Population, Deforestation and Biodiversity Erosion in the Context of Rural Agricultural Expansion in South Eastern Nigeria

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Abstract

This study attempts to model the relationship between macro demographic factors at the aggregate village level data and the various indices of deforestation arising from rural agricultural expansion. In a multiple regression analysis of five (5) macro demographic (Causative) variables modelled against eleven (11) indices of deforestation (explanatory variables); the demographic factors critical to explaining variations in the various indices of deforestation were delineated. The population size of settlements, farm space density, and the size of households were identified to influence to various degrees, variations in deforestation indictors. The magnitudes of these effects were however, low, evident by low elasticities between population and deforestation variables.

Introduction

Population growth is generally reported in the literature as the major cause of environmental change and degradation (Philip, 1990; McNamara, 1992a; Ajaegbu, 1992a; Davis & Bernstam, 1991). Soil deterioration, deforestation and loss in genetic and species diversity are factors now commonly associated with this phenomenon (Charkeseliani, 1990; Agarwal, 1992). Though the extent to which the population factor accounts for environmental damage has not yet between taken into consideration, few studies however delineate this specific contribution (Bilsborrow & Delargy, 1991; Ajaegbu, 1992b; NEST, 1991; Aina & Salau, 1992; Ologe, *et al* 1992). It is becoming evident in the literature that the population environment relationship cannot readily be cast in a unidirectional fashion (Davis & Bernstam, 1991; Ajaegbu, 1992b), as attempted by McNamara (1992) and justified by Philip (1990).

A complex and multi-dimensional array of factor is now being identified as critical to environmental damage. These factors emanate from the nature of human interaction with the environment (Gourou, 1980; Carrey & Schwartzberg, 1969; Salau, 1992; Salau, 1993). Thus other than relying on the pressures of human population as being solely responsible for environmental change; the size and growth rate of population, the level of technological capabilities, the level of human consumerism, mans social organization and the way man perceives his environment are presently being identified as the key factors that set the rules, method and rate at which the environment is exploited. (Bisong, 2001). Earlier studies on population and land use change sought to draw links between population densities, intensity of agriculture and food production (Boserup, 1965; Bisong, 2001; Mortimore, 1971; Morgan, 1955). The environmental consequence of the adaptation to population growth and pressure was however given little emphasis.

Later works however began to draw attention to some forms of environmental problems associated with man's interaction with the soils such as population pressure and the subsequent reduction in fallow as it affects soil desiccation, soil erosion and other forms of soil deterioration (Areola, 1990; Okai. 1992). A few studies in recent times have further extended the application of population and land use studies to the conservation needs have forest biodiversity (Myers, 1991; Zaba, 1991). The amount of forest cover available to each individual, a vital measure of forest pressure is estimated to have declined globally by 50% since 1960 to 0.6 hectares per person (Gardner-Outlaw & Engelman, 1999). The observed decline in the ratio of forested land to human beings is attributed to population expansion (Gardner-Outlaw & Engelman, 1999). An emerging viewpoint however holds that although population growth is a factor in natural resource depletion and environmental decline, the question of whether it is the Proximate or fundamental cause still remains to be proved (Global Biodiversity Support Program, 1999). Proponents of this view point holds that the population problem in the context of natural resource and biodiversity decline must be seen beyond the role of absolute numbers and density, and must incorporate other socio-economic variables as mediating between population and environment.

A distinction has therefore been made by some contributors between population and market-based explanations on deforestation (Angelson, 2000; Angelson, Shitindi & Arrestad, 2000). In the context of the study region Lowe (1990) for instance, while reporting that the highest degree of species endemism in biological diversity in Africa occurs in the low land evergreen moist forest of the Cross River State, notes that the over-exploitation of the forest reserves through subsistence farming and cash cropping, hunting for bush meat, and logging activities pose a threat to the survival of these species and the maintenance of genetic diversity. Expanding further on the role of agriculture on deforestation and subsequent biodiversity decline, Philip (1990) maintains that deforestation in the Nigerian context has resulted largely from two processes: the increase in area of subsistence farming as a result of the need to feed a growing population; and the spread of cash crop by peasant farmers to obtain income (McNamara, 1992a).

Cash cropping is observed to have replaced forest cover in the high forest zone with the cultivation of tree crops such as cocoa, cola, oil palm and rubber for exports. The rising prices of foodstuffs have also resulted in the competition of arable crops for forestlands. Vast tract of land in Nigeria has as a result become devoid of forest as could be observed prior to 1970 where forest came to the road edges such as along Benin-Asaba, Obubra, Agoi and Arochukwu, Abakaliki roads. This forest has long disappeared. In Lowe's (1990) viewpoint, pressure on forest can be reduced if the productivity of arable land is enhanced. A number of other recent studies have called attention to the negative repercussions the loss in biodiversity will have on the prospects of feeding the growing human populations (Ehrlich, Enrlich & Daily, 1993; Ehrlich, Enrlich & Daily, 1993; Spore, 1993; Sattaur, 1991; Sasson, 1990). The common concern in all these studies is the disappearance or erosion of the once diverse range of plant and animal species as they are being replaced by the commercial uniform varieties or modern high yield varieties. The studies are also unanimous about the implication of these trends for social, economic and ecological security for agricultural and ecological systems. Although habitat destruction is identified as the major cause of biodiversity decline and extinction, and the factors of population growth and agricultural expansion are regarded as the major determinants of habitat destruction; the dearth of empirical data to justify these assertions and the poorly understood human and ecological factors within the rural agricultural processes, that serves to exacerbate further habitat destruction and subsequent biodiversity decline/erosion are significant gaps in the literature. This paper therefore seeks to quantify or delineate the effects of macro demographic factors on deforestation in the context of rural agricultural expansion; and to identify the deforestation indicators sensitive to demographic change.

Materials and Method

Study Area

Twelve settlements in the rainforest of Cross River State, South-Eastern Nigeria are the main focus of this study. They fall within the present Local Government Areas of Akamkpa, Ikom and Etung in the Cross River State. These regions are home to the Oban Division of the Cross River National Park and its associated support zones; the Cross River North and South Forest Reserves and the Ukpon, Umon, Oban East and West Reserves, including numerous tracts of Community Protected forest areas (Fig.1) The region occupies a land area of 7908.47km2, or 42.8% of the total land area of the Cross-River State. It lies between latitudes 5”20 and 6”20N and longitudes 8”05 to 8”45E. About 70% of the high forest areas in the Cross River State, South Eastern Nigeria are confined within this zone. The Cross-River State in itself boasts of approximately 31% of the total remaining area of tropical high forest in Nigeria. The total forest Estate area of Cross River State including the Cross River National Park Covers approximately 7,290sq kms (35). The 1991 census estimates the entire population of the study area at 290,548 persons with Akamkpa and Ikom/Etung LGAs placed at 114,924 and 175,624 people respectively. While the overall state population density (crude) can be placed at 101 persons per km^2, the Oban area (Akamkpa LGA) has a significantly lower population density at 22.8 Persons per km^2.

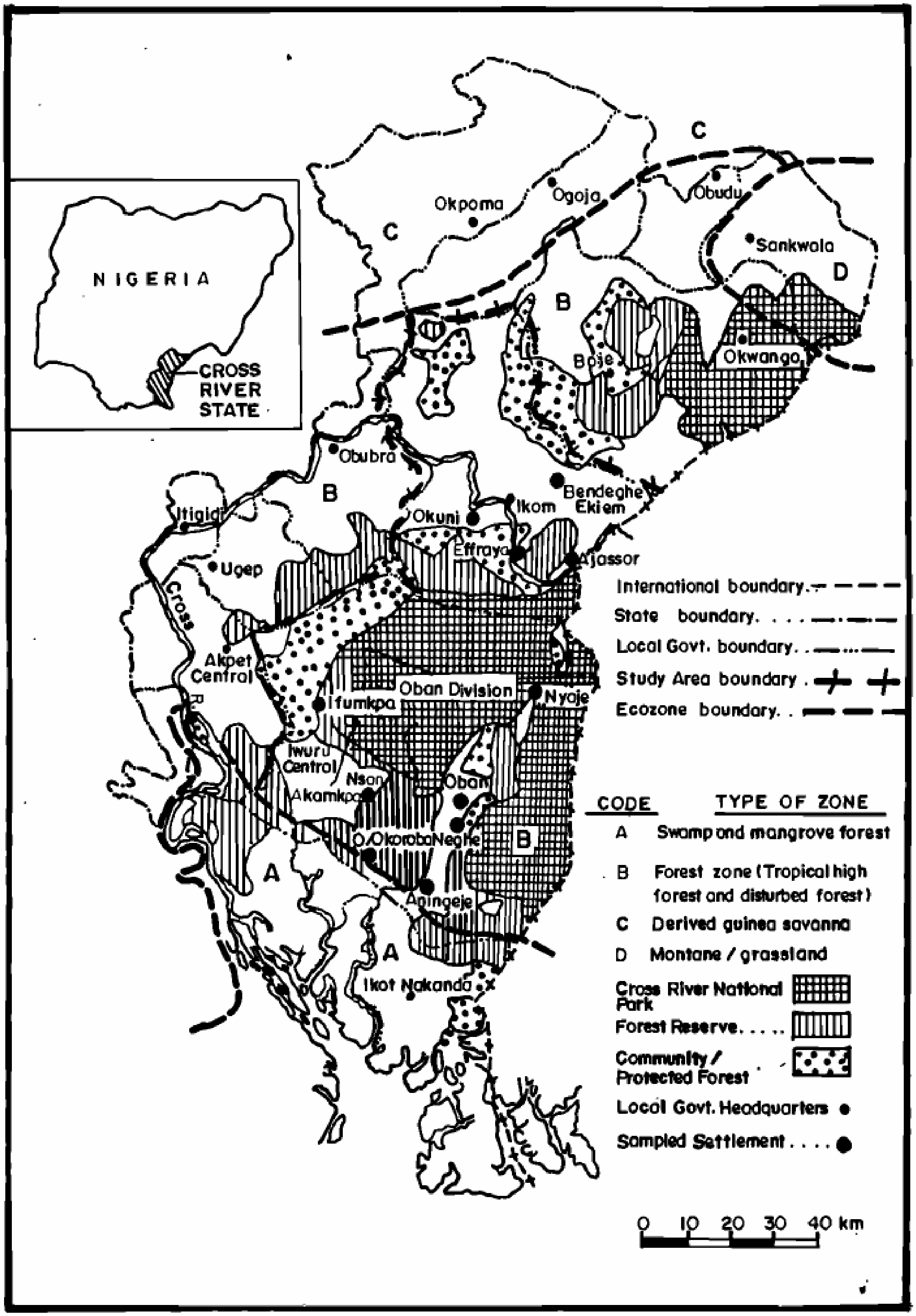

Fig. 1 : CROSS RIVER STATE SHOWING ECOLOGICAL ZONES, FOREST LAND-USE TYPES AND SAMPLED SETTLEMENTS

The Ikom/Etung areas have a much higher density of 61 persons per km^2. Agricultural land in the region is predominantly used for the cultivation of plantain and banana farms, perennial tree crop farms, homestead trees and gardens; and other staples such as cassava, cocoyam, maize, yam, melon, etc. (36, 37). Bush fallow cultivation is clearly dominant as it engages about 84% of the population.

Method

The study employed the use of questionnaire administered to 864 households in twelve (12) sampled settlements. The settlements were purposively selected based on their proximity to the different forest categories, but stratified to reflect the large, medium and low settlements with respect to their population sizes. The number and proportion of sampled households in each of the settlements are shown in Table 1.

The specific data collected were the demographic and socio- economic characteristics of the population, such is, the size of household dependency levels, population size of settlements and agricultural density. Data on land and forest use characteristics were also collected such as cropping and fallow patterns, average number and size of farm plot average size and frequency of forest clearings, and levels of floral and annual species extinction. With the use of aerial photographs, the size of deforested areas around each settlement was estimated. The multiple regression analysis was used to model the impact of demographic variables on deforestation indicators arising from agricultural causes.

Results and Discussion

An attempt is made quantify the effects of some selected macro demographic factors (for aggregate village level data) like average household size, dependency ratio, population size and farm space density on indices of deforestation such as crop area, crop/fallow area, total deforested area, flora and fauna species extinction etc. It is aimed at identifying the critical macro demographic variables responsible for deforestation and the extent and magnitude of their impact. In Table 2 is data used for the analysis.

Table 1: Sampled Settlement And Attributes Of The Study Area

S/n	***Settlements***	***Population size 1993***	***Estimated Number of Households***	***Number of Sampled Households***	***Percentage of Sampled Households to total number Estimated Households***	***Locational Characteristics Of Settlements by Forest Category***
1	*Bendeghe Ekiem (BE)*	*8278*	*1067*	*150*	*14*	*Community Forest*
2	*Effraya (EF)*	*1387*	*133*	*50*	*37*	*Forest Reserve (Cross River North)*
3	*Okuni (OK)*	*5418*	*584*	*99*	*17*	*Distant Forest Reserve (Cross River South/Community Forest*
4	*Ajassor (AJ)*	*5556*	*410*	*100*	*24*	*Forest Reserve (Cross River North/community Forest*
5	*Nsan (NS)*	*2365*	*211*	*50*	*24*	*Forest Reserve /National Park*

6	*Oban Okoroba (OO)*	*378*	*21*	*18*	*86*	*Enclave in Forest Reserve (Oban west)*
7	*Iwuru (IW)*	*1417*	*151*	*47*	*31*	*Community Forest*
8	*Ifumkpa (IF)*	*671*	*70*	*50*	*71*	*Large Community Forest/National Park/Forest Reserve*
9	*Oban (OB)*	*3474*	*357*	*78*	*22*	*Community Forest/ National Park/ Forest Reserve*
10	*Neghe (NJ)*	*590*	*70*	*38*	*54*	*Community Forest/ National park*
11	*Nyaje (NJ)*	*1750*	*243*	*63*	*26*	*Community Forest/National Park*
12	*Anningeje (AN)*	*6710*	*902*	*121*	*11*	*Forest reserve/ Small community forest*
13	*Total*	*37994*	*4038*	*864*	*21*	

The regression model is given by the equation:

$$\mathbf{y = d_0 + a_1x_1 = a_2\, x_2 + a_3\, x_3 + an_4\, xn_4 + a_n\, x_n + e}$$

Where: $\mathbf{y}$ = the dependent variable

$\mathbf{x_i}$ = the i^{th} independent variable, i = 1, 2, 3, … , n

$\mathbf{a_i}$ = the regression parameter (coefficient) associated with the variable **i**,
e = the stochastic error term with the usual properties.

Table 2 Selected Demographic Variables and Deforestation in the Cross River Rainforest

Settlement	Row	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16
IKOM CHARGE																	
Bendeghe Ekiem (BE)	1	7.76	31.85	51.85	8278	147.69	26.09	56.05	56.30	0.0068	16	16	9.40	27.72	7.016	3.15	56.30
Efraya (EF)	2	10.44	51.61	91.84	1387	31.37	19.17	44.21	54.18	0.0390	10	13	7.22	18.04	5.830	1.56	46.06
Okuni (OK)	3	9.28	56.88	122.00	5418	88.92	33.45	60.93	61.15	0.0110	8	8	7.74	30.56	5.830	3.19	60.93
Ajassor (AJ)	4	13.55	62.25	107.46	5556	189.04	10.73	29.39	32.79	0.0059	9	9	8.64	68.07	8.740	3.08	29.80
AKAMKPA CHARGE																	
Nsan (NS)	5	11.22	68.75	120.41	2365	70.51	24.61	33.54	69.15	0.0290	5	10	3.70	6.86	5.250	0.44	33.57
Oban Okoroba (OO)	6	9.00	67.77	122.00	378	204.32	0.38	1.85	2.18	0.0058	1	8	6.28	13.17	4.060	0.44	2.18
Iwuru (IW)	7	9.10	90.78	154.00	1417	30.42	26.38	46.58	46.58	0.0330	6	13	7.30	22.57	6.030	3.67	46.30
Ifumkpa (IF)	8	9.52	104.63	196.44	671	58.81	2.28	11.41	11.46	0.0170	5	8	3.08	8.10	3.640	4.15	11.46
OBAN CHARGE																	
Oban (OB)	9	9.73	64.44	120.00	3474	65.33	47.37	53.18	13.86	0.0220	12	31	7.71	27.21	3.560	1.79	53.77
Neghe (NE)	10	8.45	77.77	137.00	590	62.83	4.45	9.39	9.67	0.0160	24	24	4.89	10.13	3.710	1.68	9.67
Nyaje (NJ)	11	7.21	64.18	105.57	1750	184.41	3.79	9.24	9.58	0.0055	8	19	12.63	24.63	4.700	3.79	9.47
Aningeje (AN)	12	7.44	88.24	179.91	6710	197.75	32.75	37.33	55.95	0.0083	16	34	7.02	11.90	8.640	2.61	40.00

SOURCE: Author's Field Data, 1994

The variables reflected on the table are defined as follows:

C1 = Average Household size
C2 = Dependency ration (0-14yrs) + 65 yrs
C3 = Dependency ration (0-19yrs) + 65 yrs
C4 = Population size
C5 = Farm space density
C6 = Cropping area (sq km)
C7 = Crop/fallow area (sq km)
C8 = Total deforested area (sq km)
C9 = Deforestation ratio
C10=Animal species extinction
C11=Flora species extinction
C12 =Average no. Of plots per person
C13 =Average plot size per person
C14 =Average size of recorded clearing
C15 =Average frequency of forest clearing
C16 =Deforested area net of government plantations.

The independent variables used in the regression analysis are average household size (C1), dependency ration 1-14 yrs. (C2), dependency ration 0-19yrs (03), population size (C4), farm space density (C5). The dependent variables are C6 to Cl6 as defined above. In the actual regression runs, C2 and C3 were found to be highly collinear. They returned a correlation coefficient of 0.967. This suggests that both cannot be used as independent variables in the same egression equation due to the factor of multi-collinearity. The actual regression analysis thus employs only four independent variables (C1, C2, C4 and C5) against eleven dependent variables (C6 to C16). The regression results are presented in Table 3. In the regression between crop area (C6) on four independent variables C1, C2, C3, C4 and C5 three of the variables C2 (dependency ration), C4 (population size) and C5 (farm space density) were statistically significant with very low P-values. The P-values are reported in brackets below the parameter estimates they correspond. Population size (C4) for instance has a P-value of 0.031 which implies that population size is statistically significant at 3.1 percent level.

The four variables C1, C2, C4 and C5 together accounted for about 59 percent of the total variation in C6 (crop area). In the case of the dependent variable C7 (crop/fallow area), the size of household (C1) and the dependency ratio (C2) were not statistically significant in explaining its total variation; whereas C4 (population size) and C5 (farm space density) were statistically significant in explaining the variation in C7. The four variables taken together accounted for 84 percent of total variation in C7. With respect to C8 (total deforested area) and C16 (deforested area net government plantations), only two variables C4 (population size) and C5 (farm space density) were found to be statistically significant in explaining changes in deforestation as reflected in variables C8 and C16. The four variable (C1, C2, C4, and C5) jointly accounts for 68 percent of total variation in C8 and 73 percent of variation in C16.

Table 3 Multiple regressional analysis of macro-demographic factors and deforestation

The Regressional Equation: Cj= Aj + A1*C1 + A2*C2 + A3*C4 + A4*C5 (j = 6, 7,… 16)						
Row	**C1**	**C2**	**C4**	**C5**	**R2**	**Crit**
C6	-0.599	0.029	0.004	-0.131	59	C2, C4, C5
	(0.785)	(0.031)	(0.031)	(0.063)		
C7	0.100	-0.176	0.006	-0.211	84	C4, C5
	(0.959)	(0.369)	(0.01)	(0.004)		
C8	1.65	-0.133	0.007	-0.24	68	C4, C5
	(0.62)	(0.74)	(0.02)	(0.032)		
C9	0.0009	-0.00004	-0.0000006	-0.00013	76	C5
	(0.48)	(0.76)	(0.576)	(0.032)		
C10	-1.286	-0.008	0.0010	-0.03	28	None
	(0.303)	(0.946)	(.318)	(0.43)		
C11	-2.400	-0.115	0.0013	-0.0107	33	None
	(0.186)	(0.513)	(0.356)	(0.824)		
C12	-0.350	-0.064	-0.00001	-0.013	47	None
	(0.428)	(0.174)	(0.972)	(0.295)		
C13	5.75	-0.133	0.0019	0.067	43	C1
	(0.034)	(0.57	(0.309)	(0.312)		
C14	0.316	0.020	0.0005	0.006	51	C4
	(0.196)	(0.406)	(0.02)	(0.388)		
C15	-0.137	0.012	-0.000005	0.0064	0	None
	(0.530)	(0.570	(0.970)	(0.315)		
C16	0.08	0.19	0.006	-0.213	73	C4, C5
	(0.907)	(0.35)	(0.003	(0.005)		

Notes: The values in brackets are the P-values

For variable C9 (deforestation ratio) which expresses the ratio of total deforestation area to the population size of settlements, only one of the four independent variable (C5) was statistically significant in explaining it at 3.2 percent level. All the four independent variables however jointly accounted for 76 percent of the total variation in C9 (deforestation ratio). None of the four independent variable (C1, C2, C4, C5) were statistically significant in explaining the variations in variable C10 (Animal Species extinction), C11 (floral species extinction), C12 (average no. of farm plots per person) and C5 (average frequency score of forest clearing). Although the joint contribution of all variables accounted for 28%, 32% and 47% respectively in explaining variations in C10, C11 and 012.

Average size of household (C1) was interestingly found to be the only variable among the four independent variable as that was statistically significant in explaining the variations in C13 (the average plot size per person). The interesting aspect of the result is that household size had hitherto never showed up as being statistically relevant in explaining the variations in any of the dependent variables but only significant in relation to the size of farm plots. The result confirms earlier analysis of micro- demographic variables when household size was statistically significant in explaining the variations in forest resource use variable particularly that of size of farm plot (38). At the macro level analysis, it has shown up again as a critical factor (the only critical factor) in explaining variations in average size of farm plots per person (C13). It is critical at a 3.4 percent level i.e. about 97% confidence level and accounts for 43% of the total variation in average plot size per person. With respect to the average size of recorded clearing for survey area (C14), only population size (C4) among the four independent variables were critical in explaining its variation at 2 percent level. The combined impact of the four variables jointly accounts for 51 percent of the total variation in C14. Given the fact that multiple regression deals with the joint contribution of the independent variables on the dependent variable, it was average size of household (C1) was interestingly found to be the only variable among the four independent variables that was statistically significant in explaining the variations in C13, the average plot size per person).

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Given the fact that multiple regression deals with the joint contribution of the independent variables on the dependent variable, it was thought necessary to investigate further the contributions of each of the important independent variables on the various deforestation indices. The results are reported in Table 4. A profile of the result indicates that the dominant factor in deforestation is population size. It was statistically significant at whatever index of deforestation used. This was closely followed by farm space density. Both factors together accounted for 77.6% of the variation in deforestation indices such as the expansion of crop/fallow area, 48.6% variation in crop area, 58.5% variation in total deforested area, 67.1% variation in deforestation ratio and 48% of variation in the average size of clearing. They are all statistically significant in explaining the above stated variations at over 95% confidence level or less than 5% level of significance.

Table 4 Regressional Analysis Of Macro-Demographic Factors And Deforestation (Parameter Estimates Of The Regression Equation)

Regression Model: Cj = A1 + A2*C2 + A3*C3 + A4*C4 (j = 6, 7, …… 16)						
	C2	**C3**	**C4**	**C5**	**R^2**	**Critical Factors**
C6	0.034 (0.871)		0.0045 (0.021)	-0.129 (0.05)	42.4	C4, C5
C6		0.033 (0.733)	0.0045 (0.015)	0.129 (0.047)	43.1	C4, C5
C6	-0.177 (0.47)				0.0	
C6			0.003 (0.068)		22.4	C4
C6				-0.058 (0.105)	0.0	
C6			0.0044 (0.009)	-0.128 (0.36)	48.6	
C6	0.0334 (0.895)		0.0032 (0.112)		13.9	
C7			0.007 (0.00)	-0.211 (0.00)	77.6	C4, C5
C7			0.0049 (0.026)		34.6	C4
C7				-0.093 (0.38)	1.6	
C8			0.0052 (0.065)	-0.122 (0.013)	231.4	C4
C8			0.0079 (0.004)	-0.249 (0.13)	58.5	C4, C5
C9				-0.0015 (0.0)	69.5	C5
C9			-0.0009 (0.164)	-0.0014 (0.002)	10.3	
C9			-0.0 (0.618)	-0.0014 (0.002)	67.1	C4, C5
C9			-0.0	-0.0014 (0.002)	67.1	C5
C16			0.0049 (0.028)		33.7	C4
C16			-0.099 (0.301)	-0.099 (0.301)	1.7	
C13	$5.211C_1$ (0.062)				23.8	C1
C14			0.005 (0.006)		50.9	C4
C14			0.00046 (0.019)	0.0042 (0.525)	48.0	C4, C5
C16			0.000489 (0.028)		39.7	C4

Population size alone explains 23% of the total variation in deforested area, 33.7% of variation in deforested area net government plantations, 22% of variation in crop area, 35% for crop/fallow area variations and 51% of variation in average area of recorded clearing for survey year. The above relationships are shown in Figures 2.to 2.4 representing the scatter plot with their respective lines up best fit.

No other demographic variable singularly recorded such feats among the macro-demographic factors in explaining the pattern of deforestation. The size of household is however critical in explaining the pattern of resource use where the natural resource use variable in question is the average size of farm plots per person. It explained 28% of the total variation in average per person plots size.

This relationship is visually represented in Figure 2.5. Farm space density expressed as the number of persons per unit of agricultural land is the next most critical variable to population size in explaining the deforestation phenomena. This variable however has no statistically significant effect on deforestation when acting alone. It yielded a rather insignificant level of explanation (1.4%) with respect to the total variation in deforestation. Population size when acting alone exerts a positive impact on deforestation and accounts for 25% of total variation in deforestation area as earlier observed. Its impact on deforestation increases in concert with farm space density. We may therefore conclude that population size reinforces the effect of farm space density on deforestation and vice versa. They together account for 58.5% of total variation in deforestation area. The same pattern can be observed on the impact of population size and Farm space density on such indices of deforestation like crop area (C6) and crop/fallow area (C7). For instance the joint action of population size and farm space density account for 77.6% of total variation in the crop/fallow area (C7). Acting independently of each other, population size and farm space density accounted for 34.6% and 168% respectively of the total variation in the Crop/fallow area.

Summary and Conclusion

Population size and density are the most critical of the demographic variables at aggregate village level data that impacts positively on the various indices of deforestation. Farm space density however, had no significant statistical impact on most indices of deforestation except in conjunction with the population size of the settlements. The size of household was found to be critical only in explaining variation in the average size of farm plots, but yielded no such significance in explaining the variation in deforestation indicators. The above in a measure validates the research hypothesis that deforestation and forest resource use pattern; of communities in the Cross River State Rainforest, South-eastern Nigeria, is related to the micro and macro level demographic factory such as the size of households, the population size of settlements, firm space or agricultural density, and the dependency burden of the rural households. The magnitudes of their effects are however low due to the very poor elastic ties between population and deforestation variables.

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