The Structure and Determinants of Land-use Intensity among Food Crop Farmers in Southwestern Nigeria

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Abstract

Increased food production in Nigeria has over the years been attributed to area expansion while reports of shortened fallow period of farmlands are suggestive of shift towards intensification. The study examines the structure of land-use intensification in food crop production in Southwestern Nigeria towards determining its drivers and concordance with condition for sustainable intensification. The results showed that land-use intensification is characterized by high frequency of cultivation (79%) and high cropping intensity estimated as 1.24years/ha. Cropping intensity was however higher in the derived and southern guinea savannah than forest agroecology. However, about 48%, 32% and 12% made use of inorganic fertilizer, tractor and herbicide respectively. Farm and farmer specific attributes significantly influenced level of land-use intensity of food crop farmers. The structure of land-use intensity portrays challenges for sustainable growth through intensification thus underscoring the need for adequate focus on sustainable land management messages by the extension system.

Keyword: Fallow intensity, Cropping intensity, Agro-ecology, Food production Southwestern Nigeria

1. Introduction

Attainment of food self sufficiency is a prominent developmental agenda facing most nations of Sub Sahara Africa (SSA). This has severally been attributed to persistent imbalance between population and food growth rate (Rosegrant *et al* 2001, USDA 2006). Nigeria by virtue of its prominent position as the most populous nation in the region is in no way facing lesser challenges as regards reducing the countries dependence on food import through improvement in food self sufficiency ratio which is in turn pivoted on increased domestic food production. However, previous increased in food production has been attributed mainly to expansion in cultivated land areas (areas cultivate to food crop) rather than productivity of the arable lands. The inherent limitation of this approach is however evident in the decline in Nigerian agricultural land area by 15.4% (FAO, 2000 estimate) attributable to land alienation, degradation and loss of about 351 000 hectares annually to desertification (Brown, 2005). Bamire and Manyong (2003) also attributed the decline to population growth and the consequent pressures from competing demands for land over times; which have resulted in cultivable land being withdrawn from its traditional agricultural uses, reduction in land-man ratio and average size of farmland.

In addition, reports of shortened fallow period (Adelana and Ojo-Atere 1997, Aromolaran 1998, Agbonlahor *et al* 2003, Bamire 2003, Oyekale 2007) pervades literature on the dynamics of the Nigerian farming systems thereby underscoring increase in land-use intensity through continuous or intensive cropping. Although, literature on intensification (Boserup 1981, Buckles and Erenstein 1996, Erbaugh 1999) have affirmed the potential of achieving agricultural growth through intensification, commensurate use of modern inputs were identified as fundamental condition for sustainable growth through increased land-use intensity. In the absence of this, increased land-use intensity could lead to continuous depletion of soil fertility, decline in productivity, loss of soil structure, soil erosion and land degradation (Sivanappan 1995, Upton 1996 and Cassman 1999, Erbaugh 1999). Estimates from FAO have however shown tremendous decline in the use intensity of these modern inputs (notably fertilizer and tractor) especially among the peasant farmers that dominate Nigerian agriculture. This undoubtedly creates a divergence between the need to seek food growth through intensification and the condition for sustainable growth in the country. This divergence is rather indicative of the challenges in the possible quest for increased production through increase land-use intensity.

Nonetheless, the ingenuity of the Nigerian farmers in adjusting to emerging challenges of the production environment cannot be overlooked. Such ingenuity has the long years of experience of the farmers and their interaction with the research system as its bedrock. The application of such experience becomes handy as farmers adapt different cropping systems (Hassam, 1996) to fit different compelling agro-ecological and socio-economic circumstances. Consequently, farmers constantly make decisions on what production methods and technologies are best suited for the prevailing environment, and system of farming. For instance, the desired duration to maturity, and hence a suitable cultivar to be planted, depends on whether double or single cropping is followed and the same applies to the optimal time of planting. These scenarios obviously portray a complex of interacting factors that could either undermine or enhance the country's quest for the much needed growth in the food sub-sector through increased intensity. Against these backgrounds, there is need to further investigate the condition under which arable land is cultivated more intensely and determine whether the prevailing land use intensity has the potential for the desired growth in the food sub-sector of the nation's agriculture. The specific objectives are to examine the conditions under which land is used more intensely by the farmers and identify the drivers of land-use intensity among the farmers

2. Materials and Methods

2.1 Study Area

Southwestern geopolitical zone of Nigeria represents a geographical area spreading between Latitude 6^oN and 4^oS and Longitude 4^oW and 6^oE. It has a land area of $114{,}271km^2$ representing 12% of the country's land mass and comprises of 6 States namely Ekiti, Lagos, Ogun, Ondo, Osun and Oyo States. The zone is characterized by a typically equatorial climate with distinct dry and wet seasons and a main growing season lasting up to 9 months. Average rainfall is 1480mm with a mean monthly temperature range of 18^o-24^oC during the raining season and 30^o-35^oC during the dry season. The zone also has four distinct sub-ecologies comprising of swamp mangrove forest, moist and dry lowland forest, woodland forest and savanna mosaic and the soil has low to medium productivity potential (FMA&RS 1997). The population is predominantly agrarian with notable food crops including yam, cassava, maize, cowpea and soybean and cash crops like cocoa, oil palm, rubber, coffee, kolanut, plantain and citrus ((Olaseni *et al*, 2004).

2.2 Data and Sampling Technique

Data for the study was generated through a farm survey conducted between May and July, 2008). Notable data collected included farm specific characteristics including socio-economic characteristics of the selected food crop farmers, method of land acquisition, distance of farm to market and homestead, crops cultivated, length of cropping cycle, production and land management practices, level of use of purchase and cultivation input, crop varieties grown (local or improved), input and output data, wages and prices of labour, inputs and outputs, and many other data relevant to the scope of study.

Data were elicited through personal interview conducted with the aid of questionnaire administered on 400 food crop farmers selected by multi-stage stratified random sampling technique. The first stage was the selection of two States (Ondo and Oyo) representing one-third of the six States that make up the Southwest geopolitical zone. Secondly, each of the States was then stratified into existing Agricultural Development Programme (ADP) zones with two ADP zones selected randomly from each of the two States (Oyo State: Ibadan-Ibarapa and Saki Zones) (Ondo State: Zone 1 and Zone 2). The third stage was the random selection of one-third of the Local Government Areas (LGAs) from list of LGAs in each of the zones as listed in the village listing documents of the respective State ADPs adopted as the sampling frame. Consequently, 6 LGAs were randomly selected out of 18 listed in Ondo State and 10 out of 29 LGAs listed in Oyo State. Finally, food crop farmers were randomly selected from the list of farmers in each of the selected LGAs. The number of farmers selected in each ADP Zone and LGAs were determined by probability proportional to the size of farming households in the zones and LGAs respectively. However, 341 questionnaires certified as containing enough information out of the 400 administered were used for the analysis.

2.3 Analytical Techniques

The study made use of both descriptive and inferential statistics. The study generated land-use intensity scores using two indexes namely Fallow Rotation Index (FRI) as proposed by Rothenberg (1980 quoted in Ebraugh 1999) and Cropping Intensity Index which measures the proportion of the year for which the land is occupied by crop proposed by Dayal et al (1978). The FRI is given as:

$$FRI_i = t_i / C_i$$

Where:

FRI_i = Fallow Rotation Intensity (0<R≥1)

t_i = Number of years for which cropland is consecutively cultivated before been allowed to fallow

C_i = Length of cropping cycle (addition of years of consecutive cultivation and period of Fallow)

Consequently, farmers were classified into fallow rotation pattern using the Fallow Rotation Intensity index has advanced by Rothenberg (1980) whereby FRI<33 = shifting cultivation (low) 33≤R≤66 Bush Fallow systems (medium) and R>66 is permanent/continuous cultivation (High).

In accounting for the crop-load effect, the study estimated cropping intensity index following Dayal (1978). The index measures the intensity of cropping to which the land is subjected to over a growing season and it is defined as the proportion of the year by which the land is occupied by an economic crop. This approach as proposed by Dayal (1978) apart from accounting for variation in choice of cropping system, also takes into consideration the diversity in gestation of crop specie and cultivars, and the choice of multiple cropping. The index reveals those areas where intensity can be increased by raising level of multiple cropping because it shows the average number of months a hectare of land is under cultivation. According to Dayal (1978), a situation where the average crop month is more than 9 months hardly offers any scope for increasing intensity through multiple cropping when considering rainfed agriculture. The cropping intensity index is thus measured as

$$CI = 1 \Big/ 12 \left[\sum_{i=1}^{n} A_{ci} \, . \, d_i \Big/ S \right]$$

Where

CI = Cropping Intensity Index (crop year/ha)

A_{ci} = Land area under crop i

D_i = The duration of crop i in the field in months

S = The net sown area in the land unit concerned.

Similarly, CI≤33 (low) 33<CI≤66 (medium) and RCI> 0.66 (High), The groupings were equally ranked as 1, 2, and 3 for low, medium and high respectively and later aggregated to generate a Composite Land-use Intensity Groupings on a 6 point Likert Scale as Low = 2, Medium = 3-4, High = 5 and Very High = 6. Analysis of Covariance (AnCova) was used to examine the interrelationship between level of land-use intensity and certain explanatory variables like agro-ecological zones, input use level, farmers' socio-economic characteristics, and production systems. The choice of the model as noted by Okike et al (2001) lies in its ability to control for the influence of continuous variables (covariates) when determining the influence of grouping variables (factors) on level of land-use intensity among the farmers. Consequently, the interest is to test the null hypothesis about the effects of factor variables on the means of various groupings of a joint distribution of land use intensity in addition to determining the influence of the covariates on the level of land-use intensity.

The analysis of covariance model is specified as:

$$L_i = a + \phi_1 Z_1 + \ldots\ldots \phi_n Z_n + \beta_1 \; X_{i11} + \beta_2 X_{i2} + \ldots\ldots\ldots \beta_k X_{ik} + + \upsilon_i$$

Where:

L_i = Measures of land use intensity (i.e. Fallow Rotation Intensity and Cropping Intensity Index).

The (Zs) are the grouping variables while the covariates (X_is) comprise of farm and farmer specific socio-economic characteristics.

Z_1 = Agro-ecology (Forest =1, Savannah =0)

Z_2 = Sex of farmer (Male=1, Female = 0).

Z_3 = Tenure Security (Owned =1, rented/pledged = 0)

Z_4 = Non farm income (Yes = 1, No =0)

Z_5 = Cultivation of Legume crop (Yes = 1, No = 0)

Z_6= Use of tractor (Used = 1, Not used =0).

Z_7 = Contact with extension (Yes=1, No contact = 0)

X_1 = Years of experience in farming

X_2 = Years of formal education

X_3 = Household size (number)

X_4 = Farm size (ha)

X_5 = Fallow potential (Proportion of total land area available for fallow)

X_6 = Number of farm locations

X_7 = Distance of farm from farmer's homestead (kilometers)

X_8= Proportion of land area cultivated to tree crop

X_9 = Crop Diversification (Herfindhal index)

X_{10} = Fertilizer use intensity (kg/ha)

X_{11} = Agrochemical use intensity (L/ha)

b_i and β_k are parameters to be estimated.

U_i = Disturbance term.

3. Results and Discussion

3.1 Land Allocation among Food Crop Farmers

The importance of farm and farmer specific characteristics as fundamental determinants of the level and allocation of resources in farm production has been widely debated in literature and evidence of the influence of such factors on access to production resources, awareness and adoption of technology, managerial capabilities and consequently productivity (Pender *et al* 2004, Idiong 2007; Okoruwa *et al* 2009) have been established. At some instances, a level of heterogeneity in attributes along certain line of demarcations which could be ecological, demographic, resource and human capital endowment have been observed to influence capabilities of farmers or productivity of production systems.

The pattern of land allocation among food crop farmers in the study area is shown in Table 1. Average size of total land holding was estimated at 3.88ha out of which the farmers cultivated 2.83ha while 1.06ha was left to fallow. The farmers allocated 1.74ha (representing 61.48 % of cultivated land) to food crop production while 1.09ha (38.52 %) was allocated to tree crop production. The estimated size cultivated to food crop by the farmers was similar to farm size of 2.4ha reported for farmers in Southwestern Nigeria by Oyekale (2006). However, the results of this study showed that the total size of farmland cultivated to food crop in the derived savannah (1.91ha) and Southern guinea savannah (1.98ha) were significantly higher than the land area cultivated to food crops by farmers in the rain-forest agroecology (1.51ha) although there was no significant difference in average size of individual plot across the agro-ecologies. Similarly, land area engaged in tree crop production was significantly higher in the forest agro-ecology (1.56ha) than in the derived savannah (0.78) and southern guinea savannah (0.50) agro-ecologies respectively.

Also, allocation pattern by socio-economic characteristics of the farmers (Table 2) showed that although total size of farm holding; size cultivated to crops and average size of food crop plot did not differ between male and female farmers, the farm size cultivated to food crop by male farmers (2.09ha) was significantly higher than the size cultivated to food crop by female farmers (1.70ha). Also, total size of holding and total land area cultivated were significantly larger for farmers who had no non-farm sources of income (4.24ha) and 3.10ha) than farmers with non-farm sources of income (3.59ha and 2.62ha). The results also showed that total land holdings (3.96ha), area cultivated (2.90ha), total size of food crop farm (1.73ha) were significantly larger for land owners than the total land holding (2.52ha), area cultivated (1.49ha) and size of food crop farm (0.91ha) estimated for tenant farmers respectively. However, average plot size for food crop of tenant farmers (1.00ha) was significantly higher than that of land owners (0.87ha). In addition, farmers who are members of associations had and cultivated larger holdings than farmers who did not belong to any association.

Although the study showed that total land area cultivated to food crops was larger in the savannah agro-ecologies thereby indicating a greater potential for appreciable level of mechanization by this category of famers in the management of their farms, this may not likely be possible as the average size of each plot was still considerably low across the agro-ecologies. Buyinza (2009) noted that land fragmentation results in holdings that are too small to be economical and consequently makes farmers to depend less on farming as the main source of income especially in situations where non-agricultural opportunities exist. Also, the influence of sex, land ownership and membership of association in access to land resources was evident in the study area.

3.2 Production Systems adopted in Food Crop Production

Major factors influencing the degree of stress to which land is subjected to, fertility depletion, opportunity for soil fertility maintenance and regeneration include the choice of cropping systems and crop combinations. The influence of these factors is inherent in the nutrient requirement and uptake capabilities of the crops, the gestation period of the crops, the ability to balance nutrient uptake with natural replenishment in the choice of crop combinations and the ensuing strength of competition between component crops. Intercropping was commonly practiced by about 67% of the farmers (Table 3) with prominent crop combinations as maize/cassava (50.4%), maize/cassava/yam (11.8%), and cassava/yam (3.3%) and maize/sorghum (2.9%). Sole maize (16.2%) was however the commonest crop grown under monoculture (Table 4).

The need to create security against potential risk of monoculture has been identified as one of the driving forces behind intercropping as a form of diversification among smallholder farmers (Muhammad *et al.* 2003; Preston, 2003). Nevertheless, one of the basic challenges in multi-cropping systems is the inherent competition among the component crops for space, soil nutrients, moisture and so on. And when the cultural practices adopted by the farmer do not cater for such competitions adequately; reduction in soil fertility, land degradation and consequently, low productivity result (Makinde *et al* 2007). The distribution of food crop farmers by their use of modern technologies (fertilizer herbicides and tractor) shows that majority of the farmers were not making use of these technologies on their farm. About 31%, 48% and 12% were found to have used tractor, fertilizer and herbicides respectively on their farms. However, a larger percentage of the farmers used tractors (77.8%) and fertilizer (62.2%) in the southern guinea savannah than in the other agro-ecologies while use of agrochemicals was generally low across the agro-ecologies (Table 5). The results in Table 6 also showed that the use of fertilizer was more prominent with cereal based cropping systems than with non-cereal based cropping systems. Although the use of modern technologies was generally low among the farmers, the study showed that tenant farmers were more in the use of labour/cost saving technologies than land owners and this could probably be indicative of the level of cost consciousness among the tenant farmers.

3.3 Land-use Intensity and Its Determinants in Food Crop Production

The attributes of the fallow rotation pattern in food crop production in the study area is presented in Table 7. The average length of fallow was 3.0 years. Consequently, average Fallow Rotation Intensity for the food crop farmers was 0.74 indicating that food crop farmers in the study area engaged their farmland in continuous cropping. Similar result was obtained by Oyekale (2007) with an estimated Fallow Rotation Intensity of 0.71 for farmers in Southwestern Nigeria. Also, Table 7 shows that averagely, the farmers had their farm land occupied with food crop for an average of 14.82 months but this significantly differs across agro-ecologies. Farmlands were occupied by food crops for higher number of months in the derived savannah agro-ecology (17.29months/ha) than in the forest (12.36months/ha) and southern guinea savannah (15.21months/ha) respectively. Similarly, lands engaged in intercropping were occupied by crops (17.14months) than land engaged in sole cropping (10.09months). Averagely, cropping intensity index was higher in the derived savannah (1.44years/ha) and southern guinea savannah (1.27years/ha) than in the forest (1.03years/ha). Average cropping intensity index for the study area was estimated as 1.24years/ha thereby implying that food crop farmers in Southwestern Nigeria could no longer seek increased production through multiple cropping as the land is averagely engaged for more than 9 months (Dayal 1978).

Table 8 shows the classification of the farmers on the basis of the fallow rotation and cropping intensity indexes using the framework advanced by Rothenberg (1980) and Dayal (1978) respectively. The classification into fallow rotation pattern shows that about 75% of the food crop farmers have engaged their land in continuous cropping while about 19% and 6% engaged in bush fallow and shifting cultivation respectively. In addition, the distribution according to the level of cropping intensity showed that about 79% of the farmers engaged their land in high cropping intensity while about 8% and 13% had their land under low and high cropping intensity respectively. Consequently, land-use in food crop production in southwestern Nigeria is characterized by continuous cropping under high cropping intensity and the pattern is similar across agro-ecologies. However, the re-classification of the farmers on the basis of the aggregate ranked score for the two indexes showed that majority of food crop farms were cultivated under high (30.8%) and very high (53.08%) intensity respectively while about 15% and 1% came under medium and low use intensity respectively (Table 9).

The results of the comparison of the farmers' socio-economic characteristics across the land-use intensity category (Table 10) showed no significant difference in means among the four intensity categories ($P \leq 0.05$) as regards farming experience, years of education, household size, fertilize-use intensity and agrochemical use intensity. However, the results indicate that farmers in low intensity category were significantly older in age (62.75years) than farmers in the medium (51years), high (58.09years) and very high land-use intensity (52.32years) categories. Similarly, farmers in the low intensity category are older (38years) in farming than the farmers in the medium (23.47years), high (28.81years) and very high intensity (26.26years). As well, farmers in the very high intensity category cultivated significantly larger farm size (1.87ha) than farmers in the other intensity categories. The results also show that farmers in the low intensity group cultivated farmland that are farther away from their residence (5.75km) than farmers in the medium (2.92km), high (4.89km) and very high (3.62) intensity categories. In the same vein, farmers in the low intensity category also had their farm located farther away from the major market (15.75km) than farmers in the medium (6.54km), high (9.77km) and very high (6.40km) categories. Finally, farmers in the high and very high intensity categories engaged in lower crop diversification index of 0.47 and 0.49 respectively compare to the crop diversification index of 0.61 estimated for farmers in the medium intensity category.

3.4 Determinants of land-use intensity

The results of the analysis of covariance (AnCova) are presented in Table 11. The result showed that the explanatory power of the model specified for the Fallow Rotation Intensity (FRI) and Cropping Intensity are very high with adjusted R-squares statistics of 91.9% and 65.9% respectively. The value of the Levene's test of homogeneity which is not significant showed that the assumption of homogeneity of variance for the AnCova model has not been violated in the specified model. The estimated coefficients showed that fallow rotation intensity differed between farmers by cultivation of legume cropping after controlling for the effect of the covariates (continuous) variables. Farmers who cultivated legume crop subjected their farmland to higher cultivation intensity (0.77) than farmers who did not cultivate legume (0.74). Similarly, level of cropping intensity differed among farmers by agro-ecology, sex, tenure security, use of tractor and contact with extension groupings. Cropping intensity was significantly higher among farmers in the savannah agro-ecology (1.13year/ha) than farmers in the forest agro-ecology (0.97year/ha) while cropping intensity was significantly higher among male famers (1.11year/ha) than female farmers (0.99year/ha). Tenant farmers significantly had their farmland under higher cropping intensity (1.12year/ha) than land owners (0.98year/ha). Also, farmers who used tractor had higher cropping intensity (1.10year/ha) than farmers who did not (0.99year/ha) while cropping intensity was higher among farmers who had contact with extension agents (1.21year/ha) than farmer who did not (0.89year/ha).

Also, the results of the influence of the covariates showed that fallow rotation intensity significantly increased with increase in household size, fallow potential of farmers land holdings, distance of farm location from farmers homestead and proportion of cultivated holding engaged in tree crop cultivation. However, fallow rotation intensity among the farmers decreased with increase in age and distance between farm and market. Similar analysis on cropping intensity showed that cropping intensity increased among the farmers with increase in household size but significantly decreased with increases in number of farm locations, distance between farm locations and farmer's home and crop diversification index.

Previous studies (Okike *et al*, 2007, Nambiro. 2008) starting with the von Thunen model of 1826 have commented extensively on the influence of location as measured by the remoteness or otherwise of farm locations to farmers' homestead, cities or commercial centers on land use pattern. Most famous concession in this regard has identified market access, population pressure as principal drivers of increased land use intensity. These results have shown that younger age, large household size, and increase access to market are more likely to motivate farmers to subject land to increased cultivation intensity while farms that are located further away from farmers home would likely be cultivated more frequently. Understandably however, the influence of household size on land-use intensity suggests that outside the consideration for market pressure, household food need is another important driver of intensity especially as it dictates the magnitude of crop diversification which in turn has a significant bearing on the level of cropping intensity. This is usually the case when the need to cater for the varying food need of the family ranked high in the farmers' production objective, as often the case in predominantly subsistence agriculture of developing agriculture.

4. Conclusion

This study has shown evidence of increasing pressure on land that is characterized by increased frequency of cultivation of farmland and high cropping intensity. It was however paradoxical to observe that the increased land use intensity is taken place when food crop farmers still had about 28% of their land holding under fallow thereby suggesting that increased land-use intensity could not have been entirely due to acute land scarcity.

Other motivating factors in this regard as shown by the study included household size, proximity of the farm location to market, and age of the farmers. The direction of influence of these factors indicated that policies directed at enhancing market access and attracting younger people to food crop farming perhaps through improved infrastructure like good road network and other production incentives would ordinarily increase land-use intensity.

Also, the influence of household size could be viewed as having a two-way influence arising from the availability of family labour for increased land-use intensity and the associated increase in the challenges of meeting household food need that might call for further land-use intensification. Although this study has shown the prevalence of high land-use intensity in food crop production in the study area, however, the condition under which this took place fell short of what was advocated for sustainable growth through intensification. Land is been cultivated more intensely under low level of use of modern input while the prominent crop combination took little or no cognizance of the potential of maintaining soil fertility through natural replenishment by legume based cropping systems. Consequently, the structure of land-use intensification in Southwestern Nigeria portrays a remote potential for sustainable growth through increased intensity. This invariably points to the need for inclusion of messages bothering on sustainable intensification especially in messages targeted at young farmers who have been shown to be more disposed to increased land-use intensity. Such messages should focus on emphasizing the inherent potential in the choice of crop combination and crop rotation pattern on soil fertility maintenance and sustainable agriculture.

References

Adelana B. O. and J. O. Ojo-Atere. (1997). *Soil and water management* In: The Nigerian Agricultural Research Strategy Plan and Extension Delivery: Policy concepts and consensus to the year 2010. In: Proceedings of the workshop on the National Agricultural Research Strategy Plan and Extension Service/Input Delivery. NARP, FMA&NR, Abuja.

Agbonlahor M.U, Aromolaran A. B. and Aiboni V.I. (2003). Sustainable soil management practices in small farms of Southern Nigeria: A poultry-food crop integrated farming approach. *Journal of Sustainable Agriculture,* 22.4:51-62.

Bamire A. S. and V. M. Manyong. (2003). Profitability of intensification technologies among smallholder maize farmers in the forest-savanna transition zone of Nigeria. *Agirculture, Ecosystems and Environment*, Vol 100:111 – 118.

Boserup E. (1981). *Population and technological change.* Chicago: Chicago University Press.

Brown L. E. (2005). *Outgrowing the Earth*: The Food Security Challenge in an Age of Falling Water Tables and Rising Temperatures. Earth Policy Institute. W.W. Norton & Co., New York**.** www.earth-policy.org 6th June, 2010

Buckles D and O. Erenstein. (1996). Intensifying maize-based cropping systems in the Sierra de Santa Marta, Veracruz. NRG. Paper 96-07 D.F.: CIMMYT.

Buyinza Mukadazi. (2009). Land-use Intensity in the Tree Cropping Homesteads of kamuli, Eastern Uganda. *Agricultural Journal,* 4.2:46 – 51 Medwell Publishing.

Cassman K G. (1999). Ecological intensification of cereal production systems: Yield potential, soil quality and precision agriculture. *Proceedings of National Academy of Sciences,* Vol. 96 pp. 5952-5959.

Dayal E. (1978). A measure of cropping Intensity. Professional Geographers XXX (3):289-296.

Erbaugh J. M. (1999). Agricultural Intensification in Uganda: Progress or environmental involution. In: *African Crop Science Proceedings*. 4:599-607, African Crop Science Society.

Hasam R. M. (1996). Planting strategies of maize farmers in Kenya: a simultaneous equations analysis in the presence of discrete dependent variables. *Agricultural Economics,* 15:137-149.

Idiong I. C. (2007). Estimation of Farm Level Technical Efficiency in Small scale Swamp Rice Production in Cross River State of Nigeria: A Stochastic Frontier Approach. *World Journal of Agricultural Sciences,* 3.5:653-658. IDOSI Publications.

Makinde, E. A., Saka, J. O. and Makinde, J. O. (2007). Economic evaluation of soil fertility management options on cassava-based cropping systems in the rain forest ecological zone of south western Nigeria. *African Journal of Agricultural Research,* 2.1:007-013.

Muhammad Tahir, Muhammad AM, Asif T, Rashid A. (2003). Agroeconomic advantages of different Canola-based intercropping systems. *Pakistan J.Agronomy,* 2(1):40-43.

Nambiro Elizabeth. (2008). *Trends in land use and agricultural intensification* in Akamega, Western Kenya. Inaugural Dissertation. Pg.8. Rheinischen-Friedrich-Wilhelms-Universität Kenia (Nairobi) [Online] Available: http://hss.ulb.uni-bonn.de/diss_ (June 10th 2010)

Olaseni O., Agbeja B. O. and S. K. Adeyoju. (2004). Dynamics of forest revenue system collections and forestry development in Ondo State, Nigeria, between 1991 and 2000. *Food Agriculture & Environment*, Vol. 2 (1): 365 – 369. WFL Publishers. www.world-food.net (May 1st, 2010).

Oyekale A. S. (2007). Intensive land use and efficiency of food crop production in Southwestern Nigeria. *Agricultural Journal,* 2.2:174-179.

Okike I, M. A. Jabar, V. Manyong, J.W. Smith, J. A. Akinwumi and S. K. Ehui. (2001). Agricultural Intensification and efficiency in the West African Savannahs: Evidence from northern Nigeria. Socio-economics and Policy research Working Paper 33. ILRI (International Livestock Research Institute), Nairobi Kenya. 55pp.

Okoruwa V. O., A.O. Akindeinde and K.K. Salimonu. (2009). Relative economic efficiency of farms in rice production: A profit function approach in North Central Nigeria. *Tropical and Subtropical Agroecosystems,* 10 (2009): 279 – 286.

Pender J, Nkonya E, Jagger P, Sserunkuumab D, Ssali H. (2004). Strategies to increase agricultural productivity and reduce land degradation: evidence from Uganda. *Agricultural Economics,* 31:185-195.

Preston Sullivan. (2003). *Intercropping principles and production practices*. Agricultural Systems Guide. Appropriate Technology Transfer for Rural Areas (ATTRA) [Online] Available: http://attra.ncat.org/attra-pub/PDF/intercrop.pdf. (June 5th, 2010)

Rosegrant M. W., Paisner M. S., Meijer S and Witcover J. (2001). 2020 Global Food Outlook: Trends, alternatives, and choices. A 2020 Vision for Food, Agriculture, and the Environment Initiatives. pg:1-14 IFPRI, Washington D. C.

Sivannappan R. V. (1995). Soil and water management in dry lands of India. *Land Use Policy,* 2.2:165-175.

USDA. (2006). Food Security Assessment: Electronic Outlook Report from the Economic Research Service, 2005/GFA-17 United State Department of Agriculture (USDA), Pg. 46-47. [Online] Available: October 26th, 2008 from www.ers.usda.gov Pg. 46-47. (January 2nd 1010).

Table 1. Size of Land Holdings and Allocation according to Agro-ecologies

	Land Allocation (ha)				
	Forest (n=152)	Derived Savannah (n=144)	Southern Guinea Savannah (n=45)	Pooled (n=341)	F-stat
No. of farms	1.91(0.50)	2.06(0.58)	2.16(0.64)	2.01(0.56)	4.44**
Total Holding (ha)	4.10(2.17)	3.75(2.08)	3.54(1.58)	3.88 2.07)	1.78
Total Cultivated (ha)	3.06(1.97)	2.69(1.84)	2.48(1.27)	2.83(1.84)	2.46
Total Fallow (ha)	1.04(0.76)	1.06(0.74)	1.08(0.60)	1.06(0.73)	0.06
Food Crop (ha)	1.51(0.90)	1.91(1.17)	1.98(0.87)	1.74(1.03)	7.11*
Tree crop (ha)	1.56(1.83)	0.78(1.40)	0.50(0.79)	1.09(1.60)	13.07*
Average food plot size (ha)	0.83(0.49)	0.93(0.48)	0.96(0.41)	0.89(0.48)	2.00

* Significant at $P \leq 0.01$, ** Significant at $P \leq 0.05$, Figures in brackets are Standard Deviations

Source: Computed from Field Data 2008

Table 2. Size of Land Holdings and Allocation by Socio-economic Characteristics

Characteristics	Tot al Size	Total Cultivated	Total Food size	Average Plot size
Sex				
Male	3.95(2.13)	2.85(1.91)	2.09(1.01)	0.97(0.38)
Female	3.31(1.36)	2.62(1.29)	1.70(1.04)	0.88(0.49)
ANOVA Value	3.29	0.55	4.77**	1.18
Age Group (years)				
21 – 40	3.45(1.95)	2.27(1.78)	1.52(0.96)	0.77(0.47)
41 – 60	3.83(1.93)	2.82(1.71)	1.78(1.00)	0.91(0.47)
Above 60	4.18(2.46)	3.08(2.17)	1.76(1.17)	0.89(0.51)
ANOVA Value	1.62	2.27	0.86	1.22
Non-farm income				
Yes	3.59(2.23)	2.62(1.98)	1.67(0.91)	0.88(0.47)
No	4.24 (1.78)	3.10(1.62)	1.85(1.10)	0.90(0.50)
ANOVA Value	8.69*	5.63**	3.08	0.18
Education Status				
Educated	3.81(2.16)	2.75(1.92)	1.69(0.98)	0.87(0.46)
Non Educated	3.93(1.99)	2.89(1.78)	1.80(1.08)	0.91(0.50)
ANOVA Value	0.27	0.44	0.88	0.59
Tenure Security				
Land Owner	3.96(2.06)	2.90(1.86)	1.73(1.04)	0.87(0.48)
Tenant	2.52(1.08)	1.49(0.85)	0.91(0.65)	1.00(0.44)
ANOVA Value	7.79*	9.14*	7.92 *	3.93**
Association Membership				
Yes	4.46(2.47)	3.25(2.29)	1.97(1.21)	1.01(0.56)
No	3.74(4.46)	2.73(1.73)	1.69(0.99)	0.86(0.46)
	6.14**	4.12**	3.44	4.58**

Figure in parentheses are standard deviation

*Significant at P≤0.01, **Significant at P≤0.01

Table 3. Cropping System Adopted by Farmers by Agro-Ecology

Cropping System	Forest	Derived Savanna	Southern Guinea Savanna	Total
Sole Cropping	64(42.11)	34(23.61)	14(31.11)	112(32.85)
Inter Cropping	88(57.89)	110(76.39)	31(68.89)	229 (67.15)

*Values in parenthesis are percentages

Source: Computed from Field Data 2008

Table 4. Specific Crop Combination

Specific Crop Combination	Total
Maize/cassava	137(50.37)
Maize/cassava/yam	32(11.76)
Maize/Sorghum	08 (2.94)
Cassava/Yam	09 (3.31)
Sole maize	44(16.17)
Sole Cassava	08(2.94)
Sole Yam	35(12.87)
Total	273(100.0)

*Figures in brackets are percentages

Source: Computed from Field Data 2008

Table 5. Modern Input Usage by Ecology

Modern Input Usage	Forest	D.Savana	S.G.Savanah	Total
Tractor				
Used	51(33.6)	22(15.3)	35(77.8)	108(31.7)
Not Used	100(65.8)	122(84.7)	10(22.2)	232(68.0)
Fertilizer				
Used	60(39.5)	77(53.5)	28(62.2)	165(48.4)
Not Used	91(59.9)	67(46.5)	17(37.8)	175(51.3)
Agrochemicals				
Used	06(3.9)	22(15.3)	12(26.7)	40(11.7)
Not Used	146(96.1)	122(84.7)	33(73.3)	301(88.3)

*Figures in parenthesis are percentages.

Source: Computed from Field Data 2008

Table 6. Relationship between Modern Input Usage and Major Type of Crop Combinations

Usage of modern Inputs	Major Crop Combination Type (N=314)					Chi-Square Statistics
	Cereal/Root Crop	Cereal/Root/ Tuber crop	Sole Cereal	Sole Root crop	Sole Tuber crop	
Tractor						
Used	40 (29.4)	14 (46.7)	12 (29.3)	04 (40.0)	07 (20.6)	6.607
Not Used	96 (70.6)	16 (53.3)	29 (70.7)	06 (60.0)	27 (79.4)	
Fertilizer						
Used	69 (50.7)	13 (43.3)	27 (65.9)	03 (30.0)	03 (8.8)	28.91*
Not Used	67 (49.3)	17 (56.7)	14 (34.1)	07 (70.0)	31 (91.2)	
Agrochemical						
Used	14 (10.3)	02 (6.7)	03 (7.3)	01 (10.0)	01 (2.9)	2.171
Not Used	122 (89.7)	28 (93.3)	38 (92.7)	09 (90.0)	33 (97.1)	

Figures in parenthesis are standard deviations.

* Significant at (P≤0.01).

Source: Computed from Field Data 2008

Table 7. Indexes of Land-use Intensity across Agro-ecologies

Fallow Rotation	Forest (n=152)	Derived Savanna (n=144)	Southern G. Savanna (n=45)	Pooled	F. stat
Years of Continuous cultivation	12.02(7.60)	12.28(7.52)	9.42(7.24)	11.79(7.55)	2.62
Length of Fallow	2.92(1.58)	3.25(2.12)	2.56(1.19)	3.01(1.80)	2.90
Cropping Cycle	14.94(7.56)	15.53(7.28)	11.98(7.45)	14.80(7.49)	3.98**
Fallow Rotation Intensity	0.76(0.17)	0.73(0.22)	0.73(0.14)	0.74(0.19)	0.78
Cropping Intensity					
Month/ha	12.36(5.35)	17.27(8.39)	15.21(6.08)	14.82(7.25)	18.81*
Year/ha	1.03(0.44)	1.44(0.70)	1.27(0.51)	1.24(0.60)	18.89*

*Significant at (P≤0.01) ** Significant at (P≤0.05). Figure in parenthesis are standard deviations

Source: Computed from Field Data 2008

Table 8. Distribution of Farmers by Land-use Intensity pattern across Agro-ecology based on Fallow rotation and Cropping Intensity Indexes

Land-use Intensity Pattern	Forest (N=152)	Derived Savanna (N=144)	Southern G. Savanna (N=45)	Total
Fallow Rotation				
Shifting Cultivation	02(1.3)	17 (11.8)	02 (4.4)	21(6.1)
Bush Fallow	31 (20.4)	16 (11.1)	16(35.6)	63(18.5)
Continuous cropping	119(78.3)	111(77.1)	27 (60.0)	257(75.4)
Cropping Intensity Group				
Low	15 (9.93)	07(4.86)	04 (8.88)	26(7.65)
Medium	27 (17.88)	12(8.33)	06(13.33)	45(13.24)
High	109(72.19)	125(86.81)	35(77.78)	269(79.11)

Figures in parenthesis are percentages

Source: Computed from Field Data, 2008

Table 9. Land-Use Intensity Group by Agro-ecologies

Land-use Intensity Group	Intensity Ranked Score	Agro-ecologies				Total
		Forest	Derived Savannah	Southern Savannah	Guinea	
Low	3	04(2.65)				04(1.17)
Medium	4	20(3.25)	29 (20.14)	02(4.44)		51 (14.96)
High	5	27 (17.88)	52 (36.11)	26 (57.77)		105(30.79)
Very High	6	101 (66.45)	63(43.75)	17 (37.78)		181 (53.08)

Figures in parenthesis are percentages

Source: Computed from Field Data, 2008

Table 10. Socio-economic Characteristics of Farmers by Land-use Intensity Group

Characteristics	Land-use Intensity Group				F.Stat
	Low (n-4)	Medium (n=51)	High (n=105)	Very High (n=181)	
Age	62.75(2.62)	51(9.36)	58.09(10.48)	52.32(9.29)	10.87*
Farming experience	38(4.00)	23.47(10.13)	28.81(11.94)	26.26(12.40)	3.64**
Years of education	3(2.45)	4.41(4.65)	3.79(5.72)	4.16(5.57)	0.24
Household size	5.75(3.69)	7.02(4.00)	7.98(3.39)	7.45(3.29)	1.36
Farm size	1.25(0.79)	1.36(0.62)	1.73(0.95)	1.87(1.16)	3.73**
Fallow Potential	0.40(0.34)	0.31(0.23)	0.31(0.19)	0.27(0.80)	1.60
Distance of Farm to Home (km)	5.75(3.20)	2.92(2.25)	4.89(2.99)	3.62(2.89)	7.35*
Distance of Farm to Market (km)	15.75(3.30)	6.54(7.57)	9.77(8.21)	6.40(10.45)	7.40*
Fertilizer intensity(kg/ha)	143.48(75.87)	169.41(462.92)	92.39(237.89)	214.91(724.82)	1.01
Agrochemical Intensity (litre/ha)	2.29(1.85)	1.90(3.50)	0.61(2.08)	1.49(3.78)	2.45
Crop Diversification Index	0.50(0.35)	0.61(0.24)	0.47(0.19)	0.49(0.17)	6.35*

*Significant at $P \leq 0.01$ ** Significant at $P \leq 0.05$

Source: Computed from Field Data, 2008

Table 11. Drivers of Land-use Intensity

	Fallow Rotation Intensity		Cropping Intensity	
Factors	Coefficient	Estimated Mean Value	Cropping Intensity Index	Estimated Mean Value
Constant	1.521(0.041)*		0.345(0.245)	
Factors				
Ecology: Savannah	0.007(0.007)	0.75(0.10)	0.154(0.044)*	1.13
Forest		0.76 (0.11)		0.97
Sex: Female	0.002(0.20)	0.75(0.01)	-0.123(0.062)**	0.99(0.08)
Male		0.75(0.01)		1.11(0.05)
Tenure Security: Tenant	-0.009(0.008)	0.75(0.01)	0.136(0.050)*	1.12(0.07)
Land Owner		0.75(0.01)		0.98(0.06)
Alternative Income Source: No	-0.003(0.007)	0.75(0.01)	-0.027(0.041)	1.03(0.06)
Yes		0.75(0.01)		1.06(0.06)
Legume cultivation: No	-0.023(0.008)*	0.74(0.01)	0.037(0.049)	1.06(0.05)
Yes		0.77(0.01)		1.03(0.07)
Tractor Usage: Not Used	-0.004(0.007)	0.75(0.01)	0.102(0.041)**	1.10(0.06)
Used		0.75(0.01)		0.99(0.06)
Contact with Extension: No	-0.010(0.015)	0.75(0.01)	0.325(0.094)*	1.21(0.04)
Yes		0.76(0.02)		0.89(0.10)
Covariates				
Age	-0.013(0.001)*		0.005(0.004)	
Years of Education	0.000(0.001)		0.002(0.004)	
Household size	0.006(0.001)*		0.109(0.006)*	
Farm size	-0.001(0.004)		0.025(0.023)	
Fallow potential	-0.025(0.002)*		-0.173(0.121)	
No. of farm locations	0.002(0.006)		-0.092(0.036)**	
Home distance to farm	0.005(0.002)*		-0.014(0.009)*	
Farm distance to market	-0.009(0.001)*		-0.003(0.004)	
Land area to tree crop (%)	0.013(0.001)*		-0.021(0.068)	
Fertilizer intensity	-0.000(0.000)		-0.000(0.000)	
Agrochemical Intensity	-0.001(0.001)		-0.000(0.006)	
Crop Diversification Index	0.026(0.020)		-0.883(0.122)*	
Adjusted R^2	0.919		0.659	
Levene's Test of Homogeneity: F(P)	1.172(0.218)		1.28(0.12)	

*Significant at P≤0.01, ** P≤0.05

Values in parentheses are standard error of the estimates.

Source: Computed from Field Data, 2008