Determinants of Agricultural Intensification in Southwest Nigeria

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Abstract: Declining agricultural production in many developing countries has prompted increased use of some inputs while continuous cropping prevails. This study analysed the factors promoting different forms of agricultural intensification in southwestern Nigeria. Data collected from randomly selected farmers in selected states in southwestern Nigeria were used. Results show that farmers from Osun State have the highest indices of intensification with respect to land use intensity, fertilizer use intensity and crop diversification. The censored regression showed that lost working days, use of fertilizers, crop rotation, and having more inherited land increased land use intensity while use of organic manure, minimum tillage and poverty reduced crop diversification index. Fertilizer use intensity increased with the use of minimum tillage and household size while hired and family labour use intensity increased with household size. It was recommended that in the face of increasing land degradation, farmers' access to fertilizer must be increased and efforts to reduce their poverty level must be promoted, among others.
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Introduction

The use of land for agricultural production remains one of the strongest influences affecting environmental quality in many developing countries. Practices like unguided application of agrochemicals, bush burning and mechanized land cultivation affect the quality of soil and vegetative cover (Scherr, 1999). Policy makers are now confronted with the challenges of increasing agricultural production to stimulate economic growth and reduce poverty, while the issue of natural resource degradation requires urgent attention (Vosti, 2001).

Conventionally, intensive agricultural production can be expressed as increase in the use of inputs of labour or capital on a smallholding, in order to increase output per hectare. Alternatively, agricultural intensification can be defined as an increase in agricultural production per unit input of labour, land, time, fertilizer, seed, feed, or cash (FAO, 2004). Boserup's "induced innovation" concept asserts that increasing population stimulates increasing demand for agricultural products. As land, therefore, becomes more costly compared with labour, incentives emerge for more intensive use of land in order to reap the benefits of the enlarged market opportunities. Similarly, Cleaver and Schreiber (1994) hypothesized the "downward spiral concept". This states that poverty, overpopulation, and land degradation create a self reinforcing nexus that further promote degradation of natural resources and poverty. This is because the process of soil mining in the form of agricultural intensification triggers soil erosion and results in decline in land productivity.

The downward-spiral and induced innovation scenarios have been found under different situations (Pender, 1998). A comparison of the downward spiral and induced innovation revealed that outcome is largely dependent on how well a society adapts to rapid population growth, globalization, market development, technological change, climatic change, and agro-ecological conditions. Forsyth et al., (1998) showed that poor people increasingly exploit natural resources as a result of population growth, limited access to land, access to marginal land of low productivity and limited resources for investment. This situation led to lack of resources for sustainable resource management and declining food production. Several authors have also noted that decline in wages and unemployment among the poor can result in increased land clearing and deforestation.

Bourn and Wint (1994) noted that in SSA, livestock biomass increases with rising levels of human population and increasing intensity of land use. It was stressed that the findings are consistent with expectations of the "Boserup hypothesis", and reflect the process of "autonomous intensification" of agricultural production (Boserup, 1981), through initial co-existence and gradual integration of animal husbandry within local farming systems.

Osemeobo (1993) evaluated the land use pattern of smallholders for cassava production in

Southern Nigeria. He found that the users' rights on land, farm yield and access to farmland all influenced land-use intensity. Okike et al., (2001) determined the factors influencing agricultural intensification in the northern part of Nigeria. The results showed that land use intensity was largely influenced by land-man ratio, herd size, rate of application of manure and fertilizers, crop labour and years of experience in mixed farming. Also, land use intensity increased as land human population ratio increased but decreased at very high land human population ratio due to the possibility of labour shortages. Also, increased fertilizer application led to increase in labour use intensity, but the reverse was the case for manure application per hectare.

Randrianarisoa and Minten (2001) found that in Madagascar, poorer households had low labour productivity, but their return to land was high. It was recommended that much economic gains would result if poor farmers have access to fertile land. Also, the analysis revealed that sound education, always influenced agricultural production. While the poor depend on upland crops, diversification into high value crops by the rich enhances economic welfare. This paper attempts to determine the factors influencing agricultural intensification in southwest Nigeria. The specific objectives are to compute some indicators of agricultural intensification and describe them, and analyse the effect of some socioeconomic and cultural factors on the indicators of intensification.

Materials and methods

The data

Data for the study were collected from Oyo, Osun and Ekiti states in the southwestern part of Nigeria. The states enjoy tropical climate with two distinct seasons – rainy season from April to October and dry season from November to March. The traditional practice of slash and burn agriculture predominates, and this is expected to be followed by a period of fallow for the soil to regain lost fertility.

The multistage random sampling procedure was used. The first stage involved random selection of three states from the southwest Nigeria. At the second stage, two Local Government Areas (LGAs) were randomly selected from each of the chosen states. The third stage involved the random selection of three villages from each of the selected LGAs, from where households were selected for interview. A total of 350 questionnaires were administered based on available cost and time. Samples were selected in proportion to the estimated population of farmers in the villages.

In Oyo State, the selected LGAs were Akinyele and Lagelu. A total of 120 questionnaires were administered out of which only 100 were good for inclusion in the final analysis. In Ekiti State, a total of 110 were administered to farmers in Ikole, and Ado Ekiti LGAs. Out of the questionnaires administered, only 100 were good for inclusion in the final analysis. In Osun State, a total of 120 questionnaires were administered in Obokun and Ife Central LGAs. Out of the administered questionnaires, 103 were good for inclusion in the final analysis. The rejected questionnaires contained insufficient information.

Analytical procedures

In order to analyse the socioeconomic/cultural factors explaining some indicators of agricultural intensification, a censored Tobit regression analysis of covariance (ANCOV) was used (Okike et al., 2001). The estimated models are stated below:

$$LUI_i = \beta_1 + \beta_2 EXP_i + \beta_3 DBB_i + \beta_4 DMC_i + \beta_5 DOM_i + \beta_6 DCC_i + \beta_7 EDC_i + \beta_8 SZE_i + \beta_9 DZTi + +\beta_{10} FCI_i + \beta_{11} FCB_i + \beta_{12} FCP_i + \beta_{13} MKD_i + \beta_{14} POV_i + \beta_{15} LWD_i + \beta_{16} DFT_i + e_i \ldots\ldots\ldots\ldots (1)$$

$$CDI_i = \varphi_1 + \varphi_2 EXP_i + \varphi_3 DBB_i + \varphi_4 DMC_i + \varphi_5 DOM_i + \varphi_6 DCC_i + \varphi_7 EDC_i + \varphi_8 SZE_i + \varphi_9 DZTi + \varphi_{10} FCI_i + \varphi_{11} FCB_i + \varphi_{12} FCP_i + \varphi_{13} MKD_i + \varphi_{14} POV_i + \varphi_{15} LWD_i + \varphi_{16} DFT_i + f_i \ldots\ldots.(2)$$

$$FUI_i = \sigma_1 + +\sigma_2 EXP_i + \sigma_3 DBB_i + \sigma_4 DMC_i + \sigma_5 DOM_i + \sigma_6 DCC_i + \sigma_7 EDC_i + \sigma_8 SZE_i + \sigma_9 DZTi + \sigma_{10} FCI_i + \sigma_{11} FCB_i + \sigma_{12} FCP_i + \sigma_{13} MKD_i + \sigma_{14} POV_i + \sigma_{15} LWD_i + g_i \ldots\ldots.(3)$$

$$FLI_i = \rho_1 + \rho_2 EXP_i + \rho_3 DBB_i + \rho_4 DMC_i + \rho_5 DOM_i + \rho_6 DCC_i + \rho_7 EDC_i + \rho_8 SZE_i + \rho_9 DZTi + \rho_{10} FCI_i + \rho_{11} FCB_i + \rho_{12} FCP_i + \rho_{13} MKD_i + \rho_{14} POV_i + \rho_{15} LWD_i \rho_{16} DFT_i + h_i \ldots..(4)$$

$$HLI_i = \rho_1 + \rho_2 EXP_i + \rho_3 DBB_i + \rho_4 DMC_i + \rho_5 DOM_i + \rho_6 DCC_i + \rho_7 EDC_i + \rho_8 SZE_i + \rho_9 DZTi + \rho_{10} FCI_i + \rho_{11} FCB_i + \rho_{12} FCP_i + \rho_{13} MKD_i + \rho_{14} POV_i + \rho_{15} LWD_i \rho_{16} DFT_i + k_i \ldots..(5)$$

Where $\beta_s, \varphi_s, \sigma_s, \rho_s$ are the estimated parameters (s = 0…16) and i refers to individual farmers (i = 1…303)
LUI_i = land use intensity of i*th* farmer measured by the modified Rutherberg's index (Rutherberg, 1980). $LUI_i = A_i / L_i$ with A_i = number of seasons the land was cultivated by i*th* farmer, L_i = total number of seasons land would have been cultivated if under continuous cropping.

CDI_i = crop diversification index measured by the Herfindal Index which is $\sum_{i=1}^{13}\left(\frac{C_i}{\sum_{i=1}^{13} C_i}\right)^2$ with C_i being the area of land planted to i*th* crop.

FUI_i = fertilizer use intensity [fertilizer applied (kg)/land area sq meter]

FLI_i = family labour use intensity (number of family labour (man day)/land area (ha)

HLI = hired labour use intensity (number of family labour (man day)/land area (ha)

LWD_i = lost working days due to sickness

EXP_i = years of farming experience

SZE_i = household size

POV_i=poverty rate (poverty line [2/3 mean per capita expenditure of the population]/mean per capita expenditure of i^{th} household)(Foster et al., 1984).

LAF_i = land area fallowing (ha)

FCI_i = food cropland areas inherited (ha)

FCB_i = food cropland areas borrowed (ha)

FCP_i = food cropland areas purchased (ha)

DCR_i = dummy variable for using crop rotation (yes = 1, otherwise= 0)

DFT_i = dummy variable for using fertilizers (yes = 1, otherwise = 0)

DCC_i = dummy variable for using cover crops (yes = 1, otherwise = 0)

DBB_i = dummy for bush burning (yes = 1, 0 otherwise)

DED_i = dummy for education (formal education = 1, otherwise= 0)

DMC_i= dummy for using mulching (Yes = 1, otherwise = 0)

DOM_i = dummy for using organic manure (Yes = 1, otherwise= 0)

DZT_i = dummy for using zero tillage (Yes = 1, otherwise = 0)

e_i , f_i, g_i, h_i, k_i = residual/error terms

Results and discussions

The results in Table 1 show that 91.75%of the house heads in all the states are male. Average age is highest in Ekiti State with 54.17 years, while all the farmers have an average of 52.83 years. In like manner, average farming experience is highest in Ekiti State with 31.17 years while farmers from all the states have an average of 28.75 years. Ekiti State records the highest average household size of 7.19 persons, while Osun State records the highest percentage of 57.28 being formally educated.

Table 1: Some Socio-economic Variables of the Farm Households in Southwestern Nigeria

Variable	Oyo State	Ekiti State	Osun State	All States
Total number of households	100	100	103	303
Male farmers (%)	96.00	92.00	87.37	91.75
Age of house head (mean)	50.22	54.17	54.06	52.83
Years of farming (mean)	26.69	31.17	28.42	28.75
Household size (mean)	6.68	7.19	6.74	6.87
Formal education (%)	52.00	57.00	57.28	55.44

The upper segment of Table 2 shows the indices of agricultural intensification. Results show that land use intensity is highest in Osun State with 95.43%, while Ekiti State has the lowest (51.20%). The three states have an average land use intensity of 71.09%. This shows that continuous cropping is most predominant among farmers from Osun State.

Table 2: Agricultural Intensification Indices and Use of Some Cultural Practices in Southwestern Nigeria.

Variable	Oyo State	Ekiti State	Osun State	All States
Index of Intensification				
Land use intensity (mean)	65.90	51.20	95.43	71.09
Crop Diversification (Mean)	18.48	43.19	68.19	43.53
Fertilizer use intensity (kg/sq meter)	0.0070	0.0056	0.0092	0.0073
Labour use intensity (family) (man day per hectare)	31.22	31.90	27.03	29.75
Labour use intensity (hired) (man day per hectare)	16.94	18.15	26.19	20.23
Usage of land management/cultural practices (%)				
Mulching	62.00	42.00	71.84	58.74
Crop rotation	64.00	48.00	88.35	66.99
Organic manure	30.00	29.00	14.56	24.42
Fertilizer application	69.00	47.00	82.52	66.34
Cover crop	25.00	29.00	24.27	26.07
Bush burning	70.00	73.00	79.61	74.26

Also, using crop diversification as index of agricultural intensification, the indices were computed. The crops planted were maize, tomatoes, leafy vegetables, okro, melon, cassava, cocoyam, plantain/banana, pepper, soybean, yam and cowpea. Farmers from Osun State have the highest output diversification index of 68.19%, while Oyo State has the lowest (18.48%). Average output diversification for the three States is 43.53%.

Intensity of fertilizer use is another form of agricultural intensification. The analysis reveals that Osun State farmers have the highest (0.0092), while Ekiti State has the lowest (0.0056). It can be deduced that allowance for fallowing as shown by land use intensity decreases where fertilizer usage is high. Intensity of fertilizer use is an average of 0.0073 kg/m^2 for all the three States.

Farmers from Ekiti State have the highest family labour use intensity (31.90 man-day per hectare), while those from Osun State have the lowest (27.03 man day per hectare). However, Osun State farmers have the highest hired labour use intensity (26.19 man-day per hectare), while Oyo State farmers have the lowest (16.94 man-day per hectare).

The lower segment of Table 2 shows the use of land management practices, which indirectly depict intensification. The results show that 71.84% (highest) of the farmers in Osun State were using mulching, while 42% (lowest) used it in Ekiti State. Also, 88.35% (highest) of the farmers in Osun State were using crop rotation, while 48% (lowest) used it in Ekiti State. The use of organic manure is highest in Oyo State (30%) and lowest in Osun State (14.56%). Fertilizers were applied by 82.52% of the farmers in Osun State, while only 47% use it in Ekiti State. Bush burning was most widely used in Osun State (79.61%), while cover crops were most widely planted in Ekiti State (29%).

Table 3 shows the results of Tobit maximum likelihood estimates for the determinants of agricultural intensification (estimated with Limdep 7.0 statistical package). The sigma values for all the equations are statistically significant ($p<0.01$). This shows that the model produced good fit for the data. The Condition Index was estimated with SPSS 10.0 statistical package in order to determine the collinear variables. However, age as a variable was removed due to its high level of collinearity with farming experience. The low values for the estimated condition index reveals that multicollinearity was not a problem in the estimated models.

The estimated parameters show that the farmers that were using slash and burn method of land preparation have significantly higher labour use intensity ($p < 0.10$). This might have resulted from employment of many family hands for such menial job of bush gathering, stumping and burning. The practice of mulching requires significantly higher use of hired labour ($p<0.01$). This might be due to the fact that farmers that indicated mulching were those planting yam which requires ridge making. The tediousness of ridging may therefore make them employ more of hired labour. Also, the use crop rotation significantly increases land use intensity ($p<0.01$). This can be explained from the fact that rotating crops enhances productivity of land and this may facilitate continuous cropping. Also, the use of organic manure significantly reduces land use intensity and crop diversification ($p<0.10$).

Farmers who planted cover crops have significantly higher family and hired labour use intensity ($p < 0.10$). The parameter of family labour use intensity is higher showing that farms planted with cover crops use higher family labour. This is expected because when farmlands are grown with cover crops like melon, much care is needed during weeding, and hired labour may not exercise the needed patience. As expected, those using fertilizer have significantly higher land use intensity ($p<0.01$). Therefore, as land nutrient diminished due to continuous cropping, the farmers adopted applying of fertilizers. Hypothesis 1 is hereby rejected.

As farming experience increases, fertilizer use intensity and hired labour use intensity significantly decrease ($p<0.05$). These findings reveal that old and experienced farmers may not be able to afford or have access to fertilizers. Also, the experienced ones, who are also the oldest could not use much of hired labour. This might have resulted from possibility of having enough children to work on the farms.

Farmers with formal education have significantly higher crop diversification index (implying more specialization) and less family labour. Education may enhance the understanding of the farmers about the expected cropping intensity and the type of crops to be grown. In like manner, the educated may be involved in some non-farm income generating activities that make them employ less of family labour.

As household size increases, crop diversification significantly increases ($p<0.05$). Intensity of family labour use increases significantly with increase in family size ($p<0.01$). Also intensity of hired labour use increases significantly as household size increases ($p<0.01$). The same applies to fertilizer use intensity that has a positive sign and statistically significant ($p<0.01$).

Table 3: Tobit Regression Analysis of the Determinants of Agricultural Intensification in Southwestern Nigeria

Variable	Parameter for Land Use Intensity	Parameters for Crop Diversification	Parameters for Fertilizer Use Intensity	Parameters for Labour Use Intensity	Parameters for Hired Labour Use Intensity
Constant	0.2874*** (4.154)	0.4610*** (5.266)	-75.7972* (1.830)	11.6531 (1.174)	6.2025 (0.767)*
Bush burning	0.0496 (1.498)	0.0335 (0.776)	10.3575 (0.524)	8.8716** (1.848)	1.1820 (0.299)
Mulching	0.0265 (0.803)	-0.0125 (-0.291)	12.4779 (0.651)	-6.8334 (-1.417)	13.2707*** (3.337)
Crop rotation	0.1575*** (4.428)	0.0003 (0.006)	24.6973 (1.161)	3.3003 (0.634)	-3.6189 (-0.843)
Organic manure	-0.0721* (-1.826)	-0.0987* (-1.892)	-26.0865 (-1.088)	-3.3390 (-0.582)	1.9376 (0.407)
Cover crop	-0.0292 (-0.813)	0.0393 (0.846)	6.1553 (0.279)	11.7310** (2.235)	6.5776* (1.640)
Minimum tillage	-0.0016 (-0.044)	-0.1424*** (-3.019)	46.6742** (2.170)	3.7377 (0.716)	-2.9179 (-0.676)
Fertilizer application	0.1840*** (5.311)	0.0029 (0.066)	-	4.3808 (0.865)	1.4597 (0.350)
Farming experience	-0.00008 (-0.075)	-0.0001 (-0.095)	-2.0353*** (-2.830)	-0.1942 (-1.135)	-0.2738** (-1.960
Formal education	-0.0041 (0.131)	0.0786* (1.912)	27.4867 (1.447)	-7.5224 (-1.643)	-0.8571 (-0.228)
Household size	0.0020 (0.384)	0.0160** (2.427)	16.1482*** (5.298)	2.2142*** (2.951)	2.3003*** (3.778)
Food cropland inherited	0.0396*** (4.343)	0.0112 (0.955)	2.2898 (0.423)	-5.2064*** (-3.915)	-2.4423** (-2.267)
Food cropland purchased	0.0232 (0.943)	0.0521* (1.650)	33.3411** (2.379)	-6.6866** (-1.860)	-0.9336 (-0.321)
Food cropland borrowed	0.0717 (1.428)	0.0405 (0.628)	45.2578 (1.595)	-6.9879 (-0.947)	13.4217** (2.277)
Market distance	-0.0007 (-0.138)	-0.0068 (-1.050)	1.9272 (0.631)	1.1874 (1.606)	1.6533*** (2.733)
Poverty index	0.0019 (0.095)	-0.2415*** (-8.605)	-12.6917 (-1.067)	0.7381 (0.251)	-9.8608*** (-4.019)
Lost working days	0.0069*** (3.840)	0.0030 (1.318)	-1.4155 (-1.143)	0.1569 (0.595)	-0.2168 (-1.008)
Sigma	0.2438*** (22.998)	0.3054*** (19.823)	136.2225*** (18.395)	35.3075*** (22.896)	28.3640*** (20.963)
Condition Index	16.39	16.39	15.61	16.39	16.39

Note: * **= p<0.01, ** = p < 0.05, * = p < 0.10 (t-statistics values are in brackets)

As the land hectarage owned through inheritance increases, land use intensity significantly increases ($p < 0.01$). In many rural areas, inherited lands are closer to the village than any other land areas and may because of this be subjected to continuous cropping. However, as the number of land hectarage owned through inheritance increases, family and hired labour use intensity significantly decreases ($p<0.05$). Crop diversification indices and fertilizer use intensity significantly increase with increase in cropland purchased ($p < 0.10$), while family labour use intensity decreases. Hired labour use intensity significantly increase with increase in the hectarage of land owned through borrowing.

As market distance increases, hired labour use intensity significantly increases ($p<0.01$). Increased poverty significantly increases lower intensity of hired labour use ($p<0.01$) and crop diversification index. Lower use of hired labour may be due to inability to afford the daily wages for hiring labour. The finding for crop diversification shows that the poor plant many crops in order to meet their basic needs. The number of days farmers lost due to sickness significantly increases land use intensity ($p<0.01$). This is expected because sickly farmers may not be able to trek the long distance in search of fertile land. Therefore, inability to control common health problems in the rural areas may compel agricultural intensification in the form of continuous cropping.

Recommendations

Agricultural intensification in southwestern Nigeria will continue to increase due to scarcity of fertile arable land and decline in fallow periods. This study investigates the intensification processes and concludes that farmers are overexploiting the land nutrients by using continuous cropping and the agricultural production process is somehow labour intensive.

The analysis reveals that increase in the number of days farmers could not go to work due to illness will result in increased land use intensity. The need to therefore ensure that health services are provided in the rural areas can be underscored. A healthy man is able to travel far in search of good land instead of continuously cultivating the ones available near the village.

Increasing the rate of poverty will increase the number of crops that farmers cultivate on a plot of land and reduce the use of hired labour. Therefore, an attempt to reduce rural poverty is a clear way of ensuring sustainability in the agricultural production system. This is important because soil degradation can be aggravated by unguided or excessive mixed cropping. Review of the policy framework for poverty alleviation in Nigeria with a goal of ensuring that the rural households are fully catered for is essential.

The need to promote soil conservation practices is highlighted by the findings of the study. It was found that application of fertilizer and the use of crop rotation increase land use intensity. This shows that with appropriate soil conservation technologies, intensive land use will increase. However, how sustainable this could is beyond the scope of this paper. Moreover, planting of cover crops increases intensive use of family labour. Sustainable land use by means of planting cover crops is therefore labour intensive and any factor that hinders availability of family labour will have some adverse effect on their cultivation. Efforts set at developing a hybrid of cover crops or planting technologies that will be less labour demanding will go a long way in promoting cultivation of these soil nutrient enhancing crops.

Finally, the use of fertilizer increases land use intensity. However, this study clearly reveals that rural farmers no longer apply fertilizer in the right quantity. There is a need to ensure timely provision of fertilizers to farmers in southwestern states. Encouragement of fertilizer production by indigenous industries will also increase supply.

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