	62%	0.525	78%	0.725	94%	0.925
Average	**71%**	**0.6375**	**78.5%**	**0.73125**	**90.75%**	**0.884375**

Table 4. LULC Accuracy Assessment (Producer's Accuracy and User's Accuracy) for Niger, Kwara, and Benue States for the years 1990, 2000, 2013, and 2020.

	Producer's Accuracy (%)					User's Accuracy (%)				
LULC	**VG**	**WB**	**AL**	**BL**	**BA**	**VG**	**WB**	**AL**	**BL**	**BA**
1990	100.00	66.00	80.00	100.00	98.00	92.59	76.74	74.07	100.00	100.00
2000	100.00	66.00	80.00	100.00	98.00	92.59	76.74	74.07	100.00	100.00
2013	100.00	66.00	80.00	100.00	98.00	92.59	76.74	74.07	100.00	100.00
2020	100.00	66.00	80.00	100.00	98.00	92.59	76.74	74.07	100.00	100.00

LULC: VG: Vegetation; WB: Waterbody; AL: Agricultural Land; BL: Barren Land; BA: Built up Area.

3.2. Description of the Extent of Changes in Land Use and Land Cover (LULC)

Changes in land use are a direct indication of ecological migration [38]. As seen in Table 5, Figure 2a,b and Appendix A, in Niger state between 1990 and 2020, the agricultural land experienced the largest increase with an annual rate of 7.44 units, while barren land and vegetation had the largest decrease of above 7 units each per year. There was also a slight increase in built-up areas and a slight decrease in water bodies. In Figure 3a,b and Appendix A, we can see that there was a drastic reduction in agricultural land and barren land in Kwara state between 1990 and 2020, while there was a reduction in vegetation, barren land, and water bodies. Benue state, as indicated in Figure 4a,b and Appendix A showed a similar LULC change like that of Kwara state, except that there was a marginal increase in the water bodies. This result indicated that Niger state has more tendency to cultivate crops than other two states due to the increase in agricultural land of the state. Furthermore, the increase in the built-up areas in these three states, especially in the cities, can be attributed to the migration of people from the rural areas to cities thereby, necessitating the need to meet the housing shortage and other basic amenities and infrastructure like transportation networks, roads and communication networks of the urban areas. In addition, several studies revealed that there has been a continuous conversion of other LULC classes to built-up areas in these three states in recent times, and this has been attributed to the increase in the rate of urbanization [24,35,39].

Table 5. Classified, Percentage Change and Annual Rate of Change of LULC 1990–2020 for Niger, Kwara, and Benue States.

State	**Class**	**1990**		**2000**		**2013**		**2020**		**Magnitude of Change (1990–2020)**		**Annual Rate of Change**
		Area (km^2)	**(%)**	**Area (km^2)**	**(%)**	**Area (km^2)**	**(%)**	**Area (km^2)**	**(%)**	**Area (km^2)**	**(%)**	
Niger	Vegetation	28,604	40.40	41,720	59.60	9513	13.00	11,661	16.00	−16,943	24.79 **Decrease**	7.44
	Water body	1169	2.02	1031	1.01	1268	2.00	1373	2.00	204	0.30 **Increase**	0.09
	Agricultural land	19,361	27.27	18,564	26.26	47,618	67.00	50312	71.00	30,951	45.29 **Increase**	13.59
	Barren land	19,521	27.27	6685	9.09	9287	13.00	2293	3.00	−17,228	25.21 **Decrease**	7.56
	Built up area	2465	3.03	3121	4.04	3435	5.00	5481	8.00	3016	4.41 **Increase**	1.32
	Total	**71,121**	**100.0**	**71,121**	**100.0**	**71,121**	**100.0**	**71,121**	**100.0**	**68,342**	**100**	
Kwara	Vegetation	5623	15.88	14,872	41.99	12,586	35.53	10,123	28.58	4500	36.91 **Increase**	11.07
	Water body	57	0.16	51	0.14	64	0.18	54	0.15	−3	0.02 **Decrease**	0.007
	Agricultural land	19,671	55.54	11,597	32.74	15,365	43.38	13,579	38.34	−6092	49.97 **Decrease**	14.99
	Barren land	9977	28.17	8540	24.11	6837	19.30	10,399	29.36	422	3.46 **Increase**	1.04
	Built up area	91	0.26	361	1.02	568	1.60	1266	3.57	1175	9.64 **Increase**	2.89
	Total	**35,420**	**100.0**	**35,420**	**100.0**	**35,420**	**100.0**	**35,420**	**100.0**	**12,192**	**100**	
Benue	Vegetation	7849	25.07	2919	9.32	4569	14.59	4025	12.86	−3824	15.83 **Decrease**	4.75
	Water body	16	0.05	145	0.46	171	0.55	192	0.61	176	0.73 **Increase**	0.22
	Agricultural land	18,818	60.11	22,399	71.54	12,922	41.27	10,559	33.73	−8259	34.18 **Decrease**	10.25
	Barren land	4160	13.29	5111	16.33	8801	28.11	8122	25.94	3962	16.40 **Increase**	4.92
	Built up area	465	1.49	734	2.35	4846	15.48	8408	26.86	7943	32.87 **Increase**	9.86
	Total	**31,308**	**100.0**	**31,308**	**100.0**	**31,308**	**100.0**	**31,308**	**100.0**	**24,164**	**100**	

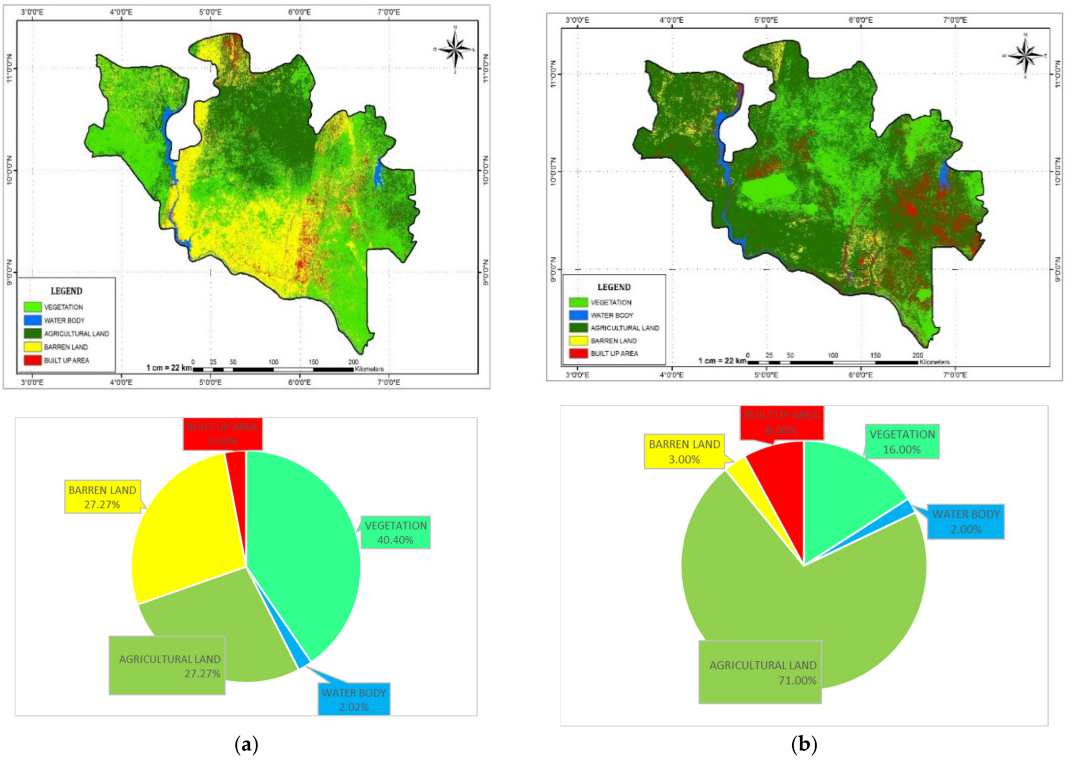


Figure 2. Classified LULC for Niger State for 1990 and 2020. (**a**) Classified LULC for Niger State for 1990. (**b**) Classified LULC for Niger State for 2020.

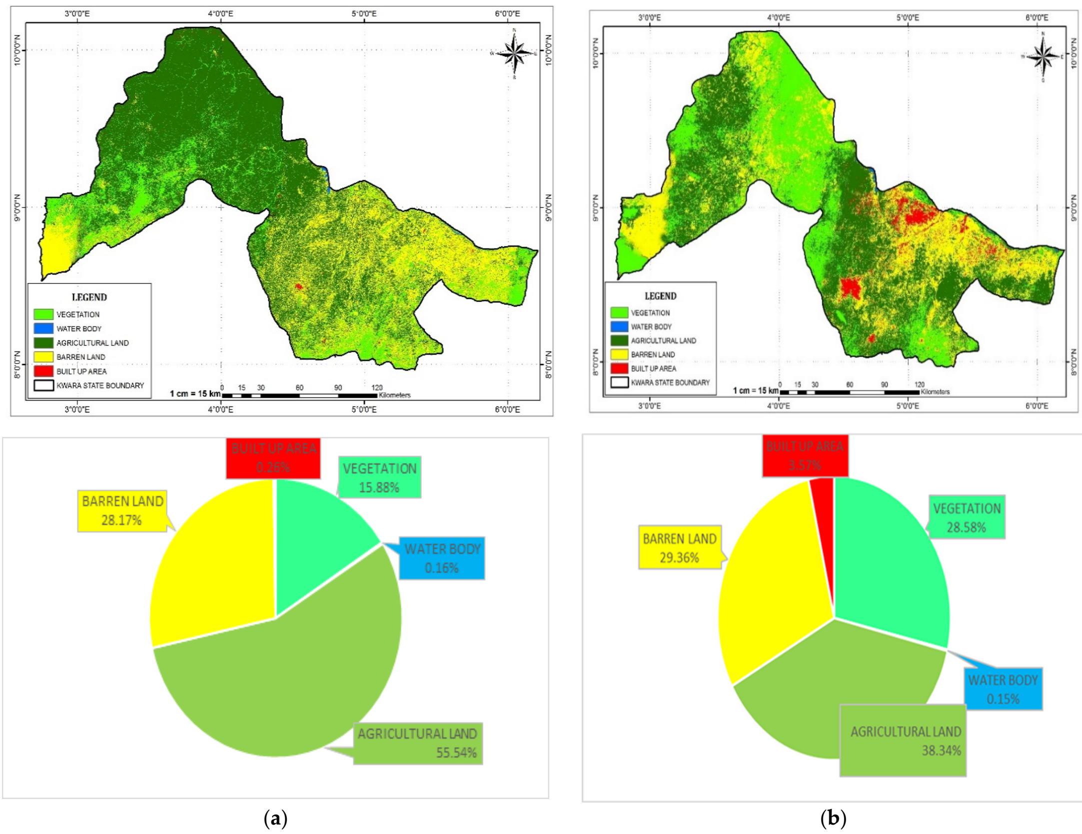
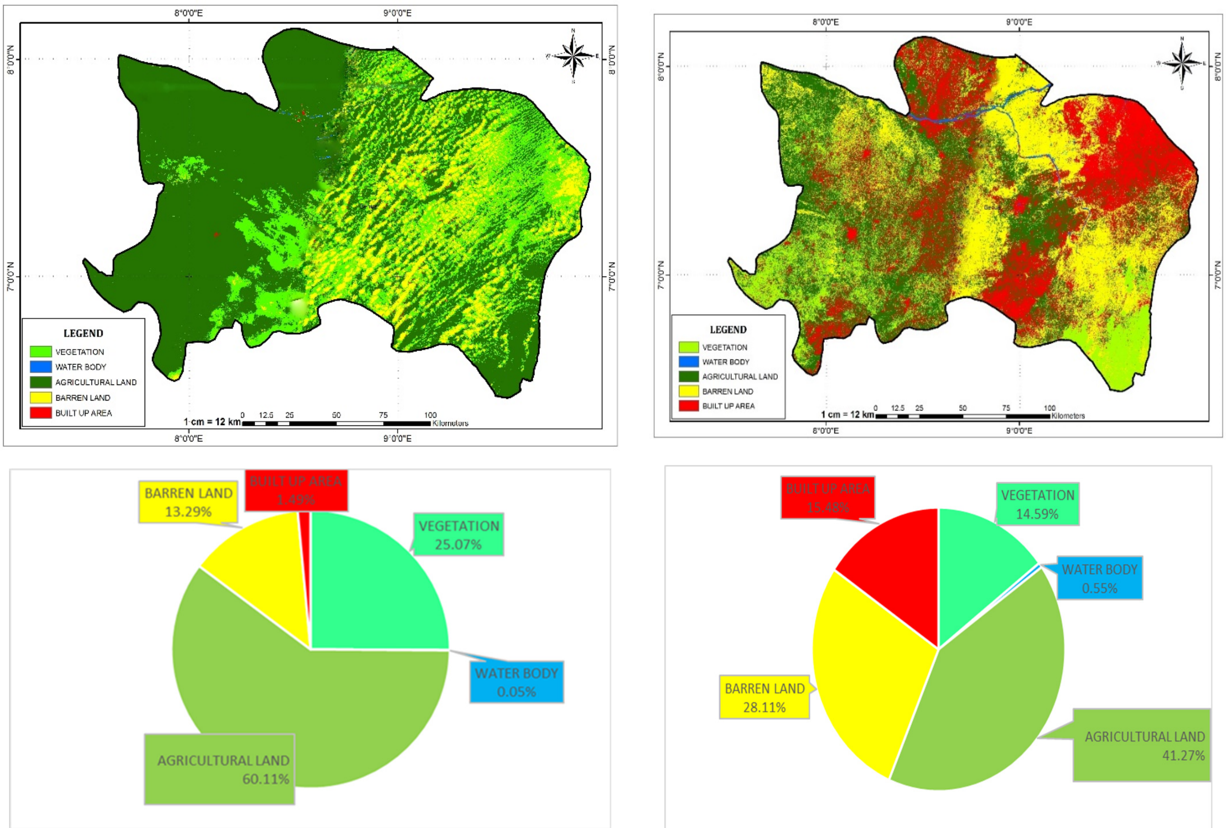


Figure 3. Classified LULC for Kwara State for 1990 and 2020. (**a**) Classified LULC for Kwara State for 1990. (**b**) Classified LULC for Kwara State for 2020.



(**a**) (**b**)

Figure 4. Classified LULC for Benue State for 1990 and 2020. (**a**) Classified LULC for Benue State for 1990. (**b**) Classified LULC for Benue State for 2020.

3.3. The Resultant Effects of LULC Changes and Migration on the Food Security

To evaluate the resultant effects of LULC changes and migration on the food security of the three states, efforts were made to analyze the impacts of LULC on migration and the effects of LULC on food crop production.

3.3.1. Impacts of LULC on Migration

To evaluate the influence of changes in LULC on migration, Univariate regression analysis was conducted using Equation (8). The results presented in Table 6 showed that changes in vegetation, water body, and agricultural land have little or no influence on the rate at which people migrate in and out of these three states. On the contrary, conversion of other LULC classes to barren land and built-up areas negatively influenced migration of people in and out of the three states except in Benue state in which changes in built-up areas have little or no influence on their rate of migration. The results also indicated that 63.7%, 54.7%, and 63.2% of net migration in Niger state, Kwara state, and Benue state, respectively, was influenced by the changes in all five classes of LULC.

Table 6. Univariate Regression Analyses Showing the Influence of Changes in LULC on Migration in Niger, Kwara, and Benue States.

State			VG	WB	AL	BL	BA	R^2
Niger	NetMig	*p*-value	0.117	0.108	0.110	0.004	0.002	0.637
		Coeff.	−150.622	9425.086	−247.240	−24.570	−76.485	
Kwara	NetMig	*p*-value	0.289	0.764	0.371	0.005	0.002	0.547
		Coeff.	6.107	2249.173	−27.764	33.074	−146.095	
Benue	NetMig	*p*-value	0.119	0.112	0.111	0.014	0.953	0.632
		Coeff.	2012.620	133980.975	728.388	−23.600	−0.178	

Coeff. = Coefficient, NetMig = Net Migration, VG = Vegetation, WB = Waterbody, AL = Agricultural Land, BL = Barren Land, BA = Built-up Area.

3.3.2. Effects of LULC on Food Crop Production

To evaluate the resultant impacts of LULC change on crop production, estimated cultivated land area and crop yields data of maize, rice, groundnut, cassava and yam for the three states obtained from National Agricultural Extension and Research Liaison Services (NAERLS), Zaria-Nigeria were analyzed as presented in Appendix B. Efforts were also made to calculate the yield per land area cultivated (Figures 5–7), there has been fluctuations in the area of land apportioned for cultivation of the crops in Niger state except for cassava, which has been increasing over the last 15 years. These fluctuations in the estimated cultivated land area led to myriad changes in the yields of all the five crops in the state. Despite the appreciable increase in the estimated cultivated land area for all five crops over the last 15 years in Kwara state, there have been fluctuations in the quantities of the yields produced during these years. Similarly, there has been a continuous increase in the estimated land area for the cultivation of all the crops in Benue state except for rice and groundnut, which decreased in 2015 and yam, which declined in 2020. This continuous increase over the 15 years translated to a drastic increase in yields of all the crops except yam. Regarding crop yield per cultivated land area, there was a drastic and continuous decrease in yam and rice in all three states, while others showed various degrees of fluctuations. The increase in estimated cultivated land areas from available land mass in Kwara and Benue states, as indicated in Appendix B, despite the reduction in agricultural land of these two states between 1990 and 2020, as depicted in Table 4 and Figures 3 and 4, could be attributed to farmers shifting their attention to these five common staple crops in the areas thereby expanding the cultivated land areas of these five crops from the available land mass.

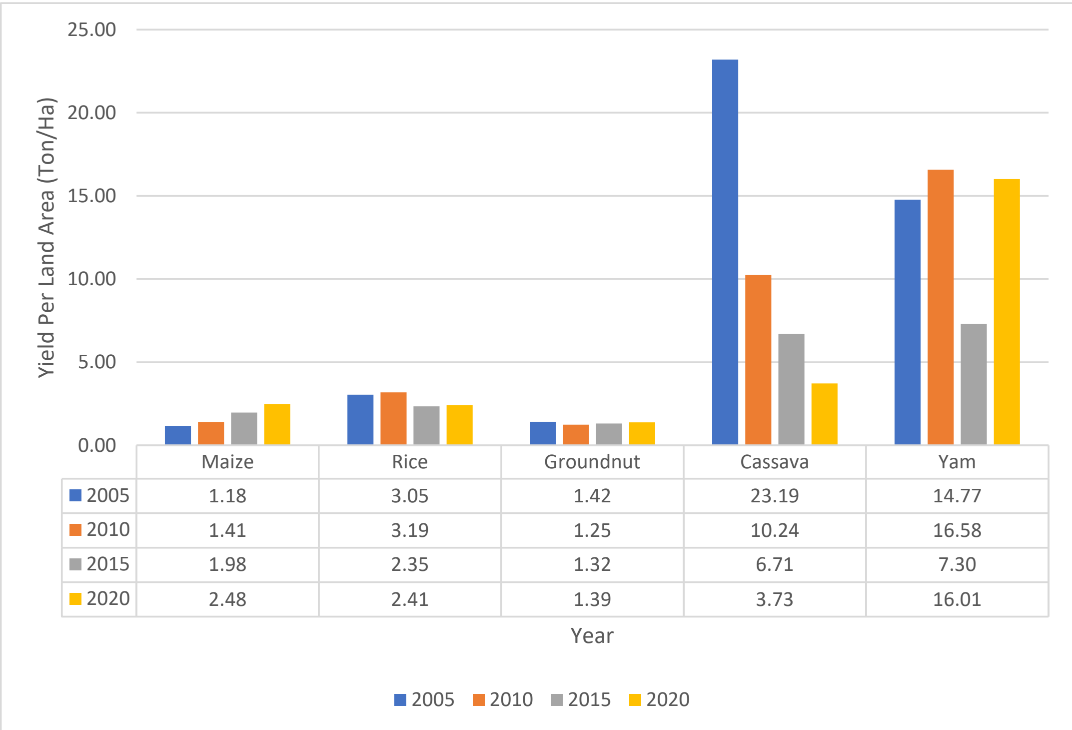


Figure 5. Estimated Yield per Land Area for Niger state. Source: NAERLS, Zaria-Nigeria.

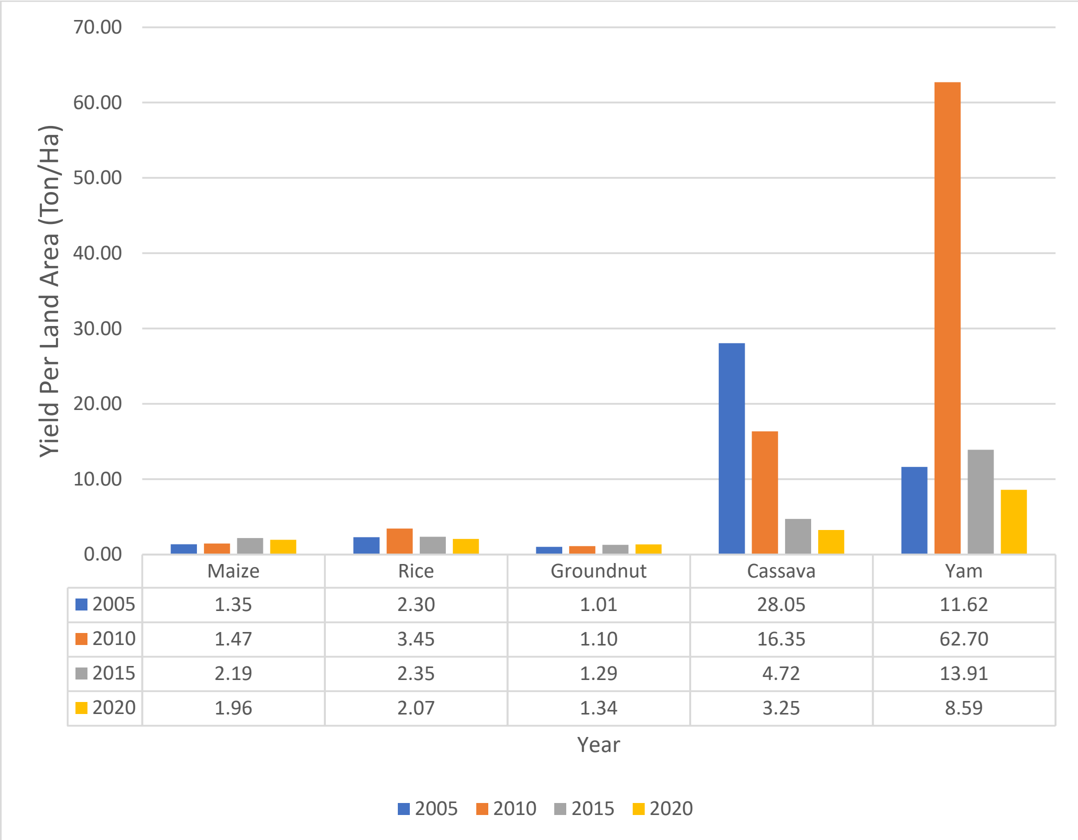


Figure 6. Estimated Yield per Cultivated Land Area for Kwara state. Source: NAERLS, Zaria-Nigeria.

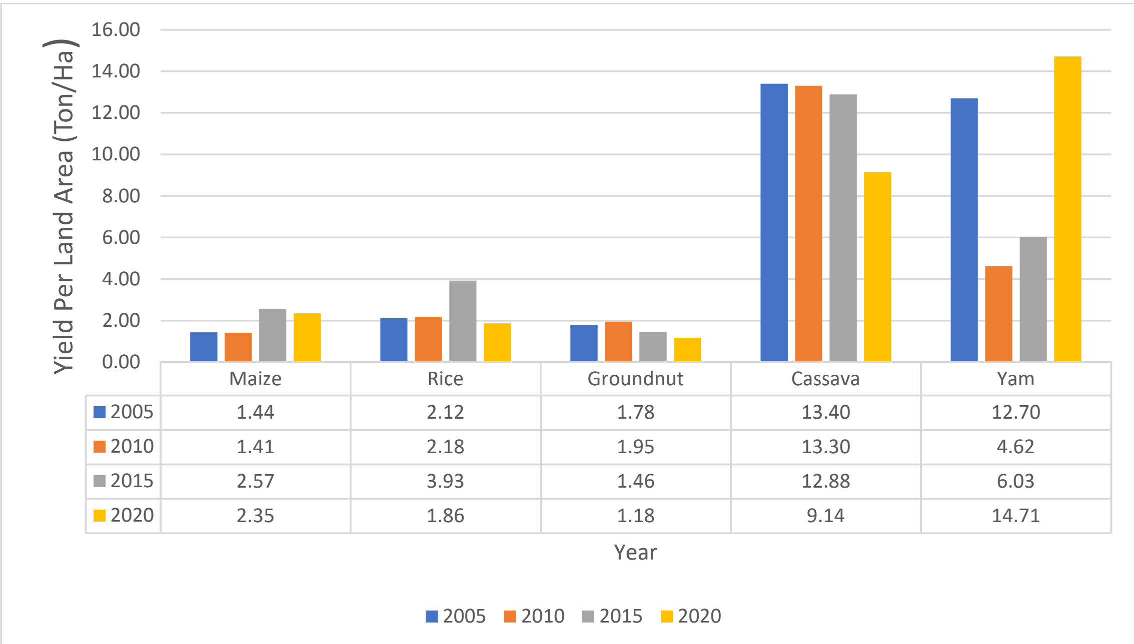


Figure 7. Estimated Yield per Land Area for Benue state. Source: NAERLS, Zaria-Nigeria.

3.3.3. Household Survey

To validate the results of the analysis of LULC and its influence on migration, efforts were made to analyze the outcome of the field survey (household questionnaire, focus group discussions, and expert interviews), as presented in Table 7. In the three states, outmigration is the commonest pattern of migration. There were at least three family members on average of each of the respondents that migrated in the last five years. The majority of these migrants, who were male and young, went to the neighboring states. This pattern of migration happens in every rainy season. Most of the participants during the stakeholders' meetings and expert interview attributed migration of young men to nearby states during the raining season due to destruction of farmlands as a result of flooding, especially in farmlands situated near the river sides, hence, some of the young farmers usually migrate to the areas that are not prone to flooding to continue with their farming activities, while most of them migrate to the cities to look for greener pasture. According to them, some of these migrants do not always come back to their former locations.

According to the respondents, changes in LULC exacerbated by environmental and socio-economic factors are responsible for the migration of people in the study areas. The environmental factors that determine the rate of migration are majorly the state of the fertility of the soil and the rate of land/soil degradation in the area. Furthermore, availability of land, demographic pressure and hunger, and land insecurity are the major socio-economic factors that influence the rate of migration in the study area.

Table 7. Results of Household Survey on Migration Patterns.

Variable	Percentage
Pattern of Migration	
In-migration	14.9
Out-migration	81.4
Cross border migration	3.7
Number of migrated family members in the last five (5) years	
1–5	73.9
6–10	18.7
Above 10	7.5
Destinations of migrated family members	
Neighbouring town	55.3
Another state	44.7
Frequently migrating gender	
Male	80.7
Female	19.3
Age categories of migrants	
Elderly	6.0
Youth	89.4
Children	4.6
Frequency of migration of family members	
Every month	11.3
Every year	15.4
Every raining season	40.4
Every drying season	2.8
Once in a while	30.1
Environmental factors determining migration	
Soil fertility	46.5
Land/soil degradation	29.7
Deforestation	9.7
Poor soil profitability	10.4
Unfavourable weather condition	3.7
Socio-economic factors influencing migration	
Land availability	43.6
Demographic pressure	31.2
Hunger	15.4
Land insecurity	9.8

Source: Fieldwork 2021.

3.4. Resultant Effects of Migration and Changes in LULC on Crop Production

The results of multivariate regression analysis for maize, rice, groundnut, cassava, and yam for Niger, Kwara, and Benue states are presented in Table 8. The results showed that the model was able to describe the variations in the yields of food crops ranging from 95.5% (0.955) for rice in Benue state to only 29.7% (0.297) in the case of cassava in Niger state. The regression analysis showed a lot of significant relationships, while only few, mostly with cassava, are insignificant. The coefficients can be used to assess the impacts of changes in net migration and LULC on food crop yields. The sign of the coefficients indicated the direction of the change in food crop yields with respect to net migration and LULC. Changes in maize yields are largely explained by changes in net migration and LULC, as these variables accounted for 87.1%, 70.7%, and 92.0 changes in maize yields in Niger, Kwara and Benue states, respectively. Furthermore, 74.1%, 76.2%, and 95.5% variations in the yields of rice in Niger, Kwara, and Benue states, respectively, are explained by changes in net migration and LULC. Similarly, groundnut yields in Niger, Kwara, and Benue states with respective R-squared values of 0.942, 0.936, and 0.898 are majorly influenced by the changes in net migration and LULC. Cassava yields showed a weak relationship in all three states. Only 29.7%, 40.9%, and 36.8% in cassava yields variations in Niger, Kwara, and Benue states, respectively, are controlled by changes in net migration and LULC, while changes in net migration and LULC have high impacts on the yields of yam in Niger, Kwara, and Benue states with respective r-squared values of 0.522, 0.698, and 0.752. Furthermore, net migration was a major variable that influenced the yields of groundnut and yam in Niger state. Maize yields in Niger and Benue states and yam in Benue state are influenced by changes in all the classes of LULC. Other classes of LULC had varied degrees of impact on the yields of the five food crops across the three states. These results showed that net migration and changes in LULC have a great impact on the yields of the five food crops in all three states.

Table 8. Multivariate Regression Analyses Showing the Influence of Net Migration and LULC on Crop Yields of Niger, Kwara, and Benue States.

State	Crop		NetMig	VG	WB	AL	BL	BA	R^2
Niger	Maize	*p*-value	0.402	0.017	0.018	0.017	0.013	0.004	0.871
		Coeff.	0.001	0.791	−48.123	1.286	0.094	0.344	
	Rice	*p*-value	0.166	0.314	0.245	0.281	0.004	0.020	0.741
		Coeff.	−0.003	−0.648	46.104	−1.122	−0.202	−0.454	
	Groundnut	*p*-value	0.000	0.001	0.000	0.000	0.052	0.022	0.942
		Coeff.	0.003	1.446	−88.427	2.322	−0.91	−0.332	
	Cassava	*p*-value	0.192	0.628	0.623	0.629	0.575	0.461	0.297
		Coeff.	0.025	−3.114	192.911	−5.003	0.317	1.248	
	Yam	*p*-value	0.024	0.322	0.283	0.301	0.010	0.015	0.522
		Coeff.	−0.070	−9.544	635.345	−16.140	−2.607	−7.175	
Kwara	Maize	*p*-value	0.341	0.026	0.826	0.350	0.004	0.001	0.707
		Coeff.	0.001	−0.054	−6.045	0.110	−0.166	0.826	
	Rice	*p*-value	0.069	0.614	0.624	0.308	0.049	0.048	0.762
		Coeff.	−0.003	−0.014	−17.084	0.152	−0.137	0.566	
	Groundnut	*p*-value	0.328	0.000	0.121	0.161	0.045	0.000	0.936
		Coeff.	0.001	−0.093	21.167	−0.079	−0.055	0.549	
	Cassava	*p*-value	0.065	0.563	0.873	0.885	0.883	0.732	0.409
		Coeff.	0.016	−0.094	32.706	−0.124	−0054	0.520	
	Yam	*p*-value	0.615	0.622	0.314	0.058	0.003	0.008	0.698
		Coeff.	0.010	0.203	−536.889	4.521	−3.625	12.779	
Benue	Maize	*p*-value	0.651	0.001	0.001	0.001	0.044	0.007	0.920
		Coeff.	0.000	15.664	1023.150	5.504	0.093	0.038	
	Rice	*p*-value	0.969	0.018	0.015	0.017	0.399	0.000	0.955
		Coeff.	<0.0001	5.983	403.900	2.141	−0.17	0.057	
	Groundnut	*p*-value	0.971	0.000	0.000	0.000	0.058	0.521	0.898
		Coeff.	<0.0001	−15.567	−1013.039	−5.479	−0.077	−0.007	
	Cassava	*p*-value	0.774	0.686	0.686	0.692	0.503	0.153	0.368
		Coeff.	0.001	4.825	316.186	1.676	0.058	0.036	
	Yam	*p*-value	0.105	0.018	0.016	0.016	0.005	0.013	0.752
		Coeff.	−0.014	104.799	7051.711	38.088	−1.202	0.290	

Coeff. = Coefficient, NetMig = Net Migration, VG = Vegetation, WB = Waterbody, AL = Agricultural Land, BL = Barren Land, BA = Built-up Area. Sources: NAERLS, Zaria-Nigeria and United Nations.

4. Discussion

Our findings on the Land Use and Land Cover (LULC) of Niger state between 1990 and 2020 showed that most of the vegetation, barren land, and water areas in the state had been converted to agricultural land and built-up areas, possibly because of an increase in population, which necessitated an increase in food supply and settlement. We discovered that most of the conversion of other LULC classes to agricultural land and vegetation occur in the rural areas and along the riverine areas of the state, while their conversion to built-up areas occurs in the cities, and this is in agreement with the outcome of the study of Salami et al. [39], which indicated that there was a continuous conversion of vegetation to farmland and built-up areas in Garatu Urban Corridor of Minna, Niger State between 2000 and 2019. They attributed these changes to unprecedented urban growth as a result of rural-urban migration and urbanization. The LULC of Kwara and Benue states between 1990 and 2020 showed that most of the vegetation, agricultural land, and water bodies in the two states have been converted to built-up areas and Barren land. This conversion was traceable to an increase in population which necessitated the conversion of most of the agricultural land to built-up areas to solve the problem of shelter. We inferred that as a result of continuous application of agrochemicals like pesticides, herbicides, fungicides, insecticides, among others, most of the agricultural land became barren, while some portions were abandoned for some time, change in weather made some of them to be converted to vegetation. Presently, Niger state has a comparative advantage over Kwara and Benue states in terms of available land for agricultural production, and if this opportunity is effectively utilized by relevant government agencies, it will boost the food security of the state. Furthermore, we asserted that Niger state would be food secure considering a high increase in agricultural land and a little increase in built-up areas in the last 30 years provided concerted effort is made to ensure continuous increase in agricultural land while at the same time reduce the pressure on the city's infrastructure by discouraging rural-urban migration but in the case of Kwara and Benue states with a high decrease in agricultural land and continuous astronomical increase in built-up areas over the last 30 years, if it is business as usual, then the food security of the region and the entire country is under a serious threat.

Regarding the impacts of changes in LULC on migration, we found out that changes in vegetation, water body, and agricultural land had little or no impacts on the rate of migration in the three states, whereas a rapid increase in barren land and built-up areas had caused a significant migration of people from the three states and if this remains uncontrolled, it will have a serious impact on the food availability in the region and country as a whole.

According to FAO [40], food security is measured by four components: Food availability, food accessibility, food stability, and food utilization/consumption. The analysis of the crop yield and estimated cultivated land area indicated that there were fluctuations in the area of land used and this led to fluctuations in the quantities of the yields of these five crops. We discovered that the fluctuations in the available land for agricultural production were a result of changes in land use across different locations in the study area, as presented in our various LULC maps. Additionally, we found out that there was a significant impact of the combination of net migration and changes in LULC on the yields of five major food crops in the three states, as changes in the yields of these food crops are majorly determined by this combination. Furthermore, most of the participants during our Focus Group Discussion corroborated this assertion by stating that there has been a drastic reduction in all the indicated components of food security because most of the young farmers are migrating out of these locations to look for greener pastures.

Furthermore, the results of our LULC and field survey indicated that outmigration is very common in all three states. We inferred that as changes in LULC lead to the massive migration of people in the study areas, migration also impacts LULC, such as the conversion of agricultural land into barren land, especially in Kwara and Benue states, is directly related to the impacts of outmigrated members who left agricultural land uncultivated and this is similar to the current situation of Bhanu Municipality of Tanahun district of Nepal, as reported by Bhandari et al. [41]. This conversion is mostly witnessed along the border towns. According to the majority of the respondents of household survey, at least an average of three members of each household outmigrated in the last five years, most of whom are young men who left their communities for neighboring states because of poor soil fertility, degraded soil, limited land availability, demographic pressure, hunger, and land insecurity.

5. Conclusions

We conclude that between 1990 and 2020, there has been an increase in agricultural land and built-up areas in Niger state, while most of the vegetation, agricultural land, and water body areas in Kwara and Benue states have been converted to built-up areas and barren land. These changes in LULC in North Central Nigeria have led to the massive migration of young farmers to the neighboring states. There was a continuous drastic reduction in food production as a result of changes in the land use and migration in recent years. Thus, we recommend that all the relevant stakeholders should invest in infrastructure and create an attractive environment to reduce the rate of rural-urban migration and boost agricultural production. It is also recommended that all the vast barren land in the region, especially in Kwara and Benue states, should be converted to productive use.

The results of this study can be used by policymakers and researchers to assess the current state of LULC and its potential future impacts on migration and food security in Nigeria. Due to the diversity of North Central Region of Nigeria, the consideration of the three states as the representation of the whole region and the consideration of net migration of Nigeria as the representation of the three states are considered the main weaknesses of this study.

Author Contributions: Conceptualization, S.O.O., A.A.O., S.S. and C.F.; methodology, S.O.O., A.A.O., S.S. and C.F.; software, S.O.O. and C.F.; validation, S.O.O., A.A.O., S.S. and C.F.; formal analysis, S.O.O., A.A.O. and C.F.; investigation, S.O.O., A.A.O., S.S. and C.F.; resources, S.O.O., A.A.O., S.S. and C.F.; data curation, S.O.O., A.A.O., S.S. and C.F.; writing—original draft preparation, S.O.O.; writing—review and editing, S.O.O., A.A.O., S.S. and C.F.; supervision, S.O.O., A.A.O., S.S. and C.F. and Funding acquisition, C.F. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement: The data presented in this study are under the copyright of WASCAL and can be made available on request from the Executive Director of West African Science Service Centre on Climate Change and Adapted Land use (WASCAL), Accra, Ghana, West Africa.

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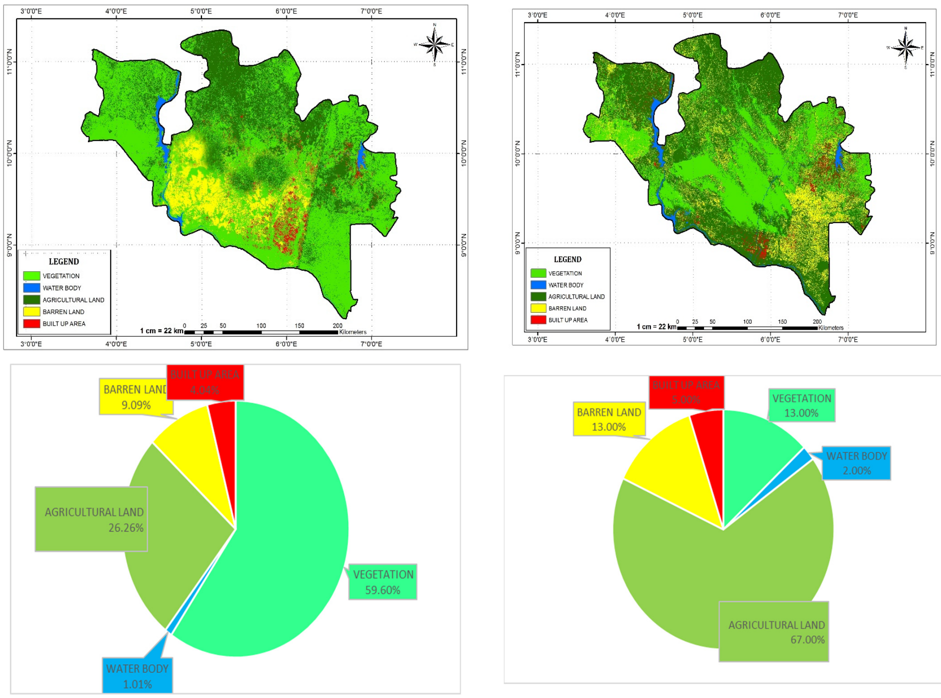
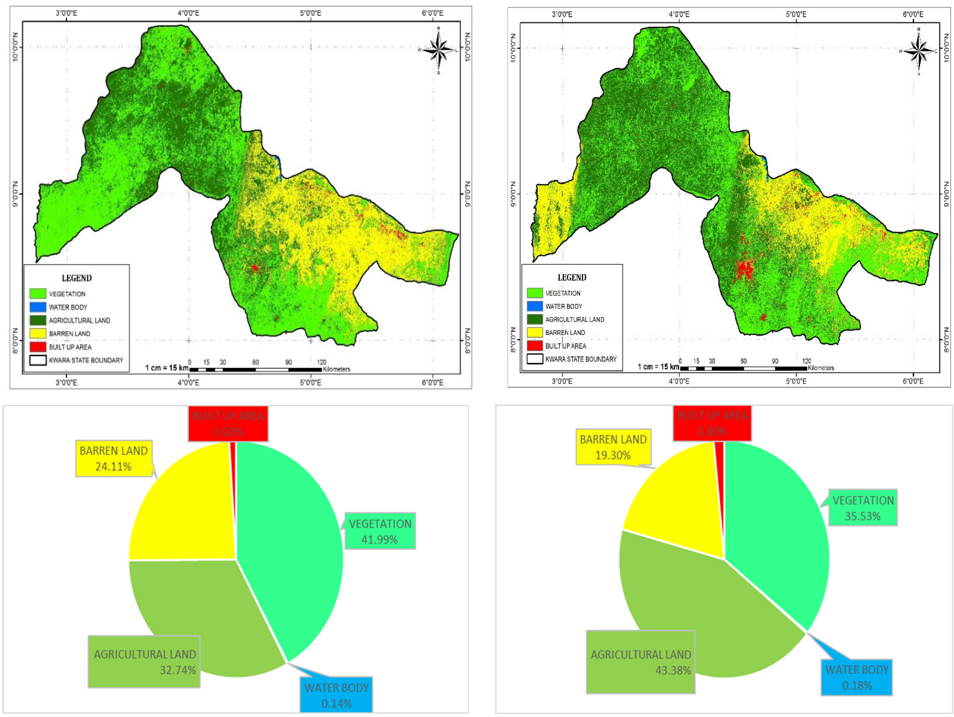
Conflicts of Interest: The authors declare no conflict of interest. The roles in the conceptualization, collection, analyses, or interpretation of data in writing the manuscript, and the decision to publish the results are basically by the authors.

Appendix A



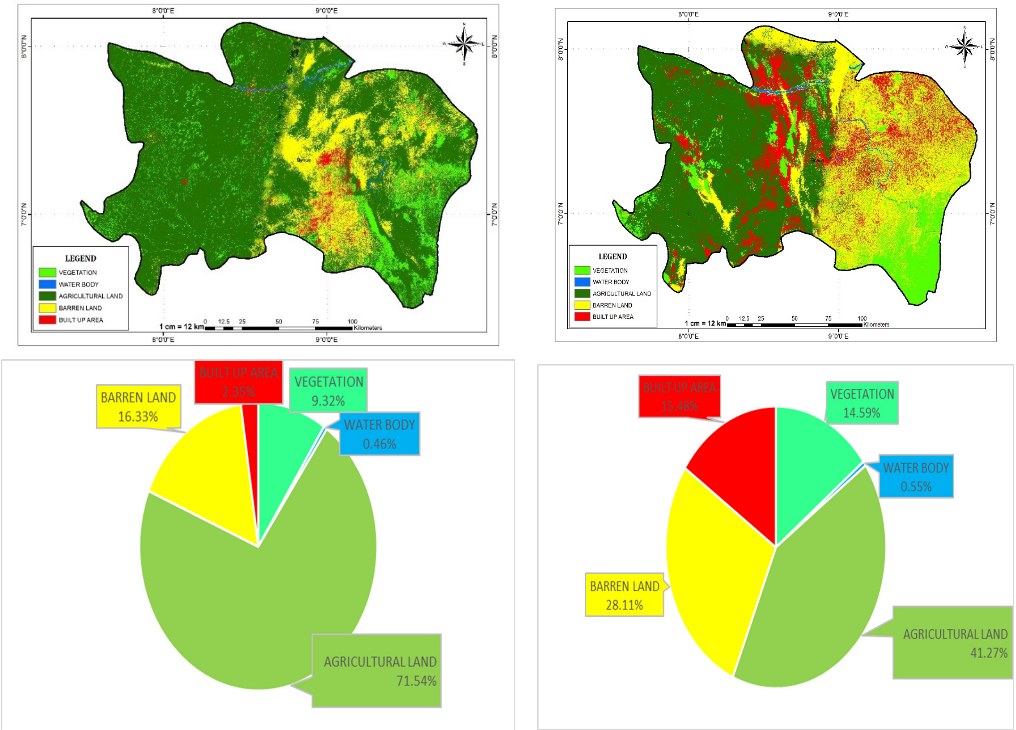
(**a**) (**b**)

Figure A1. Classified LULC for Niger State for 2000 and 2013. (**a**) Classified LULC for Niger State for 2000. (**b**) Classified LULC for Niger State for 2013.



(**a**) (**b**)

Figure A2. Classified LULC for Kwara State for 2000 and 2013. (**a**) Classified LULC for Kwara State for 2000. (**b**) Classified LULC for Kwara State for 2013.



(**a**) (**b**)

Figure A3. Classified LULC for Benue State for 2000 and 2013. (**a**) Classified LULC for Benue State for 2000. (**b**) Classified LULC for Benue State for 2013.

Appendix B

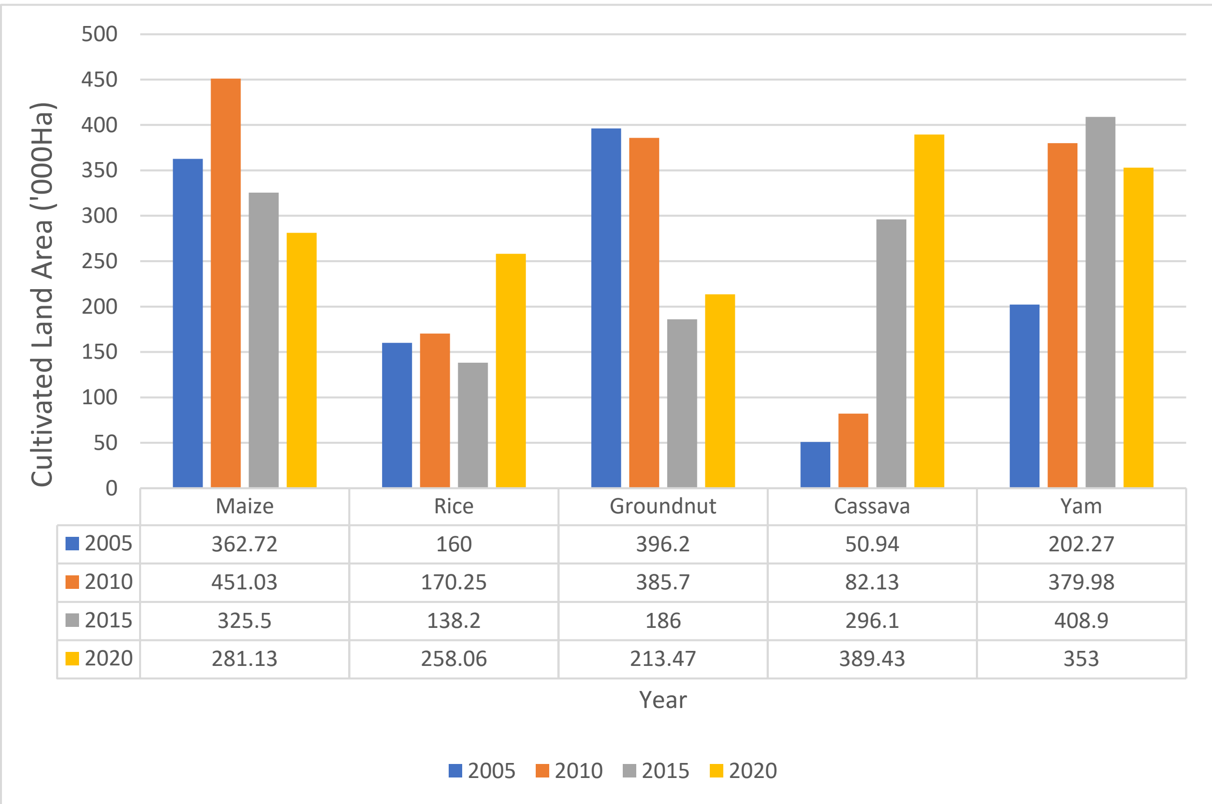


Figure A4. Estimated Cultivated Land Area for Niger State. Source: NAERLS, Zaria-Nigeria.

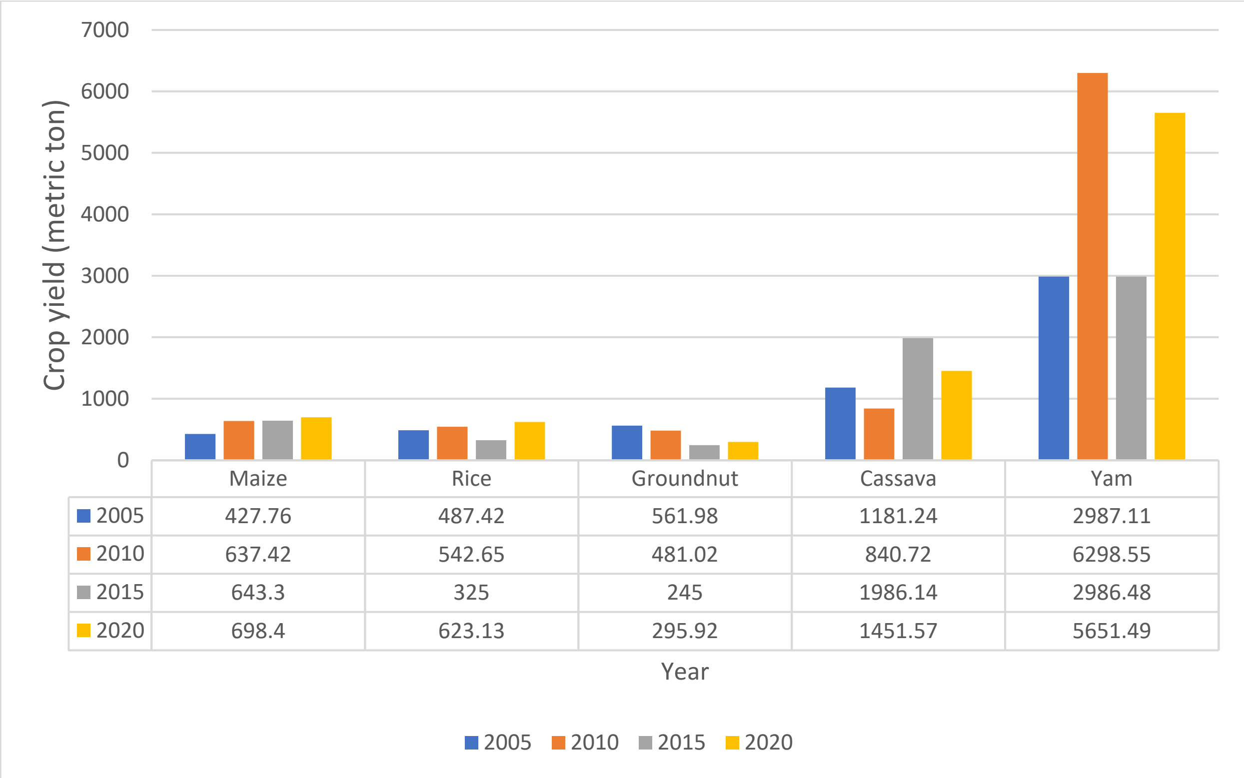


Figure A5. Estimated Crop Yield for Niger State. Source: NAERLS, Zaria-Nigeria.

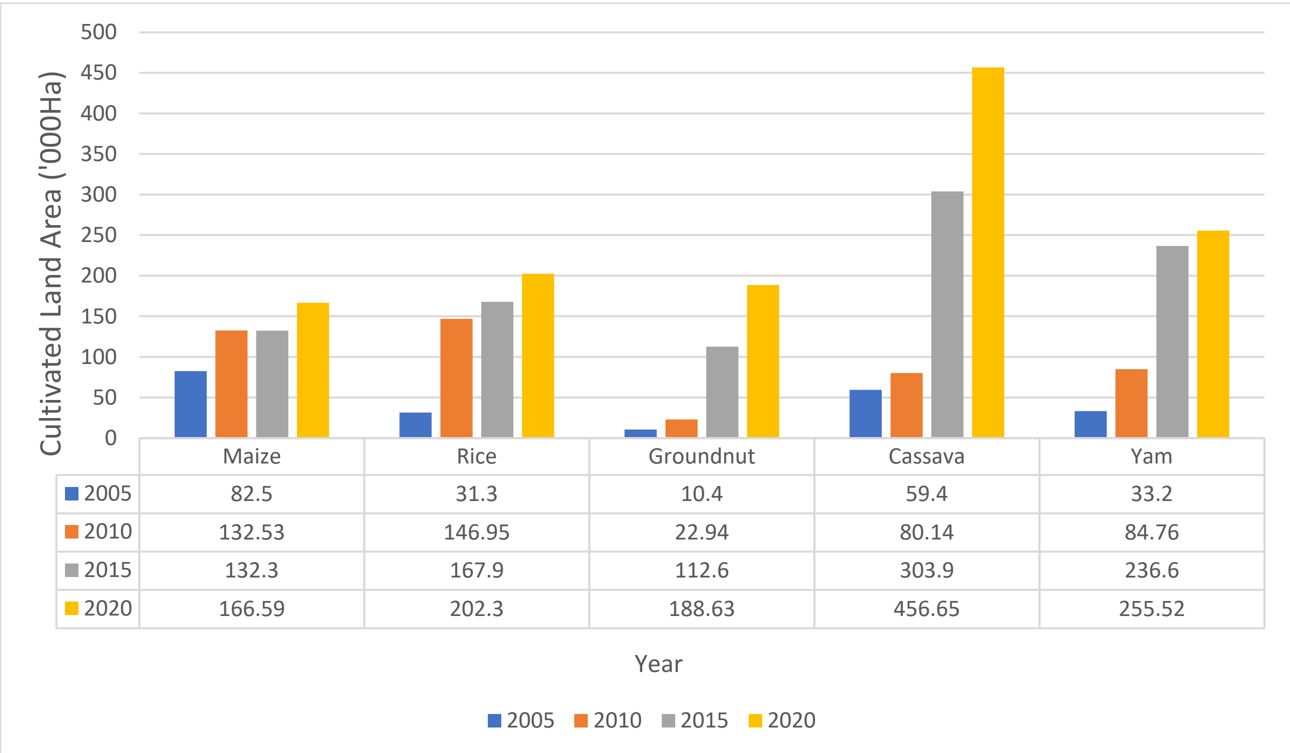


Figure A6. Estimated Cultivated Land Area for Kwara State. Source: NAERLS, Zaria-Nigeria.

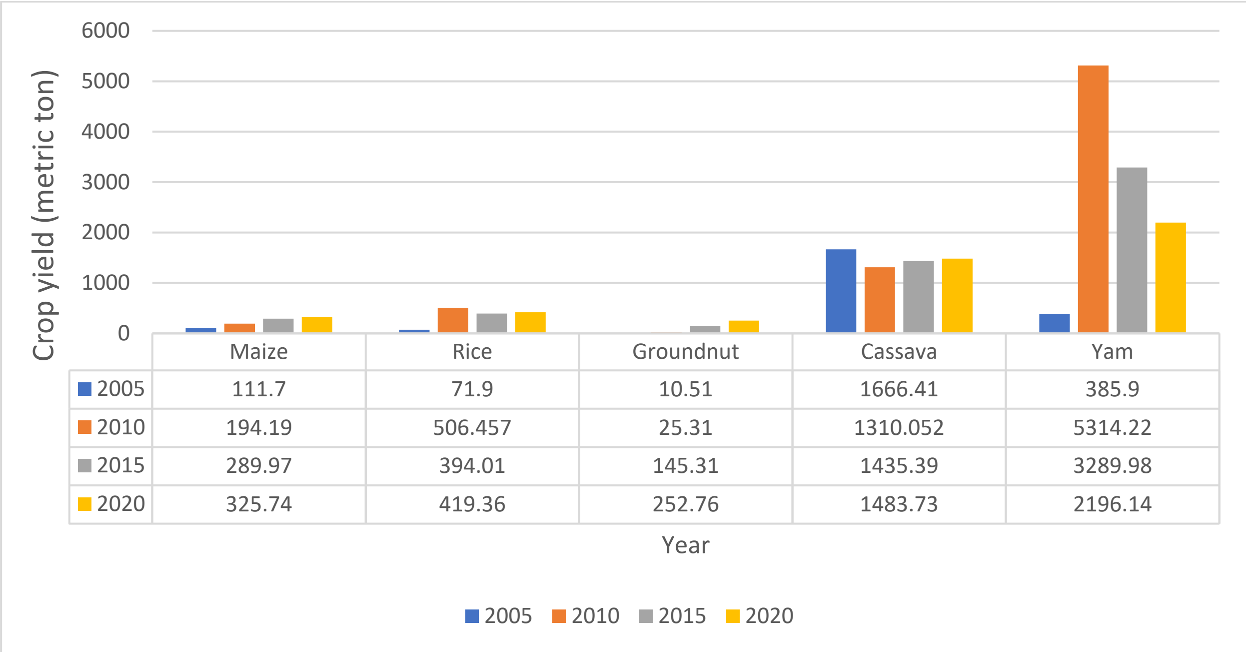


Figure A7. Estimated Crop Yield for Niger State. Source: NAERLS, Zaria-Nigeria.

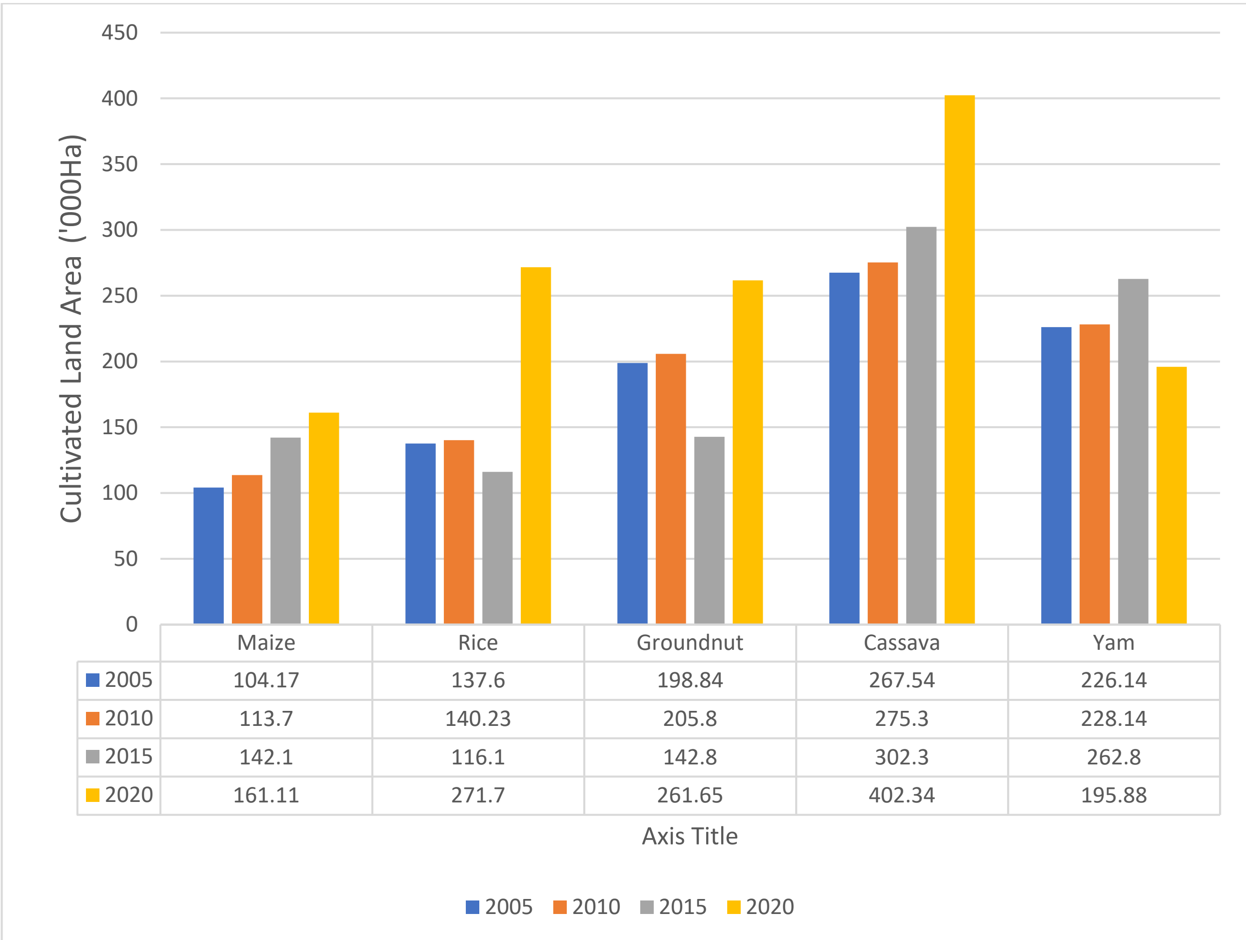


Figure A8. Estimated Cultivated Land Area for Benue State. Source: NAERLS, Zaria-Nigeria.

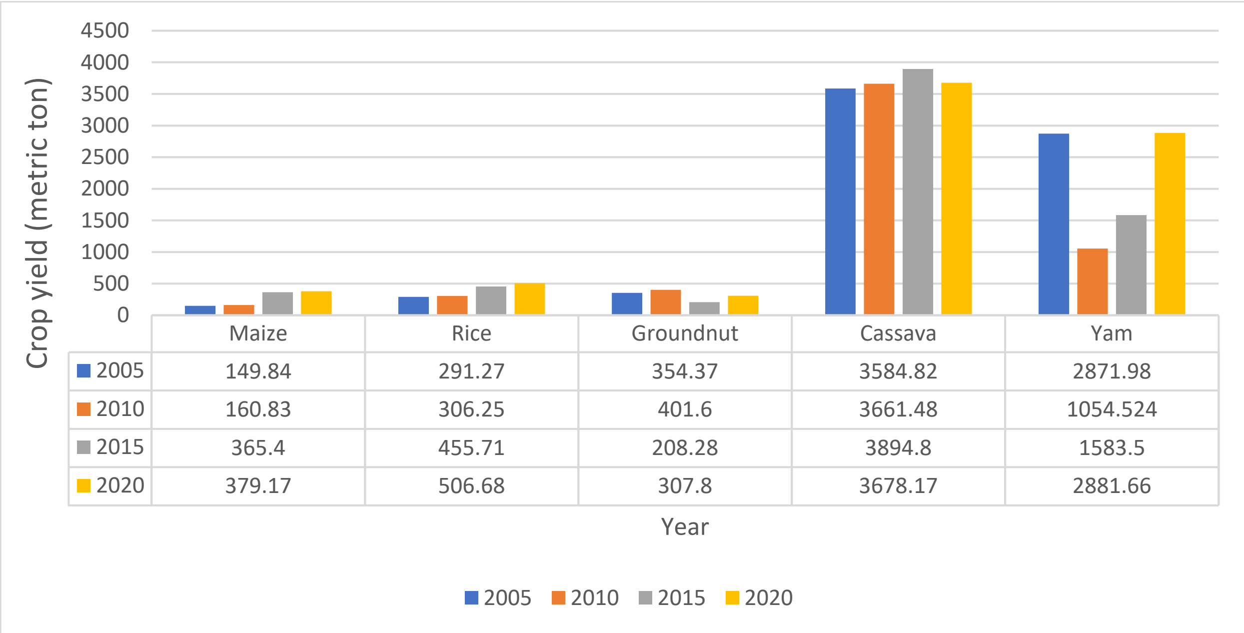


Figure A9. Estimated Crop Yield for Benue State. Source: NAERLS, Zaria-Nigeria.

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