5 Remote Sensing

The Expected Role Of Remote Sensing Data In The National Development (Ghana): A General Appraisal

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ABSTRACT

The effective application of satellite remote sensing data as general data base for national development of resources started in the developed countries after the launching of the ERTS series (now Landsat series) in the early 1970s.

The paper highlights possible areas where such data could be applied for the optimum utilisation of both renewable and non-renewable natural resources in Ghana. A case study of the practical application of remote sensing data in the fields of geology, hydrology and forestry is made to illustrate the immense potential of this new tool for the collection of data for national development.

Keywords: remote sensing, imagery, Landsat, Salyut, SPOT, desertification, reaforestation.

INTRODUCTION

During the early days of space exploration it was the U.S.A. and U.S.S.R which had the exclusive use of data collected by spacecrafts sent up by their respective governmental agencies. However, after the successful launching of the American Landsat and the Soviet Salyut programmes in the early 1970's, enormous amount of information became available for both experimentation and later application in various fields.

Since then the use of remote sensing methods of collecting data has become imperative in today's socio-economic and technical advancement of both developed and developing countries. Satellite imagery has been utilised in the detection and monitoring of natural and artificial phenomena which before then was impossible. With the launching of SPOT and LANDSAT D, better information (both quantitative and qualitative) is generally received about the earth than before. Unfortunately most developing countries in Africa including Ghana are not making use of this technologically advanced methods of collecting data for national development.

Sectors of the national economy where remote sensing data could be of paramount necessity include the following:

i. Agriculture: the monitoring of stress affecting growth and harvesting of agricultural produce.

ii. Forestry : the monitoring of boundaries and quality of different vegetational zones.

iii Non-renewable Natural Resources: the detection and monitoring of geological and geomorphological features.

iv. Water Resourses: the detection and monitoring of hydrological elements.

v. Environmental Protection: the monitoring of environmental changes.

vi. Mapping: the monitoring and evaluation of landuse pattern and their mapping on medium and small scales.

AGRICULTURE

The maximisation of agricultural produce in any developing country is crucial to the provision of adequate basic stapples to its people. To be able to increase agricultural produce, old and

new technologies must be combined since the old technologies were incapable of the task and the new technologies are too expensive for countries like Ghana.

Agriculture in Ghana is difficient in the supply of essential detailed meteorological and climatic data. These data could be supplied with the use of weather satellites like Meteosat with a high probability of accuracy. For example the farmers should know when to plough, plant and when to harvest depending on the meteorological conditions prevailing at any time.

Monitoring of small farm holdings as in the case of the farmers in most developing countries has been very difficult with the Landsat imagery. However, it is expected to improve considerably with the SPOT imagery since the ground resolution is better and since it provides the possibility for stereo vision. Farmers could be advised to switch from mixed farming to mono farming to better benefit from this new technique since it gives better spectral registration of parcels.

Remote sensing techniques could be used to monitor the behaviour of crops grown on plantations from the early stages of their growth till the harvesting time. Through this the yield potential could be estimated for the season and any stress could be detected and necessary action taken. The technique will thus be suitable for areas like the Brong Ahafo, Northern and the Greater Accra regions where the land is basically low lying and plantation farming in crops like maize, rice and yams have been in existence over a long period. Maize estimation based on remotely sensed data conducted by Peden in Kenya during 1984 produced highly appreciable results. The estimate of yield obtained from this experiment compared favourably with Kenya's Ministry of Agriculture and Livestock Department's projections for the year. It was found out that sampling which normally took five weeks to complete using ground methods took only one day using remote sensing techniques.

Remotely sensed data have the potential in improving livestock keeping in the country especially in the northern areas of Ghana. During each year information on possible grazing areas and usable water bodies will go a long way to assist livestock keepers to properly plan the movement of their animals, rather than move them southward even though there might be areas in their regions with equally good grazing pastures.

In the tropics often a limitation to agriculture productivity has been soil erosion. Satellite imagery could be used to provide a synoptic picture of how serious erosional activities are and necessary action taken to remedy the situation.

The location and destruction of locust and certain wild grasshoppers has been a major world agricultural problem for some time now. The problem of detection of habitat has almost been solved through the use of the multistage analysis using remote sensing techniques.

Landsat imagery has successfully been used in the detection of desert locust by Pedglay in Saudi Arabia. The Food and Agricultural Organisation has used Landsat imagery in mapping out locust habitat in Northwest Africa (Morocco, Mali, Algeria, Tunisia and Libya), East Asia, India and Pakistan and has made plans for mapping in West and East Africa as well as the Near East. Ghana's agriculture could benefit from such an exercise since wild grass hoppers are destroying crops in this country.

VEGETATION

Currently, Africa is experiencing its worse draught situation for some time now. Vegetation types, quality and quantity has suddenly become very important parameters in the world energy balance. Countries, especially in the Sahel region have witnessed their one time rich vegetation turn into woodland savannah, semi desert and desert. The rate at which this desertification problem is growing is so alarming that scientists all over the world are working hard to finding lasting solution to it.

The causes leading to this situation are well known and include overgrazing by livestock, certain farming practices, the indiscriminate felling of trees by timber contractors for short term gains and natural disaster like bush fires etc.

Remotely sensed data from orbiting satellites could be utilised for the mapping

of boundaries of the vegetation zones at any one time. This could provide an effective and dynamic tool for assessing the rate of desertification in the northern region of Ghana. An accurate mensuration of the areas of cocoa farms, forests, forest reserves and other cash crops damaged during the 1983 bush fires in Ghana is an important parameter for future policy making in these sectors. This could be achieved through the use of Remote Sensing Techniques (both aerial and satellite imagery). The author's experience shows that areas of forest reserves damaged could be determined through the use of Landsat imagery. By comparing imagery of the area before and after the damage had happened, the extent of the damage could be assessed and quick decision taken as to the appropriate reaforestation remedies necessary. Work done in Niger by MacLeod (USA) concerning desertification using Landsat imagery showed that it is a very important tool for monitoring boundaries of vegetational zones due to the long period of draught in that country. Both aerial and satellite imagery have been successfully used in Nigeria, Bolivia, Brazil to name only a few in the third world. Remote Sensing techniques have been used to spot bush fires in a number of countries including the U.S.A. and Australia recently.

GEOLOGICAL EXPLORATION

Satellite imagery has been known to be applicable for:

i. mapping of regional and local fracture systems that control ore deposits;
ii. detection of surface alternation effects associated with ore deposits and generally providing basic data for geological mapping[1]

Ghana is a mineral rich country with many of its ores not mapped out. So with the aid of satellite imagery most of these ores could be explored. Landsat imagery has been used in a number of developing countries for the exploration of ore. Notable examples include the copper prospecting in Pakistan, exploration for oil in eastern Kenya, gold district mapping in the Philipines and the oil exploration in Quantamala [2].

A Seminar sponsored by the UN on Remote Sensing Applications for developing countries in 1977 made a number of important recommendations which go to support the use of remotely sensed data in this field. The delegates affirmed the application of remote sensing for oil prospecting and geology by means of structural features which are significant with respect to the localisation of mineral and energy resources and the location of seismic activity. It was also accepted that Landsat MSS can be used for mapping rock types, geochemical anomalies to the occurrence of mineral deposits of various types.

WATER RESOURCES AND LAND-USE PATTERNS

The provision of drinking water for the whole world population has been one of the major undertakings by the U.N. In Ghana, the Ministry responsible for water resources is considering drilling bore holes in communities without access to pipe borne water. Remote sensing data could help in the identification of aquifers through geological mapping. Surface drainage is easily assessed using Landsat imagery. Landsat imagery is very useful in mapping out large water bodies and could be used in monitoring the surface area of the lakes, Volta and Bosomtwi over the dry and wet seasons by examining the shore line changes that may occur. Satellite imagery could prove very useful in monitoring periodical flooding and flow of rivers and lakes which cause a lot of destruction in the country.

The application of satellite imagery for land-use mapping has already been proved to be very useful to planners in the large towns and cities especially Accra and Kumasi.

ENVIRONMENTAL PROTECTION

In recent years the voice of the environmentalist has been heard by those who care everywhere. This is especially louder in the developed than in the developing countries. Wherever they may be the message in all cases is the same: the parameters of the environment must be protected to ensure its balance now and in the future. In Ghana there are two organisations whch are concerned with the protection of the environment namely, the Environmental Protection Council

and the Ecological Society. The management of ecological systems which give protection to the habitat of wild life would greatly be improved if remote sensing data is used. This method would ensure that information is updated.

With the aid of meteorological satellites data on the levels of pollutants in the atmosphere could be estimated. It would be both economically and socially better now to tackle the pollution problem very seriously than to wait until they approach European and North American levels before spending huge amounts of money to clean an already destroyed atmosphere. With the use of satellite imagery, it should be possible to map out towns and cities which are most polluted [3].

Water pollution is another sector where remote sensing data could be helpful. The quantities of industrial and domestic wastes being driven into the sea, rivers and lakes in the country are fast increasing. There is therefore the need for a better method of monitoring such activities with the aim to preventing eutrophication of the country's freshwater bodies. The case of the Volta lake is particularly important, the quantities of algae, mud and other waste materials at any time must be accurately known since it is an important parameter in the country's energy equation.

Recently a regional committee has been formed to look into methods and techniques of overcoming erosion along the West African coastline. This is another secton where Remote Sensing could play an important role since as early as 1977, the U.N. Seminar on Remote Sensing had approved of its use. The delegates at that Seminar [4] had agreed that remote sensing data could be used for the following oceanographic applications.

i. Analysis of coastal dynamics, ie. shoreline changes, nearshore current patterns, directions and relative densities.

ii. Improvement in the mapping of shallow waters.

iii. Monitoring of on-shore environmental changes (including land use).

iv. Mapping of the distribution of oil on water (using reflectance properties)

v. Providing improved small scale maps (1:2 000 000) of some near shore areas.

A particular place in Ghana where marine remote sensing data could be very applicable would be the Keta district where sea erosion is a problem. The use of Landsat imagery for marine application has been demonstrated in several countries including Philippines.

CARTOGRAPHY

In most developing countries the availability of maps is a problem. With Satellite imagery cartographic maps could be compiled within a short time. Cartographic maps of 1: 250 000 and smaller scales have been made through the use of Landsat imagery. Landsat and Salyut imagery is very useful in the revision of old cartographic maps as well as making new thematic maps for the different disciplines (eg. forestry, water resources, highway, urban studies etc). With the launching of SPOT, it is now possible to assemble maps on Ghana to about 1: 50 000 or larger scales.

EQUIPMENT AND COST

In discussing the cost involved in the application of remotely sensed data, the following cost elements should be taken into consideration among others:

i. the cost of data acquisition

ii. data processing and dissemination

iii. the establishment of ground controls (geodetic) and cartographic printing.

The cost of data acquisition here excludes the cost of the launching and operation of the platforms involved but includes the purchase of either CCTS (Computer Compatible Tapes)or film based products. The cost of one CCT is currently between $1000 - $5000 (platform dependant). Data could also be acquired on film either black and white or colour. The acquisition of the CCTs implies the establishment of a mainframe computer set up, hence the purchase and instalment of an appropriate computer system capable of handling the volume of data envisaged on the national level. The cost of data processing includes the cost of computer processing of electro-optical

transmitted data or the duplication of film products. The cost of establishing geodetic ground controls would be similar to that of the conventional land surveying operations. The same can be said about the cost of cartographic printing. The only advantage of satellite imagery (eg. SPOT) is the greatly reduced number of stereo models as compared with conventional mapping using aerial photographs.

Some of the equipment needed for the effective application of Satellite remote sensing data may include, spectrometers, desitometers, radiometers etc. for the purposes of calibration and instruments like Kartoflux, MSP4C, Interpreterscope mirror stereoscopes etc. for the interpretation of the data received. There would be the need for the establishment of a modern photographic and printing laboratory for the development and printing of both photographic and map products.

It is now clearly evident that the total cost discussed above could be categorised into two main groups, that is, capital expenditure, which include items like, an operational computer system, instruments for calibration, interpretation and printing. The second category would be recurrent expenditure for cost items like, the maintenance of the various sets of equipment installed, the purchase of CCTs, film products and the general cost involved in the general running of the facility. In view of the above and with knowledge of current prices, the cost involved in establishing a national remote sensing facility would be in the order of $0.5m - $1m.

A CASE STUDY

To illustrate practically how satellite images may be used in the various fields as has already been explained in the previous paragraphs, a case study dealing with hydrology, geology and vegetation was undertaken. A visual interpretation of three Landsat (Black and White) images of the same scale (1: 1000 000) was made and three thematic maps prepared accordingly.

Vegetation:

The image in Figure 1 represents a section of the forest reserves of the Brong Ahafo and Ashanti regions - (between Lat. 6°30' - 8°00'N and Long. 1°30' - 3°00'W). It is a 1973, November Landsat coverage. Figure 2 shows the interpretation of the image in Figure 1. Figure 3 is a reference map of the forest reserves of the area under study. The forest reserves are distinguished from the general vegetation cover, due to their almost regular shapes as well as their darker tones. It was not possible to differentiate between the two predominant vegetation cover of the area namely the Celtis - Triplochiton and the Antiaris Chlorophora Associations. This was because the two are both deciduous forest types and therefore have similar reflectance. It was possible to delineate within the forest reserves, sections which have been affected either by clear-out for timber or bush fires as in the case within the Pamu-Berekum and the Bosumkese reserves. Two major observations which could be made as a result of the interpretation were that:

i. apart from the forest reserves, there remains very little virgin forest left in a region considered to be one of the most densely forested in the country;

ii. hydrological elements are closely associated with the vegetation and therefore are easily recognised due to the darker tones depicting healthy vegetation.

The first observation makes the case for an integrated scheme for both clear-out and reaforestation very urgent if the forest nature of the vegetation were at least to be maintained. A field verification trip coupled with some existing forest data confirmed both observations made by the author.

Hydrology (Drainage)

Figures 4 and 5 show the image and the thematic maps of the area under study. It is a Landsat coverage (9° 30' - 10° 30'N and 2° 30' - 3° 30'N) of partly north-western part of Ghana along the middle section of the Black Volta and partly some territory of Ivory Coast. Almost all the major hydrological elements could be delineated. The region could be said to be very well

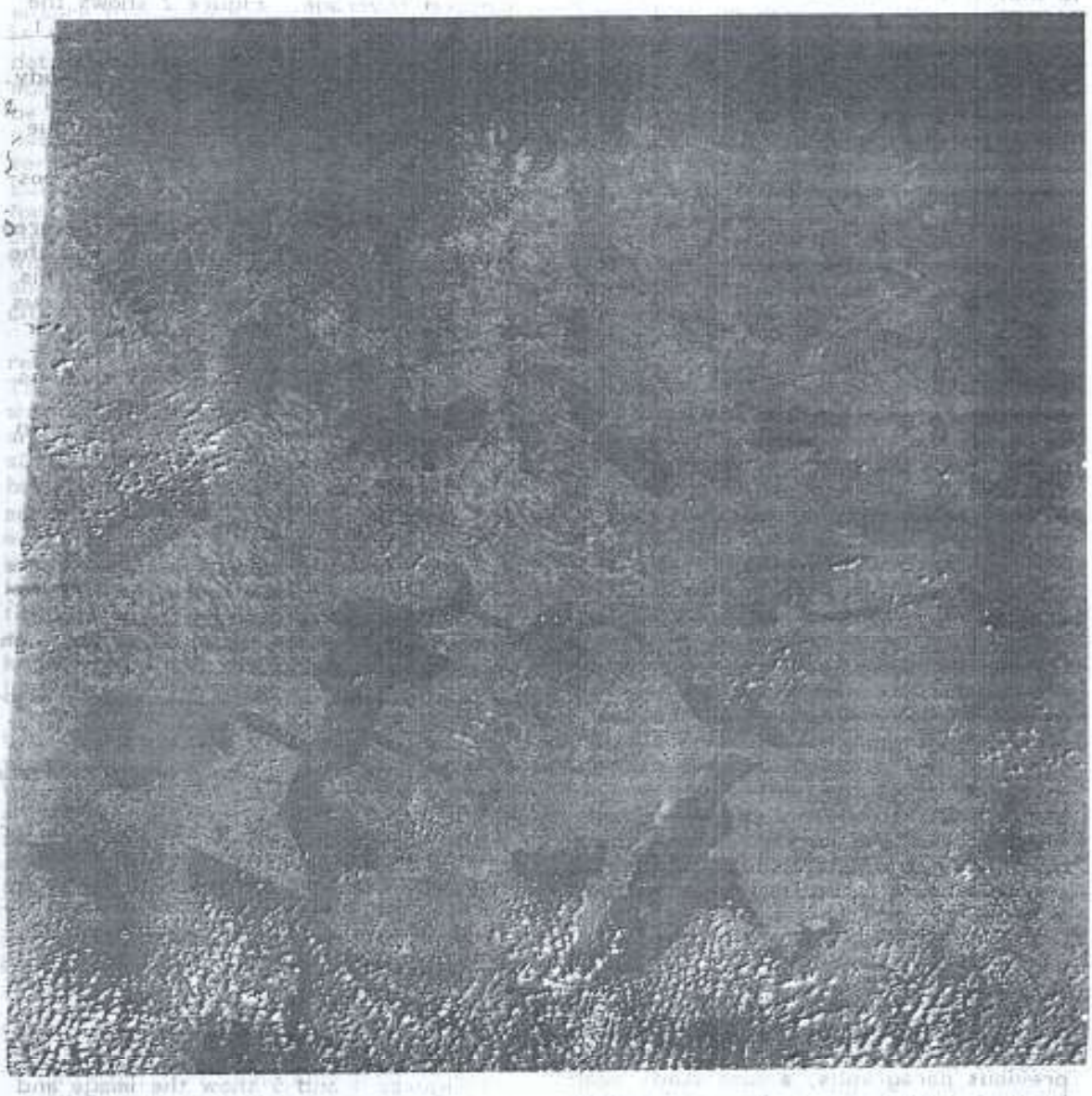

FIG.1 LANDSAT IMAGERY SHOWING THE FIRST STUDY AREA
(The Regular Darker Tones show the Forest Reserve Boundaries. The White patches depicts clouds cover. Scale 1: 1000 000)

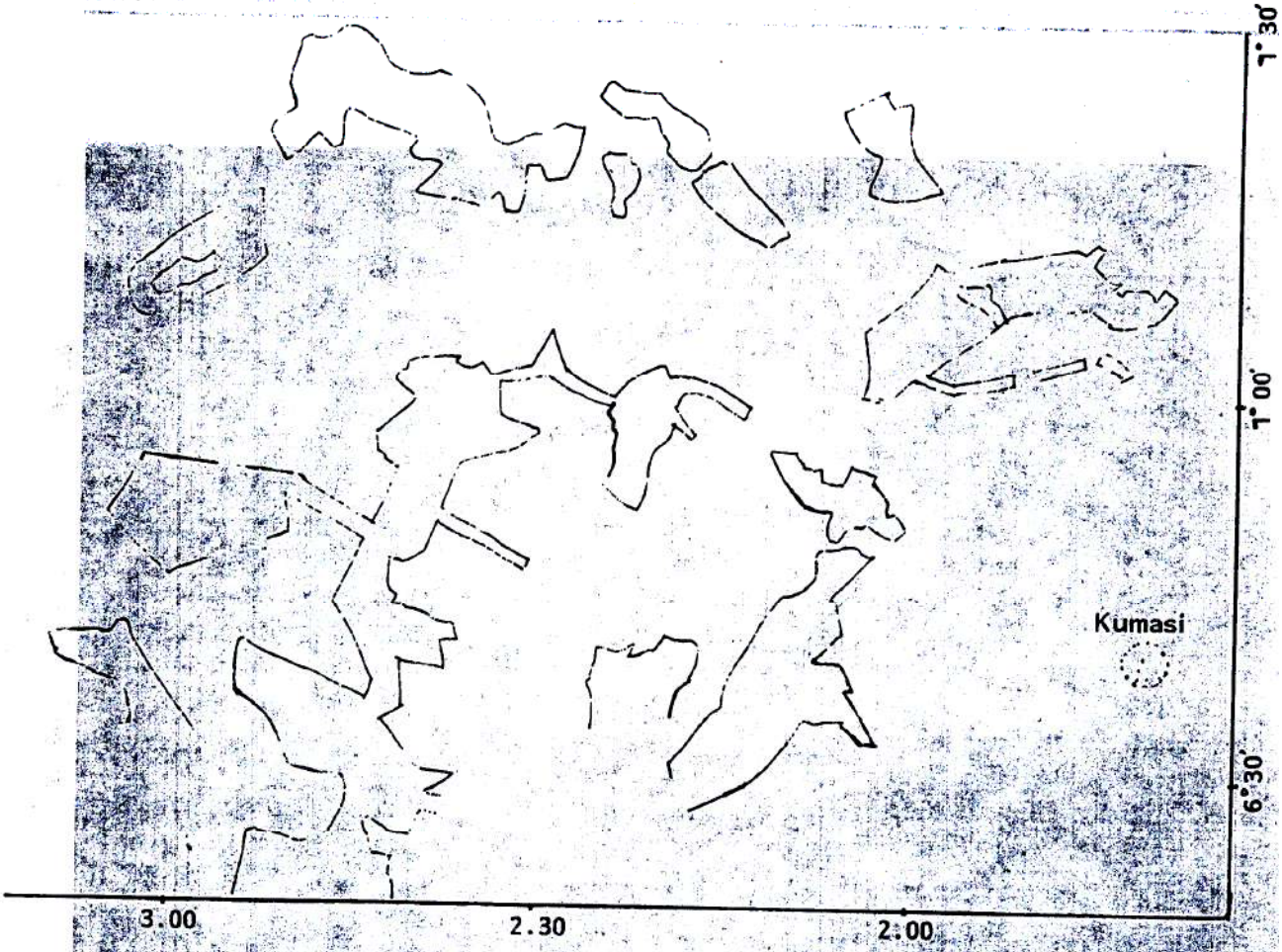

FIG.2 THEMATIC MAP MADE FROM THE LANDSAT COVERAGE IN FIGURE 1 SHWOING THE BOUNDARIES OF THE FOREST RESERVES IN THE STUDY AREA (Scale 1:1000 000)

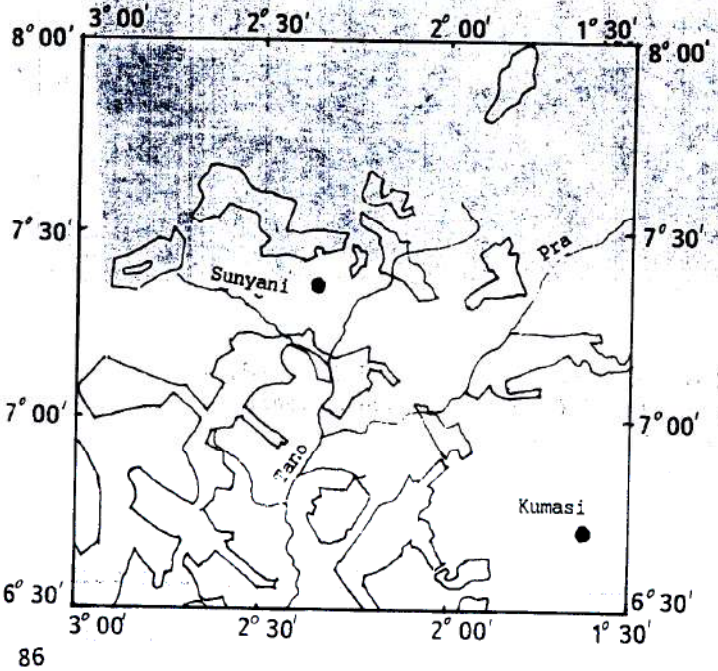

FIG.3
A REFERENCE FOREST RESERVES MAP OF THE FIRST STUDY AREA (SCALE 1: 2000 000)

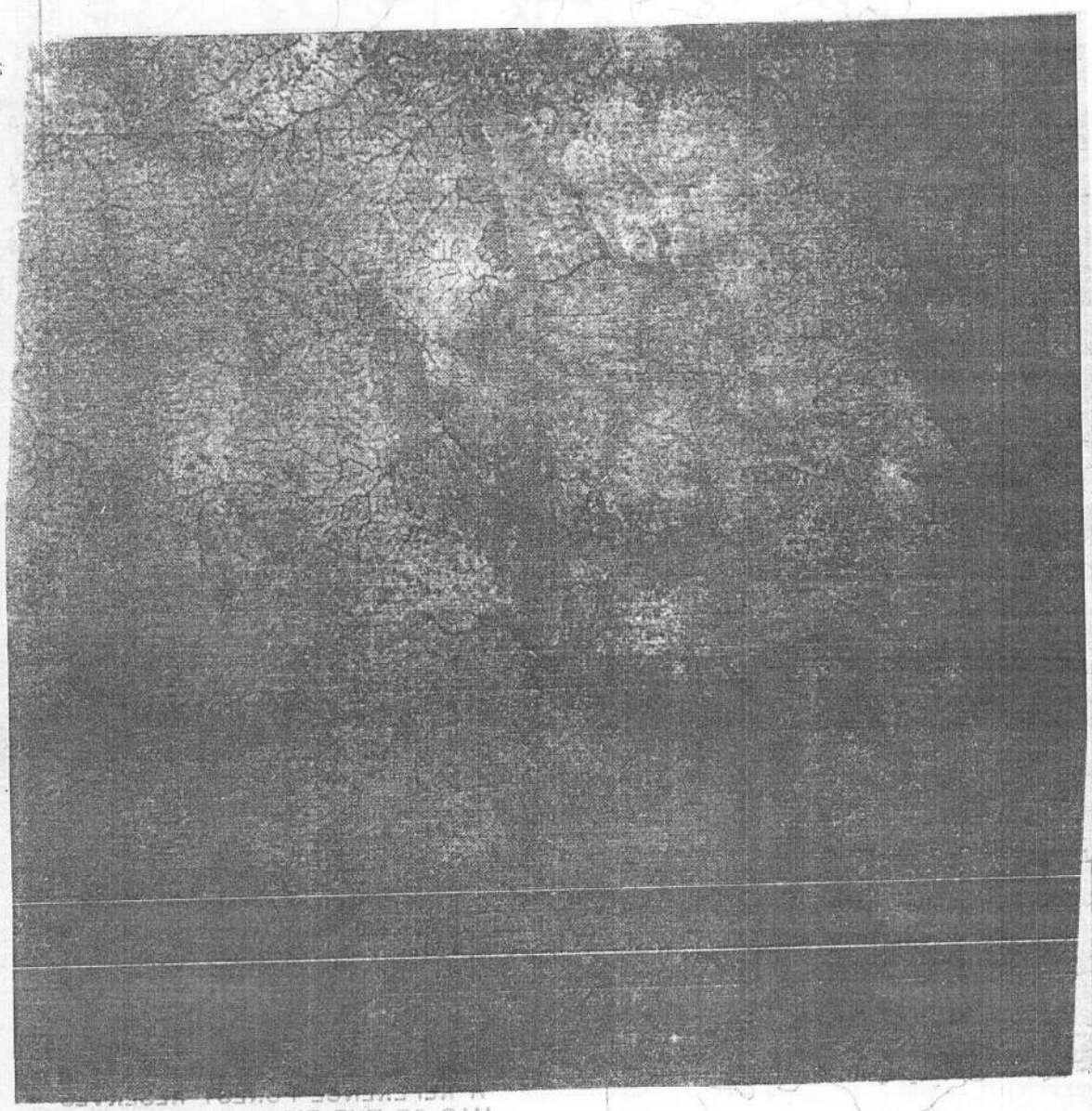

FIG 4: LANDSAT COVERAGE OF THE SECOND STUDY AREA
(This Shows some parts of Ghana and Ivory Coast
Scale 1: 1000 000)

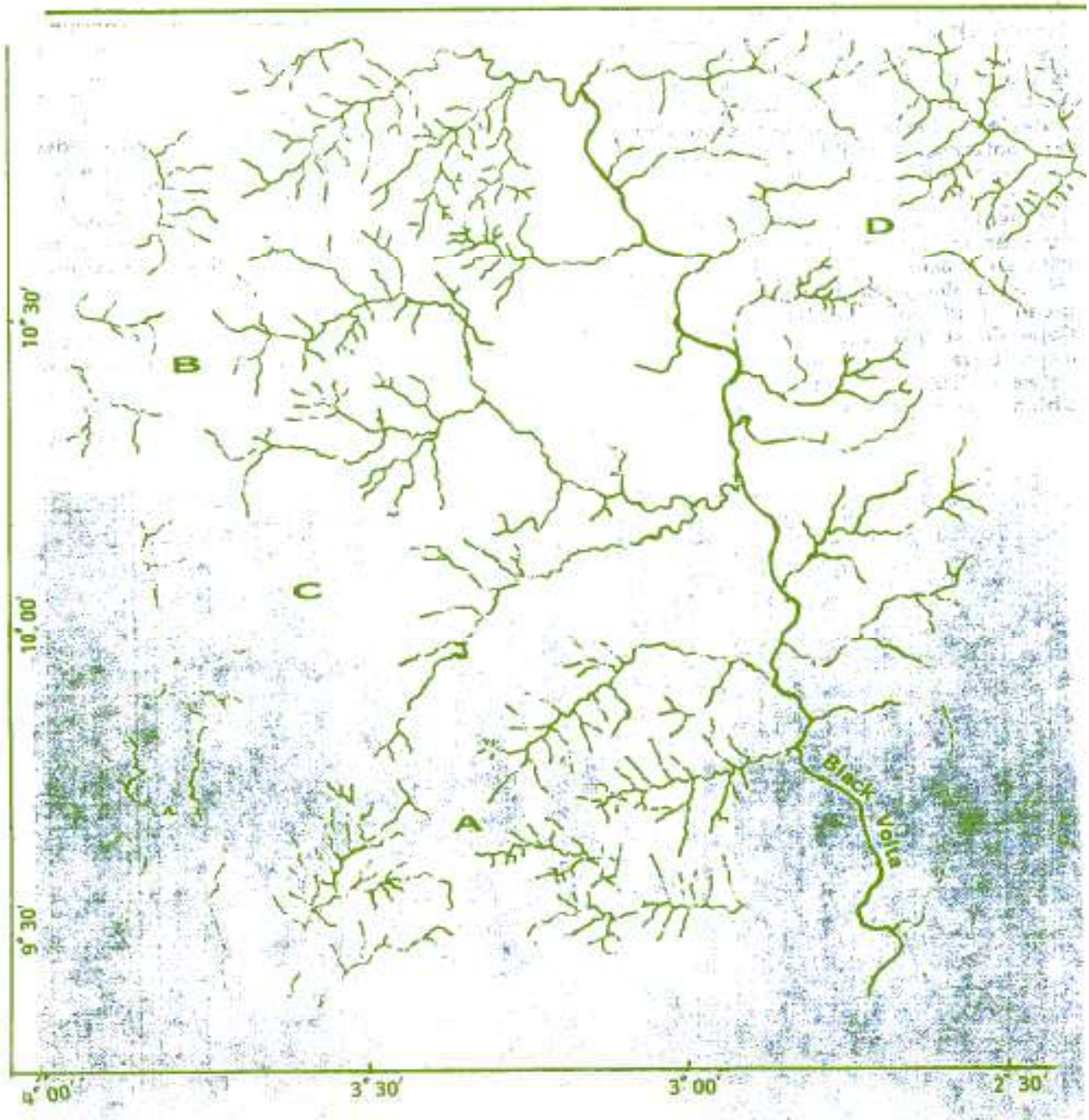

FIG.5 A THEMATIC MAP SHOWING THE DRAINAGE PATTERNS OF THE SECOND STUDY AREA (Scale 1: 1000 000)