POPULATION GROWTH AND ENVIRONMENTAL CHANGE ASSESSMENT IN SOME URBAN FRINGES OF GHANA USING AERIAL PHOTOGRAPHS

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ABSTRACT

Population management in the developing world has become very prominent in the discussions relating to the rate and quality of development in these countries. The key question to be answered is how large is the population and at what rate it is growing. The next important question is usually, what the effect of this population and its growth rate is having on the environment. The paper tries to seek some answers to these questions with the analysis of aerial photographs of some suburbs of Kumasi and Accra on a temporal analytical basis. Aerial photographs together with other census data are used to estimate the present population at the time of flight. A comparison is made between population from aerial photographs and that estimated using national census data. Some assessment of the impact of population growth on the environment is made.

***KEYWORDS**: Aerial-photographs, population growth, environmental degradation, temporal analysis, tribal-equalization.*

INTRODUCTION

Population has become the focus of both socio-economic and environmental studies for some time now and it is likely to remain the same in the future. It is because of this fact that all countries spend huge sums of money to know their population size, its density and distribution in space and time. However the quality of these population data varies from country to country with the accuracy deteriorating in the developing countries sometimes for the reasons of ethnic or tribal equalization in the quest for political power. Although conventional population census is taken every ten years, it has become imperative to estimate population by other means in between this period for the purposes of community improvement project planning. This is particularly so in developing countries where the populations are basically rural and therefore the rural-urban migrations is very high especially during the last two decades resulting in high annual urban growth rates of sometimes over six percent. This means that about five years after the census has been conducted about 25% twenty-five percent of the population in urban centers would be living in new sectors not represented in the statistics of the country [1]. This is the beginning of the creation of shanty towns or slums or zongos in the cities including all the usual environmental degradation parameters, such as intense agricultural activities in the urban fringes which leads to high rate of soil degradation and erosion, unacceptable sewerage management system, substandard dwelling units, unacceptable solid waste management arrangements etc.

In order to help the local political administrators and technocrats to solve the problem of the population growth and its associated problems of; how many schools, the quality and quantity of potable water, basic health care facilities, solid and liquid waste disposal structures, road network density etc; a technique of using remotely sensed data is introduced. It must be emphasized that this is not a new technique even though it has not been applied in this direction in the country before.

METHOD

During the last decade, the International Donors, the World Bank and the I.M.F have been advising that developmental planning be carried out with a lot of emphasis on the local community. So it is now common to hear local political administrators placing emphasis on community-based projects as opposed to large national projects administered from top to bottom. With this in view five communities were selected for the investigations. The communities are Ayigya, Kentinkrono-Nsenie, Anwomaso, Oduom, Ayeduase all suburbs of varying degrees of Kumasi, the capital of Ashanti Region and Nungua, a suburb of Accra, the capital of Ghana.

Nungua

Nungua lies on the Accra-Tema trunk road. For the purposes of this study, the town is bounded on the west and the east by the Songo and Mokwe lagoons respectively. The Accra-Tema rail line serves as its northern boundary, while the Gulf of Guinea forms the Southern limit of the township. The native inhabitants are farmers and fishermen. The suburb can be subdivided into two parts; the native family dwelling units made up of predominantly swish mud houses in the south; and b) the modern one family sandcrete houses to the north. Aerial photographs flown in 1968, 1974 and 1986 were used in the investigations. The scale of the vertical aerial photographs were as follows: 1:20,000, 1:40,000 and 1:10,000 respectively.

B.E. Kwesi Prah

Procedure

1. Mirror stereoscopes were used in scanning through the photographs
2. House counts were conducted for the two dwelling unit types identified.
3. Occupancy rates (persons/house) were estimated through field investigations for the two categories
4. The population estimates for 1968 and 1986 were then made.

Ayigya

This is a suburb of Kumasi on the trunk road to Accra, opposite the University of Science and Technology. This suburb is fast becoming heavily populated and therefore there is the need to properly and timely estimate the population in order to plan and design the right essential services for the area. The only available aerial photographs which were used were flown in 1961 and 1972 and were of 1:10,000 and 1:5,000 scales respectively.

Procedure

1. The aerial photographs were viewed with mirror stereoscopes
2. Two typical clusters of buildings were identified, the Ayigya and the Ayigya Zongo clusters of almost the same building material.
3. The house count was conducted and the average population density per house estimated from the results of the field investigation.
4. The population for the two clusters was estimated based on the parameters estimated from (3)

Ayeduase, Kentinkrono-Nsenie and Anwomaso-Oduom

These are small settlements situated within 6-10 kilometers from Kumasi central, on the Kumasi Accra road. These villages are typical and can be said to be very representative enough at least in the Ashanti region. They are made up of typical family buildings, constructed with mud and lateritic bricks, normally at the center of the settlement. At the peripheral of the settlements are found the modern sandcrete buildings normally of single family occupancy. The aerial photographs used were flown in 1971 and of the scale 1:5000.

Procedure

a) the aerial photographs were carefully scanned through using mirror stereoscopes

b) Three dwelling unit type were identified and the house count in each case conducted.

c) Some random selection of houses were made and their occupancy members established. From these numbers an average density for each type of dwelling unit was calculated.

d) The estimated population for each category was then calculated and the total population for the settlement computed.

In all the sites selected for the project, the dwelling unit count method was employed in the population estimation. This choice was made as against for example the estimation based on land-use area because in the rural setting there are usually no clear boundaries of properties, or dwelling zones. Instead there is always a distinct cluster of traditional family houses at the nucleus with units of different types scattered on the fringes. This makes it difficult to compute the dwelling unit areas with any appreciable accuracy. In view of this and since the area so computed becomes the main parameter in the estimation of the population, it was rejected in favour of the dwelling unit count. The dwelling unit count method states that the estimated population = Number of dwelling units x Average dwelling unit size (occupancy rate)

Environmental Impact Assessment

In all the sites selected, a conscious effort was made to understand the dynamics of some of the environmental parameters with the view to comparing their variation over the years under study. Some of the parameters include:

1. The general conditions of drainage in the settlements
2. Liquid and solid waste disposal management (i.e for example the number and extent of the refuse dumping sites and how far away they are from the settlement).
3. General land-use and land form patterns
4. Soil erosion both within and outside the settlements.
5. The quantity and quality of the houses in the settlements
6. The number and state of social facilities like pipe-borne water stands, schools and toilet structures.

All these were done employing photo interpretation methods using mirror stereoscope and the various aerial photographs covering the areas under investigation. Some land-use plans were made, showing the extent of the changes that has taken place in the settlements: These were followed by ground truth investigations. During the site investigations it became apparent that

there was rampant defecation in the bushes in Ayigya, one of the settlements. This led to the actual counting of the public toilet buildings in the settlement. In Nungua an attempt was also made at determining the directions of spread of the settlement with the aim of establishing the degree of degradation in each sector of the settlement. This was done by reducing all the interpreted plans to the same scale using a pantograph and then superimposing them. In this way the variations over the years became apparent and therefore the directions of spread was detected. It must be emphasized that since the photographs for the investigations were not current a lot of field work had to be done especially talking to the older residents of the settlement.

RESULTS

The results of the investigations were broken into two, the results of the actual population estimation and that of the impact assessment. Tables 1 and 2 show the results of the population estimated from using aerial photographs and data from the national census (Table 3) using conventional methods for the various years which were available. As was expected population estimated from the two sources were not the same. The variations ranged between 10% over estimation and 11.5% under estimation. The main contributing factor for the magnitude of variation was the fact that dwelling unit density used for the calculation was difficult to obtain since the photographs were old and therefore the author had to depend on the figures given by the elderly in the households. It is also true that the dwelling unit density may not necessarily be entirely homogenous over the whole residential area. The other factors could include the following:

a) that the national census results with which the comparisons were made, were themselves not entirely free from errors as indeed all census results are with some errors and Ghana's could not be an exception more so being a developing country.

b) Houses in the non-residential areas were assumed not to contain any population. This is generally not true since it is not unexpected to find people sleeping in stores, kiosks, car pentry shops to mention a few, in the suburbs of the urban centers.

The results of the environmental change assessment

TABLE 1: Population Estimation of some Communities

Name of Settlement	Dwelling Unit Count on Aerial Photograph					Average member of persons per dwelling unit				
	1961	1968	1972	1974	1986	1961	1968	1972	1974	1986
Ayigya	203			317		24			22	
Ayeduase			83					18.4		
Nsenie-Kentinkrono			70					19.8		
Oduom-Anwomaso			51					21.4		
Nungua (South)		740			897		14			28
Nungua (North)		520			1956		4			5

TABLE 2: Population Estimation of some Communities

Name of Settlement	Estimated Population using Aerial photograph					Population Estimation from Census using Growth Rate 2.9% for Ashanti, 5.6% for Gt. Accra					Deviations (%)
	1961	1968	1972	1974	1986	1961	1968	1972	1974	1986	
Ayigya	4872			6974		24			22		
Ayeduase			1528					1389			+10
Nsenie/ Kentinkrono			1505					1560			-3.5
Oduom-Anwomaso			1092					1042			+4.9
Nungua		12440			34896	7514	11007			35040	-11.5

TABLE 3: Census Data Available

Name of Settlement	1960	1970	1984
Ayeduase		1311	
Nsenie-Kentinkrono		1473	
Oduom-Anwomaso		1013	
Nungua	7100	13,800	30,000

investigation has been depicted in Tables 4 and 5 and figures 1 to 6. The most striking parameter which experienced a dramatic change over the years under investigations is the land-use pattern. In all the settlement studied, most of the land for agricultural use had gradually been converted into residential units and social services, often haphazardly done. In most Ghanaian settlements, development starts most of the time long before layouts are designed. This by itself may not pose too much problem if the layout had taken the already existing developments into consideration during the design stage. Tables IV and V show the changes that have taken place in the case of Ayigya and Nungua over a tim e span of eleven and eighteen years respectively. There is a noticeable increase in the provision of educational and civi-cultural faculties as well as commercial activities as a result of the fast population growth of both settlements though it is most pronounced in Nungua.

In all the settlements, it was noticed that surface erosion outside the settlements had deteriorated as a result of the pressure on the agricultural lands by the population increase. Within the settlements, the volumes of liquid waste from the various houses just followed the land gradient and where several of them joined together, small gullies had been formed. This process is greatly magnified during the rainy season when soil erosion in the settlements are severe. The top soils are carried away by these gullies leaving some foundations of some houses exposed. This is a common phenomenon in almost all the small settlements in the country. This eventually, leads to the collapse of these buildings when not attended to in good time.

TABLE 4: Ayigya Land-Use Between 1961 and 1972

Land-Use Main Components	1961		1972		Percentage increase over 18 years
	Area in Hectares	Percentage of Total Area	Area in Hectares	Percentage of Total Area	
Residential (Ayigya Zongo)	11.8	12.6	19.2	20.5	+ 7.9
Residential (Ayigya)	8.8	9.4	10.9	11.6	+ 2.2
Farmlands	19.4	20.7	8.9	9.5	-11.2

Total area under study = 94.0 hectares.

It can be seen from Table 4 that most of the farmlands lost over the years was taken up for residential activities.

TABLE 5: Nungua Land-Use Between 1968 and 1986

Land-Use Main Components	From 1968 Photographs		From 1986 Photographs		Percentage increase over 18 years
	Area in Hectares	Percentage of Total Area	Area in Hectares	Percentage of Total Area	
Residential	118.2	33.2	354.6	75.2	+ 42.0
Commercial	6.2	2.0	13.2	2.8	+ 0.8
Educational	24.0	8.0	61.7	13.1	+ 5.1
Farmlands	145.6	48.3	12.1	2.6	-45.7
Industrial	5.0	1.7	22.3	4.7	+ 3.0

Total area under study = 299.0 hectares

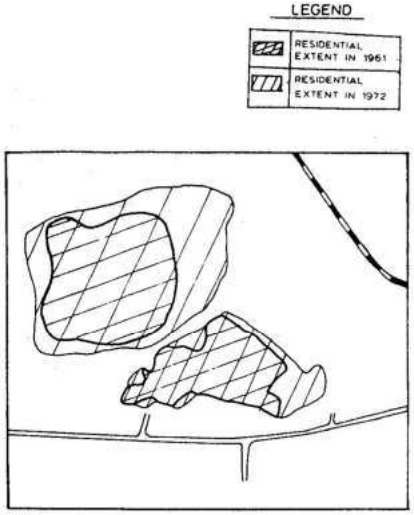

Fig. 1: The Extent of Residential area of Ayigya in 1961 and 1972

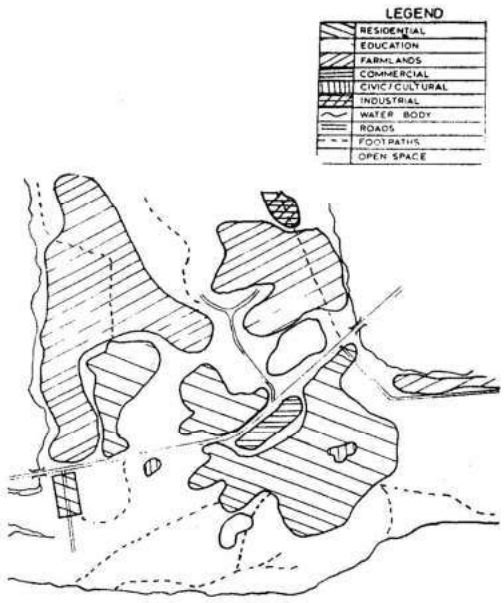

Fig.3 : Land Use Map of Nungua as at 1968

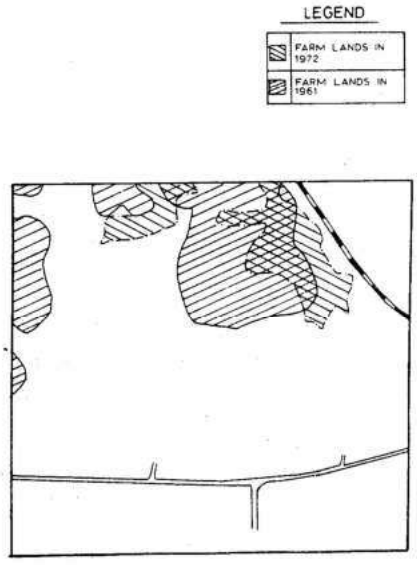

Fig. 2 : Sketch Showing Farm Lands of Ayigya in 1961 and 1972 from Aerial Photographs

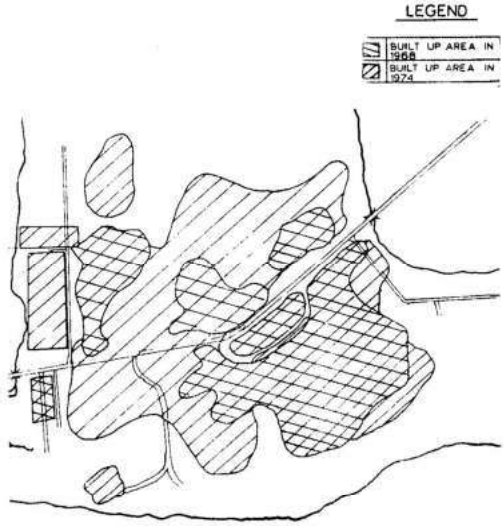

Fig.4 : Nungua - Built Up Areas in 1968 and 1974

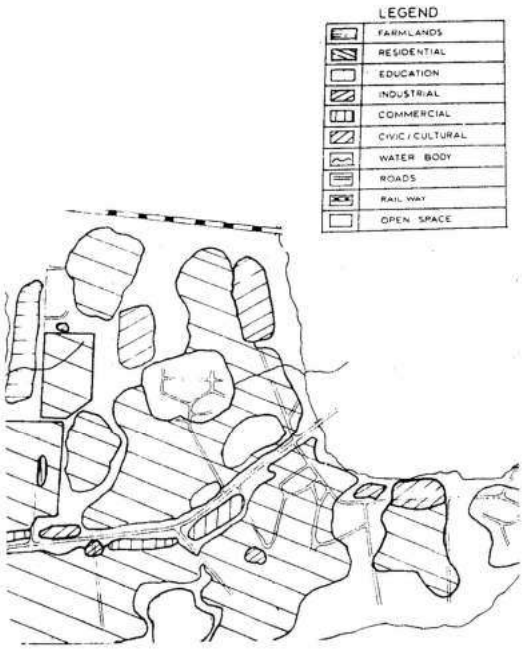

Fig. 5 : Nungua - Land Use at 1986

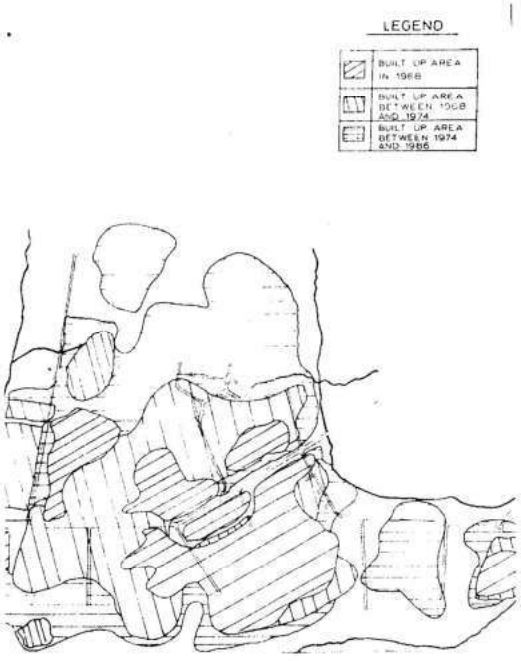

Fig. 6 : Built Up Area Between 1968 and 1986 - Nungua

The general sanitary conditions of the settlements had also deteriorated in almost all the study areas. The number of refuse dumping sites had increased over the years, some of them very close to residential units. Some of the sites were not well defined and therefore seemed not to have been authorised. But it appeared that the major sites were becoming increasingly far from some of the new residential units, therefore the residents just dump their refuse into any open space available near their houses. As a result of this practice some of the residential areas are littered with refuse. In the case of Ayigya and Nungua, some of the old refuse dumping sites are now well in the residential areas and it is a common practice for defecation in the bushes just surrounding them. At the time of photography in 1974 Ayigya had only five public toilets serving a population of almost seven thousand people. This severe pressure on the facility may explain particularly the reasons for defecation in the bushes in the immediate vicinity of these public toilets. It was also generally observed and confirmed during ground truth data collection that, wherever the soil was a good aggregate for construction, large tracts of land have been excavated and transported for building construction. This has left some of the farmlands and seashore either bare or waterlogged and unfit for any economic activities.

CONCLUSIONS

From the results obtained from the study the following conclusions could be drawn, that:

1. Population estimation in urban suburbs and small rural settlements using aerial photographs are possible at a faster rate than the conventional methods employed so far in the country and therefore must be encouraged.

2. The cost involved in estimating population using photographs could be relatively lower if the acquisition of the photographs are done not solely for population census alone but a more integrated approach is established where the cost could be distributed (for example, acquisition for agricultural, geological and forest management).

3. The technique could be used at least to supplement or check unexpected conventional census results which normally occurs in the developing countries as a results of political considerations.

4. The house/dwelling unit count method could be employed even with old aerial photographs for population estimation for medium to small settlements provided the new dwelling units built after the flight of the photography can be identified
and counted easily on the ground. In the villages however an additional effort should be made at identifying and counting the number of collapsed housing units after the flight since it is now a major problem in the rural settle-

ments in the country.

5. Population impact assessment is very easily conducted with aerial photographs since they serve as historical documents of how the settlements was and is at any moment as a result of certain dynamic parameters of which population growth rate is one.

6. There is a direct linkage between population growth pressure and environmental degradation and the two can be investigated together with the use of remotely sensed data.

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REFERENCES

1. **Lo. C.P.**, Applied Remote Sensing, 1986.
2. **Stanley, J.**, A case study of Ayigya, 1975.
3. **Curvan, P.**, Principles of Remote Sensing, 1985.
4. **Mather A.S.**, Land use, 1986.