POPULATION DYNAMICS AND NATURAL RESOURCES IN THE VOLTA RIVER BASIN OF GHANA

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ABSTRACT

The Volta River basin, which covers about 400,000 km^2 is one of the most economically deprived areas in Africa (average annual income is estimated at US$ 800 per year) although precious mineral resources (gold, diamond, manganese, bauxite etc.) abound. Rain-fed and some irrigated agriculture is the main economic activity of the majority of the population living in this region. High population growth rate has brought in its wake a lot of consequences for agricultural land, water and forest resources. This paper, which concentrates on the Volta River Basin in Ghana examines the trend and pattern of population growth and distribution within the various sub-basins from 1960 to 2010. The main sources of data for determining the variables used, i.e , population size, population density, settlement and urbanization, of the sub-basins, and their subsequent projection are derived from the Population Census Reports of Ghana, for 1960, 1970, 1984 and 2000. The study also examines the effect of population growth on three key natural resources (agricultural land, water and forest resources). Results show that there were increases in population, settlements and the level of urbanization in all the sub-basins of the Volta River in Ghana between 1960 and 2000. Projections also show that these increases will continue in the future. Also, population growth is causing shortfalls in agricultural land, deforestation and high demand on water resources in some of the sub-basins of the Volta River.

KEYWORDS: Population, Natural Resources, Volta River Basin, Human Settlement, Land Use/Coverage Change

INTRODUCTION

The Volta River basin, covers about 400,000 km^2 and includes six West African countries namely, Ghana, Burkina Faso, Togo, La Cote d'Ivoire, Benin, and Mali. It is one of the most economically deprived areas in Africa (average annual income is estimated at US$ 800 per year) although precious mineral resources (gold, diamond, manganese, bauxite etc.) abound. Rain-fed and some irrigated agriculture is the main economic activity of the majority of the population living in this region. Population growth rate is high (about 3% per annum) and this has brought in its wake, increasing pressure on agricultural land, forest and water resources.

It has been argued that as population increases, so is the need for land, to expand settlement infrastructure and other utilities (Benneh and Agyepong, 1990). This paper focuses on the Volta River Basin in Ghana, an area that has come under intensive studies in recent times, due to changing land use, rainfall reliability, and water demands (Braimoh, 2004; Duadze, 2004; Codjoe, 2004; Agyare, 2004; Codjoe, 2005).

The paper examines the trend and pattern of population growth and distribution within the various sub-basins of the Volta River from 1960 to 2010. This is due to the fact that human activities are the major drivers behind land use/cover change, demands for water and other natural resources. An understanding of the past, current and future dynamics of the population in the basin, would greatly enhance the management of natural resources, which will subsequently lead to sustainable development. Variables that are considered include the absolute population, population density, settlement and urbanization. Finally, the study also examines the effect of population growth on agricultural land, water and forest resources, using studies already conducted by the author and other researchers.

POPULATION-NATURAL RESOURCE NEXUS: CONCEPTS AND THEORIES

Concept and theories of the population-natural resource nexus are generally divided into linear and non-linear views. The linear views assume linearity between population and natural resource use as found in the Malthusian and Boserupian views.

The Malthusian view analyses population growth as a threat to the inherent limit of arable land to provide food, shelter and sustenance. It argues that food production could only grow at an arithmetic rate compared to population that grows geometrically. Thus, population growth would ultimately outstrip the capability of any economy to meet the demand for food, owing to the ecological constraints imposed by natural resources. It perceives that if preventive measures or checks are not put in place, poverty, disease, famine and war, which are social checks, would automatically place a check on population growth (Malthus, 1960; Ehrlich and Ehrlich, 1977; Gilbert, 1999). It suggests that population demands thus place direct limits on the availability of resources and that resources, in turn, place a direct restriction on population growth. The Malthusian theory, formulated before the agricultural revolution, presumes that the productivity of environmental resources such as land is fixed.

Writing after the agricultural and industrial revolutions, Boserup (1965 and 1981) takes this technological change into account. She suggests that increasing population pressure mostly leads to an increase in land use intensity. Thus, every population through technological innovations adapts itself to the best fitting land use system according to population density. In her view, so long as an area has low population density, there will be room for long fallow periods, and required outputs for agriculture can be obtained without the investment of additional capital. However, in highly

populated areas, there will be the need to sustain a large growing population, and this will culminate in the adoption of more intensive farming methods, which will require additional labour input per unit area. On the whole, even though this scenario will bring about a diminishing return on the labour and capital that has been invested, on the other side of the coin, it will bring about an increase in the total agricultural output.

The non-linear views are the multiplicative, mediating, development dependence and complex system perspectives. The multiplicative view states that population interacts in multiplicative ways with other factors, such as levels of consumption and technology, to have an impact on the environment. One of the most frequently used multiplier approaches is the "IPAT" equation. In the "IPAT" equation, total environmental impacts (I) are seen as a product of population size (P), the level of affluence or per capita consumption (A), and the level of technology (T). The "IPAT" equation implies that although population, consumption or technology might be considered as independent causes of environmental impact, it is their combined effect that is of most interest (Ehrlich and Holdren, 1974; Harrison, 1992 & Commoner, 1992).

The mediating perspective emphasizes that social, cultural and institutional factors play a mediating role in determining population-environment relationships. Social scientists are inclined to consider the impact of social, cultural and institutional factors on population-environment relationships, and much recent research implicitly or explicitly reflects this viewpoint (Blaikie and Brookfield, 1987 and Bilsborrow, 1992).

Also, the development dependency (Jolly, 1991 and Martine, 1992) view collapses all social, cultural and institutional factors that mediate population-environment relationship into the large concept of 'development' and focuses on the way in which development processes mediate population and environment relations.
Finally, the complex system and adaptive strategy view considers mediating factors as well as environment and population in a structured way or as a complex of interrelated systems. This approach aims to understand how ecological and human-driven systems (socio-cultural, demographic, and economic) dialectically interact and interconnect to form larger "socio-ecological systems" (Gallopin et al., 1988) within which population and environment relationships are embedded.

STUDY AREA

The Volta River Basin has been geographically divided into five main sub-basins. These are the White Volta, Black Volta, Main Volta, Daka and Oti sub-basins. The White Volta sub-basin is located in the north of Ghana, extending southwards to about latitude 8^0 30' N (see Figure 1). It covers all Districts in the Upper East Region. It also includes sections of Wa, Sissala, Lawra, Jirapa-Lambussie, and Nadowli Districts in the Upper West Region. In the Northern Region, parts of Bole, West Gonja,

Savelugu-Nanton, Gushiegu-Karaga, Saboba-Chereponi, East and West Mamprusi Districts fall within the White Volta sub-basin.

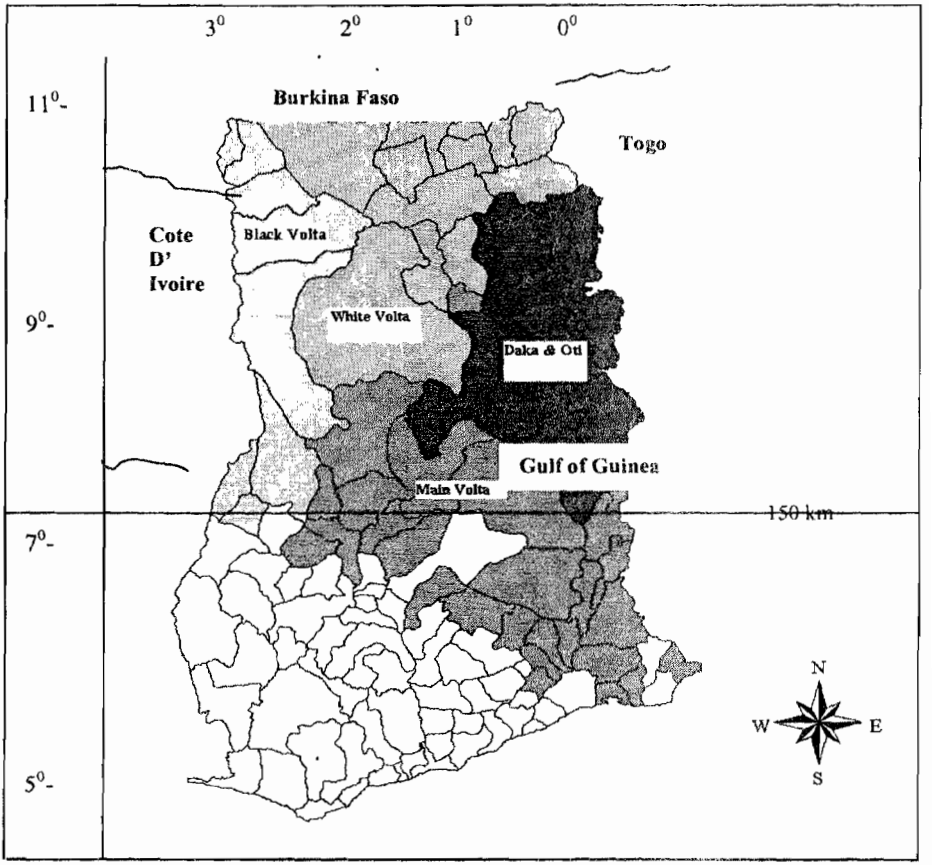

Figure 1: Map of Ghana Showing the Sub-Basins

The Black Volta Sub-basin extends narrowly from the north-west of Ghana southward across the middle belt up to about 7^0 45' N and 10^0 W, as its eastern most spatial extension. It covers parts of the Upper West, Northern and Brong Ahafo Regions. Sissala, Lawra, Jirapa-Lambussie, Nadowli and Wa Districts in the Upper West Region; parts of Bole and West Gonja Districts in the Northern Region; Atebubu, Nkoranza, Wenchi, Berekum and Jaman in the Brong Ahafo Region constitutes the Black Volta Basin.

The Main Volta Sub-Basin is the largest of all the sub-basins of the Volta River in Ghana and it stretches over a greater part of Central and Eastern Ghana. Districts

from six regions namely Northern, Brong Ahafo, Ashanti, Volta, Eastern and Greater Accra, constitute the Main Volta sub-basin.

The Oti sub-basin is found along the eastern fringes of the Northern Region across the middle belt to the northern portions of the Volta Region. Latitudinally, it extends from about 10^0 50'N to around 7^0 30'N and covers parts of East Mamprusi, Gushiegu-Karaga, Saboba-Chereponi, Yendi, Nanumba, East Gonja and the whole of the Zabzugu-Tatale District in the Northern Region. The total area of the Oti sub-basin is 17,942 km^2.

Finally, the Daka sub-basin is mainly in the Northern Region. It stretches narrowly across the middle belt from about latitude 10^0 15' N. It shares borders with the Main Volta sub-basin to the North. It is made up of parts of the Gushiegu-Karaga, Saboba-Chereponi, Yendi, East Gonja, and Nanumba Districts in the Northern Region and a small proportion of Krachi District in the Volta Region.

METHODOLOGY

The main sources of data for determining the population sizes of the sub-basins and their subsequent projection are derived from the Population Census Reports of Ghana, for 1960, 1970, 1984 and 2000. The Census Reports present information on population at the national, regional and local authority levels. The Census Districts (Local Authorities prior to 2000 and Districts in 2000) therefore do not have common boundaries with that of the river sub-basins. The problem that was confronted with in developing this paper was how to aggregate a number of local authorities/Districts to represent one river sub-basin, since the river sub-basins' boundaries cut across a number of local authorities/Districts.

To overcome the challenge, a map of local authorities of Ghana was superimposed on the river sub-basins map to determine which local authorities fall within each of the river sub-basins. However, the population of major settlements (urban settlements with population 5,000 or more as at 1984) was added to the sub-basin in which they are spatially located. Thus, having taken these major settlements and added them to sub-basins to which they are physically located, a uniform distribution of each local authority's population was assumed and the relative proportions of its population calculated and added to the sub-basin in which it is located. On the other hand, the population of local authorities that fully fall into one river sub-basin was added wholly to the river sub-basin in question without determining any proportions.

By using the methodology described above, the population of each river sub-basin according to the 1960, 1970, 1984 and 2000 Population Censuses has been estimated to form the basis for projecting into the future. To achieve this objective, the proportion of each local authority/District's population falling into each river sub-basin was estimated. After, the population growth rate for 1984-2000 in respect of each local

authority was assumed to remain relatively constant throughout the projection period (1984-2010). Each local authority's population estimated to fall within each river sub-basin was projected using the population growth rate for the particular local authority for 1984-2000 and the total aggregated to form the total population for each river sub-basin at each point in time during the projection period. With the areas of the local authorities known, the same procedure was adopted to determine the size of each river sub-basin in square kilometres. This facilitated the estimation of the population density for each river sub-basin relative to each local authority during the projection periods.

RESULTS AND DISCUSSIONS

Population

As shown in Table1, the White Volta sub-basin, which covers a total of 43,830 km^2, had a population of 518,569 in 1960, 877,037 in 1970, 1,280,660 in 1984, and 1,616,895 in 2000 (Ghana Statistical Service, GSS, 1989 and 2002). The period between 1960 and 1970 experienced a 69% increase in the population, compared to 46% increase in 1970-84. On the other hand, the period 1984-2000 registered a 26% increase in population. The population of the sub-basin, more than doubled within a period of 24 years, i.e., between 1960 to1984. Using an inter-censal growth rate of 1.5% during the period 1984-2000, the population of the sub-basin has been projected to reach about 1,933,687 by 2010 representing a 20% increase on the basis of the 2000 Population and Housing Census Report. The analysis further shows that the population of the White Volta sub-basin would experience a 273% increase that is almost quadrupling within half a century (1960-2010).

Table 1: Population of the Volta Sub-Basins, 1960 – 2010.

Sub-Basin	Area (Km^2	Population					
		1960	1970	1984	2000	2010	Growth rate (1984-2000)
White Volta	43830	518569	877037	1280660	1616895	1933687	1.5
Black Volta	30582	277011	388099	607372	736722	921154	1.2
Main Volta	59486	876146	1416432	2052555	3032857	4268927	2.5
Oti	17942	106423	227632	350480	557910	771533	3.0
Daka	8124	48079	91429	127439	198851	260761	2.8

Source: Ghana Statistical Service (GSS), 1989 and 2002.
**Projected Figures*

One important factor that has affected the population of the White Volta sub-basin is the Onchocerciasis or river blindness disease (GSS, 1995). It is caused by the parasite *Onchocerca Volvulus* and transmitted by the black fly, *Simulium Damnosum*. The fly breeds mainly in fast flowing riverain areas about 30 km on each side of the river. In addition to causing blindness, it is a major obstacle to socio-economic development. The National Onchocerciasis Secretariat reported in the 1984 review of the Onchocerciasis Control Programme (OCP) that in 1974 when the programme operation started, more than one million people were suffering from Onchocerciasis and at least 100,000 persons were blind or had their eye-sight seriously impaired. Furthermore, large areas of fertile, riverain land had been abandoned due to the heavy toll of the disease on the inhabitants of the Onchocerciasis -infested areas. The hard hit areas in the White Volta sub-basin are the Sissili and Kulpawn basins, Fumbisi-Yabaga, Bongo, Zebila and Nangodi areas. Even though Onchocerciasis has been eradicated in Ghana, people are afraid to migrate back to these areas for fear of re-infection.

The Tono Irrigation Project near Navrongo in the Upper East Region has also played a role in the distribution of the population of the White Volta sub-basin. The Tono project was started in 1975 and completed in 1985. The dam was constructed over the Tono River and disrupted the lives of several villages in the Kassena-Nankana and Builsa Districts. The entire project area covered 3,860 hectares, of which 2,500 were developed for irrigation affecting eight settlements (GSS, 1995).

The Gonja resettlement scheme has also contributed to population movements and distribution within the White Volta sub-basin. During the pre-independence years, the Government of Ghana felt that modernization and improvements in agriculture could not be achieved only through the improvements of the traditional system of production. It was also felt that large-scale farms could be established to demonstrate the possibility of mechanised farming. Resulting from this, the Gonja Development Company was established in 1951. The project was assigned the objective of experimenting with mechanized farming and the use of fertilizers, in the Gonja District, to raise foodstuff production in the region. Some Frafra settlements in the sub-basin were resettled under this scheme (GSS, 1995).

Further, the Fumbisi Valley project has also played a role in the distribution of the population in the White Volta sub-basin. In 1985, the Government of Ghana selected the Fumbisi valley and other areas to assist spontaneous voluntary settlement. The objective was to improve rural infrastructure by introducing physical and social amenities for improved conditions of life, which would help in controlling further urban drift by encouraging in-migration. It was also to strengthen or create new service centres and provide marketing services and facilities for inputs and farm produce (GSS, 1995). Although some migrants went to these areas, on the whole the Fumbisi Valley Project did not attain its objective of becoming a growth pole centre in the White Volta sub-basin, and movements from the sub-basin has continued to present times.

Finally, seasonal flooding and massive bush fires, which raged in the country in 1983, have all had an effect on the distribution of the population of not only the White Volta sub-basin, but also the other sub-basins in northern Ghana. The bush fires, which were particularly felt in the Northern parts of the Volta basin destroyed a third of all farms and it is on record that most farmers moved to other parts of the country from the hard hit areas (GSS, 1995).

The Black Volta sub-basin covers a total of 30,582 km^2. Its population was 277,011, 388,099, 607,372 and 736,722 in 1960, 1970, 1984 and 2000, respectively (GSS, 1989 and 2002). Between 1960 and 1970, there was a 40% increase in the population, compared to 57% increase in 1970-84. Furthermore, the period 1984-2000 registered a 21% increase in population. The population of the Black Volta sub-basin, more than doubled within a period of 24 years, i.e., between 1960 to1984. Moreover, the inter-censal growth rate of the Black Volta sub-basin during the period 1984-2000 was 1.2%. The inter-censal growth rate has been used to project the population of the sub-basin and the projection shows that the sub-basin would have a population of about 921,154 by 2010. The projection further shows that the population of the Black Volta sub-basin would likely experience a 233% increase that is more than tripling within half a century (1960-2010).

The Main Volta sub-basin, the largest of all the sub-basins covers a total of 59,486 km^2. In 1960, it had a population of 876,146 and in 1970 its population was 1,416,432. The population of the Main Volta sub-basin rose to 2,052,555 in 1984, and in 2000 it was 3,032,857. Projections show that the sub-basin's population would reach about 3,566,035 by 2010. An increase of 62% was recorded in the population of the Main Volta sub-basin between the period 1960 and 1970, compared to 45% increase in 1970-1984. The period 1984-2000 experienced a 48% increase in population. The population of the Main Volta sub-basin, more than doubled between 1960 to1984, and it has been projected to reach about 4,268,927 by 2010, using an inter-censal growth rate of 2.5% during the period 1984-2000. Furthermore, the population of the Main Volta sub-basin would likely experience a 387% increase that is almost quintupling within half a century (1960-2010).

One important characteristic of the population of the Main Volta sub-basin is the mass movements to frontier agricultural areas. One significant area that comes to mind as far as this issue is concerned is the Afram Plains. Situated north of the Kwahu Scarp, about 2,725 km^2 (47.4%) of the total area of 5,754 km^2 is under the water of the Volta Lake (GSS, 1995). The favourable and suitable topography, climate, vegetation and reasonably rich soils allow for large-scale agricultural development both under the manual and mechanized farming practices. Added to this is the government's policy of encouraging the exploitation of the high food and industrial crop potentials of the plains through the provision of tractors, bulldozers and other implements, which has resulted in the large influx of people into the area (Godwyll, 1990). The population of the Afram Plains grew from 10,660 in 1960 to

31,486 in 1970 and to 82,725 in 1984. This gave an inter-censal population change of 195.4% between 1960 and 1970 and 162.7% between 1970 and 1984. This was the highest percentage increase for all local council areas in the whole country between 1970 and 1984. The very large increase in population between 1970 and 1984 was largely due to migration (GSS, 1995).

Finally, the construction of the Kpong hydroelectric project in the southern portions of the Main Volta sub-basin has also played a role in the distribution of the population within the sub-basin. Located downstream from the Akosombo Dam and powerhouse, the Kpong hydroelectric project involved the construction of a dam, powerhouse spillway and dykes which created a head-pond covering an area of about 3,500 hectares. Five ethnic groups were affected by this project and six main settlement areas of nearly 7,000 people were displaced.

The Oti sub-basin covers a total of 17,942 km^2. Like the other sub-basins, its population has increased over the years from 106,423 in 1960 to 557,910 in 2000. In 1970 when the second modern population census was undertaken in Ghana, the Oti sub-basin's population was 227,632 and in 1984 it was 350,840. The population of the Oti sub-basin has been projected to reach about 771,533 by 2000 using an intercensal growth rate of 3.0% between 1984 and 2000. Further analysis show that between 1960 and 1970, there was a 114% increase in the population, compared to 54% increase in 1970-84. Furthermore, the period 1984-2000 registered a 59% increase in population. The population of the Oti sub-basin, more than tripled within a period of 24 years, i.e., between 1960 to1984 (GSS, 1989 and 2002). The inter-censal growth rate of the sub-basin during the period 1984-2000, which was 3.0%, has been used to project the population of the sub-basin which shows that the sub-basin would have a population of about 771,533 by 2010. The projection further reveals that the population of the Oti sub-basin would experience a 625% increase (more than seven-fold) within half a century (1960-2010).

An important factor that has affected the population distribution of the Oti sub-basin is ethnic conflicts. Even though ethnic conflicts can be said to be a phenomenon that is predominant in the northern portions of the Volta Basin in Ghana, it could be argued to have prevailed more in the Oti sub-basin. Bloody conflicts, which have brought in their wake devastation of groups of people and in some instances desolation of entire settlements, have raged between the Nanumba and Konkomba (1980), Gonja and Vagla (1984), Konkomba and Bimoba (1990) and Nawuri and Gonja (1991). Even though, the immediate causes of these conflicts may vary, the remote causes have always been a struggle for land resources and these conflicts have had tremendous impacts on the population of the sub-basin.

Finally, the Daka sub-basin is the smallest of all the sub-basins of the Volta River in Ghana. It covers a total area of only 8,124 km^2 and its population has increased over the years from 48,079 in 1960 to 91,429 in 1970. During the 1984 population census, the Daka sub-basin recorded a population of 127,439 and it has been projected that

its population would reach about 260,761 by 2010 using an intercensal growth rate of 2.8% between 1984 and 2000. Between 1960 and 1970, there was a 90% increase in the population, compared to 39% increase in 1970-84. Furthermore, the period 1984-2000 registered a 56% increase in population and its population more than doubled within a period of 24 years, i.e., between 1960 to1984 (GSS, 1989 and 2002). Moreover, the inter-censal growth rate of the Daka sub-basin during the period 1984-2000 which was 2.8% has been used to project the population of the sub-basin which shows that the sub-basin would have a population of about 260,761 by 2010. The projections further show that the population of the Daka sub-basin would experience a 442% increase (more than five-fold) within half a century (1960-2010).

The analysis above has shown that population growth rates have been increasing in all the sub-basins of the Volta River in Ghana, with the Oti sub-basin recording the highest (3.0%) and the Black Volta sub-basin, the lowest (1.2%) between 1984 and 2000. Projections also show that the increases in population will continue in the future. Factors such as environmental (flooding, bush fires, Onchorcerciasis), development of resettlement and irrigation schemes, hydro-electric power generation projects, movement to frontier agricultural areas, together with key socio-political processes (e.g. land conflicts), have accounted for the distribution of the population in the various sub-basins.

Population Density

As shown in Table 2, the population density of the White Volta sub-basin was 12.4 persons per km^2 in 1960, 20.6 persons per km^2 in 1970, 29.6 persons per km^2 in 1984 and 36.9 persons per km^2 in 2000 (GSS, 1989 and 2002). Projections show that the population density of the sub-basin would be about 44.1 persons per km^2 by the year 2010.

Table 2: Population Density of the Volta Sub-Basins, 1960 – 2010.

Sub-Basin	1960	1970	1984	2000	2010*
White Volta	12.4	20.6	29.6	36.9	44.1
Black Volta	9.0	12.7	20.0	24.1	30.1
Main Volta	1.7	23.8	34.5	51.0	71.8
Oti	5.9	12.7	19.5	31.1	43.0
Daka	5.9	11.3	15.7	24.5	32.1

Source: Ghana Statistical Service (GSS), 1989 and 2002.
**Projected Figures*

The Black Volta sub-basin on the other hand had a population density of 9.1 persons per km^2 in 1960, 12.7 persons per km^2 in 1970, 20 persons per km^2 in 1984 and 24.1

persons per km^2 in 2000. The population density of the sub-basin would be 30.1 persons per km^2 in the year 2010.

The population density of the Main Volta sub-basin was 14.7 persons per km^2 in 1960, 23.8 persons per km^2 in 1970, 34.5 persons per km^2 in 1984 and 51.0 persons per km^2 in 2000. The population density of the sub-basin has been projected to be about 71.8 persons per km^2 by the year 2010. From the analysis in Table 2, the population density of the Oti sub-basin can generally be described as a low one. The population density was 5.9 persons per km^2 in 1960, 12.7 persons per km^2 in 1970, 19.5 persons per km^2 in 1984 and 31.1 persons per km^2 in 2000. The population density of the Oti sub-basin according to projections would be about 43.0 persons per km^2 by the year 2010. Finally the population density of the Daka sub-basin was 5.9 persons per km^2 in 1960, 11.3 persons per km^2 in 1970, 15.7 persons per km^2 in 1984 and 24.5 persons per km^2 in 2000 and would be 32.1 persons per km^2 in the year 2010.

It is clear from the above that population density is increasing in the White Volta, Main Volta, Oti and Daka sub-basins and this has a potential of causing land accessibility problems, since the majority of the population are farmers. However, population density has not increased dramatically in the Black Volta sub-basin between the period 1984-2000. Furthermore, the projections show that even though population density will increase by 2010, the increase will not be at an alarming rate. The Black Volta sub-basin can therefore be considered as an area of low population pressure.

Settlement

Table 3 shows that there were 1,245 settlements in 1960, 1,966 in 1970, and 3,677 in 1984 in the White Volta sub-basin. Projections show that the sub-basin would have about 9,424 settlements in 2000, and 18,981 by 2010. The number of settlements for 2000 for all the sub-basins has been projected, due to the fact that, even though preliminary results of the 2000 Population and Housing Census has been released, the one on settlements is still being processed.

Table 3: Number of Settlements in the Volta Sub-Basins, 1960 - 2010

Sub-Basin	Number of Settlements				
	1960	1970	1984	2000	2010
White Volta	1245	1966	3677	9424	18981
Black Volta	658	1072	2119	4969	8688
Main Volta	2250	4157	8217	23498	52785
Oti	408	841	1490	3630	7187
Daka	177	319	510	935	1442

Source: Ghana Statistical Service (GSS), 1989 and 2002.
*Projected Figures

According to the analysis in Table 3, there were 658 settlements in 1960, 1,072 in 1970, and 2,119 in 1984 in the Black Volta sub-basin. It has been projected that the sub-basin would have about 4,969 settlements in 2000 and 8,688 by 2010. Furthermore, there were 2,250 settlements in 1960, 4,157 in 1970, and 8,217 in 1984 in the Main Volta sub-basin and projections show that the largest sub-basin of the Volta River in Ghana would have about 23,498 settlements in 2000 and 52,785 by 2010.

The number of settlements in the Oti sub-basin has increased from 408 in 1960 to 1,490 in 1984. The number of settlements in the sub-basin was 841 in 1970 and has been projected to reach 3,630 in 2000 and would be about 7,187 by the year 2010. Settlements increased from 177 in 1960 to 319 in 1970 in the Daka sub-basin. The number of settlements continued to increase in 1984 with a total of 510 and 935 in 2000 using the growth rate between the period 1970 and 1984. It is expected that the number of settlements of the Daka sub-basin, would be 1,442 by 2010.

It must be mentioned that most of the settlements within the White Volta, Black Volta, Oti and Daka sub-basins are very sparsely populated. Another characteristic of the settlements is that they are widely scattered and this has consequences for developmental programmes, since conflicts arise as a result of the location of developmental infrastructure.

Urbanisation

In Ghana, the term "urban" refers to settlements with populations of 5,000 or more. The population living in urban areas has been calculated for the Volta sub-basins in Ghana, and it is shown in Table 4. In 1960, urban areas constituted 5.6% of the White Volta sub-basin, in 1970 it was 7.1%, in 1984, 11.4%, and in 2000 it was 15.9%. The population living in urban areas for the sub-basin has been projected to be about 18.1% by 2010.

Table 4: Urban Population of the Volta Sub-basins 1960-2010

Sub-Basin	Urban Population and Proportion									
	1960	%	1970	%	1984	%	2000	%	2010*	%
White Volta	30352	5.6	64282	7.1	147225	11.4	256625	15.9	350025	18.1
Black Volta	25014	9.0	34725	8.9	92945	15.3	197013	26.7	408119	44.3
Main Volta	14498	16.6	327033	23.1	546766	26.6	854182	28.2	1205833	28.3
Oti	7491	7.0	13165	5.8	36920	10.5	118874	21.3	259147	33.6
Daka	-	-	-	-	-	-	-	-	-	-

Source: Computed from Ghana Statistical Service (GSS), 1989 and 2002.
*Projected Figures

Urban areas constituted 9% of the Black Volta sub-basin in 1960, 8.9%, in 1970, 15.3% in 1984, and 26.7% in 2000. The population living in urban areas for the Black Volta sub-basin has been projected to reach about 44.3% by 2010. Urbanisation in the Main Volta sub-basin was 16.6%, 23.1%, 26.6% and 28.2% in 1960, 1970, 1984 and 2000, respectively. It has been projected to slightly increase to about 28.3% by 2010.

Urban areas constituted 7% of the Oti sub-basin in 1960, and 5%, in 1970, indicating a slight decline. In 1984, urban areas constituted 10.5% of the population living in the Oti sub-basin, while in 2000; urban areas constituted 21.3% of the sub-basin. The population living in urban areas for the Oti sub-basin has been projected to reach about 33.6% by 2010.

From the analysis above, the White Volta sub-basin has been shown to be predominantly rural in character. The analysis also shows that the sub-basin would maintain its rural characteristics even by the year 2010. The reason for this phenomenon is obviously the observed out-migration from the area. These kinds of out-migration have been documented in the past (see for instance Manshard, 1961; Hill, 1963; Nabila, 1975) and in more recent studies (Hill, 1998 and Codjoe, 2006). The Black Volta sub-basin like the White Volta sub-basin has been predominantly rural in character from 1960-2000. However, this situation has been projected to change in the near future, since 44.3% of the population in the Black Volta sub-basin would be living in urban areas in 2010.

With regard to the Oti sub-basin it has been predominantly rural in character from 1960-2000. However, this situation has been projected to change, due to the fact that more than a third (33.6%) of the population in the Oti sub-basin would be living in urban areas by 2010. Finally, the analysis shows that there was no urban area in the Daka sub-basin from 1960-2000. The Daka sub-basin, which has portrayed a rural characteristic, is expected to remain entirely rural through the year 2010.

Population and Natural Resources in the Volta Basin

This section reviews studies that have been undertaken to demonstrate the effect of population growth on agricultural land, water and forest resources in the Volta River Basin.

In a study on impact of population on agricultural land use in the Volta Basin, Codjoe (2004) showed that two Districts in the White Volta sub-basin, namely the Bolgatanga, and Bawku East Districts, will experience agricultural land shortfalls in the year 2010, as a result of population growth. The reasons given were that the Bolgatanga District, hosts the Bolgatanga town, which is the administrative capital of the entire Upper East region of Ghana. It has therefore attracted a larger number of migrants.

As far as the Bawku East District is concerned, it has the Bawku Township as its capital, and is a commercial border town between Ghana and Burkina Faso. Due to this, there has been an influx of migrants to the town over the years. Secondly, the Bawku East District has maintained a large population, as a result of the discovery of new mining areas in the 1980s. These mines have attracted many migrants who are mainly small-scale miners, practising what is called "*galampsey*" in the local parlance. The activities of these small-scale miners in these already densely populated areas have resulted in high soil degradation; an issue that has been a major concern for the government. For example, lands, which were hitherto used for agricultural production, have been converted to mining and this scenario is expected to continue (GSS, 1995).

In the Daka sub-basin, one District, Krachi, will experience agricultural land shortfall in 2010. The only reason that was attributed to this occurrence is the fact that most of the area in the District is already under water, since it was inundated when the Akosombo Dam was built. This limits the land area suitable for agriculture. Population has, however, increased over the years, and projections show an increase into the future, since the area is important both commercially and agriculturally.

Furthermore, the Bongo District in the White Volta sub-basin was estimated to have low agricultural land availability, and about four other Districts (Lawra, Tolon-Kumbungu, Bawku West and Kassena-Nankana) would have moderate agricultural land availability in the year 2010. This gives an indication that it may not be too long before the sub-basin experiences pressure on agricultural land as a result of population increase.

In a study in the Black Volta sub-basin, Duadze (2004) revealed that population increased from 1984 to 2000 by 32% and since a high proportion (75%) of the economically active population were farmers, it was concluded that population played a role in land degradation. Declining soil fertility in the farmlands and increasing population, therefore caused pressure on land, which led to land degradation. This in turn caused the farmers to move to other areas to farm. This practice was purported to have resulted in progressive loss of woodland.

On the impact of population growth on forest cover, Codjoe (2004) concludes that the Jaman and Berekum Districts that fall within the Black Volta sub-basin would have depleted forest cover as a result of changes in population density. All the other Districts within the sub-basin would have some amount of forest cover in 2010, irrespective of changes in population density that might occur. On the other hand, the Krachi District in the Daka sub-basin would also experience depleted forest cover in 2010 as a result of increase in population density.

Finally, on water resources, Osei-Asare (2005) concluded that household size is a significant determinant of drinking water demand in the Volta basin, since an

increase in household size increases the drinking water budget allocation of households. This finding suggests that more drinking water is consumed with an additional household member and there is pressure on water resources in the Volta River basin as a result of population increase.

CONCLUSION

The Volta River basin in West Africa is experiencing increasing pressure on land and water resources mainly as a result of rapid population growth rates. This paper, which focused on the Volta River Basin in Ghana, examined the trend and pattern of population growth and distribution within the various sub-basins from 1960 to 2010. This was specifically because of the fact that human activities are the major drivers of land use/cover change as well as other natural resources. Results show that there were increases in absolute population, population density, settlements and the level of urbanization in all the sub-basins of the Volta River in Ghana. Projections also show that these increases will continue in the future.

This study has demonstrated that high population growth is having negative impacts on agricultural land, forest and water resources in some areas of the Volta River Basin. Although extensive areas of Ghana are still sparsely populated, most of the vast areas have no potential for agricultural expansion due to poor soil quality, and the few potential areas have already been settled over the years. The study recommends that every effort must be made by government to slow down the rapid rate of population increase in Ghana as a whole and the Volta River Basin. This will go a long way to bring about sustainable management of the natural resources in the basin. Further research is needed to consider the combined effect of population growth, other socio-economic factors, as well as rainfall and geomorphology on agricultural land, water and forest resources in the Volta River Basin.

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