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An Almost Ideal Demand System (AIDS) for Forest and Agricultural Land Demand in Nigeria

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Abstract: Nigerian land use demand model was estimated using the AIDS model. Results showed that restricted method of estimation gives a better result than the unrestricted considering the significance of hectarage elasticities. The assumption of homogeneity was violated by the unrestricted method of estimation. Both the restricted and unrestricted methods of AIDS model estimation comply with the assumption of adding up, although, both violate the symmetry assumption. Increase in national income will lead to increase in the total hectare demanded in all the land use classes. Substitution or price effect is stronger as a factor influencing demand for all the land use classes. Permanent cropland and arable land show complementary relationship from the cross price elasticity. Arable land and permanent pasture show complementary relationship. Forest and woodland versus permanent crops are substitutes.

Key words: Land use, forest land, agricultural land, AIDS model

INTRODUCTION

Land use implies the end to which land is allocated, assuming a conscious decision to use it for a desired purpose (Marion, 1960; Reardon, 1998). Therefore, land can be used for various purposes, which include agricultural production, urban or rural settlement and forestry or occupancy. Vink (1975) noted that the use to which the land is put in a certain area and at a certain time is to satisfy human needs, either material or spiritual. It can therefore, be concluded that land use is the application of labour to an area of land for production purposes or settlement.

Furthermore, land use is a non-static concept. It changes in accordance with the changes in the factors such as population, land tenure systems and the level of technology. Thus, with time, as population increases, levels of technology change, villages widen beyond their boundaries and towns tend to increase in size, so does the land use pattern change. With mechanization of agriculture, adequate and proper land classification maps, land outputs will increase to meet the changes in demand of the growing population for food and other recreational activities (Adegboye, 1986).

Similarly, the dynamics of land use in many African nations have resulted into land degradation that is largely accelerated by progressive deforestation (Barbier, 2000). Recently, the existence of synergistic, intricately interwoven and mutually reinforcing nexus between agriculture, population and the environment in many nations of the Sub-Saharan Africa (SSA) has been recognized (Cleaver and Schreiber, 1993, 1994). Accordingly, the International Food Policy Research Institute (IFPRI) began an initiative for A 2020 Vision for Food, Agriculture and the Environment in 1994 to evaluate current situations and trends in food production, consumption and distribution. This was to facilitate a solid international agreement on the directions of food policy in the next 2 and half decades (Scherr and Yadav, 1996). Among the most seriously deliberated issues was the land use pattern that often results into resource degradation. Although, it was argued that land availability constraint is relatively unimportant to global food supplies (Crosson, 1994), some perceived that global food supplies over the long-term period is highly threatened by this problem (Brown and Kane, 1994; Pimentel *et al*., 1995). There were also serious concerns about the effect of land use and resource degradation on the livelihoods of rural dwellers, particularly those in seriously degraded agricultural areas (IFAD, 1992).

No doubt, shortage of high quality agricultural land is a major problem confronting small-scale farmers in many regions of the world (FAO, 1998). In Nigeria, agricultural production involves four broad systems of land use. These are crop production, animal husbandry, fishery and forestry. The Nigerian small-scale farmers largely depend on traditional methods of farming. These farmers are facing various land use constraints, which is one of the major sources of declines in agricultural productivity. Suppose rural households choose to stay on degraded

land, its declining productivity will not be able to support growing rural populations, not to consider the nation as a whole. Thus, some households are forced to abandon existing agricultural areas in search of new forest land. Where land is scarce, land fragmentation and continuous cropping persist with little or no soil conservation investments (FAO, 1991).

In the rural areas, land use patterns are governed mainly by the requirements of the agricultural industry, which is important for the livelihood of the people. The use of land for village construction, local markets construction, road construction, church and mosque buildings are of secondary importance. Although, agriculture remains the dominant consideration in the land use decision of farm households, the same forces such as increasing population, the requirement of new crops, the growth of commerce and government action with regard to the preservation of the country's forest wealth have somehow altered traditional concept of land use (Adegboye, 1966, 1986). The objective of this study is to estimate a land demand model with respect to the different forms of uses to which land is put. The findings will be useful for proper understanding of the relationships between different forms of land use as reflected by their returns per hectare. In the remaining parts of the study, the materials and methods of data analysis, results and discussions and recommendations are presented, in that order.

MATERIALS AND METHODS

Sources and limitations of data: The data used in this study, were the national aggregates for the land use patterns obtained mainly from secondary sources. The major sources include the several issues of the Production Yearbook published by the Food and Agriculture Organization (FAO), FAOSTAT web site (www.fao.org), the Federal Office of Statistics (FOS) annual abstract of statistics and several issues of the Central Bank of Nigeria's (CBN) annual reports and statement of accounts. The data on forestland were up to 1996, the exponential growth rate method was used to project for missing values up to 2000.

For descriptive purpose, the study period can be divided into two. First, 1961-1980, which was characterized by low population, low rate of urbanization, agricultural policies that were not too demanding on the environment and little threat from depletion of the ozone layers resulting into climatic vagaries. The second period, 1981-2000 can be described as the period of high population density, high rate of urbanization, increasing threats from climate vagaries and adoption of agricultural policies like the green revolution and the Structural Adjustment Program (SAP) that largely characterized by increased use of agrochemicals.

Forest and agricultural land demand model: The Almost Ideal Demand System (AIDS) was used to estimate the land demand function. Along with its flexibility, it allows the assumptions of homogeneity and symmetry to be tested or successfully imposed during empirical analysis The AIDS model is specified as:

$$w_{it} = \partial_i + \sum_{i=1}^{j} \ell_{ij} \ln P_{jt} + \Phi_i \ln (H/P) + \varepsilon_t \quad (1)$$

Where:

w_{it} = Share of ith Land use in overall hectares cultivated in year t.
P_{jt} = Price of jth commodity (proxied as returns per hectare) in year t.
ℓ_{ij} = Estimated coefficient of prices.
Φ_i = Estimated coefficient of hectares cultivated.
H = Total hectares demanded.
P = Price index.

The price index can be further defined as:

$$\ln P = \alpha_0 + \sum_k \alpha_k \ln P_k + 1/2 \sum_j \sum_k a_{kj} \ln P_k \ln P_j \quad (2)$$

The price index makes Eq. 1 to be non-linear. In order to make it linear, the Stone's index has been incorporated. The index, according to Stone (1953) is specified as:

$$\ln P^* = \sum w_j \ln P_j \quad (3)$$

The linearized form of AIDS model can then be re-written as:

$$w_{it} = \partial_i + \sum_{i=1}^{j} \ell_{ij} \ln P_{jt} + \Phi_i \ln (H/P^*) + \varepsilon_t \quad (4)$$

Applied demand theory indicates four basic restrictions that must be satisfied by any estimated demand system for the sake of theoretical consistency. The adding up condition is automatically satisfied by the AIDS model and is capable of satisfying the three other restrictions, although, it does not necessarily do so. From Eq. 1, the adding up condition implies that:

$$\sum_i \partial = 1, \sum_{ji} \ell_{ij} = 0, \sum_i \Phi_i = 0 \quad (5)$$

Homogeneity is satisfied if:

$$\sum_j \ell_{ij} = 0 \quad (6)$$

and symmetry assumption is satisfied if

$$\ell_{ij} = \ell_{ji} \quad (7)$$

Following Chalfant (1987) and Ahmed and Shams (1994), the Marshalian and Hicksian elasticities are computed from the estimated parameters of the Linear Approximation AIDS model (LA/AIDS) in Eq. 4 as follows:

Marshalian (Uncompensated):

$$\varepsilon_{ii} = -1 + (\ell_{ij}/w_i) - \Phi_i \text{ (own - price)} \quad (8)$$

$$\varepsilon_{ij} = (\ell_{ij}/w_i) - \Phi_i\ (w_j/w_i) \text{ (cross - price)} \quad (9)$$

Hicksian (Compensated):

$$\acute{\varepsilon}_{ii} = -1 + (\ell_{ij}/w_i) - w_i \text{ (own - price)} \quad (10)$$

$$\acute{\varepsilon}_{ij} = (\ell_{ij}/w_i) + w_j \text{ (cross - price)} \quad (11)$$

The hectarage demand elasticity is derived as:

$$\check{n}_i = 1 + \Phi_i/w_i \quad (12)$$

RESULTS AND DISCUSSION

Description of trends in land areas in Nigeria: Land use in Nigeria can be broadly classified as forest, agricultural land and other land. Data on forest include woodland and it took cognizance of natural and planted forests. The agricultural land classification considers the land under arable land, permanent crops and permanent pasture, while other land focuses on such non-agricultural uses of land for such purposes as road construction, industrialization, housing etc. The areas of land under forests have declined since, the 1960s (Table 1). The mean forestland area between 1961-2000 is 14,673,580 ha with a variability index of 22.53%. In 1961-1980, the average forestland area is 17,440,950 ha with variability index of 10.67%, while that of 1981-2000 is 11,906,200 ha with variability index of 14.17%.

Further analysis shows that the average deforested land areas declined from 360,600 ha in 1961-1965 to 276,200 ha in 1976-1980 after, which it latter increased to 308,200 ha in 1996-2000. Ehui and Hertel (1992) estimated deforestation rate in Cote d`Ivoire to be 300,000 ha year^{-1} which was noted to be one of the highest in the world (Bene *et al*., 1972; Bertrand, 1983; OTA, 1984; Allen and Barnes, 1985). This implies that Nigeria can be ranked as one of the nations with the highest rate of deforestation. The average forestland deforested in 1961-1980 is 317,450 ha with variability index of 10.48%, while that of 1981-2000 is 287,000 ha with variability index of 30.77%.

Table 1 further shows that average agricultural land area increased from 69,004,000 has in 1961-1965 to 72,580,200 ha in 1991-1995, after which it decreased to 70,243,250 ha in the 1996-2000 period. This decline could imply that previously cultivated agricultural lands are now being converted into non-agricultural purposes. Agricultural land area has the lowest average growth rate of -0.57% in 1996-2000. Between 1961-2000, average agricultural land area cultivated is 70,485,250 ha with variability index of 1.61%, which implies low variability between the data. Average agricultural land area is 69,676,750 ha in 1961-1980, while that of 1981-2000 is 71,293,750 ha.

Analysis of land area devoted to permanent pasture shows that the average area of land in this category, was stable at 40,000,000 ha between 1961-1990. However, as from 1996, the area of permanent pasture began to decrease with its values for 1991-1995 and 1996-2000 being 39,984,200 and 31,504,200 ha, respectively. Since, these land areas are those normally grown with grasses and shrubs for livestock grazing, recent reduction in its area is an indication that less land areas are gradually being kept for livestock. In the face of increasing demographic pressure, without substantial conversion of forestland to agricultural land, agricultural production will gradually expand to some permanent pasture land.

Furthermore, between 1961 and 2000, average permanent pasture is 39,916,050 ha with variability index of 0.61%. Table 1 shows that average arable land area in Nigeria increased from 26,600,000 ha in 1961-1965 to 30,060,400 ha in 1991-1995. However, the value decreased to 28,325,000 ha in 1996-2000. Furthermore, the period 1986-1990 has the highest growth rate of 0.61% for the arable cropland. Average value of arable land in 1961-2000 is 28,069,980 ha with variability index of 3.86%. The mean values of arable land areas for 1961-1980 and 1981-2000 are 27,214,000 and 39,832,100 ha, respectively. Also, in 1961-1980, 1981-2000 and 1961-2000, the geometric growth rates for arable land were 0.26, 0.06 and 0.17%, respectively.

Land areas of permanent crops increased steadily from 2,408,000 ha in 1961-1965 to 2,538,000 ha in 1996-2000 period. Between 1961-2000, land areas devoted to permanent crops has an average value of 2,499,325 ha with coefficient of variation of 2.0%. The permanent land areas in 1961-1980, 1981-2000 and 1961-2000 have geometric growth rates of 0.27, 0.005 and 0.14%, respectively. The computed mean of permanent crop land

Table 1: Average and growth rates of different forms of land use in Nigeria

	Forest and woodland		Agric land		Permanent pasture		Arable land		Permanent cropland		Other land	
Period	Average ('000 ha)	Rate of deforestation (%)	Average ('000 ha)	Growth rate (%)	Average ('000 ha)	Growth rate (%)	Average ('000 ha)	Growth (%)	Average ('000 ha)	Growth rate (%)	Average ('000 ha)	Growth rate (%)
1961-1965	19869.20	1.7890	69004.00	0.15	40,000	0.0	26600.0	0.38	2408.00	0.20	2203.80	12.64
1966-1970	18153.80	1.7896	69524.00	0.23	40,000	10.0	27084.0	0.53	2436.40	0.61	3399.20	5.37
1971-1975	16586.40	1.7494	69920.00	0.04	40,000	0.0	27436.0	0.07	2484.00	0.20	4570.60	6.28
1976-1980	15154.40	1.7599	70259.00	0.10	40,000	0.0	27736.0	0.23	2523.00	0.15	5663.60	3.64
1981-1985	14064.80	1.8694	70710.20	0.23	40,000	0.0	28175.2	0.58	2535.00	0.00	6302.00	1.68
1986-1990	12646.60	2.0578	71703.20	0.25	40,000	0.0	29175.2	0.58	2535.00	0.00	6727.20	0.72
1991-1995	11135.80	2.6267	72580.20	0.06	39984.2	0.05	30060.4	0.37	2535.60	0.03	7361.00	1.49
1996-2000	09777.60	3.0529	70243.25	-0.57	31504.2	0.0	28325.0	-0.58	2538.00	0.00	10206.75	5.65

Sources: Computed from data from Food and Agriculture Organization (FAO) database (www.fao.org) and Federal Ministry of Agriculture and Natural Resources, Nigeria

Table 2: Unrestricted parameter estimates and tests of homogeneity

Land class	Permanent crop	Arable land	Permanent pasture	Forest and woodland
Constant term (∂_i)	0.045472*	-0.020944	0.62832*	0.34715*
Hectarage parameter (Φ_i)	-0.0007494	0.010688	-0.00859	-0.00134
Permanent cropland price (ℓ_{i1})	0.0013231***	-0.027271***	0.0090397*	0.0016908
Arable land price (ℓ_{i2})	-0.039028*	0.52731*	-0.36002*	-0.12826
Permanent Pastureland price (ℓ_{i3})	0.038496*	-0.51923*	0.35799	0.12274
Forest and woodland price (ℓ_{i4})	-0.0011784***	0.11062*	-0.0087092*	-0.10073*
$\Sigma\ell_{ij}$	0.00038	0.091429	-0.00169	-0.0893
R^2	0.9708	0.9563	0.9694	0.9871

*Statistically significant at 10%; **Statistically significant at 5%; ***Statistically significant at 1%

Table 3: Restricted estimates of the parameters

Land class	Permanent crop	Arable land	Permanent pasture	Forest and woodland
Constant term (∂_i)	0.0136066**	0.47587**	0.23468*	0.27584
Hectarage Parameter (Φ_i)	0.0048672*	0.011931	0.062610*	-0.079398**
Permanent cropland price (ℓ_{i1})	-0.0007079	-0.033751	-0.016914***	0.051396**
Arable land price (ℓ_{i2})	-0.010441*	-0.33447**	-0.027181*	0.37295**
Permanent Pastureland price (ℓ_{i3})	0.0096701*	0.34042**	0.022047*	-0.37300**
Forest and woodland price (ℓ_{i4})	0.0014785**	0.027818	0.022133*	-0.051348**
R^2	0.92305	0.83197	0.89859	0.95374

*Statistically significant at 10%; **Statistically significant at 5%; ***Statistically significant at 1%

areas in 1961-1980 is 2,462,750 ha with variability index of 1.94%, while that of 1981-2000 is 2,535,900 ha with variability index of 0.06%.

Table 1 further shows that average land areas for those classified as other land (devoted to urbanization, industrialization, road construction, housing etc.) increased from 2,203,000 ha in 1961-1965 to 10,206,750 ha in 1996-2000. However, the rates of growth were highest for the periods between 1961 and 1980. This shows that over the years, urban development might have resulted into conversion of forest and agricultural land into other uses like housing, road construction, building of schools and hospitals and construction of other cottage industries.

Estimation of land use demand model: Table 2 and 3 presentage the parameters estimated for the unrestricted and restricted methods of demand for land in Nigeria. Analysis in Table 2 was done without imposition of any of the assumptions of adding up and homogeneity. This helps to test for compliance of the results with the theoretical expectations. Therefore, ordinary least square regression option of the Microfit Windows version 4.1 was employed in the analysis. The restricted version of the analysis (Table 3) was however, done with imposition of the assumption of homogeneity. The Seemingly Unrelated Regression Estimates (SURE) option of Microfit Windows version 4.1 was used for the analysis.

The results in Table 2 shows that the estimated parameters for prices do not comply with homogeneity assumption in the equations for arable land, permanent pasture and forest and woodland. It is only, the parameter estimated for permanent crops that comply with the homogeneity assumption. Violation of this assumption had been reported before (Deaton and Muellbauer, 1980; Ahmed and Sham, 1994). However, the assumption of adding up was complied with in the two models, but symmetry assumption was conspicuously violated.

Table 2 further shows that while many of the parameters for price are statistically significant at least at the 10% level, none of the expenditure parameters was statistically significant at least at the 10% level. However, Table 3 which shows the parameters of the restricted has

Table 4: Compensated and uncompensated own price elasticities

Land class	Type	Uncompensated	Compensated	Hectarage elasticity
Permanent crop	Unrestricted	0.95513	-0.98587	0.97501
	restricted	-1.02847	-1.05359	1.1623
Arable land	Unrestricted	0.542526	0.221258	1.0499
	Restricted	-2.00135	-2.32743	1.0352
Permanent pasture	Unrestricted	-0.23592	-0.71836	0.9818
	Restricted	-1.01608	-1.42732	1.1321
Forest and woodland	Unrestricted	-1.63572	-1.79517	0.9914
	Restricted	-1.24536	-1.48287	0.4978

some of the expenditure parameters being statistically significant at least at the 10% level. The R^2 for both the results in the restricted and unrestricted methods of estimation are large. In Table 2, forest and woodland equations have the highest values in the fashions of the analyses, explaining 98.72 and 95.37% of the variations in the values of the share of land demand for the unrestricted and restricted methods, respectively.

Table 4 shows the estimated values of compensated and uncompensated elasticities and the land hectarage demand elasticities. The uncompensated (Marshalian) elasticities measure the combined effects of income and price on demand for land, while compensated elasticities (Hicksian) focus on the price effect alone or the substitution effect. The hectarage elasticities all have positive sign with restricted method for permanent pasture being most elastic with 1.13213. This implies that if national income increases by 10%, demand for permanent pasture will increase by 11.32%. Increasing income will therefore, translate into increase in livestock investment. As this happens, more permanent pasture would be needed to keep the livestock. This positive relationship applies to all the classes of land use. A comparison of the values of hectarage elasticity for restricted and unrestricted equations reveals that the values do not follow any particular trend. However, while most of the values for restricted and unrestricted equations in the permanent crop, arable land and permanent pasture have little difference, forest and woodland shows wide disparity. The restricted equation has a value of 0. 991475, while unrestricted has 0.497843.

The compensated and uncompensated own price elasticities further show that the estimated values for restricted method are higher in all the classes of land demand, except in the forest and woodland. The restricted method for arable land has the compensated and uncompensated values of -2.32743 and -2.00135, respectively and these are most elastic. This implies that if return per hectare (proxied as price) increased by 10%, demand for arable land will decrease by 20.01%, but substitution effect or price alone would lead to 23.27% decline. The higher impact of price is a reflection of the problems confronting agricultural pricing in Nigeria. The farmers are not getting as much as they are ought to get due to several marketing inefficiencies. It is interesting to note that except for arable land unrestricted results for the compensated and uncompensated own price elasticities, the price effect in bringing about decline in demand for land in Nigeria is very strong. This implies that if farmers were getting better prices, they would not cultivate as much land as they are cultivating possibly because they would get enough money from their expected output.

Table 5 shows the values of the computed uncompensated and compensated cross-price elasticities. The Table 5 shows that in the uncompensated cross price elasticities, while permanent crop versus arable land displays a substitution relationship, the relationship between arable land versus permanent crops is complementary. This is contrary to what the results of compensated give, where the two combinations imply a complementary relationship. This shows that if returns per hectare of arable land increases, the total hectare of land cultivated to permanent crops will increase. This can be well explained from the fact that majority of Nigerian farmers (especially those in the south west and south east) cultivated both cash and food crops. Increasing return from food crops for instance, would still compel that more cash crops should be cultivated. This behavior could also result from risk minimization, in which case farmers understand that the increase in returns will be temporary. Another way of seeing, it is from the fact that farmers need to produce some food crops for their family members and it does not matter whether prices of other cash crops increase, they just have to do so for household self food sufficiency. Specifically, from the uncompensated results, if the return per hectare in permanent crops increases by 10%, the arable land area will increase by 9.346%.

In all the results, permanent pasture and permanent cropland combinations show that they are substitutes. The implication is that if returns from one increases, the land area to be demanded for other will decrease. This can be explained from the fact that most livestock farmers concentrate on their animals without being able to grow cash crops. In fact, some cash crops like cocoa require much attention that cannot be easily given if one combines the job with cattle ranching. If the returns per hectare of permanent crops increase by 10%, land areas of permanent pasture will decrease by 17.58%.

Table 5: Compensated and uncompensated cross price elasticities of unrestricted method

Land use class	Permanent crops	Arable land	Permanent pasture	Forest and woodland
Uncompensated				
Permanent crops	-	1.2930	1.29555	-0.0353
Arable land	-0.08217	-	-1.55693	0.319336
Permanent pasture	0.019621	-0.75365	-	-0.01551
Forest and woodland	0.017191	-0.80831	0.780315	-
Compensated				
Permanent crops	-	-0.96341	1.757563	0.118818
Arable land	-0.05068	-	-1.06212	0.485346
Permanent pasture	0.049065	-0.42173	-	0.139734
Forest and woodland	0.136924	-0.47314	1.250125	-

Table 6: Compensated cross price elasticities of restricted model

Land use class	Permanent crops	Arable land	Permanent pasture	Forest and woodland
Uncompensated				
Permanent crops	-	-0.40304	0.245557	0.02364
Arable land	-0.1009	-	0.9902982	0.076711
Permanent pasture	-0.03966	-0.10203	-	0.025817
Forest and woodland	-0.1220314	-0.34166	-0.09797	-
Compensated				
Permanent crops	-	-0.01012	0.796316	0.207417
Arable land	-0.06985	-	1.480867	0.240404
Permanent pasture	-0.05771	0.280686	-	0.204823
Forest and woodland	-0.07699	0.16614	0.613831	-

Table 6 further shows that most of the combinations of forest and woodland and permanent crops show that they are substitutes. This is expected because majority of cash crop production (especially cocoa and kolanut) is done on forestland. This does not mean that old farms cannot be rehabilitated. However, it can be inferred that if returns per hectare in cash crop increases, less of forestland are would be had. If returns from forest and woodland increase by 10%, the permanent crop land area will decline by 13.69%.

Unlike the results in the unrestricted method in Table 5 that easily shows more specific characterization as to whether combination of some commodities is substitute or complement, results in Table 6 do not easily show particular classification. This is possible because, it is possible for cross price elasticity to demonstrate a substitution relationship and complementary relationship (Henderson and Quantz, 1981). This implies that a commodity could be gross substitute with respect to income and price effects and complement with respect to price effect alone. Molina (1994), Yang and Koo (1994) and Janda *et al.* (2000) have found the same results.

However, permanent cropland and arable cropland show complementary relationship just as the unrestricted method in Table 5. The compensated cross price elasticity shows that a 10% increase in the returns per hectare of arable cropland will lead to 6.99% increase in the demand for permanent cropland.

CONCLUSION AND RECOMMENDATIONS

Land use in Nigeria is a dynamic process that is largely driven by economic and demographic pressures. The analysis in this study revealed, the type of interactions expected between the different forms of use of land. It was found that demand for different forms of land will keep increasing even as income of the households grow. This is a reflection of the agrarian nature of the Nigerian economy and low level of agricultural technology. To therefore, address the impending problem of land shortages and degradation, development of appropriate technologies that can cope with the fragile tropical soils found in Nigeria should be given priority.

Also, agricultural pricing policies in Nigeria must be more efficient. This study reveals that increasing returns per hectare will lead to decrease in the demand for some classes of land use. It is therefore, imperative that appropriate channels for selling agricultural products be provided. Pricing could also be better done if storage facilities are provided for such products that are perishable and development of cottage industries that could transform such products into finished goods.

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