Effects of changes in population, household conditions and farming systems on agricultural land use in the Volta river basin of Ghana, 1984-2000.

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Abstract

The Volta River basin in Ghana, which covers about 160,000 square kilometres, is one of the most economically deprived areas in West Africa. Rain-fed and some irrigated agriculture is the main economic activity of the majority of the population living in this region. Rapid population growth and low economic standards of living have brought in their wake a lot of consequences for agricultural land resources in this region (Benneh and Agyepong, 1990). As a result of rapid population growth, conflicts over land have been rife, assuming various dimensions from minor conflicts between individuals and families to large scale ones between ethnic groups (GSS, 1995).

Furthermore, increase in technological capacity particularly for farming, and affluence, in terms of improvement in general household conditions, have put more pressure on agricultural land resources. This study hypothesises that, population growth, general improvement in household conditions and improved inputs for farming has increased agricultural land utilisation in the study areas between 1984 and 2000. It incorporates concepts from the multiplicative (Ehrlich and Holdren, 1971 and 1974; Harrison, 1992; Commoner, 1991 and 1992) and mediating perspectives (Blaikie and Brookfield, 1987; Bilsborrow, 1987, 1992a and 1992b) to have a holistic understanding of the population and environment nexus.

Materials and Methods

The study used information from a longitudinal household survey undertaken between November 2001 and February 2002 among 252 households each in the Kassena-Nankana and Ejura-Sekyedumase districts. A multiple regression model used in the study is stated below and Table 1 gives the description of the variables and methods of aggregation.

$$CA_{ij} = \alpha + ß_1E_{ij} + ß_2MF_{ij} + ß_3EL_{ij} + ß_4OF_{ij} + ß_5ON_{ij} + ß_6F_{ij} + \ldots + ß_nP_{ij}$$

Table 1: Description of Variables and Aggregation method used in the Model

Abbrev.	Description	Aggregation Method
CA	Total cropped area by household (in acres) – Dependent Variable	Mean
E	Educational level of household	Mean
MF	Proportion of major farmers in household	Mean
EL	Presence or otherwise of electricity in household	Mode
OF	Household income from off-farm activities	Mean
ON	Household income from farm activities	Mean
F	Household expenditure on food	Mean
A	Household affluence (measured by ownership of Car, Motorcycle, Bicycle, TV & Radio)	Mean
AL	Household affluence (measured by ownership of livestock)	Mean
LT	Land Tenure system in households	Mode
T	Proportion of household members who use tractor on their farms	Mean
I	Proportion of household members who use Inorganic fertiliser on their farms	Mean
S	Proportion of household members who use Improved seed variety on their farms	Mean
LF	Number of years allowed for land to fallow in household	Mean
D	Household distance travelled to furthest farm	Mean
EX	Recent extended farm lands (in acres) (Extensification)	Mean
HS	Household size	Mean
P	Population of locality	Absolute
i	Locality	
j	Years (1984 & 2000)	

Study Area

The Kassena-Nankana district in the Upper East region with a population of 149,491 in 2000 (GSS, 2002) and the Ejura-Sekyedumase district with a population of 81,115 in the Ashanti region of Ghana, are the two study areas used. The Kassena-Nankana district is 84% rural and the Ejura-Sekyedumase district is 51% rural. Figure 1 is a district map of Ghana, showing the locations of the two study districts. The Kassena-Nankana district lies within the geographical area of Ghana, which experiences the single maximum rainfall regime. This implies that, areas within this rainfall regime, experiences only one rainy season from about May to August, when the sun is overhead, or almost so at the Tropic of Cancer in the northern hemisphere, followed by a long dry season. The

district experiences a mean annual rainfall of 115 centimetres (Dickson and Benneh 1995).

The Ejura-Sekyedumase district, however, experiences a double maximum rainfall regime, where there are two rainy or wet seasons. The two rainfall regimes occur from May to August and from September to October, with a mean annual rainfall of 143 centimetres. The differences in the rainfall regimes have implications for agricultural production in the two study areas.

With regards to vegetation, the Kassena-Nankana district belongs to the mid dry savannah vegetation type in Ghana. The district is characterised by few and scattered trees such as the baobab, the dawa-dawa, acacias and the shea tree, which have adapted to the environment found in the district. Grasses grow in tussocks and can reach a height of 3 metres or even more. Marked changes in the plant life of the district are experienced during different seasons of the year. During the rainy season, the vegetation in the district is very green. Trees blossom and grasses shoot up very quickly. However, immediately the rains recede, leaves begin to change colour from green to yellow and trees begin to shed their leaves. It must be mentioned that, regular burning, the grazing of livestock and cultivation have left only few trees still standing and rendered the vegetation to be open and dominated by short grasses.

The vegetation in the Ejura-Sekyedumase district can be described as wet savannah and it is composed of short branching trees, many less than 15 metres high, which do not usually form a closed canopy and are often widely scattered. The ground flora consists of apparently continuous layers of grass, some species of which reach a height of about 4 metres.

With regards to soils, Lixisols are found in both the Kassena-Nankana and Ejura-Sekyedumase district. In the Ejura-Sekyedumase district, the normal profile consists of about 30 cm of dark brown to brown, fine sandy loam overlying, from 30-152 cm, reddish brown to reddish yellow, fine sandy loam to fine sandy clay loam. They are moderately well supplied with organic matter and nutrients. Moisture holding capacity is moderately good and are easily tilled by machines and by hand. They are mainly utilised for the production of yams, maize, cassava, groundnut, beans, tobacco, cotton and vegetables but are however, subject to moderate erosion (Adu and Mensah-Ansah 1995).

The Ejura-Sekyedumase district is also made up of patches of Plinthosols. It has humus fine sandy loam topsoil approximately 12 cm or less in thickness, over brown to light yellowish brown fine sandy loam containing abundant ironstone concretions and large boulders or iron pan. They are poorly drained and medium to light textured and subject to seasonal water logging or flooding for varying periods, but generally become thoroughly dry during dry seasons. The Kassena-Nankana district also has patches of Leptosols, which consists of about 10 cm of brown slightly humus sandy loam topsoil overlying hard massive rock. Frequently, ferruginized rock brash and fragments of stones are incorporated in the topsoil. It has little agricultural value.

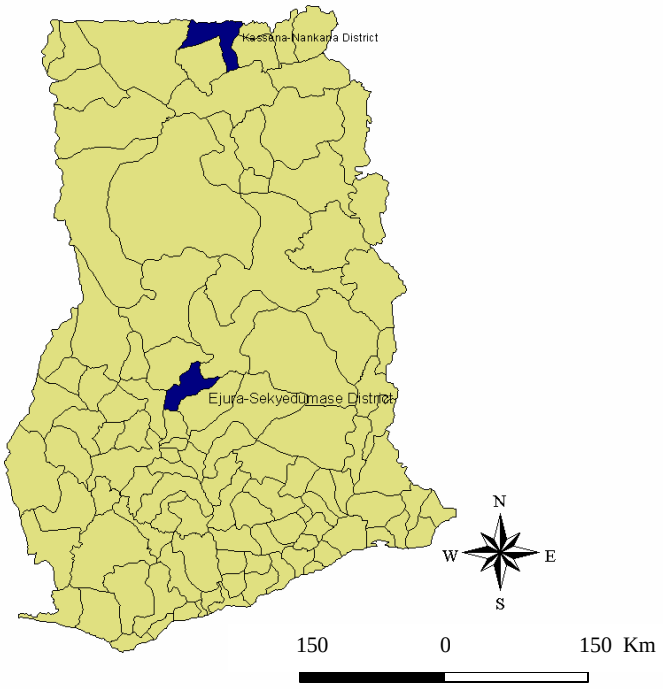

Figure 1: District Map of Ghana Showing Study Districts

Results and Discussions

General Household Conditions

General household conditions were measured by educational and occupational level of households, availability of electricity as a source of energy and expenditure on food. Table 2 shows that, 44.2% and 34.6% of the respondents in the Kassena-Nankana and Ejura-Sekyedumase districts respectively have had no formal education. Also,

majority of the population (71.9% and 69.9% in the Kassena-Nankana district, and 69.9% and 72.1% in the Ejura-Sekyedumase district for 1984 and 2000 respectively) in both district have farming as their major occupation.

Table 2: Percentage distribution of respondents by general household conditions and study area, 1984 & 2000.

General conditions	Kassena-Nankana		Ejura-Sekyedumase	
	1984	2000	1984	2000
No schooling	-	44.2	-	34.6
Major Farmers	71.9	72.7	69.9	72.1
Availability of electricity	3.0	9.9	1.0	60.3
No expenditure on food	-	4.0	-	2.8

Source: Field Survey, 2001 & 2002.

As far as electricity is concerned, only one out of ten houses in the Kassena-Nankana district had electricity in 2000, a marked difference from what pertains in the Ejura-Sekyedumase district, where six out of ten houses had electricity installed. It can be seen from the two columns that only few households in both districts did not spend money on food.

Affluence

Monthly household off-farm income, defined as income from non-farm activities earned by households, income from sale of farm produce and ownership of certain household items and livestock has been used as proxies to measure household affluence (see Table 3).

Table 3: Percentage distribution of household by affluence and study area, 1984 & 2000.

Affluence	Kassena-Nankana		Ejura-Sekyedumase	
	1984	**2000**	**1984**	**2000**
Farm income	-	48.8	-	97.6
Off-farm income	-	56.0	-	50.2
Items				
Bicycle	30.7	32.5	17.9	19.0
Car	0.6	0.5	0.7	1.1
Motorcycle	2.8	2.9	0.5	0.4
Radio	26.0	27.3	26.8	27.7
Television	2.4	3.2	8.7	9.1
Livestock				
Cattle	53.0	50.0	4.0	7.0
Sheep	56.0	52.0	18.0	20.0
Goat	67.0	75.0	25.0	31.0

Source: Field Survey, 2001 & 2002.

It can be observed from Table 3 that there is not much disparity between monthly off-farm incomes in the two districts, however, the analysis shows that, 44% and 49.8% of the households in the Kassena-Nankana and Ejura-Sekyedumase districts respectively, have members who engage only in farming and thus, have no income from non-farm activities.

Furthermore, the two study areas do not differ much as far as ownership of household items is concerned. With regards to livestock ownership, a contrasting picture was revealed. While ownership of Cattle, Sheep and Goat was very high in the Kassena-Nankana district, the situation was different in the Ejura-Sekyedumase district. Also, while ownership of Cattle and Sheep decreased between 1984 and 2000 in the Kassena-Nankana district, ownership of goats increased. However, as far as the Ejura-Sekyedumase district is concerned, there were increases in ownership of all categories of livestock between the period.

Farming Systems, Practices and Inputs

The type of farming system used, be it slash and burn, shifting cultivation, crop rotation, land fallow etc, the inputs, whether they are tractors, improved seed varieties, inorganic fertilisers, the types of land tenure, be it customary/communal, tenancy, family

or individual ownership may all play a role in affecting agricultural land use in any community. It can be seen in Table 4 below, that 11% of the farmers in the Kassena-Nankana district are tenant farmers while twice that number (22%) are tenants in the Ejura-Sekyedumase district. The Ejura-Sekyedumase district has more tenant farmers because of its status as a migrant area.

Table 4: Percentage distribution of respondents by faming practices, implements used and study area, 1984 and 2000.

Farming	Kassena-Nankana		Ejura-Sekyedumase	
	1984	2000	1984	2000
Tractor	10.3	19.8	58.1	77.4
Inorganic fertiliser	21.4	31.5	58.4	87.3
Improved seed variety	4.1	12.5	21.1	57.9
Practice of Land fallow	25.5	23.0	43.2	41.3
Mean fallow years	2.5	2.3	3.4	2.7
Land tenure (tenancy)	-	11.0	-	22.0
Extensification	-	10.0	-	52.0
Distance to farms (10kms+)	-	6.0	-	9.3

Source: Field Survey, 2001 & 2002.

According to Table 4, the use of all three farm inputs was much higher for both 1984 and 2000 for the Ejura-Sekyedumase district when compared to that of the Kassena-Nankana district. Secondly, in each district, the use of the three inputs was higher in 2000 when compared to 1984. Secondly, in both study areas, the percentage of farmers who practice land fallow has decreased slightly between 1984 and 2000 that is from 25.5% to 23% in the Kassena-Nankana district and from 43.2% to 41.3% in the Ejura-Sekyedumase district. Even more, average fallow years allowed in both districts have decreased between 1984 and 2000. A sizeable number of farmers in both districts travel a distance of 10 kilometres or more to their furthest farms and finally, while 52% of the farmers in the Ejura-Sekyedumase district have cultivated new lands within the last five years, only 10% of their counterparts in the Kassena-Nankana district have done that.

Fertility, Mortality and Migration

Comparing the demographic indicators in the two study districts, it could be seen that average annual per cent growth rate in births was higher in the Ejura-Sekyedumase district than the Kassena-Nankana district. However, there were more deaths in the

Kassena-Nankana district, when compared to the Ejura-Sekyedumase district. Furthermore, there was more out-migration from the Kassena-Nankana district when compared to the Ejura-Sekyedumase district and probably as a result of that, there was more in-migration to the Ejura-Sekyedumase district than the Kassena-Nankana district within the period 1997-2001.

Table 5: Average annual per cent growth rate of selected demographic indicators in households by study area, 1997-2001

Indicator	Kassena-Nankana	Ejura-Sekyedumase
Births	4.0	6.2
Deaths	1.2	0.8
Out-migration	3.0	2.4
In-migration	0.8	1.2

Source: Field Survey, 2001 & 2002.

Household Size

Household size is the other demographic variable used in this study. It can be seen in Table 6 below that household size varies a lot in the two study areas. While the Kassena-Nankana district had about 4.2% of the households being single member households in 1984, only 0.5% of the households in the Ejura-Sekyedumase district had single member households. The situation however, changed considerably for both districts in 2000, with none of the households having single membership.

Table 6: Percentage distribution of household size by study area, 1984 & 2000.

Household size	Kassena-Nankana		Ejura-Sekyedumase	
	1984	2000	1984	2000
1	4.2	-	0.5	-
2	12.6	4.8	20.6	2.4
3	28.9	5.6	18.4	2.8
4	13.2	15.5	12.6	6.7
5-9	37.9	58.2	42.1	63.9
10-14	3.2	11.9	4.2	17.8
15-19	-	4.0	0.5	3.6
20 & above	-	-	1.1	2.8

Source: Field Survey, 2001 & 2002.

The other interesting issue to mention is the fact that, on the whole, the Ejura-Sekyedumase district has bigger household sizes when compared to the Kassena-Nankana district.

Multivariate Analysis and Explanations of the Observed Cropped Area Patterns

The multivariate analysis has been presented in three stages: First, there is a spatial analysis for both years and both districts. The second stage considered a spatio-temporal analysis of the areas and the final stage looks at the aggregate of the study areas and years of study.

First Stage of the Multivariate Analysis

A lot of interesting findings emerge from the results of the first stage of the multivariate analysis, which has been presented in Table 7. Of much interest is the spatial difference with regards to the relationship between the independent variables and the dependent variable.

Table 7: Results of Stepwise Multiple Regression showing significant predictors of Cropped Area by Districts and Years.

Variables	Unstandardised Coefficients		t
	Beta (ß)	Standard Error	
Kassena-Nankana, 1984			
Constant	-4.12	2.79	-1.48
Fallow	6.29	0.89	7.11
Major Farmers	0.08	0.04	2.35
R = 0.92	R^2 = 0.85	Adjusted R^2 = 0.82	
Ejura-Sekyedumase, 1984			
Constant	7.29	1.12	6.52
Population	0.01	0.01	5.04
R = 0.89	R^2 = 0.78	Adjusted R^2 = 0.75	
Kassena-Nankana, 2000			
Constant	-3.19	1.27	-2.51
Furthest Farm	2.19	0.33	6.57
Off-farm income	-0.01	0.01	-5.12
Extensification	29.61	8.80	3.37
R = 0.95	R^2 = 0.90	Adjusted R^2 = 0.85	
Ejura-Sekyedumase, 2000			
Constant	11.18	0.98	11.46
Population	0.01	0.01	6.66
R = 0.93	R^2 = 0.86	Adjusted R^2 = 0.84	

It could be observed that years allowed for land to fallow and proportion of major farmers were significant predictors of cropped area in the Kassena-Nankana district in 1984. The situation however changed in 2000, since land fallow ceased to be a significant predictor of cropped area in the Kassena-Nankana district. The analysis shows that any additional major farmer in the Kassena-Nankana district in 1984, increased total cropped area by 0.1 of an acre. Furthermore, as far as the Ejura-Sekyedumase district is concerned, a demographic indicator, that is, population of the locality was a significant predictor of cropped area in 1984. Any additional person added to the locality resulted in a less than an acre increase in farmland. This could imply that, as far back as 1984, population pressure was being felt on agricultural land use in the Ejura-Sekyedumase district, a scenario that was non-existent in the Kassena-Nankana district.

Finally, it must be mentioned that all the agricultural technological indicators, namely the use of tractor, fertiliser and improved seed variety for farming, were not predictors of agricultural land use in both areas in 1984. This gives a strong indication that innovations on mechanised forms of farming had not significantly spread to any part of the study area in 1984 and simple subsistence forms of organic farming were still being practised.

With regards to 2000, distance to furthest farm, off-farm income, and extensification, were predictors of cropped area in the Kassena-Nankana district while the population of the locality again predicted cropped area in the Ejura-Sekyedumase district. With regards to income from off-farm activities, the analysis shows that extra income earned off-farm is not necessarily invested into farming activities, since the variable has an inverse relationship with farmland. Finally, the agricultural extensification variable included in the model, only affect agricultural land use in the Kassena-Nankana district.

Second Stage of the Multivariate Analysis

The second stage of the multivariate analysis considered the spatio-temporal differences between the dependent and the independent variables. Firstly, the analysis showed that, land tenure arrangement (whether owned or hired), the presence or otherwise of electricity as a source of household energy, affluence (items and livestock

ownership), the use of tractor, inorganic fertiliser and improved seed variety as well as household size did not influence agricultural land use in both districts and in both years.

Secondly, the amount of land left to fallow and the proportion of major farmers in the households were significant predictors of agricultural land use in the Kassena-Nankana district in 1984 while in 2000, the distance travelled to furthest farm, off-farm income and extensification were the predictors of agricultural land use.

Finally, the demographic indicator, that is, population of the locality has been a significant predictor of agricultural land use in the Ejura-Sekyedumase but not for the Kassena-Nankana district in both years. The fact that this variable did not influence agricultural land use at any point in time in the Kassena-Nankana district, gives ample evidence that the area has not, and is not experiencing any population pressure as far as agricultural land use is concerned. This therefore throws more light on the fact that the district since 1984, has, and continues to experience out-migration of mainly the youth to the urbanised as well as the farming and mining communities of the basin. Also, it confirms the status of the Ejura-Sekyedumase district as a migrant-receiving area.

Third Stage of the Multivariate analysis

At the third stage of the multivariate analysis, all the relevant factors were controlled for by combining the two study areas and years. The results are shown in Table 8.

Table 8: Results of Stepwise Multiple Regression showing significant predictors of Cropped Area - All Districts, 1984.

Variable	Unstandardised Coefficients		t
	Beta (ß)	Standard Error	
All Districts, 1984			
Constant	-3.88	1.99	-1.95
Fallow	3.86	0.83	4.66
Household size	1.72	0.48	3.61
R = 0.89	R^2 = 0.80	Adjusted R^2 = 0.78	
All Districts, 2000			
Constant	-9.64	4.14	-2.33
Improved Seed Variety	0.18	0.04	4.30
Household size	1.87	0.60	3.14
R = 0.87	R^2 = 0.76	Adjusted R^2 = 0.73	

It could be observed that unlike the individual years in the respective study areas, some new variables come out as significant predictors of household total cropped area. These include improved seed variety and household size. The importance of household size in the overall model emphasizes the importance of the demographic factor on agricultural land use. Any additional member added to the household in 1984 and 2000, resulted in an increase of almost 2 acres of farmland. Also, with regards to the overall model, between 1984 and 2000, the use of improved seed variety, an agricultural technological variable has become significant and any farmer who used it is estimated to increase his/her farmland by almost 0.2 acres.

Conclusion

This paper has revealed that several variables operate at the household level to influence agricultural land use and the variables used in the regression models to describe the relationship were collectively very good ones, due to the fact that coefficient of determination values for all the models ranged from 0.76 to 0.90. Secondly, these variables do not have the same characteristics for every locality and year. It comes out clearly that time and space differentials, account for whether a variable turns out to be a significant predictor of agricultural land use or not.

The paper also revealed that, as the level of analysis changed from the aggregate level to the specific study areas and years, some of the variables that came out as significant predictors at the aggregate level lost their significance. Finally, it must be mentioned that, part of the unexplained variance in the utilisation of agricultural land observed among the study areas and years, could be attributed to other factors such as physical, natural or environmental which were not considered by this paper.

The hypothesis that population growth was increasing agricultural land utilisation is confirmed in the Ejura-Sekyedumase district but not in the Kassena-Nankana district. However, the other two hypotheses namely, that increase in technological capacity particularly for farming, and affluence, in terms of improvement in general household conditions, have put more pressure on agricultural land resources were both nullified.

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References

Adu SV and Mensah-Ansah JA (1995) Soils of the Afram Basin Ashanti and Eastern Regions, Ghana. Soil Research Institute. CSIR. Memoir No.12. Advent Press.

Benneh G and Agyepong GT (1990) Land Degradation in Ghana. Commonwealth Secretariat/University of Ghana. London. Pps 33-53.

Bilsborrow R (1987) Population pressures and agricultural development in developing countries: a conceptual framework and recent evidence. World Development (Boston, Massachusetts), vol. 15, No. 2, pp. 183-203.

Bilsborrow R (1992a) Population growth, internal migration, and environmental degradation in rural areas of developing countries. European Journal of Population, vol. 8, pp. 125-148.

Bilsborrow R (1992b) Population, development and deforestation: some recent evidence. Paper presented at United Nations Expert Group Meeting on Population, Environment and Development, 20-24 January 1992, New York.

Blaikie P and Brookfield H (eds). (1987) Land Degradation and Society. New York: Metheun and Company, Ltd.

Commoner B (1991) Rapid population growth and environmental stress. In Consequence of Rapid Population Growth in Developing Countries: Proceedings of the United Nations/Institut national d'études démographiques Expert Group Meeting, 23-26 August 1988, New York. United Nations, ed. New York: Taylor and Francis, pp. 161-190.

Commoner B (1992) Population, development and the environment: trends and key issues in the developed countries. Paper presented at United Nations Expert Group Meeting on Population, Environment and Development, 20-24 January 1992, New York.

Ehrlich P and Holdren J (1971) The Impact of Population Growth. Science, vol. 171, pp. 1212-1217.

Dickson KB and Benneh G (1995) A New Geography of Ghana. Longman, Malaysia.

Ehrlich P and Holdren J (1974) Human Population and the Global Environment. American Scientist, vol. 62, pp. 282-292.

Harrison P (1992) The Third Revolution: Environment, Population and a sustainable world. London and New York: I. B Tauris and Company Ltd.

Ghana Statistical Service (1995) Migration Research Study in Ghana. Internal Migration. Volume 1. Twum-Baah KA, Nabila JS and Aryee AF (eds). Social Sector Policy Unit Ministry of Finance and Economic Planning. Commercial Associates Limited, Accra. June.

Ghana Statistical Service (2002) 2000 Population and Housing Census. Summary Report on final Results. March. Medialite Co. Ltd. Accra.