MONITORING OF ROREST AND FOREST RESERVE BOUNDARIES IN GHANA USING SATELLITE (LANDSAT) IMAGERY

B.E. KWESI PRAH
UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI
GEODETIC ENGINEERING DEPARTMENT
P O BOX 337
U.S.T., KUMASI
GHANA.

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INTRODUCTION

In most countries, the ideal ratio of forest reserves to the total general forest stands is about 25% to 75%. In Ghana however the ratio is only about 10% to 90% and this is even not stable since the reserves are being threathened by enchrochment due to human as well as external physical factors.

The present method of monitoring forest reserve boundaries in the country consumes too much time and manpower. There is therefore the need to look for a more dynamic and systematic method to replace it, since foot patrol units alone cannot be relied upon to effectively monitor changes caused to the forest stands due to disease, bush fires, inadequate cultivational practices etc. Only a limited amount of monitoring of forest volumes has been conducted with the application of aerial photography. This limitation is due partly to the fact that the country does not prossess its own aerial photographic unit and therefore has to rely on outside assistance, which most often is rather very expensive and consequently not attractive to the appropriate government departments directly involved.

The only viable and modern alternative method to solving the effective monitoring of forest and forest reserve stands is the application of satellite imagery. Since data is received every 16 or 18 days by Landsat programme, it provides a more dynamic way of information collection and has the advantage of drastically reducing the time and labour requirements. The repetitive nature of the data aquisition makes it possible for a more comprehensive and temporal analysis.

The paper seeks to demonstrate the feasibility of applying satellite imagery to the monitoring of forest stands for the first time in the country . The investigation was broken down into two phases, the first phase delt with the possibilities of producing thematic maps of forest boundaries using satellite imagery Efforts were made to revise the existing forest map.

The second phase conducted investigation to determine the causes for the changes of forest boundaries so detected and mapped during the first phase. The paper therefore investigates such causes like, clearcut for timber and its effects on the forest stands, bush fires, disease, illegal farming in the reserve zone, cultivational practices and makes proposals as to how to protect the forest stands against some of the causes mentioned above and how to help regenerate the forest stands so damaged especially the forest reserves.

The Study Area

The area under study falls within 6^{o}N - 7^{o}N 45'N and 1^{o} 30'W-3^{o}10'W (Fig. 1). It lies within the Ashanti and Brong Ahafo regions and North West of Kumasi the capital of Ashanti region. The forest reserves in the area include the Mpameso, Bia-Tano, Boukondi, Subin, Bia North, Bosomkese, Desire, Wamisa, Pamu, Berekum, Tain I and II, Amama shelter Belt, Asukesi, Afram Head waters, Tinte Bepro, Tano-Offin and some minor stands. These form part of the main forest zones of the country and part of the Antiaris Chlorophora and the Celtis Triplochiton Association (i.e. ACA and CTA). The area forms part of the heavily exploited regions for timber logs and its related wood products in the country. Cocoa and other cash crop farming is the main occupation of the inhabitants in the subregion. All these activities contribute to ernomous amount of forest clearing. This was the most affected region in the country, during the 1982-83 bush fire.

Method

Visual interpretation using satellite images, aerial photographs and reference maps was employed since this seemed the best technique at the moment. This is because the objective is not to classify the forest stands into tree types which is in its self very difficult even with the aid of computers, given the hetregeneous nature of the tropical forest which makes spectral classificational method [2] very difficult since the trees have similar reflectance response.

The multistage concept [1] of analyses was employed in this investigation. Landsat images both colour and black/white and of 1:1000000 and 1:250000 scales were used. The images were 1973 adn 1984 Landsat products. Aerial photographs covering one of the forest reserves (Bosomkese forest reserve) was used for detail analyses in that reserve. These photographs were of 1:30000 scales. Forest maps of 1:500000 and 1:2000000 scales compiled in 1969 and 1979 were used as reference materials for the interpretation. The interpretation of the black/white and the colour images were used to complement each other for the general study area.

The Bosomkese forest reserve area was chosen for a much detail analysis due to the diverse spectral characteristics of the area and also its central position with respect to the study area. A field trip with the aim of collecting ground truth was undertaken and interviews conducted with a cross section of the inhabitants of the area who are mostly farmers based

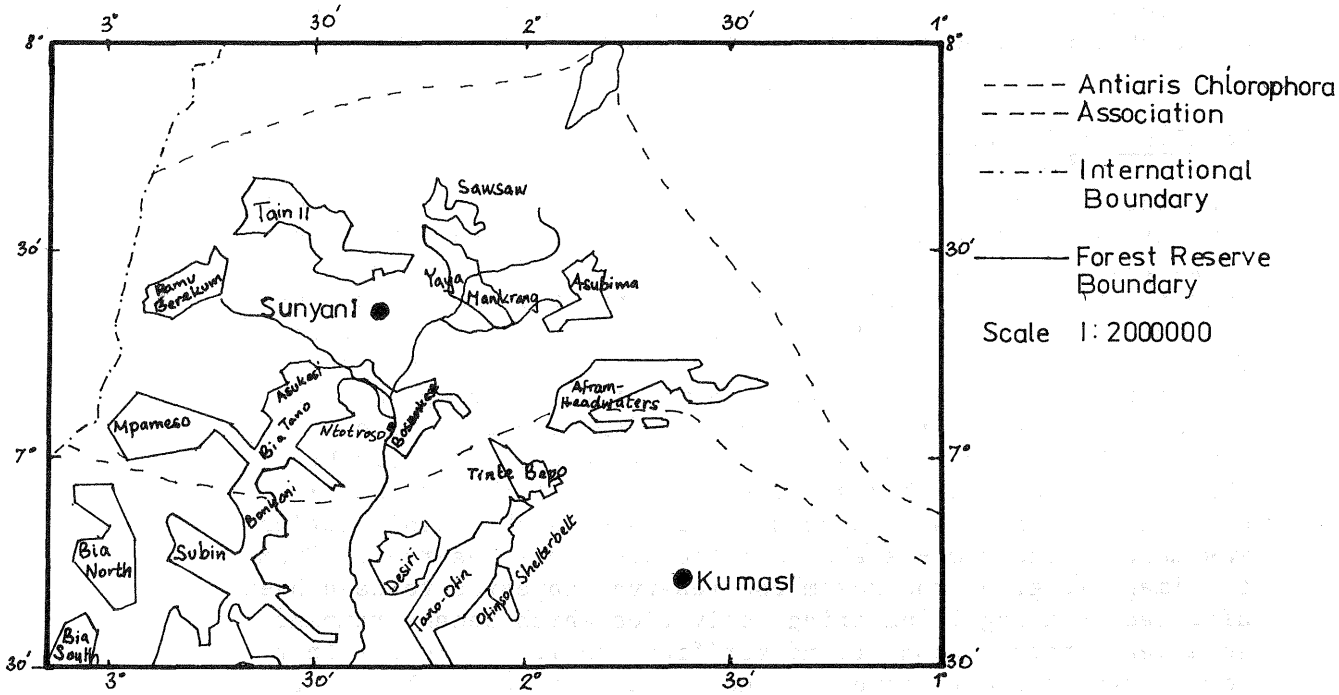

FIGURE 1: A reference map showing forest zones and forest reserves distribution, study area for the project.

on a carefully proposed questionnaire. The questionnaire was designed to seek information for example, on the farming practices, their advantages and disadvantages with respect to yield per unit, problems with soil fertility and the use of natural and antificial fertilizers, the problems of natural disasters (diseases, flooding, bush fires etc) malpractices in lumbering and methods and techniques used to overcome some of the above problems.

Results and Discussion

From the available Landsat imagery it became clear that forest boundaries could be mapped out especially the forest reserves (Fig. 2). The forest reserves appeared very distinctive on both the black/white and the colour composite. As was expected channel 7 was most useful in the forest boundary delineation. The reserves appear very distinct because in most cases their immediate surroundings had been farmed for cash crops and cocoa or made up of scattered tall trees due to recent clear cut for timber. Within the reserves it was possible to classify broadly the forest stands with respect to the ages of the trees. (i.e. old and young stands). A good examples of such classification was made on the Pamu-Berekum and the Bosomkese reserves. From the image [Fig. 3] the Bosomkese reserves appeared to have been affected by illegal lumbering activities which became rampant some years back. Upon ground verification it was learnt that some parts of the reserve had been clear cut for timber in the early 1960's, legally by Mim Timbers Company, and has been affected by bush fires in the late 1960's. An attempted afforestation programme had failed in the 1970s due to bad selection of trees. However the Forestry Department had kept on with the reafforestation programme with teak trees and it is progressing steadily. It was during the ground verification trip that a hider to unknown programme of reafforestation within the forest reserves was made known to the writer and indeed to most of the professionals community outside the forestry department. This programme is known as the TAUNGYA system. This system came into existence as a result of the need for the village communities in the vicinity of the reserves to search for arable land to farm for food crops since they had put almost all available land under cash crop cultivation (especially cocoa). They therefore approached the government and asked to be allowed to farm in the forest reserves. At the same time the farmers were searching for land to farm, the Forestry Department was also looking for funds to carry out its reafforestation programmes so the department and farmers together worked out this new system. According to the rules governing this system, the farmers form co-operative-like groupings led each by an elder who is responsible to the Department of Forestry. Each individual is allocated a plot within that given to the group in accordance to the direction of afforestation as decleared by the Forestry Department. The farmers clear the land to be reafforested and prepare the land for planting. Any food crop could be planted except the cassava plant. During the following rainy season the Forestry Department plants the approved type of tree for that particular reserve zone. This agro-foresting

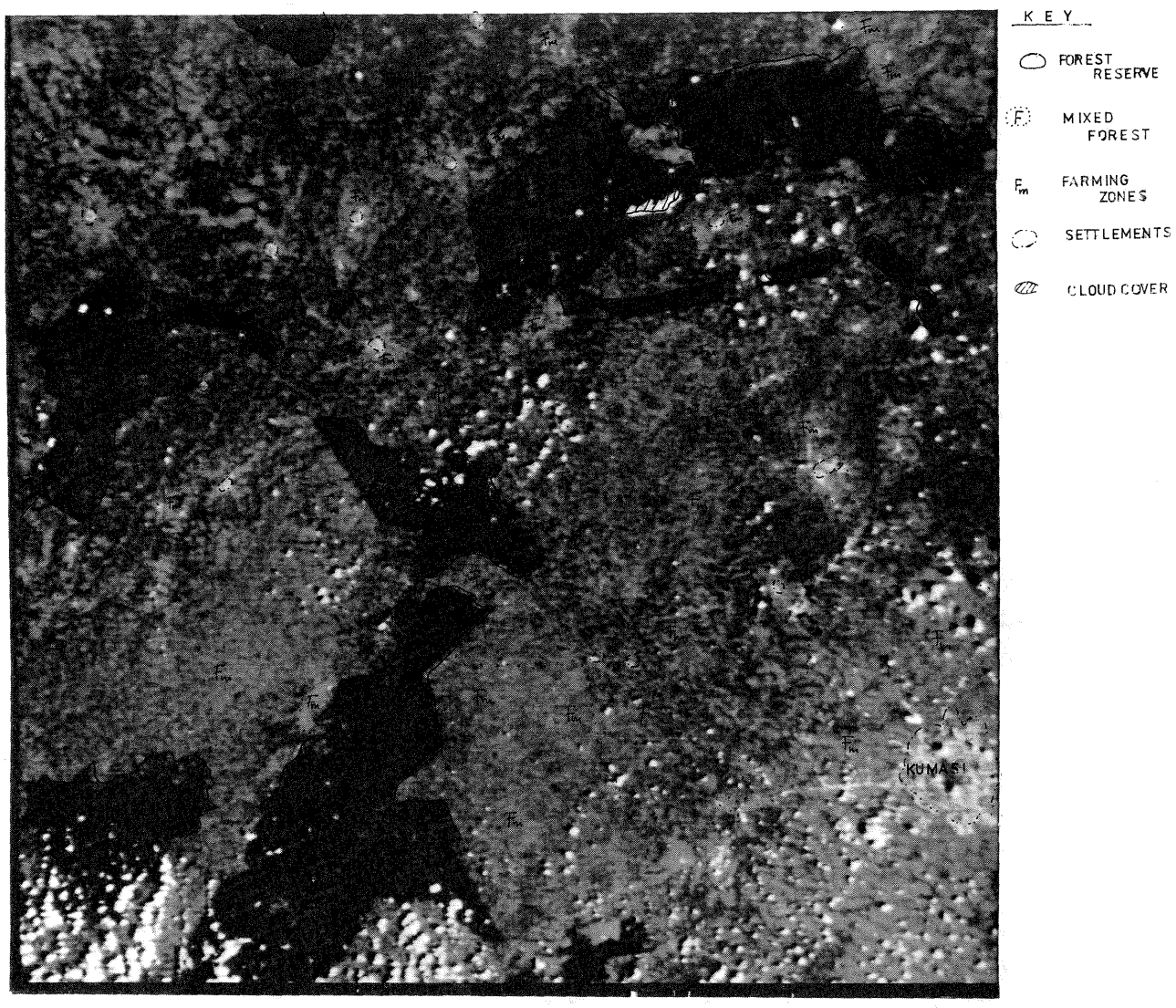

FIGURE 2: Interpretation of a Landsat imagery showing forest reserves boundaries, mixed forest (i.e. pure forest stands and cocoa farms with forest canopy), farming zones and settlements.

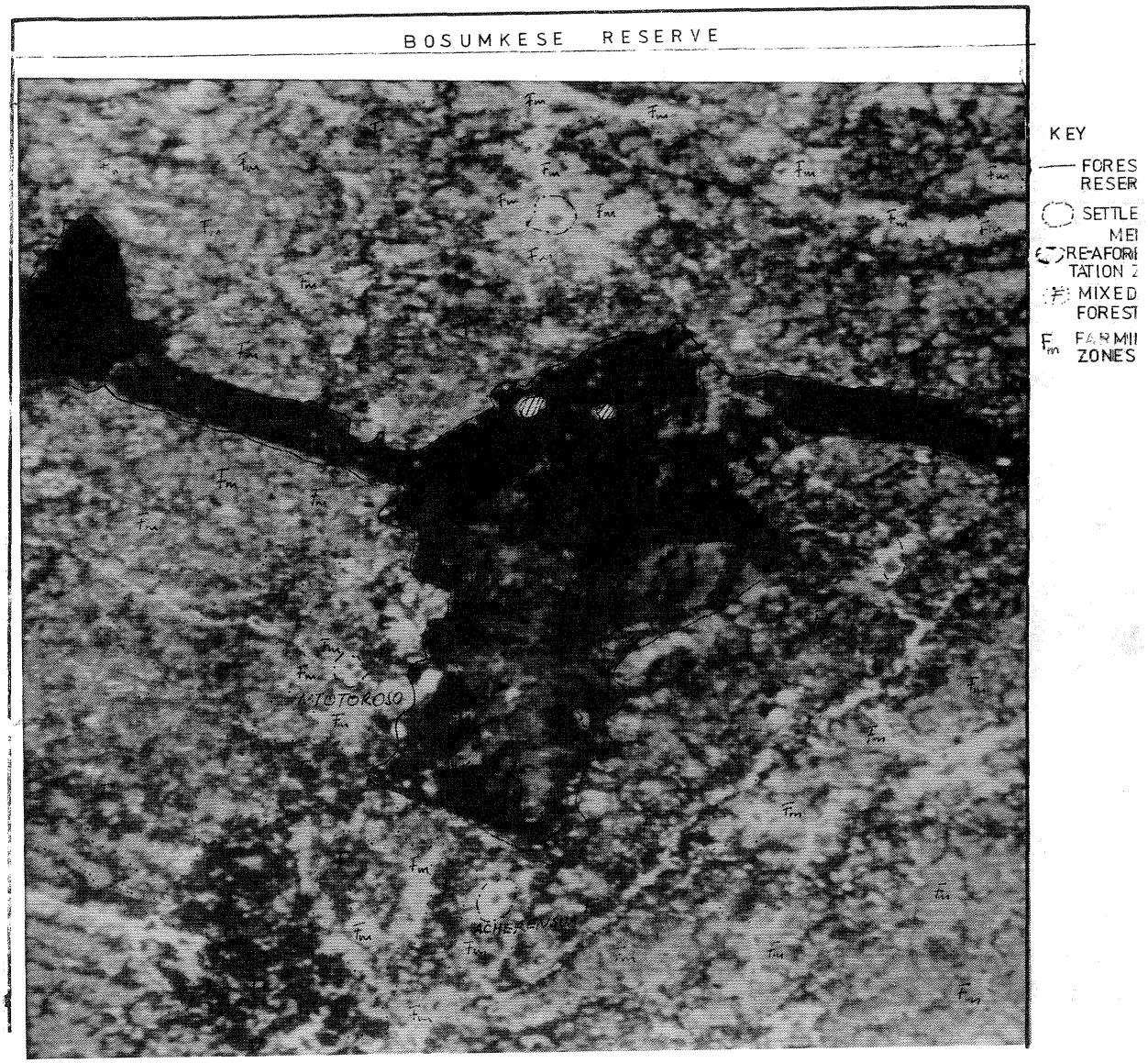

FIGURE 3 An interpretation of a Landsat imagery (25-11-73) showing details of the Bosumkese forest reserve area. The reaforestation zones represent areas either presently under reaforestation or yet to be, but had been either affected by clear cut or bush fires before. Mixed forest zones are areas either of pure forest stands or cocoa farm with forest canopy.

system goes on until the trees are matured enough for their roots to be disturbed by the agricultural practice. By this coexistence the farmers got their foodstuffs while the Forestry Department received the necessary man-labour for the reafforestation programme.

During the interview with the farmers on the site visit it became clear that the farmers were very knowledgeable about so many of the factors which affect the earnings from the land they farm. For example about 90% of the farmers asked about the application of artificial fertilizers, said they were aware of it but applied it only for vegetables and not for other food crops. Asked about the reason why they only applied it for vegetables, majority of them answered that it was not cost effective to use fertilizers for food crops since the local prices were low. Asked why they kept on with the shifting cultivation activities majority of them said they were not aware of any other farming practice except that. The rest who know about other agricultural practices also could not practice them because of the difficiences in acquiring the necessary capital. The farmers were asked whether they knew of the problem of soil erosion. About 60% said they were not aware, the 40% who were aware also did not think it a serious problem. Answering a question on the problem of the changing rainfall pattern, they all apportioned the blame on the massive indiscriminate felling of trees for timber in the forest regions. Asked if they could recollect either from history or their own experience about any natural disaster which might have caused a lot of damage to the forest stands like diseases, flooding and bush fires, they could all not remember any such problems except the 1960s and the 1982-83 bush fires which has since become a common phenemenon in the country.

Conclusion

The research project on which this article is based is only in its early stages and therefore much experience would be gained as it progresses. However some important conclusion can be drawn pertaining to the work already done.

1. All significant forest reserves can be completely and accurately identified and mapped out using Landsat images of scales between 1:200000 and 1:1000000 used for the project.

2. Outside the forest reserves it was very difficult to identify pure forests from "agro-forest" stand example of which would be the cocoa plant which is normally planted under the canopies of forests. The fact that in Ghana the various 'stools' elders decide on which parts of their lands are to be farmed, gives rise to the situation where large streches of land has been farmed in patches thus making interpretation very difficult since there is no uniform and continuous spectral signature registration. Despite the above difficulties landsat images could be used on the regional bases to identify vegetation cover be it pure forest or tree crop stands.

3 It became obvious that Landsat images could serve as a dynamic tool for the revision of the existing forest maps especially the forest reserve maps. This would be very cost effective considering the cost and time involved in compiling data for the production of the map.

4. From the results of the interview with the farmers in the forest zones examined it can be concluded that they are aware of the parameters such as effect of shifting cultivation, bush fires and indiscriminate felling of trees for timber which lead to the degradation of the forest stands though some more education may be necessary to get them actively involved in implementing the solutions to the problems such as the introduction and development of the Taungya systems outside the forest reserve zones.

5. For much detail investigation of the tropical forests the multistage concept must be applied.

From results of the investigations, it could be proposed:

1. That the monitoring be extended to cover the whole country and that a section dealing mainly with the application of Remote Sensing data be set up in the Forestry Department so that the investigation could be conducted jointly with them.

2. That education in the application of satellite data be started in the country which will help build up the necessary professionals ready to help with the utilization of such data.

3. That the farmers living in and around the forest zones should be educated and helped to form fire fighting bridgades to minimise the extend and damage to the forest stands due to bush fires.

4. That SPOT images be used since they could be viewed stereoscopically. This would enhance most likely classification of forest types which is a likely problem when using Landsat images.

Acknowledgement

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