FARM SIZE HOLDING IN NORTHERN NIGERIA: A REMOTE SENSING ASSESSMENT AND IMPLICATION ON FOOD SUSTENANCE

CONFERENCE PAPER

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ABSTRACT

Land is a main life support resource to the third world countries. In Nigeria, a major limitation to sustainable use of land and its resources is that of fickle evaluation of the available stock and level of utilization. In particular, the commonly adopted traditional techniques for land resources studies are as questionable as the sources and quality of adopted data and the generated results. This paper presents the findings on an evaluation of the per capita farm-size holding in a predominantly agricultural environment in a developing world, using the interactive remote sensing technique and Geo-Information Technology.

The study area covers, in part, six (6) Local Government Areas (LGAs) in the North West Geo-political Zone of Nigeria. The typical Sudano-Sahellian region covers some parts of the floodplain of Rivers Sokoto and Rima drainage basins and the adjoining upland areas.

The SPOT image of the area was interpreted on a Procom-2 optical image analytical equipment to assess the extent of the land cover and uses. Collateral data from administrative sources, literature searches and field activities were integrated to determine the cultivated lands per farmer.

The findings show that 66 per cent of the agricultural holdings in the area are in upland regions and cultivatable only in a short wet season of less than three month per annum. Farm holding per head is about 0.61 ha in the upland and less than 0.1 ha in the prime fadama area. Sokoto LGA has the lowest figures for all the categories of farmland types. The gloomy scenario portended by the results is discussed with special emphasis on the social and food security and sustainability in the region.

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INTRODUCTION

The concept of sustainability assumes a philosophical development whereby the needs of a generation are met without necessarily compromising the capability of the future generation to meet theirs. Relative to agriculture, sustainable development implies that food production strategies at a point in time give enough opportunities for coming generation to produce their own food. The consequence of farm size and farm holding arrangement on desired sustainable agricultural development and food production is the focus of the study.

Agricultural land is a most valued resource in developing countries. Land and its resources serve as a backbone for development in other sectors of the economy in the tropics (Omara-Ojungu, 1992). The main sectors discussed by Omara-Ojungu (1992) include mining, industry, transportation, health, education and non-formal government and service provision. Save a few mineral-rich ones among these countries, the agricultural sector accounts for over 70 per cent of the land utilization, 50 per cent of the Gross National Product (GNP) and 80 per cent of their export earnings. It is the source of livelihood of over 60 per cent of the population in the developing countries (Omara-Ojungu, 1992).

Adedokun (1977) and Akinbode (1978) discussed the crucial roles of agricultural sector in the Nigerian national development. To Akinbode (1978), the sector accounted for about 91 per cent of the country's export prior to the oil boom of the 70's. Adedokun (1977) also noted that just before the independence in 1960, the sector was employing about 81 per cent of the national labour force. It was responsible for about 65 per cent of the GPD (GDP) and 73 per cent of the foreign exchange earnings to the country. By 1963, about 56.8 per cent of the population were engaged directly in farming and about 15.6 per cent in trading businesses, majority of whose wares were agriculture (Akinbode, 1978). The sector was only overtaken by the oil and (now) gas sector following the oil boom. Yet, as at 1976, agriculture still employed about 60 per cent of the labour force in the country and was contributing about 50 per cent of its foreign exchange earning (Adedokun, 1977).

The contribution of agriculture to the economic development of the country has since nose-dived, losing to the oil and gas-producing sector. Oil and gas exploratory activities are limited to the Niger Delta only. The onshore, offshore and deep-shore areas of its almost 800 km stretch of the Atlantic Coastline is endowed with oil and gas reserves that can last beyond the next half a century at the current estimation and rate of production (Soneye, 1995). With the establishment of the Nigerian National Petroleum Corporation (NNPC) in 1977, there has been virile decision-making processes and positive results in the organizational control of the oil and gas production activities by the joint venture producer companies of which Shell Petroleum Development Corporation, Chevron Nigeria Ltd., Texaco Overseas Nig. Ltd., Nigeria Agip Oil Company and Elf Producing Nigeria Ltd are most prominent.

NNPC (1992) and DPR (1992) reported that, as at 1992, there were about 2,000 oil wells in the Niger Delta region. It was also reported that the main floodplains in the hinterland of the country have been allotted to prospecting companies as Oil Mining Leases (OMLs) and/or Oil Prospecting Leases (OPLs). Production per day was increased from 30,000 barrels per day (bpd) in 1977 to 230,000 bpd in 1980 and 445,000 bpd in 1990. Currently, the figure stands at about 1.8 million bpd. With four (4) refineries in operation, the establishment of Liquefied Natural Gas (LNG) plants and commencement of shipment of gas produce to international market, the sector now accounts for about 90% of the foreign exchange earnings to the country. It is now the pillar on which the other sectors rest, agriculture and food production inclusive (Soneye, 1995).

Despite the remarkable contribution, the oil and gas sector is of limited significance to the majority of the Nigerian populace compared to agriculture. Among the argument portended by Adedokun (1977) are (i) that the oil exploratory sector is dominated by foreign personnel and technology, (ii) that the sector has been responsible for a wider range and degree of environmental problems and subsequent socio-political consequences and (iii) that the prices of the products are less stable in the world market, thereby making the national economy less stabilized. The agricultural sector is the single most significant sector that was responsible for the initial transformation of the economy to the current economic status. It has continued to the supply of food and industrial raw materials. It supports the local purchasing power for manufactured goods. In particular, it still provides employment for almost 60 per cent of the populace (FOS, 1999). Farmers are not only limited to the dominantly rural areas of the country but also in the urban centers where market gardening is gaining prominence.

The significance of agriculture in Nigeria necessitates that adequate development indices and information be accessed for purposeful planning, management and development. In this perspective, a significant area of interest is that of land capability and management strategies. This is because a primary constraint on the accelerated development of the sector in almost all the parts of the country is that of anthropogenic exigencies, of which land fragmentation and small size holdings rank highest.

The problem is more pronounced in the northern part of the country where the Hausa feudal system is practiced extensively. As argue by Oyeleye (1977), much of the poverty in Nigeria is due to the common traditionally inefficient and poorly productive subsistence agricultural practices via land tenure system. Oyeleye (1982) and Soneye (2002) discussed some results of the attempts by the government to solve these problems with particular reference to agricultural cooperatives and management strategies respectively. Ewium et al (1998) provided a discussion on the social and environmental aspects of land-tenure system in the tropics. Their emphases were on leasehold, freehold and vesting of ownership on the local traditional ruler or head.

The concern on accelerated development of agriculture in Nigeria is on the ever-increasing land fragmentation, continuous cropping (in the face inadequate manures/ fertilizers), deteriorating soil fertility, low productivity and income of farmers. The situation has since become more critical with the constitution of the 1978 Landuse Decree which rather than transferring land ownership to the governments, has led to transfer of land ownership to powerful public "servants". The deduction is that the existing practice can hardly sustain the required crop production needs and food requirements of the country.

REMOTE SENSING IN AGRICULTURAL RESOURCES MANAGEMENT

The methods being adopted for agricultural studies in the developing country are as tedious and unreliable as the generated results there-from. Adeniyi (1986), and, Omojola and Soneye (1993) evaluated some of the methods including (i) system of trial and error; (ii) social surveys and questionnairing; (iii) field observation, survey and recording; and (iv) use of administrative records and maps. The deficiencies and gross unreliability of the techniques are also discussed in terms of poor spatial referencing, longer period of activities, human subjectivity, physical inaccessibility, higher cost, omission, non-repetitive coverage and restriction to data access.

The advantages of remote sensing in the assessment of agricultural resources are also discussed by Adeniyi (1986), and, Omojola and Soneye (1993). The specific areas

highlighted include land holding, land suitability and capability, crop surveys, population distribution and potential, transport network analysis, soil surveys, water resource surveys, crop vigour, density, maturing, growth rates and weed concentration, agro-meteorolgy, irrigation activities and drought prediction.

A single synoptic remote sensing data can hardly reflect the true position of agricultural landscape in the tropics for the fact that the agricultural pattern can be highly ephemeral both in distribution and crop types. The eco-climatic environment can also restrict the use of particular sensors during greater parts of the year. Also, more often than not, farm holdings can be ridiculously low. The multiple opportunities afforded by remote sensing in terms of sensors, resolution, repetitive coverages and complimentability of data account for the for the analytical advantages in agricultural studies.

THE AREA OF STUDY

The area of study is that of a Nigerian Topographical Sheet Number 10 (Sokoto) SE spanning latitude 13°00'N to 13°15'N and 5°15'E to 5°30'E (Fig. 1). It is about 749 km^2 in size. It covers, in parts, 6 LGAs of the present Sokoto State including Kware, Wurno, Rabah, Sokoto, Dange/Shuni and Wamako.

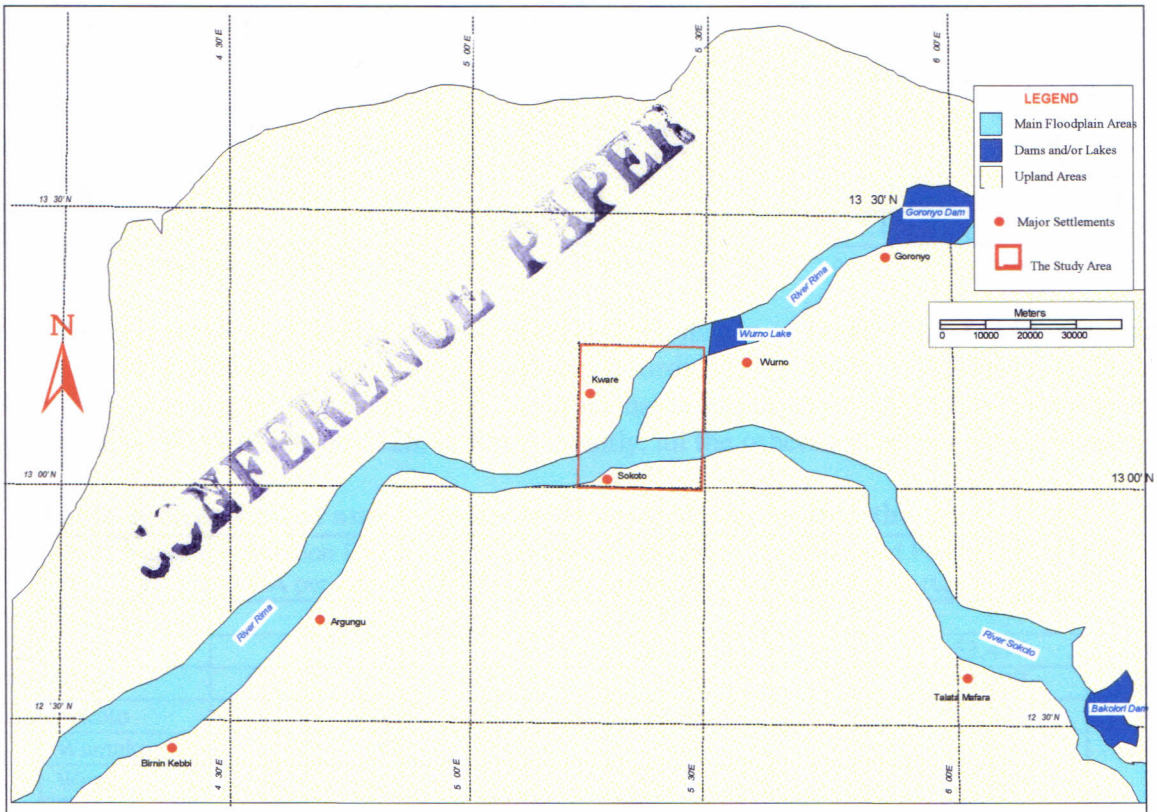


Fig 1: The Study Area

The broad floodplains of River Rima and River Sokoto cut across the extensive perennial agricultural regions. The two (2) rives are the major tributaries of River Niger in the country, before its confluence with River Benue downstream. The short annual wet season of the area lasts between the months of June and September. It has an average annual rainfall of between 350 mm and 600 mm (Bashir and Bala, 1992). Average daily temperature ranges between 26°C and 33°C for a greater part of the year. Relief ranges between about 242.6m on R. Rima floodplain and 335.3 m south of River Rima bank on Kwakwotu Hill. Naturally, the

ecology of the area is that of Guinea and Sudan Savannah fringes. The flora is typically of fire-resistant trees with mixed grasses and open patches of bare surfaces.

The human environment is that of a typical Fulani - Hausa socio-cultural organization. The major settlements are located along main access routes. The sole means of livelihood is agriculture. Hence, a larger number of settlements are found around the prime fadama areas. As discovered by Soneye (2000), the number of settlements rose from 119 (totaling 541 ha) in 1965 to 290 (totaling 2,258ha) in 1995, a change of 144% in number and 317.4% in size. More than 83% of the new settlements are cited around the floodplain area and about 56 of those upland had moved to lower relief regions during the investigation period.

The population densities in 1996 are 138, 128, 39, 3230, 89 and 188 people per square kilometer for Kware, Wurno, Rabah, Sokoto, Dange/Shuni and Wamako LGAs respectively (Table 1). At a growth rate of 2.43% (NPC, 1996), the average population density is 173 people per sq. km presently.

Table 1: Population Characteristics of the LGAs in the Study Area

S/N	LGA Name	LGA HQs	Female Population*	Male Population*	Total Population*	Total Area Extent (in km2)**	Population Density
1	Dange Shuni	Dange	73,532	74,664	148,196	2,524.4	89
2	Kware	Kware	56,807	55,599	112,406	811.6	138
3	Rabah	Rabah	45,741	42,231	87,972	2,310.9	39
4	Sokoto	Sokoto	127,706	141,819	269,525	83.0	3,230
5	Wamako	Wamako	64,024	64,630	127,654	677.2	188
6	Wurno	Wurno	49,945	45,988	95,933	747.3	128
Total			417,755	424,931	841,686	7,154.4	118

*Sources: * = Projected 2002 figures from the 1996 NPC Results (NPC 1996); ** = Soneye and Omojola (1994)*

The study is carried out within a geographical delimitation. Hence, the LGAs are only covered in parts within the defined geographical coordinates of study. As generated in the GIS environment and presented in Table 2, Kware has a landmass of 387.66 km^2, the highest proportionally. Next is Wurno (228,18 km^2). Jointly, all the others cover less than 100 km^2.

Table 2: Area Extent and Population Characteristics Within the Study Limit

LGA Name	Population Density of LGA per km^2 (B)*	Landmass within the Study Limit in km^2 (B)**	Estimated Population of Study Area (C = A X B)
Dange Shuni	89	16.22	957
Kware	138	387.66	53,497
Rabah	39	89.4	3,397
Sokoto	3,230	28.71	93,221
Wamako	188	5.06	956
Wurno	128	222.18	28,439
Total Area	118	749.23	180,376

*Sources: * = Extract from Table 1; ** = Generated in the GIS environment*

A population of 180,376 is estimated for the study segment as presented in Table 2 Sokoto LGA has a highest of 93,221, followed by Kware (53,497), Wurno (28,439) and Rabah (3,397). Dange-Shuni and Wamako have the lowest figures of 957 and 956 respectively.

In terms occupation, the dominant Hausa inhabitants are farmers. They cultivate food and cash crops along both the major and minor floodplains as well as in the upland areas. The prevalent crops are millet, sorghum (i.e. guinea corn), groundnut, beans, rice, onions,

sugarcane, and cassava, tobacco and a number of citrus. The relatively fewer Fulanis are mainly into transhumance animal husbandry. They rear herds of goats, cattle, donkeys and camels both for subsistence and commercial purposes. A few other tribes in the region are engaged in trade and commerce.

Agricultural activities in the area are impaired by both natural and human-induced factors. The high temperature in the sudano-shellian region accounts for its appreciably high evapo-transpiration while its rainfall (in less just about 3 moths of the year) and hydrology modify the soil characteristics and fertility substantially. Anthropogenic-wise, increasing inadequacy of agricultural amenities, population pressure and land fragmentation are most significant. To control some of the effects of the problems, a series of artificial controls of water supply had been embarked upon via construction of dams and reservoirs upstream. As shown on Fig. 1, these include the Goronyo Dam and Wurno Lake on River Rima and the Bakolori Dam on River Sokoto.

METHODOLOGY

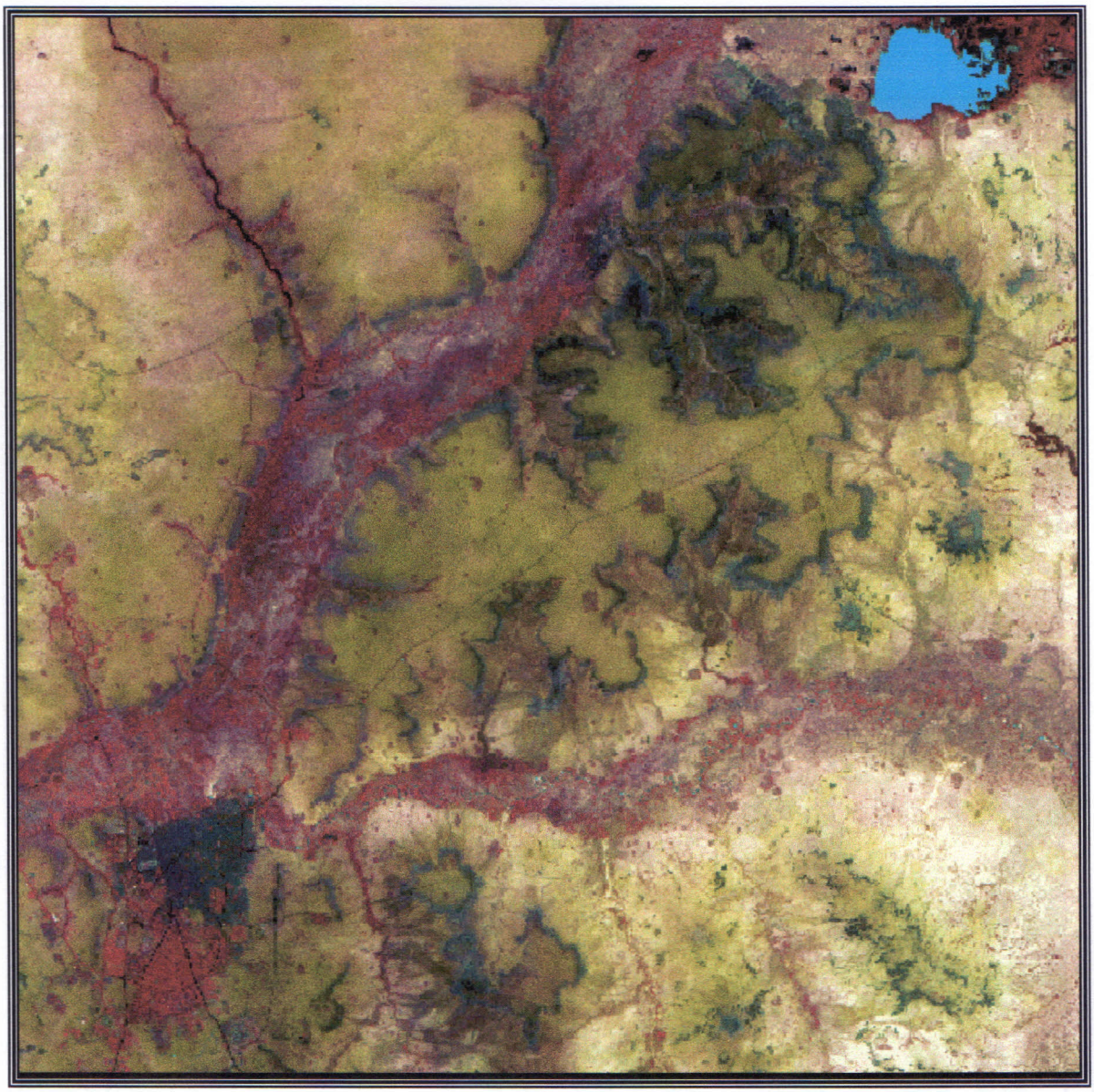
The data used, their sources and other characteristics are shown in Table 3. They include the topographical map of the area (which served as a base map), a list of other maps, the set of SPOT satellite data of the area (Fig. 2), associated field works (including interviews and measurements), Geo-positioning system and administrative records.

Table 3: Area Extent and Population Characteristics Within the Study Limit

Data Type	Date of Acquisition	Scale of Accessibility	Identification and/or Sources	Purpose and Methods
Topographical Map	Produced 1965	1:50,000	Sokoto Sheet 10 NE; from Federal Surveys Dept, Lagos	Base Map. Cartographically enlarged to 1:25,000 on transparency
Other Maps	1989 to 1991 1980 to 1983	1:5000 to 1:15,000 1:100,000 to 1:250,000	EA/SA Sketches; from NPC Sokoto Administrative Maps; from Sokoto State Secretariats	Updating and augmenting the information on the base map. Geo-rectified using appropriate instruments and procedures.
SPOT P, XS and P?XS	1995	1:100,000 and 1:200,000	Covering the Study Area; IDRC/Univ. of Waterloo & Lagos	Mapping agricultural landuses Enhanced and generated on transparencies from CCTs on Dipix Image Analysis System (Univ. of Waterloo, CANADA). Interpreted on Procom-2 Optical Analytical Equipment (Univ. of Lagos, NIGERIA)
Field Works and GPS	1996	-	-	Geo-rectification and Mapping

Interpretation of the remote sensing images and assemblage with other data sets were done in a PC-based ARC/INFO software package environment. The package was used to digitize, edit, build topology, project, generate statistics and transfer the data to an Atlas environment for visualization. The Root Mean Square Errors (RMSE) generated during the registration of the maps ranged between 0.00 and 0.03. The geographic co-ordinates on the maps were projected to the Nigerian Traverse Mercator (NTM - Minna Datum, in meters) for analytical purposes. Where necessary, Standard Macro Language (*.sml) programmes were written for the exercise.

Window-based ATLAS GIS (AGIS) software was used for the map design, production evaluation of the map. The digital maps in ARC/INFO were converted to non-compressed ASCII export (*.e00) files for subsequent transfer to AGIS via the Import/Export (I.E.) modules of the ARCINFO and AGIS packages. The latter also accepted the attribute data from the Excel (for Windows) in *.dbf format along with their spatial entities.



RESULTS

The generated map is presented in Fig. 3. The statistics for the various categories of agricultural landuse in the area is shown in Table 4. Agricultural lands account for about 53,428.ha (i.e. 71.3 per cent) of the 749.23 km^2 covered by the study. Settlements, waterbodies, sandy deposits, lateritic rock outcrops and vegetal cover (including aquatic marsh, sedge and aquatic grasses as well upland shrubs and tree nursery) are the other covers and uses of the remaining 28.7 per cent of the landmass. Sokoto LGA has no partly cultivated floodplain but intensively cultivated ones within the study limit. Equally, Dange Shuni has no partly cultivated floodplain or plantation orchard. Wurno has no plantation.

Cultivated uplands account for 35,201.9 ha (i.e. about 66 per cent) of the total farmland. It is followed by partly cultivated floodplain (11,290,9ha) and intensively cultivated floodplain (6,742.9ha). Plantation orchard has the lowest figure of 192.7ha, representing about 0.4 per cent of the entire farmland.

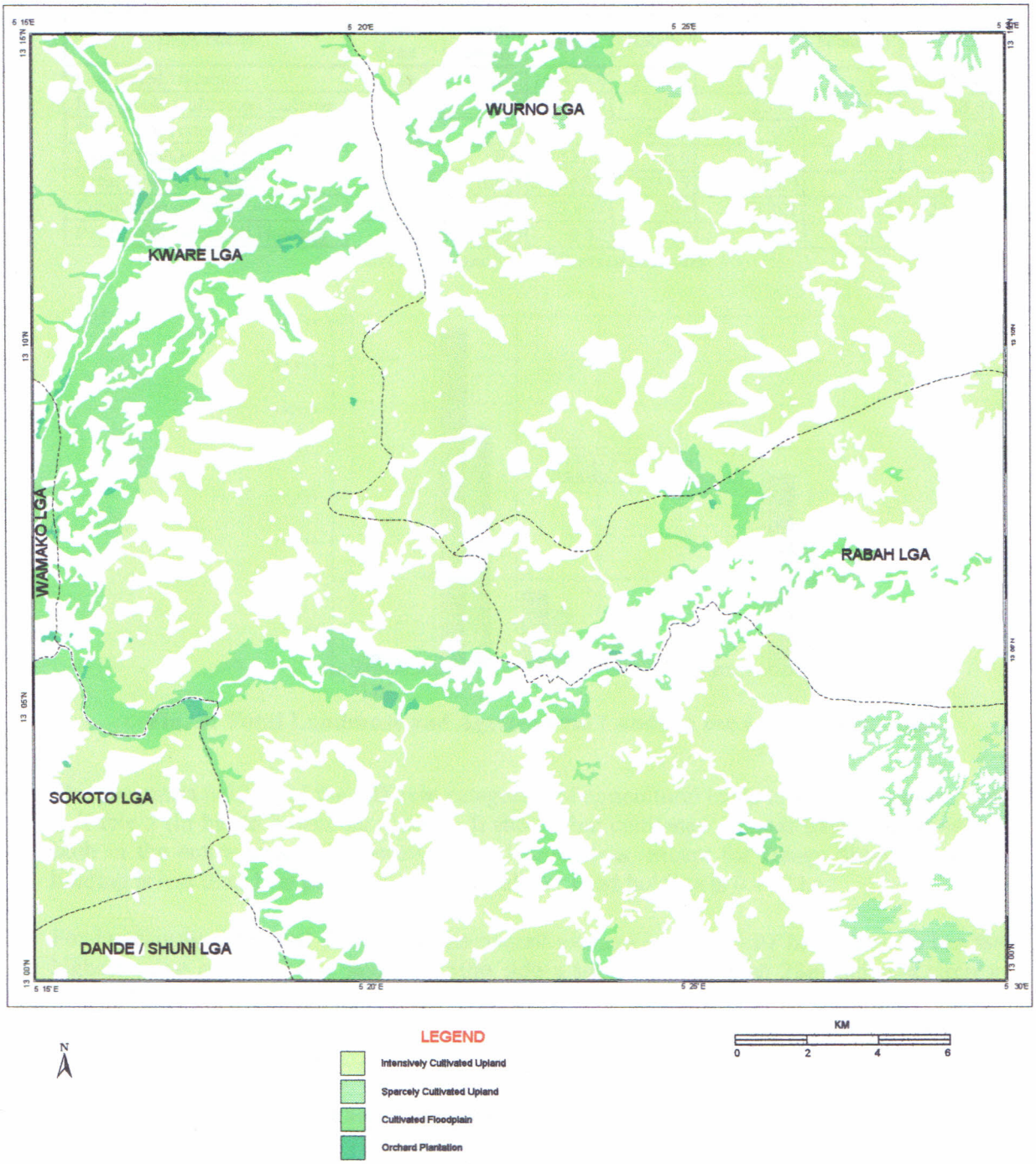


Fig. 3: Agricultural Landuse in the Area of Study

On LGA basis, Table 4 shows that Kware has the largest expanse of agricultural landuse with 27,565.2 ha. Next are Wurno (15,286.7 ha), Rabah (7,055.9 ha), Sokoto (1,988.5 ha) and Dange Shuni (1,109.9 ha) in that order. Wamako has the smallest with 422.2 ha. The information presented in Fig. 4 shows the relationship between the cultivated lands and the total landmass (presented in Table 2) proportionally.

Table 4: Area Extent and Population Characteristics Within the Study Limit

LGA Name	Total Area	Dange Shuni	Kware	Rabah	Sokoto	Wamako	Wurno
Cultivated Uplands	35,201.9	1,102.6	16,878.4	2941.3	1,750.7	0.1	12,528.8
Intensively Cultivated Fadama	6,742.9	7.3	5,021.7	619.9	209.0	236.7	648.3
Partly Cultivated Floodplain	11,290.9	0.0	5,533.9	3486.1	0.0	161.3	2,109.6
Plantation/Orchards	192.7	0.0	131.2	8.6	28.8	24.1	0.0
Total Area Cultivated	53,428.4	1,109.9	27,565.2	7055.9	1,988.5	422.2	15,286.7
Population of Study Area	180,376	957	53,497	3,397	93,221	956	28,439
Per Capita Farmland Holding	0.195	1.159	0.52	2.08	0.02	0.44	0.54

Source: GIS Analysis of Derived Statistics

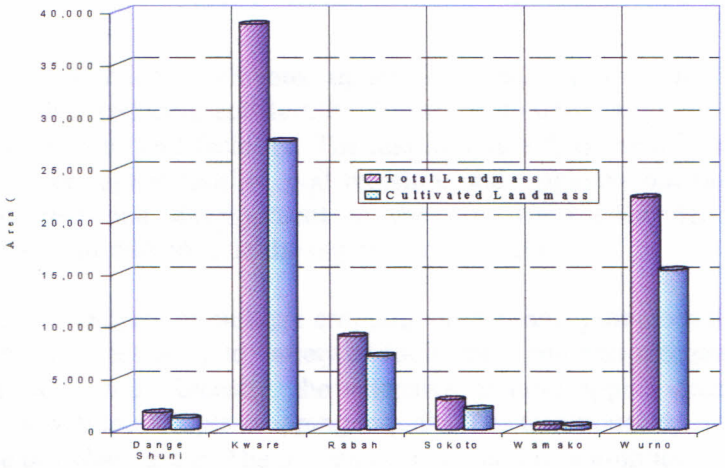


Fig. 3: Total Landmass and Agricultural Lands in the LGAs Contrasted

The per capita holding of the different categories of agricultural lands in the area is presented in Table 5 (in ha, to 3 decimal places). It shows that cultivated uplands have highest values both in the entire area and in every LGA. Nonetheless, except for Dange Shuni LGA, the holding is less than 1 ha per head. The overall per head holding is 0.402 ha.

For intensively cultivated floodplain, the overall average is about 0.07 ha. Wamako has the highest value of 0.248 (i.e. less than 50m side a square or less than 28m radius a circular farm). Next is Rabah with 0.182 ha (i.e. less than 43m side a square or less than 24m radius a circular area). Sokoto has the least with 0.002 ha (i.e. less than 1.5m a square or less than 0.8m radius a circular plot).

Table 5: Area Extent and Population Characteristics Within the Study Limit

LGA Name	Total Farmland	Dange Shuni	Kware	Rabah	Sokoto	Wamako	Wurno
Cultivated Uplands	0.195	1.152	0.316	0.886	0.019	0.0	0.441
Intensively Cultivated Fadamas	0.037	0.008	0.094	0.182	0.002	0.248	0.023
Partly Cultivated Fadamas	0.063	0.0	0.103	1.026	0.0	0.169	0.074
Plantation/Orchards	0.001	0.0	0.002	0.003	0.0	0.025	0.0
All Agricultural Lands	0.296	1.160	0.515	2.077	0.021	0.442	0.538

Source: GIS Analysis of Derived Statistics

Partly cultivated floodplain constitutes areas of transition between the upland and the intensively cultivated floodplain. It shares the problems of the former and, in some other

instances, could be characterized by events in the latter. On the average, only Rabah has farm-size of more than l ha per head.

IMPLICATION ON FOOD SUSTAINABILITY

The high proportion of agricultural land relative to the entire landmass in the area of study confirms the importance of the sector as the primary means of livelihood and landuse in the area. More importantly, however, the holding per head is too meagre for purposeful planning, management and development of the sector. The implication of the finding on food sustenance is gloomy. Beyond the fact that there is remarkable farmland fragmentation and high population pressure, the carrying capacity of the farmland is worrisomely low. Since it is practically impossible to increase the physical extent of land and its covers, a primary option is continuous cropping all the year round using the best adaptable techniques to the local environment.

Ironically, productivity within the cultivated upland is dependent on natural rainfall (of less than 3 months annually), reducing soil fertility due to continuous cropping and inadequate farm techniques, implements and facilities. The less available floodplain is more supportive of agriculture due to its higher fertility, soil moisture and irrigation potentials. Above all, agricultural management and development in the area have been depressing due to management gridlocks and dilemmas in the region (Soneye, 2002).

To survive, farmers now engage in multiple cropping on the same plot more than ever before. The practice allows for accessibility to variety of food needs and also mitigates total loss inn case of the failure of a crop. Recently, the extensive mono-cropping practice within the fadama area is giving way to multiple cropping, rapidly. The traditional upland crops are also giving way to those of upland areas. The pattern of local food consumption is equally noticed to be changing.

CONCLUSION

The study reveals that agriculture (especially food production) ranks high in human pre-occupation in the developing world. It provides employment opportunities for the teeming population. It contributes tremendously to the GDP and foreign exchange earnings. Its practice is devoid of harsh environmental impacts, contamination of soil and water for which the oil and gas producing sector is famous. The result of the remote sensing - GIT analysis reveals that the area of land available for farming in the study area is too low compared to its population. It also assumes due to identified meagre per head holding across all the LGAs, farming efficiency is low and actual production is below food requirement.

On the short term, the option adopted by the inhabitants is to emigrate to more reliable food secured areas especially during such periods when food production is short of demand. Majority of the males migrate to cities like Abuja and Lagos as "maiguards" mostly. To the government, food exportation is the only option. It is practiced largely.

On the long run, a number of considerations calls for attention, especially on the local land tenure ownership system, population control, farming methods and agricultural infrastructures. Considering the fact that a typical farmer in the area has many skimpy farms scattered in different locations in the neighbourhood, it could be more ideal if the lands can be taken over on communal basis and redistributed to farmers using such yardsticks that are acceptable to the socio-cultural environment. Controlling rapidity of population increase

particularly through high birth rate in the rural areas could also minimize dependency ratio and associated land fragmentation.

In terms of management, it will be more ideal if the revenue and other resources accruing from the oil and gas producing sector presently is expended vigorously on agricultural development. Availability and affordability of prime inputs and rural development strategies could bring forth appreciable cushion on over-dependence on agriculture as the primary source of living in the environment. Improved land management strategies will determine the achievements in other spheres of farming such as land accessibility, farming methods and technology, agricultural inputs and outputs; as well as the transformation of the socio-cultural and economic environment through stimulation of agro-based industries and other sectoral opportunities.

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