


**USING REMOTE SENSING/GIS FOR A STUDY OF
AGRICULTURAL LAND USE CHANGE IN AKWAPIM
SOUTH DISTRICT**

BY ALBERT N. M. ALLOTEY

**DEPARTMENT OF GEOGRAPHY AND RESOURCE
DEVELOPMENT, UNIVERSITY OF GHANA, LEGON,
ACCRA**



**THESIS PRESENTED TO THE DEPARTMENT OF
GEOGRAPHY AND RESOURCE DEVELOPMENT,
UNIVERSITY OF GHANA, IN PARTIAL FULFILMENT OF
THE REQUIREMENT FOR THE AWARD OF MASTER OF
PHILOSOPHY (M.PHIL) IN GEOGRAPHY AND
RESOURCE DEVELOPMENT**

MAY, 2000



G 364831

S494.5 R4 A6 5

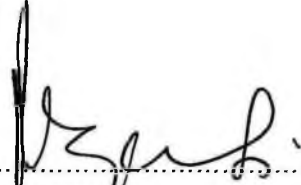
bltc c.1

DECLARATION

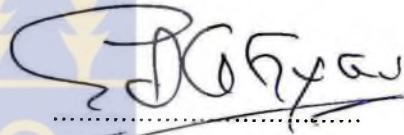
I hereby declare that this thesis is my own original research under supervision. Where references have been made or cited of other views, they have been adequately acknowledged. Furthermore, this thesis has never been presented either in part or wholly to any other institution for the award of any degree.



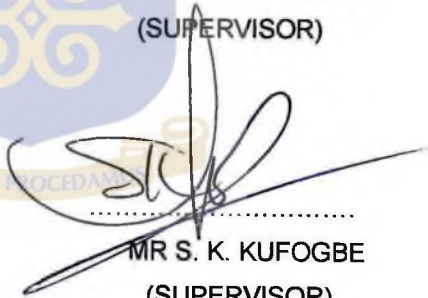
.....
ALBERT N. M. ALLOTEY
(CANDIDATE)



.....
PROF. P. W. K. YANKSON
(PRINCIPAL SUPERVISOR)



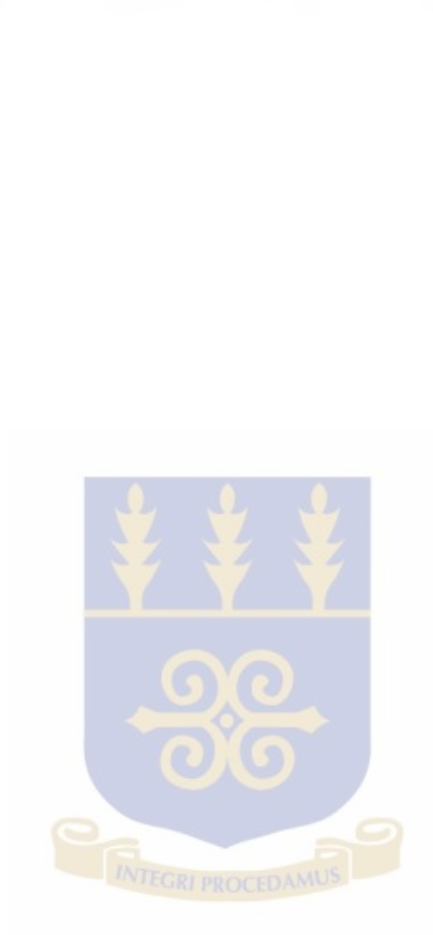
.....
PROF. E. A. GYASI
(SUPERVISOR)



.....
MR S. K. KUFOGBE
(SUPERVISOR)

DEDICATION

Dedicated to the memory of my late mother, Margaret Josiah, who died on 24th November 1998 and was buried on 12th December 1998.



ACKNOWLEDGEMENT

I wish to express my profound gratitude to all senior members of the Department of Geography and Resource Development for their constructive criticisms and contributions during the presentation of the proposal for the study at a graduate seminar. I am greatly indebted to my supervisors, Prof. P. W. K. Yankson, Prof. E. A. Gyasi and Mr S. K. Kufogbe, for their thorough and authoritative criticisms and valuable suggestions from the proposal to the final stages. My indebtedness also goes to Mr Richard Kofie of the Council for Scientific and Industrial Research (CSIR), who is a PhD student as well as a senior colleague of the Remote Sensing Application Laboratory (RSAL), Department of Geography and Resource Development, who offered many useful comments.

I wish to also acknowledge the following for their invaluable contributions towards my M.Phil programme: the DANIDA ENRECA Project for funding my fieldwork, and RSAL for the use of its facilities for my work.

I further wish to express my gratitude to Mr Alfred Mensah of the Policy Planning, Monitoring and Evaluation Division (PPMED) of the Ministry of Food and Agriculture (MOFA) for providing making the necessary data without any hesitation, to Mr George Qaiquo of the Council for Scientific and Industrial Research (CSIR), Mr Martin Adu-Owusu, Assistant Marketing Manager, New Times Corporation, Mr Joseph Antah, School of Communication Studies, University of Ghana, Miss Awo Ohenewa Agyei of the English Department, University of Ghana, Legon, and Miss Charlotte Carboo of Nungua for their

helpful comments and precious time spent in editing this work, and to Mr Samuel Adu-Prah of the Centre for Remote Sensing and Geographic Information Studies (CERSGIS), for his suggestions and constructive comments.

No amount of words can adequately express the debt of gratitude I owe my colleague students who worked in the RSAL with me: Osman Alhassan, Morgan Attua, and Opoku Pabi, all PhD candidates; and Paul Oppong, a master's candidate. This work wouldn't have been completed without their help. My sincere thanks go to my fiancée, Miss Mavis Carboo, for her constant encouragement and forbearance, and finally to all those who offered varied advice and help, but have not been mentioned specifically.

ABSTRACT

This thesis examined the changes in land use in the Akwapim South District where agriculture has undergone significant changes since the 1930s when cocoa farms were destroyed as a result of the invasion of swollen shoot disease.

The methodological approach explored Remote Sensing and Geographic Information Systems (GIS) as tools for investigating the phenomenon. Aerial photographs of 1972/74 and Landsat Thematic Mapper (TM) satellite images of 1985 and 1991 supported the analysis of changes in the land use pattern. 'Ground truthing' was then conducted to validate the findings. The analysis showed that the change in agricultural land use have not been uniform over the entire landscape during the period under study. They are more pronounced towards the central, north, and northeast where most commercial farms are sited.

To unravel the causes of the changes in land use, field investigation was conducted as a supplement to the remotely sensed data. Among the demographic, cultural and socio-economic variables examined, it was found that some indicators, such as changes in tenancy arrangements and profit maximisation as one engages in cash crop production, have put undue pressure on land resources. Among the poor farmers, continuous cultivation has resulted in soil fertility depletion, low yield and, above all, poverty. Deforestation and soil erosion are also part of the environmental threats in the Akwapim South District. The GIS approach has also created a relational

database, stored in a computer memory, which can be manipulated for the purposes of decision making in the district.

It is recommended that similar research be carried out in other districts not only in environmental resources, but also natural resources to help agricultural extension officers in planning effectively for sustainable agricultural land use in the country.

TABLE OF CONTENTS

| | | | | | |
|-------------------|-----|-----|-----|-----|-----|
| DECLARATION | ... | ... | ... | ... | i |
| DEDICATION | ... | ... | ... | ... | ii |
| ACKNOWLEDGEMENT | ... | ... | ... | ... | iii |
| ABSTRACT | ... | ... | ... | ... | v |
| TABLE OF CONTENTS | ... | ... | ... | ... | vii |
| LIST OF TABLES | ... | ... | ... | ... | x |
| LIST OF FIGURES | ... | ... | ... | ... | xii |
| LIST OF PLATES | ... | ... | ... | ... | xiv |

CHAPTER ONE

| | | | | | |
|-------|--------------------------------------|-----|-----|-----|----|
| 1.0 | GENERAL INTRODUCTION | ... | ... | ... | 1 |
| 1.1 | Background to the Study | ... | ... | ... | 1 |
| 1.2 | The Problem | ... | ... | ... | 4 |
| 1.3 | Objectives and Hypothesis | ... | ... | ... | 11 |
| 1.4 | Study Area | ... | ... | ... | 13 |
| 1.5 | Literature Review | ... | ... | ... | 22 |
| 1.5.1 | Land Use | ... | ... | ... | 22 |
| 1.5.2 | Remote Sensing | ... | ... | ... | 25 |
| 1.5.3 | Geographic Information Systems (GIS) | ... | ... | ... | 28 |
| 1.6 | Conceptual Framework | ... | ... | ... | 31 |
| 1.7 | Structure of Thesis | ... | ... | ... | 34 |

CHAPTER TWO

| | | | | | |
|-----|---------------------------------|-----|-----|-----|----|
| 2.0 | RESEARCH METHODOLOGY | ... | ... | ... | 35 |
| 2.1 | Introduction | ... | ... | ... | 35 |
| 2.2 | Remote Sensing Technique | ... | ... | ... | 36 |
| 2.3 | Map Digitizing Technique | ... | ... | ... | 36 |
| 2.4 | Database Development | ... | ... | ... | 36 |
| 2.5 | Field Sampling | ... | ... | ... | 38 |
| 2.6 | Field Interviewing | ... | ... | ... | 38 |

| | | | | |
|----------------------|---|-----|-----|----|
| 2.7 | Data Analysis and Integration | ... | ... | 42 |
| CHAPTER THREE | | | | |
| 3.0 | REMOTE SENSING DATA PROCESSING AND INTERPRETATION | ... | ... | 44 |
| 3.1 | Aerial Photographs | ... | ... | 44 |
| 3.2 | Image Processing | ... | ... | 48 |
| 3.2.1 | Classification of LANDSAT TM 1985 Imagery | | ... | 48 |
| 3.2.2 | Classification of LANDSAT TM 1991 Imagery | | ... | 55 |
| 3.3 | Changes in Land Use Pattern between 1972/74 and 1985 | ... | | 59 |
| 3.4 | Changes in Land Use Pattern between 1985 and 1991 | ... | | 63 |
| 3.5 | Summary | ... | ... | 66 |
| CHAPTER FOUR | | | | |
| 4.0 | INTEGRATION OF DATA IN GIS | ... | ... | 68 |
| 4.1 | Introduction | ... | ... | 68 |
| 4.2 | Conceptual Data Modelling | ... | ... | 70 |
| 4.3 | Data Integration and Analysis | ... | ... | 71 |
| CHAPTER FIVE | | | | |
| 5.0 | ASSESSMENT OF THE SOCIO-ECONOMIC EFFECTS OF THE CHANGES IN AGRICULTURAL LAND USE | ... | ... | 77 |
| 5.1 | Introduction | ... | ... | 77 |
| 5.2 | Population | ... | ... | 77 |
| 5.3 | Land Tenure Systems | ... | ... | 81 |
| 5.4 | Farm Size | ... | ... | 84 |
| 5.5 | Agricultural Production Systems | ... | ... | 90 |
| 5.6 | Technology | ... | ... | 91 |
| 5.7 | Changes in Crop Production | ... | ... | 94 |
| 5.8 | Summary | ... | ... | 96 |



CHAPTER SIX

| | | | | | | |
|------------|--|-----|-----|-----|-----|-----|
| 6.0 | ASSESSMENT OF ENVIRONMENTAL EFFECTS OF THE CHANGES IN AGRICULTURAL LAND USE | ... | ... | ... | ... | 97 |
| 6.1 | Introduction | ... | ... | ... | ... | 97 |
| 6.2 | Soil Fertility | ... | ... | ... | ... | 97 |
| 6.3 | Deforestation | ... | ... | ... | ... | 102 |
| 6.4 | Soil Erosion | ... | ... | ... | ... | 104 |
| 6.5 | Summary | ... | ... | ... | ... | 105 |

CHAPTER SEVEN

| | | | | | | |
|------------|------------------------|-----|-----|-----|-----|-----|
| 7.0 | CONCLUSION | ... | ... | ... | ... | 106 |
| 7.1 | Summary | ... | ... | ... | ... | 106 |
| 7.2 | Recommendations | ... | ... | ... | ... | 109 |

ACRONYMS**REFERENCES****APPENDICES**

LIST OF TABLES

| | | | | | | |
|------------|---|-----|-----|-----|-----|----|
| Table 1.1 | Output of selected food crops, 1993 – 1998 (000 metric tonnes) | ... | ... | ... | ... | 5 |
| Table 1.2 | Cropped area estimates in hectares (ha): Akwapim South District | ... | ... | ... | ... | 6 |
| Table 1.3 | Production estimates for some major crops in the Akwapim South District | ... | ... | ... | ... | 10 |
| Table 2.1 | Sample strata | ... | ... | ... | ... | 39 |
| Table 2.2 | Sample size and distribution | ... | ... | ... | ... | 41 |
| Table 3.1 | Serial numbers of aerial photographs | ... | ... | ... | ... | 44 |
| Table 3.2 | Land use/land cover classification scheme for aerial photo Interpretation | ... | ... | ... | ... | 45 |
| Table 3.3 | Principal component analysis of Landsat TM 1985 (six bands) | ... | ... | ... | ... | 51 |
| Table 3.4 | Separability for 1985 Landsat TM Image using Jeffries-Matusita Distance | ... | ... | ... | ... | 52 |
| Table 3.5 | Separability for 1985 Landsat TM Image using Euclidean Distance | ... | ... | ... | ... | 52 |
| Table 3.6 | Principal component Landsat TM 1991 Image | ... | ... | ... | ... | 55 |
| Table 3.7 | Separability for Landsat TM 1991 Image using Jeffries-Matusita Distance | ... | ... | ... | ... | 56 |
| Table 3.8 | Separability for Landsat TM 1991 Image using Euclidean Distance | ... | ... | ... | ... | 56 |
| Table 3.9 | Land use/cover classes as at 1972/74 & 1985 | ... | ... | ... | ... | 59 |
| Table 3.10 | Interpretation levels of remote sensing data integrated in the GIS | ... | ... | ... | ... | 60 |
| Table 3.11 | Changes in land use/cover types between 1972/74 & 1985 | ... | ... | ... | ... | 61 |
| Table 3.12 | Changes in land use/cover between 1985 and 1991 | ... | ... | ... | ... | 64 |
| Table 4.1 | Organization of database using the relational model | ... | ... | ... | ... | 69 |
| Table 4.2 | Metadata information used | ... | ... | ... | ... | 70 |
| Table 4.3 | Types of agricultural land use/cover changes (1985 to 1991) | ... | ... | ... | ... | 72 |
| Table 5.1 | Mode of land acquisition over 30 years | ... | ... | ... | ... | 82 |
| Table 5.2 | Comparing farm size and the number of farms owned | ... | ... | ... | ... | 85 |
| Table 5.3 | Farm size and duration of lease for commercial farmers | ... | ... | ... | ... | 89 |

| | | | |
|-----------|--|-----|-----|
| Table 5.4 | Average size of various categories of labour | ... | 93 |
| Table 5.5 | Percentage change in the amount of land to various crops production during the period under review | | 94 |
| Table 6.1 | Percentage of farmers response to fertilizer application | | 100 |

LIST OF FIGURES

| | | | | |
|-------------|--|-----|-----|----|
| Figure 1.1 | Estimated total land area cropped over five years in the Akwapim South District | ... | ... | 7 |
| Figure 1.2 | Production estimates for some major crops in the Akwapim South District in metric tonnes (1992-96) | ... | | 10 |
| Figure 1.3 | Location map of study area – Akwapim South District | | | 15 |
| Figure 1.4 | A relief and drainage map of Akwapim South District | | | 16 |
| Figure 1.5 | Mean annual rainfall at Nsawam and Aburi (1975 – 1988) | | | 17 |
| Figure 1.6 | Mean annual temperature at Nsawam and Aburi (1971 – 1998) | ... | | 18 |
| Figure 1.7 | Soil map of Akwapim South District | ... | | 21 |
| Figure 1.8 | Adopted system's model for agricultural land use change | | | 33 |
| Figure 2.1 | Conceptual representation of data planes in a GIS database | | | 37 |
| Figure 2.2 | Map of Akwapim South District showing sampled sites | | | 40 |
| Figure 3.1 | Processes of photo interpretation | ... | ... | 46 |
| Figure 3.2 | Land use/cover classes derived from aerial photos | | | 47 |
| Figure 3.3 | False colour composition of Landsat TM Image 1985 (unclassified) | ... | ... | 49 |
| Figure 3.4 | Classified & filtered Landsat TM (1985) Image of Akwapim South District | ... | | 54 |
| Figure 3.5 | False colour composition of Landsat TM Image 1991 (unclassified) | ... | | 57 |
| Figure 3.6 | Classified & filtered Landsat TM Image 1991 | ... | | 58 |
| Figure 3.7 | Total areas of land use/cover types as at 1972/74 | | | 61 |
| Figure 3.8 | Changes in land use/cover types between 1972/74 & 1985 | | | 62 |
| Figure 3.9 | Total areas of land use/ cover types as at 1991 | ... | | 63 |
| Figure 3.10 | Changes in land use/cover between 1985 and 1991 | | | 64 |
| Figure 3.11 | Changes in land use/cover from 1972/74 to 1991 | | | 65 |
| Figure 4.1 | Conceptual entity relationship | ... | | 71 |
| Figure 4.2 | Land use/cover pattern of 1985 & 1991 | ... | | 73 |

| | | | |
|------------|--|--------|-----|
| Figure 4.3 | Akwapim South District showing changing pattern of mono cropping | | 74 |
| Figure 4.4 | Akwapim South District showing changes between three main land use/cover pattern from 1985 to 1991 | ... | 76 |
| Figure 5.1 | Historical and projected population of Akwapim South District | ... | 78 |
| Figure 5.2 | Comparative analysis of population density in the Eastern Region | | 79 |
| Figure 5.3 | Population density in the Eastern Region - 1984 | | 80 |
| Figure 5.4 | Mode of land acquisition for farming over a period of 30 years (1960s-1990s) | | 83 |
| Figure 5.5 | Percentage of farmers cultivating more than two acres of cash crop | | 86 |
| Figure 5.6 | System of land acquisition by commercial farmers | | 87 |
| Figure 5.7 | Commercial farm sizes | | 88 |
| Figure 5.8 | Commercial farm size and duration of lease | ... | 90 |
| Figure 5.9 | Types of techniques employed in farming | ... | 92 |
| Figure 6.1 | Farmers and fallow periods | | 98 |
| Figure 6.2 | Method of fertility restoration | ... | 99 |
| Figure 6.3 | Farmers responses to reduction in yield | ... | 102 |

LIST OF PLATES

| | | | | |
|---------|---|-----|-----|-----|
| Plate 1 | Extensive land cleared for food crop and pineapple cultivation | ... | ... | 106 |
| Plate2 | Burial site around a village called Kojo Fosu showing little forest tree species left | ... | ... | 106 |
| Plate 3 | Fallow land covered by shrub | ... | ... | 107 |
| Plate 4 | Commercial pineapple farm around Fotobi | ... | | 107 |
| Plate 5 | Typical subsistence farm with portions of the land eroded | | | 108 |
| Plate 6 | Orange plantation belonging to one of the fruit-processing industries in the District | ... | | 108 |

CHAPTER ONE

1.0 GENERAL INTRODUCTION

1.1 Background to the Study

Almost all nations in the world depend directly or indirectly upon agriculture for livelihood. For instance, it has been observed that, the development of agriculture has led to the economic development of many nations all over the world. Much of the impetus to the industrial growth of many nations like Russia, Britain, and the United States of America was provided by the agricultural sector, even though today this contribution to their domestic product has become minimal (FAO, 1972).

In the developing world, agriculture plays a significant role in socio-economic development. According to a World Bank report, most of the developing countries that grew rapidly in the 1980s, for example China, Indonesia, and Thailand experienced rapid agricultural growth and achieved the largest improvements in diet in the preceding years (World Bank, 1996). In Sub-Saharan African (SSA) countries, the quality of life of the people depends greatly on agriculture. It is the most important sector of their economy and constitutes the major portion of land use (Gyasi, 1996). In terms of foreign exchange earnings, agriculture's contribution is very high (World Bank, 1996).

Increasing population over the years has entailed the need for an increase in food production to cater for the population. Projections for the year 2000 and beyond indicate that, due to population increase and income growth, demand for food and

other agricultural products will have to rise by over 3 per cent annually (Alexandratos, 1988). However, the degree to which it will be possible to meet future food requirements will depend on how effectively agricultural land uses are managed and the ability of the land itself to produce. Prah (1989) observed that, "the maximisation of agricultural land use in a country is very important, if the country is to produce enough to feed its people with at least the basic staple". For instance, as a response to high demand for food and agricultural resources, countries like Zimbabwe, Kenya, and South Africa have embarked upon large scale mechanised farming supported by science and research. Other SSA countries can imitate such an example to improve upon their economy.

In Ghana, agriculture is the most widespread occupation, supporting about 70 per cent of the working population and contributing more than 50 per cent of the national revenue (NARP, 1994). However, the rate of exploitation of environmental resources has increased tremendously over the years, and this can be attributed to several factors including population growth, export promotion, low adoption of technology, and bush fire. Besides, the introduction of new crops, technological advancement and the rising expectation of high standards of living are all factors contributing to the changing global environmental conditions. In terms of environmental degradation, agriculture has contributed substantially to the decline of biodiversity, and to the demise and fragmentation of natural habitats as well as the increased rate of extinction of crop and animal species (Mannion, 1995). Agriculture has also accelerated soil erosion whenever the land is being

prepared for cultivation. Benneh (1997), observing the declining agricultural productivity in Africa, attributed the causes to many factors, including:

- inadequate incentives to farmers to increase production;
- increasing poverty;
- poor administration of support services;
- lack of suitable technology and associated inputs;
- increasing competition between crop and animal husbandry;
- a shortage of suitable land in certain areas; and
- competition between cash and food crops in some regions.

Sustainability has therefore become a key concept to describe the successful management of agricultural resources to satisfy changing human needs while maintaining or improving the quality of the environment and conserving natural resources (Benneh, 1997; Okigbo, 1997). However, there is the need to take inventory of the changes that have taken place on the biophysical environment before properly assessing and effectively planning.

A land use map of Ghana, according to Amatekpor (1999, was unavailable until 1998. The 1959 land use map of Ghana is not only obsolete, but also of little or no value for intensive land use planning. The development of Remote Sensing and Geographic Information Systems (GIS) technology has enable Ghana to complete a detailed land use/cover map as well as a digital soil map, among others, of the whole country at a scale of 1:250,000 under the Ghana Environmental Resource

Management Project (GERM). The digitised maps have been stored in a GIS for easy retrieval and updating whenever needed. However, environmental conditions and land use/cover changes at any time are the products of ecological and social history. Therefore, to establish the drivers of land use/cover change, human livelihood must not be ignored. In effect, GIS becomes useful where *ecological and social situations can be linked for decision making, and remote sensing is one of the major source of data.*

1.2 The Problem

Ghana's agriculture is based on the "peasant model" Over 90 percent of food and agricultural production is in the hands of small peasants with average holdings of not more than 2 ha. Large proportion of cash crops such as cocoa, cotton, and rubber come from peasant holdings. Considering the role peasant farmers are playing in food production, government policies over the years have been focused on helping them by providing credit facilities and farm implements, among others. Furthermore, the declaration of every first Friday in December as a farmers' day (public holiday) emphasises the importance government attaches to agriculture in *the country.*

Almost all the regions in the country produce some percentage of food, irrespective of the ecological zones that they are located, but the semi deciduous forest and the forest regions are the highest contributors. Data compiled by the MOFA (Table 1.1) show that the performance of the agricultural sector has improved. For instance, the total output of four major starchy crops cultivated in

the country, namely cassava, yam, cocoyam and plantain, maintained a steady upward trend which began in 1995. In 1998, the aggregate output of about 13.4 million metric tonnes of starchy crops was about 3 per cent higher than in 1997. The output of each of these crops also increased in 1998 over their respective levels in 1997.

Table 1.1 **Output of selected food Crops, 1993-98 (000 metric tonnes)**

| Crop | | | | | | | % change |
|--------------|--------------|--------------|--------------|--------------|--------------|--------------|------------|
| | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1997-98 |
| Cassava | 5973 | 6025 | 6612 | 7111 | 7150 | 7172 | 0.3 |
| Yam | 2720 | 1700 | 2126 | 2275 | 2417 | 2703 | 11.8 |
| Cocoyam | 1236 | 1148 | 1408 | 1552 | 1535 | 1577 | 2.7 |
| Plantain | 1322 | 1475 | 1638 | 1878 | 1878 | 1913 | 1.9 |
| Total | 11251 | 10348 | 11784 | 12761 | 12980 | 13365 | 3.0 |

Source: Ministry of Food and Agriculture, Policy Planning, Monitoring and Evaluation Department (PPMED), 1999

In spite of these improvements at the micro level (district and local) the percentage contribution of food crops continues to decline (Institute of Statistics, Social and Economic Research (ISSER), 1998). The decline in food crops may be attributed to both physical (low rainfall, high temperatures, topography, and bush fire) and human factors (population pressure, farming system, over grazing, and government policy).

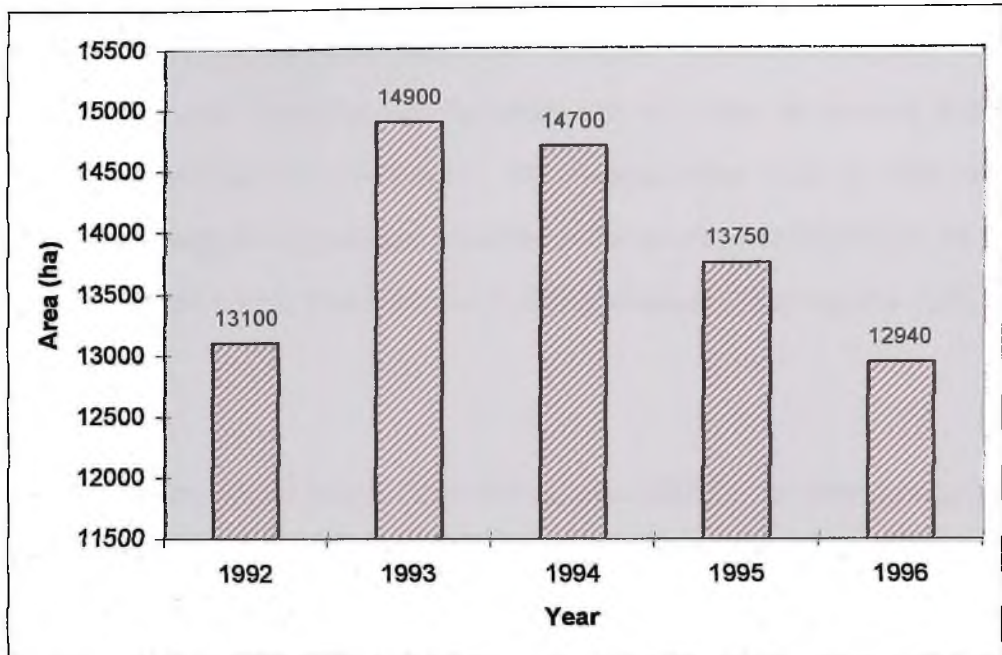
The study area, the Akwapim South District in the Eastern Region of Ghana (Figure 1.3) is one of the numerous districts that produce and supply food crops to the growing population, especially the capital of Ghana, Accra. It is also widely believed that cocoa, which is one of the major cash crops and foreign exchange earners in Ghana, was first cultivated in the district, specifically Mampong Akwapim in 1879. Cocoa cultivation later spread rapidly to other parts of the Eastern, Ashanti, Brong Ahafo, Western, and Volta Regions. In the 1930s, cocoa production declined because of an outbreak of swollen shoot disease which destroyed most of the cocoa trees, and an exhaustion of Adawaso (*lixisol*) soil series (Hill, 1963). This therefore compelled the farmers to concentrate more on food crop production. Akwapim South can boast of maize, plantain, cocoyam, cassava and vegetables, but cassava is the most ubiquitous. Table 1.2 shows some estimated cropped areas and the corresponding crops cultivated. As depicted in Figure 1.1, the estimated total cropped area declined in the four major food crops (Table 1.2).

Table 1.2 **Cropped area estimates in hectares (ha): Akwapim South District**

| Crop/ Year | 1992 | 1993 | 1994 | 1995 | 1996 |
|-------------------|---------------|---------------|---------------|---------------|---------------|
| Maize | 5300 | 6400 | 5500 | 5000 | 4200 |
| Cassava | 7100 | 7700 | 7700 | 7500 | 7600 |
| Cocoyam | 200 | 100 | 300 | 250 | 240 |
| Plantain | 500 | 700 | 1200 | 1000 | 900 |
| Total | 13,100 | 14,900 | 14,700 | 13,750 | 12,940 |

Source: Ministry of Food and Agriculture, Policy Planning, Monitoring and Evaluation Department (PPMED), 1998

Figure 1.1 **Estimated total land area cropped over five years in the Akwapim South District**



Source: Ministry of Food and Agriculture, Policy Planning, Monitoring and Evaluation Department (PPMED), 1998

Traditionally, the farmers intermix cash crops (cocoa and oil palm) with food crops of varying degrees of environmental sensitivity to optimise the use of the different soil nutrients and for checking soil erosion. Over the last three decades, the agricultural land use/cover in the area has experienced dramatic changes as reported in the Medium Term Development Plan, (1996). Currently, large scale mono cropping (of pineapples, oranges, and in few cases pawpaw) is the common farming system in the area. Other farming systems such as mixed cropping (involving food crops) and animal husbandry are still being practised, but on a smaller scale.

Government policies to promote the export of non-traditional crops have been embraced by most farmers especially in the Akwapim South District. The number of exporters of non-traditional agricultural products, especially pineapples and pawpaw, has been increasing over the years, with more than 30 per cent of the increase emanating from the district. For instance, from 1986 to 1989, the number of pineapple and pawpaw exporters in the country increased from 39 to 60, out of which 80 per cent emerged from the Akwapim South District (ISSER 1991).

According to the Ghana Export Promotion Council (GEPC), the Akwapim South District contributes about 60 per cent of pineapple and 30 per cent of vegetables to the export market of the country. In 1994, about 14,954 tonnes of pineapple were exported from the district, earning over 5 million US dollars (GEPC, 1994). Notable among these commercial farmers were Koranco, Greentex, Combined and Forest Resource Farms. They use heavy equipment and have cultivated hundreds of acres of land. For labour supply, the commercial farmers engage the services of subsistence farmers some of whom have given out their farmlands to the commercial farmers. People living in the surrounding villages are also engaged as farm help on the commercial farms.

The change in agricultural land use from cocoa to cassava, and presently to pineapple production, have affected food crop production and also caused a great deal of degradation to the environment (Medium Term Development Plan, 1996). Unlike cocoa, coffee, oil palm or cocoyam, pineapple cultivation does not require

shade trees. Large acres of land have been cleared and the land laid bare in order to enhance pineapple production. Former forested mountain tops now have only few forest trees left. The degradation of the environment seriously threatens the country's productive base, food sufficiency, social welfare, and the sustainable development of the rural areas.

Moreover, considering the hilly and rolling nature of the landscape, agro-chemicals being used mostly by commercial farmers might be washed downhill into streams and rivers when it rains, especially the Densu river which serves as a source of drinking water for both the rural communities and the western parts of Accra. Recently, many subsistence food farmers have completely taken to *pineapple farming, some have given their lands out to commercial pineapple producers, while others also have cut down the acreage of food crops to make room for pineapple cultivation.* The net result is a reduction in staple food production as shown in Table 1.3. For instance, production estimates indicate that, out of four major crops identified in the area, there has been an annual decline of 4,690 and 270 metric tonnes (MT) in cassava and maize production (Figure 1.2) respectively for the past 5 years. Though cocoyam shows a positive trend over the same period, it cannot compensate for the negative trend in the two major staples (cassava and maize). Those that remain in food production are unable to expand production to make up for the loss. Meanwhile the demand for staple food on the market continues to increase because farmers who are no more in food production must purchase all their food needs. The semi-cash crop *farmers must also purchase food to supplement the little they produce. The non -*

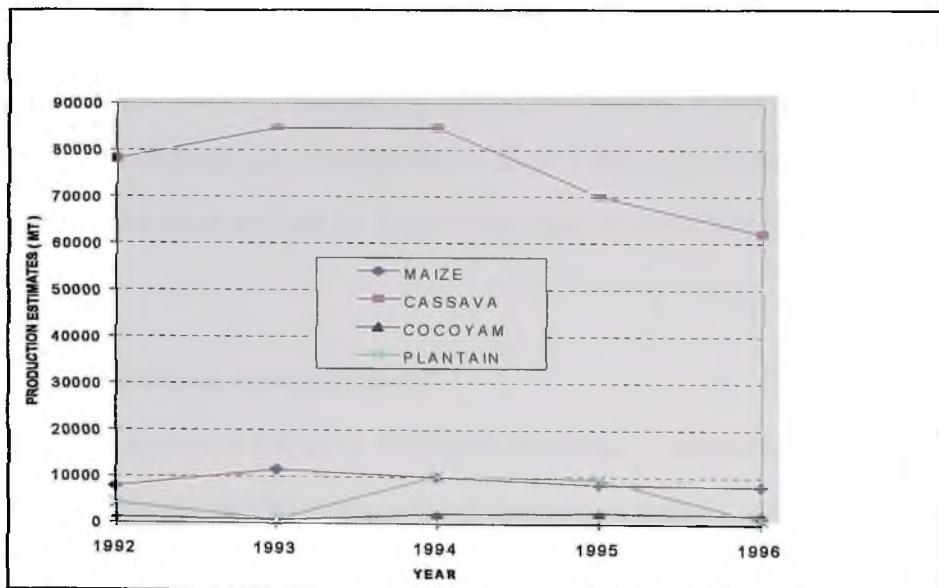
agricultural population is also on the increase, thus further increasing the demand for staple food.

Table 1.3 Production estimates for some major crops in Akwapim South District

| Crop | Year (metric tonnes) | | | | |
|----------|-------------------------|-------|-------|-------|-------|
| | 1992 | 1993 | 1994 | 1995 | 1996 |
| MAIZE | 7800 | 11500 | 9900 | 8400 | 8000 |
| CASSAVA | 78100 | 84700 | 84700 | 70000 | 62000 |
| COCOYAM | 1200 | 700 | 2010 | 2300 | 1900 |
| PLANTAIN | 4200 | 800 | 10080 | 9500 | 820 |

Source: Ministry of Food and Agriculture, PPMED, 1998

Figure 1.2 Production estimates for some major crops in the Akwapim South District in metric tonnes (1992-96)



Source: Ministry of Food and Agriculture, Policy Planning, Monitoring and Evaluation Department (PPMED), 1998

To ensure the sustainability of agricultural land use and effective assessment of environmental changes for district agricultural development planning, there is the need to assess the changes and patterns that have occurred over the years and to determine the driving forces behind them.

In this regard, environmental data are needed which can be processed into information. Remote sensing and GIS have been promoted for their cartographic value and have been used to provide broad geographic and analytical overview of diverse environmental resources. Therefore, the quickest way to increase the availability and accuracy of environmental data for effective planning and to ensure food security in the Akwapim South District is to use the remote sensing and GIS technique.

The research aims to examine and analyse the causes, extent and consequences of agricultural land use in the Akwapim South District, using remote sensing as a major data source and GIS as an analytical tool for district agricultural planning.

1.3 Objectives and Hypothesis

The study examines the forms and types of changes in agricultural land use in the Akwapim South District using remote sensing and GIS technique to find the causes of these changes. It is also to assess the socio-economic and biophysical effects of these changes, and to create a spatially referenced agricultural land use

database which can be manipulated for the purpose of decision making within the district. The specific objectives are as follows:

- a) Identify the changes in agricultural land use pattern for the period of which data is available, i.e. from 1972/74 to 1991.
- b) Identify and account for the reasons behind the changes.
- c) *Assess the socio-economic and environmental effects of the changes.*
- d) Create a spatially referenced agricultural database which has relevance to agricultural land use planning.
- e) Make recommendations for effective planning and sustainable agricultural land use.

For the purpose of this study, agriculture focused on only crop production.

The production statistics given in Table 1.3 indicate that agriculture land use has changed, mainly from food crop to cash crop production. It is, therefore, hypothesized that;

- a) the associated land uses have also changed.
- b) the changes in land use from 1972/74 to 1991 have contributed to land degradation in the form of deforestation, loss of soil fertility and erosion, among others
- c) the changes have reduced food crop production and deprived the people access to land.

1.4 Study Area

The Akwapim South District is located south-south east of the Eastern Region in Ghana (Figure 1.3). Administratively, it is one of the 15 districts in the Eastern Region. It covers an area of about three hundred and sixty square kilometres (360 sq. km). The district shares boundary to the south with the Ga and the Tema Districts, both in the Greater Accra Region; to the northwest, Suhum-Krabo-Coalta and West Akim District respectively, and to the north, Akwapim North District (Figures 1.3 and 1.4). It has Nsawam as the district capital, sited within a gap along the main highway from Accra to Kumasi.

The district generally shows a rolling relief with hills and ridges. Additionally a greater part of the district forms the plains of the Densu River. Bordering the east are portions of the Akwapim-Togo range as depicted in Figure 1.4.

The Akwapim-Togo range stretches from the mouth of the Densu river, west of Accra, and run in a north-easterly direction across the Volta Region and the Republics of Togo and Benin to the valley of the Niger river. The ridge extends to a settlement called Deگو in the Akwapim South District and rises to over 1000 ft (9.2 m) at the town called Aburi.

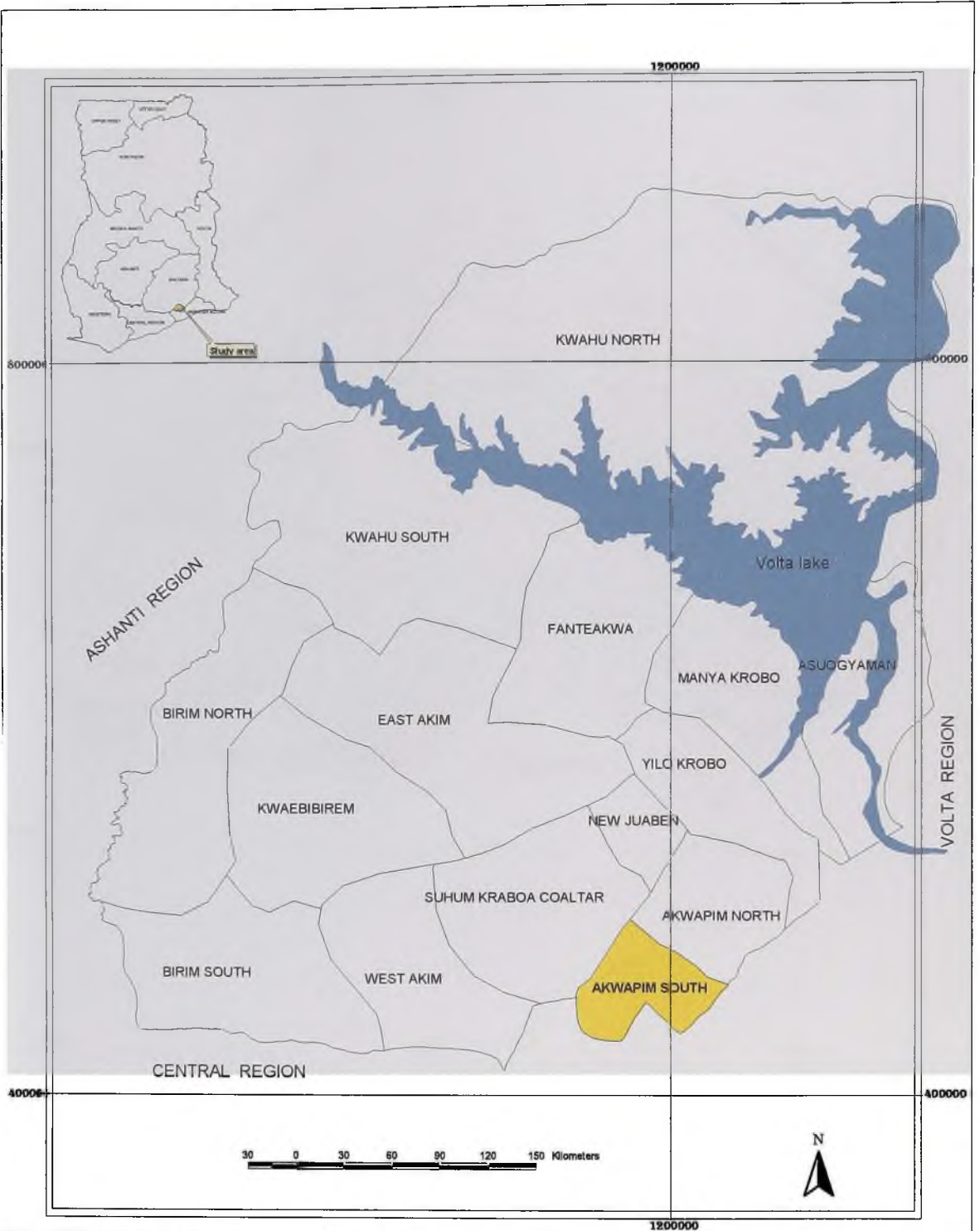
The west of the Densu is an undulating lowland ranging from 200 to 250 ft (61-76 m) high with few isolated knolls rising to 300 ft (91 m), east of the Obegima village. Another hill rises to about 550 ft south of Kwadwo Fosu (Odumase) village (Figure 1.4). In the southwest, is an irregularly shaped hill called Amama rising

higher to a summit of over 700 ft (213 m), being separated by a valley from the Nyanaw hill, which is the highest in the district. This hill rises very steeply from 250 ft (76 m) to a peak of 1618 ft (493 m). The Botokura hill, south of Duayeden in the southwest also has two separate hills, which rises steeply to summits of the same height, which is over 950 ft (290 m). The plains, on the other hand, are wider in the north (8.8 km) than in the areas around Adojiri and continue to the south of Nsawam (Figure 1.4).

The district is drained by several streams, but the Densu is the main river. It is about 115.8 km (72 miles) long, taking its source from the Atwia mountain ranges near Kibi in the Eastern Region (Soil Research Institute, 1975). It flows northeast to southwest in the district. The river meanders in a generally wide valley, and has a very low gradient towards Nsawam. It has many tributaries, but the most prominent are Pampanso, Ntua, Ahunfra, and Dobro (Figure 1.4). These streams promote agriculture, especially the cultivation of vegetables and sugarcane along the river banks.

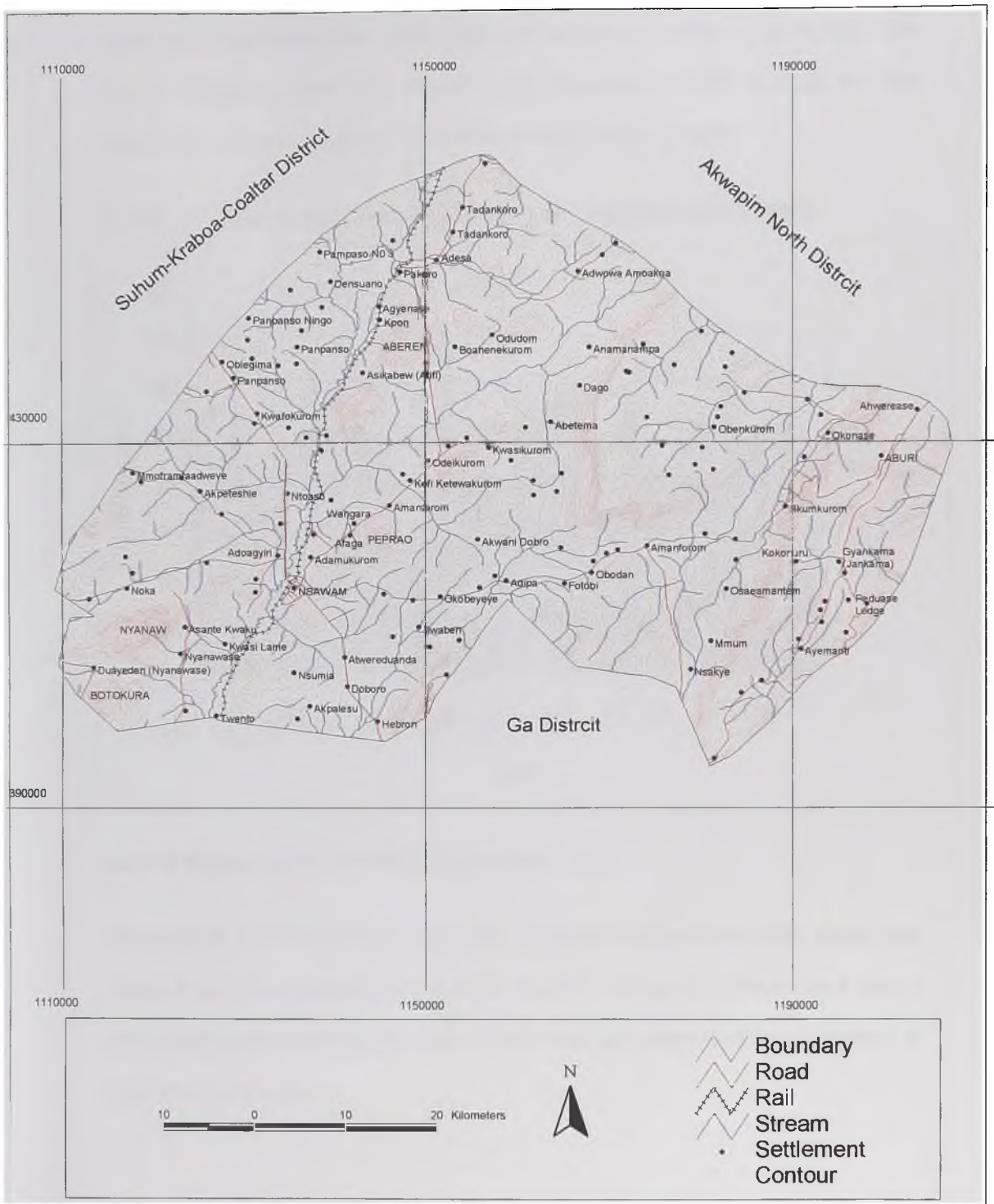
The district lies in the west semi-equatorial climatic region of Ghana, experiencing double maxima rainfall annually with mean annual rainfall of about 1,260 mm. The major rainy season starts from April and ends in July, with peaks in June. The minor season is from September to November. December and January are the dry season, characterized by dry northeast winds locally called harmattan (Dickson & Benneh 1988; Adu & Asiamah, 1992).

Figure 1.3 Location map of study area - Akwapim South District



Source: Remote Sensing & GIS Applications Laboratory, Legon

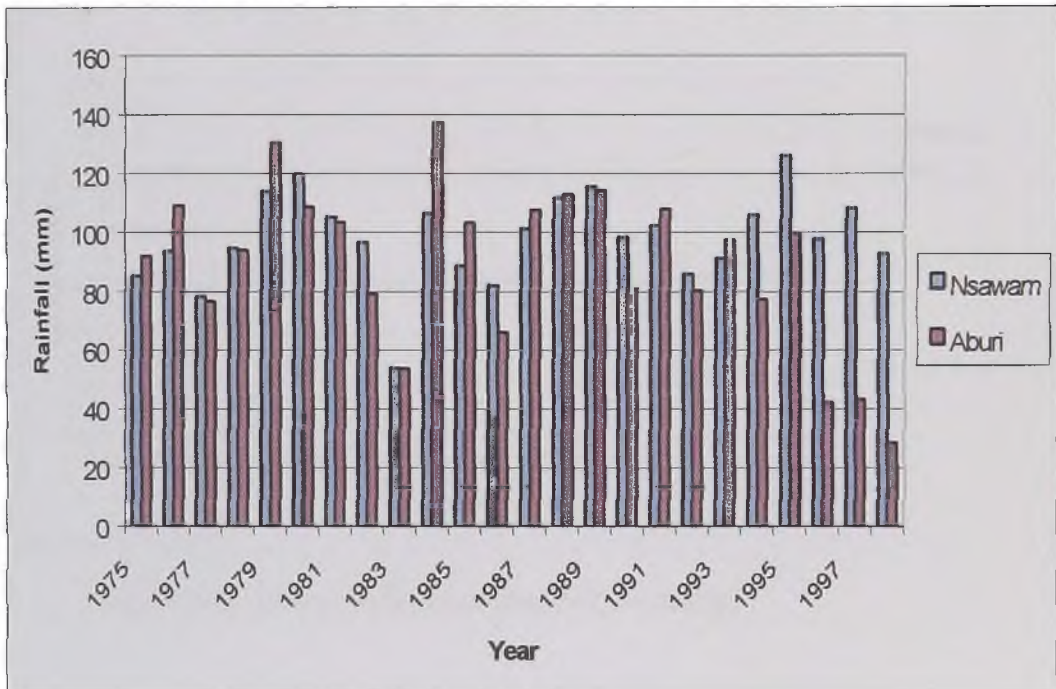
Figure 1.4 A relief and drainage map of Akwapim South District



Source: Topographic sheet , 1994.

Rainfall data collected from two stations, Nsawam and Aburi, over a period of 24 years show that there has been a general decline in rainfall (Figure 1.5). The highest rainfall of more than 130 mm was recorded in 1985 at Aburi and the lowest (50 mm) was recorded in both stations in 1983 and 1985.

Figure 1.5 Mean annual rainfall at Nsawam and Aburi (1975-1988)

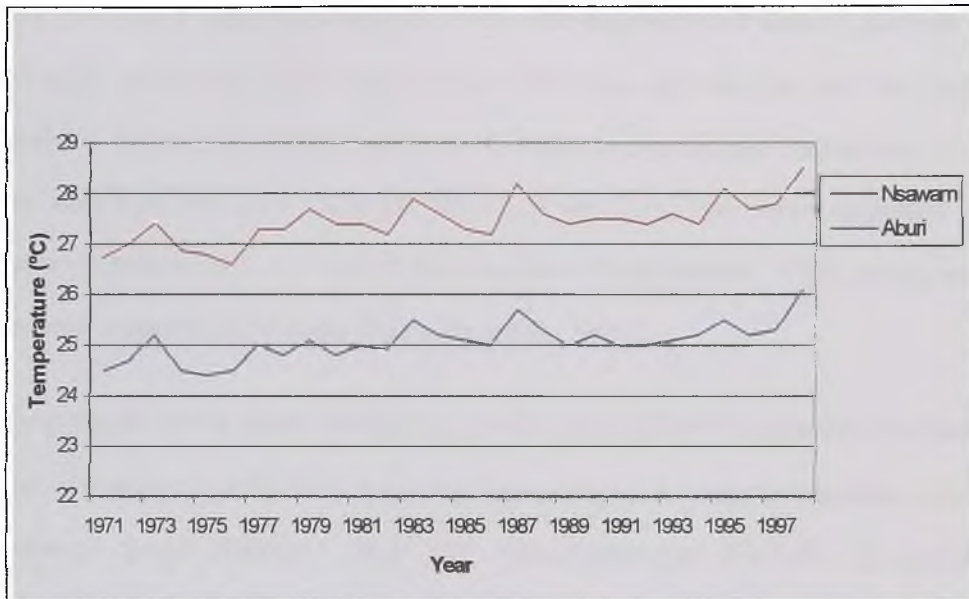


Source: Meteorological Services Department, Accra

The decline in mean annual rainfall in 1983 was not peculiar to the study area alone. It was a nationwide phenomenon, as the country was affected by a severe dry season (*harmattan*) which caused bush fires and destroyed large hectares of cash and food crops.

Figure 1.6 indicates that temperatures, on the other hand, have been very high (27 °C) over the years. However, between 1974-1976, the annual mean temperatures fell below 25 °C which was the only exception.

Figure 1.6 Mean annual temperature at Nsawam and Aburi (1971-1998)



Source: Meteorological Services Department, Accra

The vegetation of the study area can be divided into two broad categories after two ecological zones, the semi-deciduous and the transitional forest-savanna zones. The semi-deciduous formerly covered almost 90 percent of the district, running from the west, north and stretching into the whole ridge area in the east. The tree species are mainly *Celtis-Triplochiton Association* (Taylor, 1952). However, the forests have been depleted over the years. Savanna grassland has invaded areas hitherto colonised by forest species. Farming operations have

destroyed large parts of the vegetation. Regrowth vegetation in the area is rarely allowed to develop beyond thicket, due to relatively intensive land rotation cultivation. With the increase in population and the present form of land use, it will not be possible to get back to the lost forest.

The transitional forest-savanna zone forms the southern and eastern portions of the study area where the district shares boundary with the Ga and the Tema Districts. Maize and cassava are the main crops cultivated in these areas. One can infer that this zone originally bore a forest cover has been degraded by human interference in an area of poor soil and erratic rainfall. Both thicket and savanna vegetation dominate (Adu & Asiamah, 1992).

The principal soil is forest *ochrosols*, but the relief patterns make for significant local differences in soils. Four major soil types (Figure 1.7) can be identified in the Akwapim South District. They are the *Adawso-Bawjiasi Nta-Ofin Compound Association*, *Ayensu Chichiwere Association*, *Fete - Bediesi complex*, and the *Nyanáo-Opimo Compound Association* (Adu & Asiamah, 1992). These soil types promote the cultivation of a variety of crops such as cassava, maize, plantain, citrus fruits, and vegetables.

Characteristically, the *Adawso-Bawjiasi / Nta-Ofin Association* consist of grey-brown loamy humous horizons overlying stony and reddish-brown gravels. They are well drained and susceptible to drought and erosion. These soils are usually too shallow under the climatic conditions for successful growth of perennial tree crops. Nevertheless, the soils support the cultivation of maize, cassava, yam, and

pineapples. They are used most economically to produce annual and semi-perennial food crops.

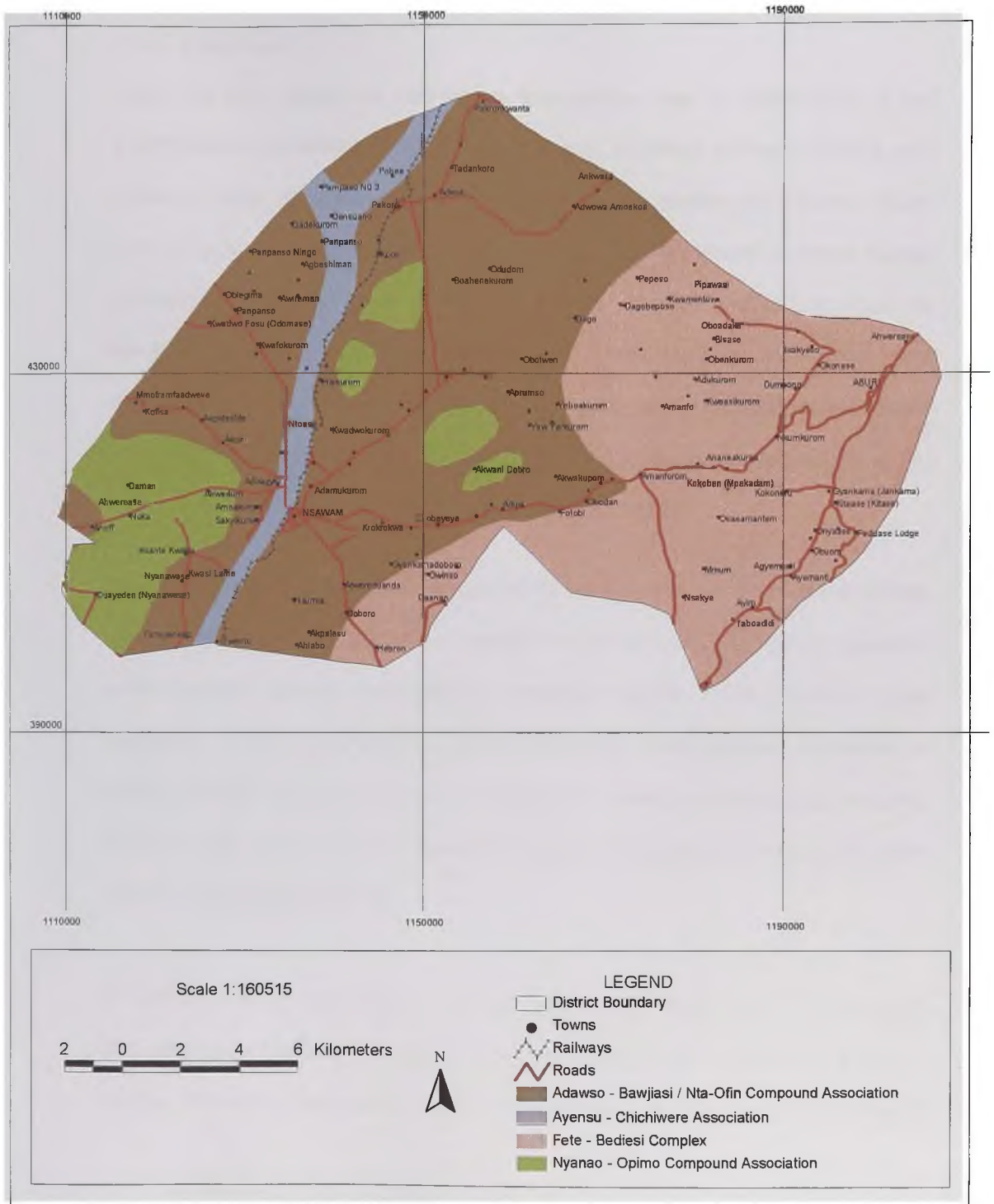
The *Ayensu Chichiwere* series form a transect in the area and are distributed along the floodplains of the Densu river and their major tributaries. The textures of these soils vary from sand to loamy sand, but may occasionally be loam further away from the river. They are generally excessively drained and droughty. They are light-textured and easy to work because of the low clay content. In spite of their *poor physical characteristics and low natural fertility, they are used for vegetable cultivation.*

The *Fete –Bediesi Complex* are located along the eastern part of the area with only a patch in the north central and the second largest soil type after *Adawso* series in the area. They are excessively well drained and normally dry out quickly on exposed cultivated plots, becoming droughty during dry periods. They vary in character from place to place. According to Adu et al. (1992), these soils have low nutrient reserves, but are suitable for a variety of tree and arable crops.

Nyanao-Opimo Compound are well or moderately well grained and retain moisture during short periodic dry spells. They are found on moderate slopes (8-5 %) where rock outcrops are few. The whole profile is moderately acid. Most of the land of this soil type is cropped to maize, cassava, tomatoes, pepper, and pineapples, but cocoa and plantain are also found in some few localities.

Figure 1.7

Soil map of Akwapim South District



Source: Soil Research Institute of CSIR, and Remote Sensing Applications Laboratory, Legon

1.5 Literature Review

1.5.1 Land Use

Land use may simply be defined as the various uses to which land is put. Examples are settlements, recreational centers, industrial centers, farming, and myriad of other uses that reflect the complexities of modern life (Mather, 1989). According to Vink (1975), land use is any kind of permanent or cyclic human intervention to satisfy human needs, either material or spiritual or both, from the complex of natural and artificial resources which together are called land. Agricultural land use, which is one of the major land uses, involves the use of land to produce of food and fibre or the management of biophysical resources by human society to raise crops and animals (Mather, 1989).

There are different categories of agricultural land use, depending on the criteria used. Agricultural land use can be classified based on crop cultivated or livestock, yield, intensity of land (management systems), season, or the specific crops cultivated. These classifications are influenced by many factors. According to Mather (1989), agricultural land use organization may be influenced by farmer's decision, the nature of the farmer's physical environment and government policies, among other factors.

In Ghana, as in any other country, agricultural land use has changed tremendously since historical times. Farming systems have changed; for instance, shifting cultivation, the earliest form of subsistence farming, has given way to

permanent cropping. Food crop production has also given way to cash crops. It is therefore necessary to find out the various reasons for these changes.

According to Agidi (1979), land use is determined by physical, economic, technological, and institutional factors. One can give many reasons to explain the changes which are either naturally induced, and human, or artificially induced. In the short run, natural factors of the biophysical environment (climatic, topographic, and edaphic) that are fundamental for agriculture remain static for considerable periods of time, while the other determinants (economic, technological, and institutional) are dynamic. Consequently, change is more associated with human factors. Farmers are therefore able to plan under the assumption that the natural factors do not change.

Grigg (1976) for instance, observed that most of the models of agricultural change have tended to assume that farmers are fully commercialised, in that their decisions are primarily influenced by changes in the price of their inputs and products, and that they seek to maximise their profits. Essentially, his study was based on the premise that change in agriculture was conditioned by population increase. Again, the primary determinant of the behaviour of peasant farmers hinges not only on labour availability arising from increased population, but also on environmental and socio-economic factors. In his view, though there would be undesirable effect(s) of population pressure on land use, nevertheless, there would be an expansion of cultivated area, more frequent cropping of the existing arable area, intensification of labour and capital inputs, and the use of higher yielding seeds and crops. This school of thought therefore considers population

growth as significant for a change from a simpler and more wasteful system of farming to a more intensive and technically advanced system.

The major proponents of this theory include Boserup (1965), Clark (1967), and Gleave & White (1996). This was against the Malthusian thesis which states that population growth is an independent variable determined by changes in agricultural productivity. That is, when agricultural productivity increases as a result of factors such as technical inventions and initiation of more advanced *techniques of farming, population growth is enhanced (Malthus, 1798).*

Blaikie & Brookfield (1987), in their discussion of population and land degradation, challenged Boserup's (1965) model, which regards population growth as important for innovations in agriculture. They argued that in many instances, population growth does not necessarily bring innovations; instead, it degrades the environment. The weakness in Boserup's (1965) model is that it isolates population as the single causal variable in a manner similar to that of the neo-Malthusians. Blaikie & Brookfield (1987) stressed that the capacity of land to increase or decrease its productivity depends on natural and human factors. These factors are, however, numerous and thus difficult to break down and analyse. Their argument, on the other hand, does not relegate Boserup's (1965) model to the background.

Gyasi (1976), in a study of farming in Sekesua-Agbelitsom in Ghana, observed that population pressure is the main underlying factor for the changes in agriculture in the area. This is reflected in intensive methods of farming by

increasing the frequency of cropping, application of fertilizer and gradual changes from cassava to maize cultivation.

Carr et al. (1991) states, among other things, that population pressure alone does not account for the changes in traditional agricultural systems. Innovations have been introduced into the traditional system through extension officers. However, the success of the innovations depends on the economic motive of profits, for farmers will accept an innovation if it will change their income.

Another school of thought associates changes in agricultural land use with the deliberate or accidental introduction of superior, exotic ideas and techniques (Gyasi, 1976). This pre-supposes that if foreign methods are not important, farming practices in traditional economies such as those of tropical Africa would remain essentially static. Apart from population pressure that may bring about a change in agricultural land use, Benneh (1972) recognised other factors which include economic conditions and increase in knowledge of social and economic *opportunities that would be gained by adopting new systems of agriculture.*

From the discussion so far, it is clear that numerous factors account for changes in agricultural land use. It is therefore imperative to examine the factors causing these changes in the Akwapim South District.

1.5.2 Remote Sensing

Remote sensing is the science and art of obtaining information about an object, area or phenomenon on the earth surface without being in contact with it

(Agyepong, 1988). The instruments that are used measure electromagnetic energy reflected or emitted by earth features. This necessary information can be derived directly from the intrinsic characteristic of the electromagnetic energy. The technique, according to Benneh (1988), overcomes the two major problems inherent in ground survey, that is, area coverage and time.

Remote sensing uses both aerial photographs and satellite imagery. In the former, special cameras on board an aircraft are used in detecting and registering reflected energy of ground features on photographic films, while the later uses platforms and multi-spectral scanners.

Globally, remote sensing has evolved as a valuable technique for many aspects of resource surveys needed for development. In Japan, Miyame et al (1983) digitally analysed Landsat MSS data of September 1980 to obtain the geographical distribution of cold, damaged rice on the Ishikari plain which is one of the largest rice production districts in northern Japan. The technique has also been used in assessing crops. For example, a prototype remote sensing system was set up in which the technique of data gathering, storage, retrieval, processing, analysis, and information dissemination were successfully used in one integrated system to experiment into a disease called *Corn Blight Watch*, known in tropical corn growing areas. This research aimed to prevent the infection of the disease.

Remote sensing, especially Landsat TM imagery, has been used to classify the land cover in the tropical highlands of Costa Rica and Ecuador (Colby & Keating

1998). Peng *et al.* (1998), in a study on monitoring farmland of high and low yield in the north of China, used both remote sensing data (Landsat TM) of different times and non-remote sensing data for compound classification. The experiences show that irrigation, soil salinity, and morphology which used to be compound factors, directly influence crop yield. In Malawi, a food security information study was conducted, using aerial photographs and area sample frame methods, to gather information on agriculture, environment and socio-economic status. The photos were first enlarged and used in the field by enumerators to identify the segment boundaries and also to account for all the land (Wigton *et al.*, 1998). In soil resource appraisal and sustainable agriculture in India, Prakash & Natarajon (1998) visually interpreted satellite imagery using interpretation elements such as tone, texture, size, shape, pattern, association, and mottles. They finally identified 21 soil mapping units which were later used to generate a land capability map.

In the area of change detection, extensive work has been carried out. For example, Mouat *et al.*, (1994) integrated remote sensing data such as historical aerial photographs, Landsat Multispectral Scanner (MSS), and Thematic Mapper (TM) into a Geographical Information System (GIS) to detect and map out changes in the Upper San Pedro River watershed in Arizona. The image products were converted into maps within a GIS to obtain the amount and direction of change within the watershed.

In Ghana, several research projects have been executed using the remote sensing technique. These include the regional soil survey of Navrongo-Bawku

area, Nasia Basin, Kpong and Tano irrigation projects, and planning of the Onchocerciasis Free Zone (Agyepong, 1989). Alhassan (1998) used Landsat TM 1985 and 1991, complemented by aerial photos and Global Positioning System (GPS), to study the change in land cover and its effects on agriculture and woodfuel sustainability in the Densu Basin of Ghana. This study is organised *along similar line as done elsewhere in Ghana according to the literature so far reviewed.*

1.5.3 Geographic Information Systems (GIS)

GIS is a tool for collecting, storing, retrieving at will, transforming, and displaying spatial data from the real world for a particular set of purposes (Bourrough, 1986). As a database system, it facilitates spatial data indexing and enables the performance of sets of operations to answer queries about spatial entities in the database (Smith *et al.*, 1987). As an organizer, it allows an automated set of functions that provides professionals with advanced capabilities for storage, retrieval, manipulation, and display of geographically located data (Ozemony, Smith & Sicherman, 1981). Any variable or feature that can be located spatially can be fed into a GIS.

Data in GIS may be visualized as stored in 'planes' or 'layers,' registered to the same co-ordinate frame of reference, which have been stacked up, with each plane dedicated to a specific theme such as land cover, land use, soil types, and water availability. This format enables one to easily compare such data in detail, and to combine several layers within the database as dictated by the end user. It

is also possible to consider the simultaneous effects of complex numerous variables together. The GIS technique has, thus, become very useful aiding decision making in planning and development, including agriculture.

The GIS technique has been used with remotely sensed data in most advanced countries to assess land capability (Corbett & Carter, 1996; Davidson *et al.*, 1994). It has also been used for precision measurement in the application of inputs such as fertilizer (Lachapelle *et al.*, 1996), crop response under variable inputs and landscape position (Goddard *et al.*, 2000; Goddard *et al.*, 1995), range condition (Ringrose *et al.*, 1996), and for determining changes in agricultural land use and their policy implications (Diaz & Arteta, 1996). In the US, GIS has been used extensively in modeling and forecasting. For example, Bliss & Reybold (1989), and Wilson *et al.*, (1993) used GIS to evaluate the impact of modern agriculture.

Desktop GIS has been promoted as a result of the popularity of site-specific farming as a way of increasing the profitability and/or reducing environmental impact of agriculture. According to Wilson (1999), the use of GIS as an advanced technology in agriculture offer many advantages, including the provision of cheaper and quicker data at various resolutions as well as diagnostics for error detection and accuracy determination, and the generation of information that can be used together with visualization tools like maps and tabular data.

At the international level, the United Nations has established the Global Environmental Monitoring Systems (GEMS) and the Global Resource Information Database (GRID) where GIS is being used to organize information from hundreds of institutions all over the world. The GEMS and GRID aim to study and monitor changes in atmospheric composition and climatic system, freshwater and coastal pollution, air pollution, food contamination, deforestation, ozone layer depletion, the build-up of greenhouse gases, and many issues related to biological diversity (UNEP, 1990).

The many GIS applications in developing countries range from resource inventory and monitoring land use planning. For example, Dale & McLanghlin (1988) give an introduction to the use of GIS and Land Information Management Systems (LIS) for cadastral problems in Third World Countries. The 27th International Symposium on Remote Sensing of Environment held in Tromso, Norway (1998) also covers a lot of research papers on remote sensing and GIS application. Besides, the Proceedings of the Africa GIS 1995 contain many papers and publications on GIS application in Africa.

The literature reviewed shows the potentials of GIS and remote sensing as tools in the field of agriculture which can also be used within the Ghanaian context. Though much has not been done in Ghana, it would be essential to explore this technology.

1.6 Conceptual Framework

The study uses the system's concept to examine the problem of agricultural land use change. Because according to Vink (1975), land carries ecosystems, and agricultural land use is one of the applications of human controls in a relatively systematic manner, to the key elements within any ecosystem to derive benefit from it.

A system may be defined as a complex whole, a set of connected parts, or an organized group of material objects (Tivy, 1990). This concept has been applied in various studies including geomorphology, hydrology, ecology, and agriculture. In environmental studies, ecosystem is the common term used.

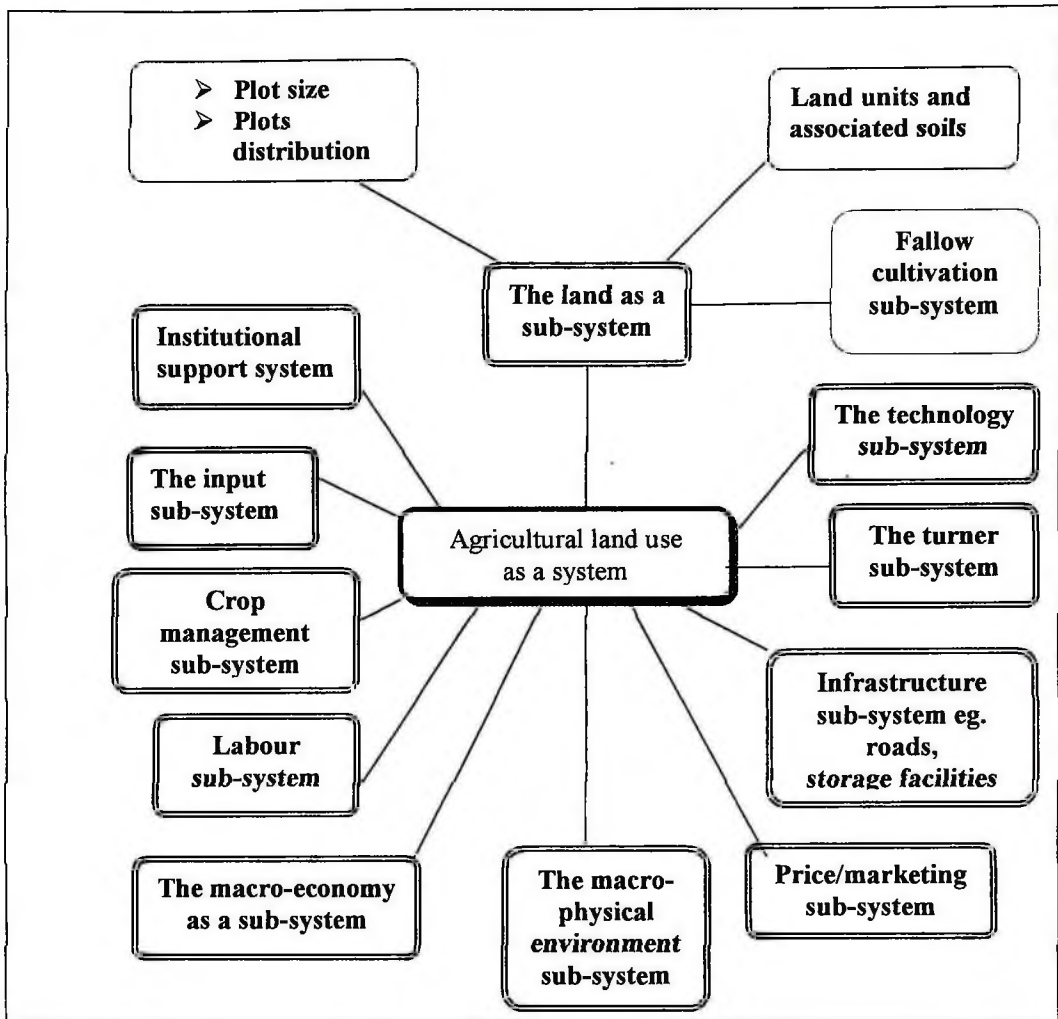
An ecosystem is broadly defined as a functional unit of the environment that includes all organisms and physical features within a given area. It thus, consists of both living or biotic, and non -living or abiotic components (Lawrence *et al.*, 1976). A dynamic relationship between the organisms and their environment ensures equilibrium in the system.

Agricultural ecosystems on the other hand, are altered natural systems managed to enhance the productivity of a selected group of producers. However, agricultural production in any given area is affected basically by the biophysical environment, economic and socio-cultural factors, and government policy. Though the physical environment and the climate conditions may be favourable for the *cultivation of a particular crop, the farmer's final decision may be determined by*

economic (demand level) and socio-cultural factors as well as the policy environment. The farmer monitors the environment, energy and material processes, and implements control that affect the system's structure and function. Any change in one part of the system will impact on, and be reflected in changes in all the other parts.

According to the study, agricultural land use is a major system with a lot of sub-systems (Figure 1.8). One of the major sub-systems of agricultural land use is land, which is affected by the fallow period, land unit and associated soils, and plot size and distribution within the area. A short fallow period (e.g, less than 5 years) would be insufficient for the land to re-gain its fertility, assuming all others *factors are held constant*. This would affect the land as a system, and consequently affect agricultural land use as a major system. Due to pressure on land as a result of large scale monocropping (commercial farming) in the area, land for subsistence farmers is limited. The farmers practise short fallows to continue farming. Farmers therefore experience low yields due to low soil fertility which threatens food security.

Other sub-systems identified in the area, which influence the main agricultural system, include institutional support, inputs used, labour, crop management practices, macro-economic system, the physical environment, marketing, technology used, tenure system, and infrastructure.

Figure 1.8 **Adopted system's model for agricultural land use change**

Source: Author's construct, 1999

Changes in any one of the listed sub systems affect the main system. The study has therefore examined the effects of changes in tenure system, technology, fallow periods, and the macro-environment as sub systems impinging on agricultural land use system in the area.

1.7 **Structure of Thesis**

The thesis comprises seven chapters. Chapters one and two give background information about agriculture and agriculture land use. They also discuss the problem of agricultural land use that calls for investigation, a review of the relevant literature, and objectives of the study. Chapter Two contains further discussions on the methodology used.

Chapter Three is devoted to remote sensing as a major source of data. It discusses the various data used, the interpretation processes, and analysis of the results. This is then lined to the database generation in Chapter Four, where the remote sensing data have been integrated into GIS to analyse the land use/cover change patterns.

Chapter Five and Six are devote to the field data analysis. Specifically, Chapter Five examines the socio-economic effects of the land use/cover changes observed from the remote sensing data, and Chapter Six examines the environmental effects.

Chapter Seven concludes the thesis by summarizing the findings and making recommendations

CHAPTER TWO

2.0 RESEARCH METHODOLOGY

2.1 Introduction

The study used the technique of remote sensing and GIS to obtain and organize the basic map sets. These were topographic and digital soil maps, aerial photographs, and digital Landsat Thematic Mapper (TM) satellite imagery. The remote sensing technique involved the use of aerial photographs, processing, and interpretation of Landsat imageries. The land use map units were digitized to create the land use map data from which land use database was created. It was later validated on the field before analysing.

The field study was required for the following reasons:

- ◆ to up-date the interpretation of the imageries;
- ◆ to conduct socio-economic survey for information to describe the land use as well as the farming systems in the area; and
- ◆ to find out how selected plots of agricultural land have changed in use over the period under review.

The field study was based on sampling of 140 respondents and 30 farm plots. Ground truth sites were selected by several criteria. These included the study objectives, sample size, and access to the sites. A Global Positioning System (GPS) was used to determine the coordinates of farm plots on the field and down-loaded onto the computer and later displayed on the imagery. The Statistical Package for Social Science (SPSS) Windows 8.0 was used to analyze the field data.

2.2 Remote Sensing Technique

A set of black and white aerial photographs of Akwapim South District (scale 1:40,000), taken in 1972/74 was visually interpreted with the mirror stereoscope. The borders of the identified land uses were transferred to the two sets of the topographical maps. The satellite images were first loaded into the computer, and enhanced by using all the six bands. The images were later subjected to both supervised and unsupervised classification, after identifying several training sites.

2.3 Map Digitizing Technique

The topographical maps (sheet 0501B2 and 0501B1), which provided the spatial reference frame for the district, were digitised. The results from the analysis of the aerial photographs and the fieldwork were also digitised by the use of PC Arc Info 3.5.1 programme. It is a common GIS software that allows for visualization and analysis of geographical data. The maps were first mounted on a digitizing table, and a hand-held device termed a puck or cursor was used to trace each map feature. Additional data (e.g., demographic data) were also added to the digital map as attributes.

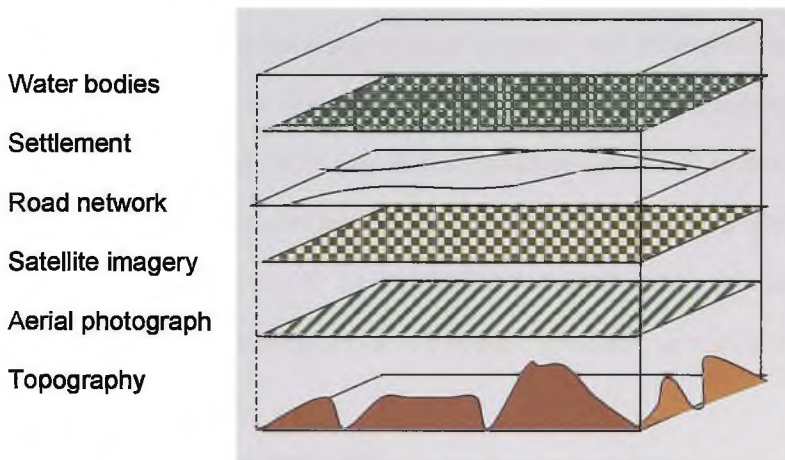
2.4 Database Development

The relational model was used to develop a database for the study. Though this model is more difficult to implement and slower in performance, it has a lot of advantages over both the hierarchical and network data models (Aronoff 1991). Some of the advantages, as summarized by Bowers (1988), are as follows:

- ◆ It is more flexible than the hierarchical and network models
- ◆ It has a sound theoretical base in mathematical theory. The mathematics of relations can be used as the basis for data processing. Other systems provide a programming language interface, but not a mathematical one.
- ◆ It is simple to understand and, therefore a good vehicle to communicate the database ideas.
- ◆ The same database can generally be represented with less redundancy than the other two models.

The remotely sensed data were vectorized and integrated into a GIS. In this format, various layers of the information gathered were compared. The overlay principle, which involves series of information or themes superimposed on another, as depicted in Figure 2.1, was used to perform the change operations.

Figure 2.1 **Conceptual representation of data planes in a GIS database**



Source: Adopted from Jensen, 1996

2.5 Field Sampling

Areas identified as farms or cultivated land, fallows, built-up areas, and forest on the aerial photograph and satellite imagery analysis were visited. In all, 30 sites were visited to verify the features observed on the imagery. Only few sites such as deep valleys and ridge tops were inaccessible for checking. Farmers found on their farms were interviewed, but farmers who were unavailable at the time of the visit were located during a follow-up and interviewed. GPS readings were taken on all the areas visited and saved on the receiver during the fieldwork.

2.6 Field Interviewing

Selection of training sites used in the classification and conduction of interview were derived from the interpreted aerial photos. Cluster sampling was used to select the areas. The total sample size of 140 farmers interviewed comprised 130 subsistence and semi-subsistence farmers, and 10 commercial farmers. To reduce the survey area of about 148 settlements, as indicated on the topographic maps of 1974, operational areas of agricultural extension officers were sought at the district agriculture office at Nsawam, out of which criteria were established. The 23 operational areas each had not less than 15 settlements. The settlements were therefore selected for investigation based on two major criteria:

- (a) accessibility by road; and
- (b) being among the top 10 food producing settlements in the district for the past two decades.

A statistical table of random numbers was then used to select eight settlements for investigation. These were Pakro, Fotobi, Panpanso, Kofisa, Nsakyee, Daman, Duayeden, and Doboro (Figure 2.2).

To ensure a fair representation of data collection, the stratified sampling technique was adopted, using three levels (Table 2.1) derived from the aerial photographs. The commercial farms were identified on the aerial photos to have definite shape, and were larger than the subsistence and semi-subsistence farms. The semi-subsistence farms have definite shape and are smaller in size as compared to the commercial farms with isolated trees. The subsistence farms also have definite shapes, with mixed vegetation and a lot of trees.

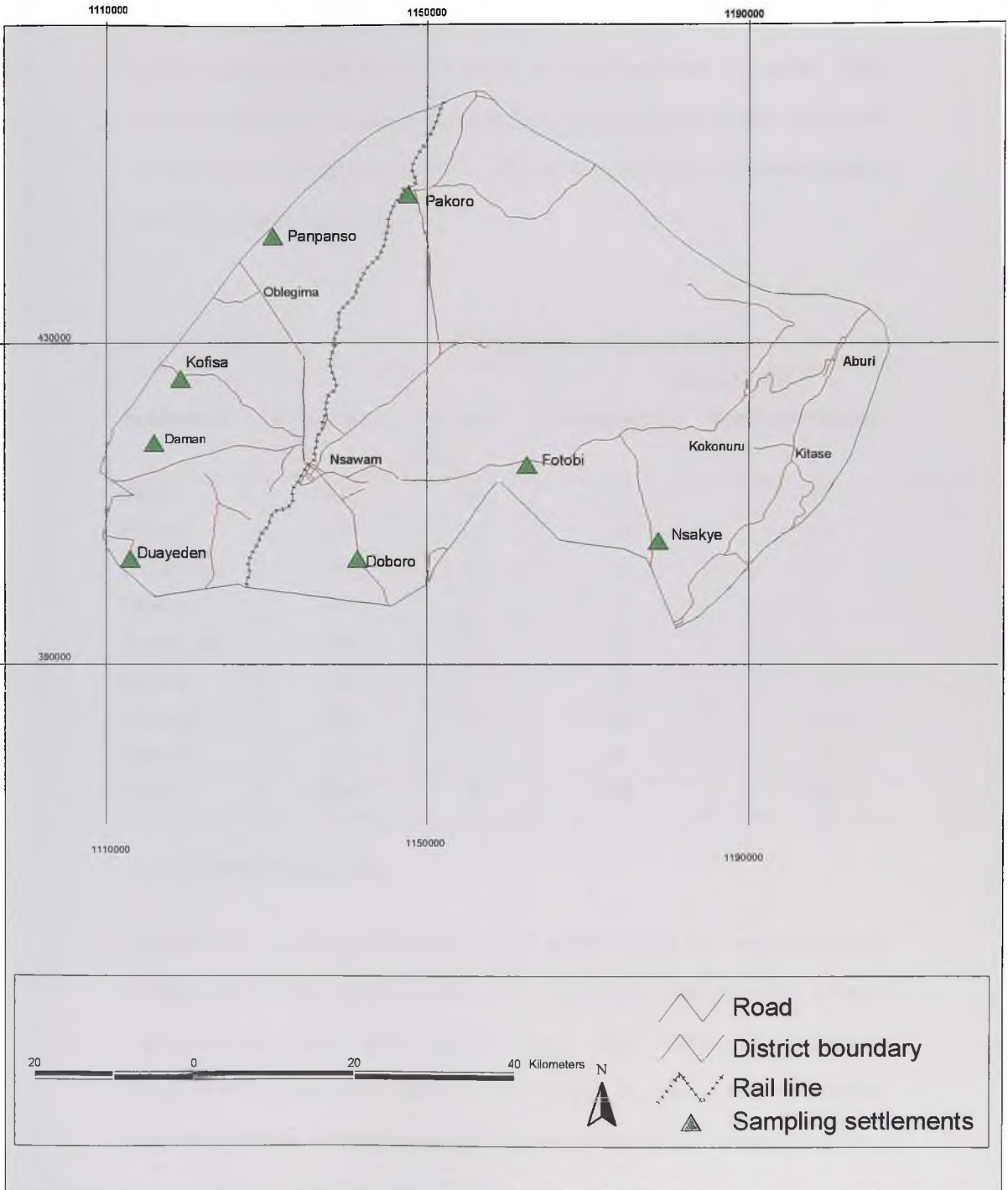
Table 2.1 **Sample strata**

| Level | Type of farming | Sample size |
|--------------|--------------------------------|--------------------|
| 1 | Subsistence farmers | 80 |
| 2 | Semi-Subsistence | 50 |
| 3 | Commercial farmers (Cash crop) | 10 |
| Total | | 140 |

Source: Field survey, 1999

Level 1 consists of subsistence farmers who grow food crops purposely for consumption with the probability of not selling any surplus. Level 2 comprises Semi-subsistence farmers who grow crops for the market, but also consume some. Most of these farmers cultivate both food and cash crops. Finally, Level 3 refers to people in commercial farming who grow only non-traditional export crops (e.g., pineapple and pawpaw).

Figure 2.2 Map of the Akwapim South District showing sampled sites



Source: Remote Sensing & GIS Applications Laboratory, Legon

Farmers were interviewed on several topics including their perception of the physical environment, size of households, number of farms that each has, method of cultivation, implements used, the history of ownership of the plot being cultivated, and the types of crops cultivated over the years. Using random sampling techniques, 65 structured questionnaires were administered to subsistence farmers within eight settlements according to the percentage of their population (Table 2.2).

Table 2.2 Sample size and distribution

| Settlement | Population 1984 | Sample (%) | Sample size | |
|-----------------|--------------------|---------------|-------------|------------------|
| | | | Subsistence | Semi-subsistence |
| Pakro | 1425 | 32 | 17 | 17 |
| Fotobi | 1218 | 27 | 13 | 13 |
| Panpanso | 102 | 2 | 3 | 3 |
| Nsakyee | 777 | 18 | 7 | 7 |
| Duayeden | 399 | 9 | 11 | 11 |
| Kofisa | 112 | 3 | 2 | 2 |
| Doboro | 360 | 8 | 10 | 10 |
| Daman | 41 | 1 | 2 | 2 |
| Total | 4434 | 100 | 65 | 65 |

Source: Field survey, 1999

Another set of 65 questionnaires was administered to semi-subsistence farmers within the sample settlements. For commercial farmers, different questionnaires were administered. There were about 14 recognised commercial farmers in the district, out of which 10 were randomly selected. The topics for the interview included the acquisition of land, number of years a

piece of land has been under cultivation, size and type of labour used, and the gender differences of the labour force.

2.7 Data Analysis and Integration

To effectively map changes in agricultural land use over time, it is necessary to integrate the processed imagery into GIS. Cowen (1988) defines GIS as a decision support system that integrates spatially referenced data in a problem-solving environment. One of the most important aspects of a GIS is that it allows disparate data sets, all geo-referenced in different systems, to be commingled. Landsat-TM scenes 1985 and 1991, aerial photographs, soil map, and topographic maps were used in the study.

The various computer softwares used included Microsoft Word '97, Microsoft Excel '97, Microsoft Power Point '97, Arc Info, Arc View 3.0, and Win Chips. Most of the charts and tables were generated from field data. Microsoft Excel was used to draw the bar graphs, pie charts, tables, and line graphs. For digitizing, database generation, and map compositions, Arc Info 3.5.1 and Arc View 3.0 programmes were used. Chips for Windows Version 4.3 were used in processing the images.

Questionnaires were coded and entered into a Statistical Package for Social Science (SPSS Windows 8.0) and analysed. Trends and inferences were drawn by using descriptive statistical techniques. Data on areas cultivated were collected in acres and later converted into metric system (hectares). The chi-square (X^2) test and ANOVA were applied to analyse data collected for

hypotheses relating to changes in land use, reduction in food crop production, and land degradation.

CHAPTER THREE**3.0 REMOTE SENSING DATA PROCESSING AND INTERPRETATION****3.1 Aerial Photographs**

Pan aerial photographs of 1974 at a scale of 1:40,000 covering the district (Table 3.1) were provided by the Survey Department in Accra. A reconnaissance survey was conducted which provided essential clues for the interpretation of the photographs and images,

Table 3.1 Serial numbers of aerial photographs

| | |
|------|-------------------------------------|
| G.60 | 103 104 105 126 127 128 129 130 131 |
| G.62 | 60 |
| G.63 | 51 52 53 54 55 56 57 58 59 |
| G.66 | 78 79 80 81 85 88 89 90 |



Source: Topographic maps, 1972/74

A mosaic was formed out of the photographs and visually interpreted by using the familiar image identification keys such as colour, structure, texture, form, and location. A tracing paper was superimposed on the aerial photos, and various polygons were created with a unique identity (Id) subject to field validation. Figure 3.1 shows a summary of the process of aerial photo interpretation.

The land use/cover classes derived from the photos included forest, farm land/cultivated field, built-up areas, shrub, fallow field and highland/mountain vegetation (Table 3.2). The polygons identified on the photos were transferred onto the satellite imagery for cross imagery comparison.

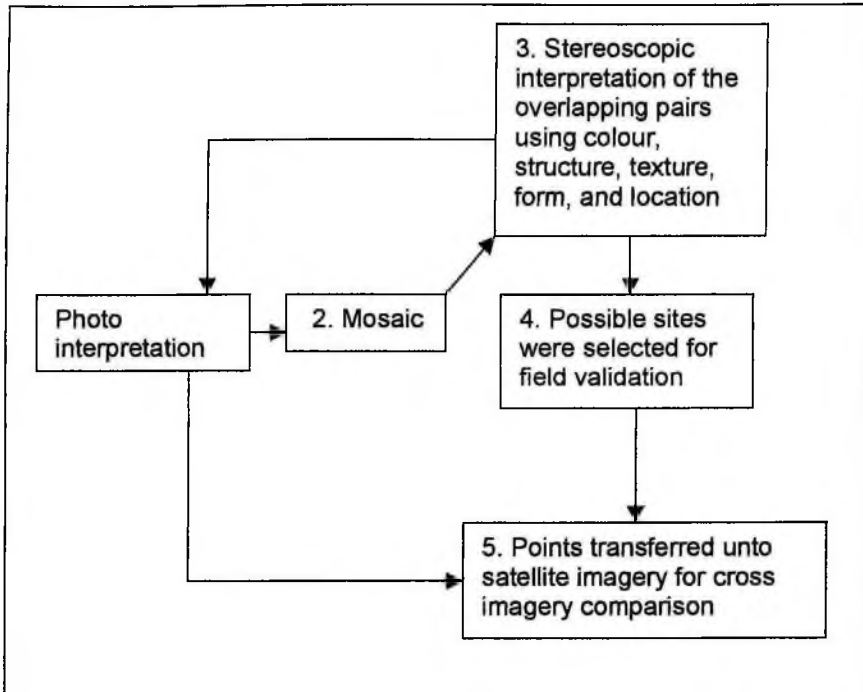
Generally, it was easy to identify farmlands and settlements on the photographs, but it was difficult identifying the types of farms. Another problem was cloud cover on four of the photographs (G.62: N0. 60; G. 63: N0s. 56, 57, and 58). These photographs, which cover areas around the Akwapim ridge, were difficult to interpret. After the interpretation, the aerial photographs were used to map land use at the scale of 1:40,000.

Table 3.2 **Land use / land cover classification scheme for aerial photo interpretation**

| Land use/cover type | Identification key |
|---|---|
| Forest (including open, close) tree crowns | Medium and very dark tone with shadows below the trees |
| Farm land / cultivated field (cultivated and cleared areas both small and large scale) | Almost bare with scattered conspicuous trees (light grey tone). Also showing well-defined edges with vegetative cover denser than fallow field (dark grey colour) |
| Built-up areas (settlements including towns, villages, commercial and service centres) | Regular shapes with communication lines (roads) either connecting or converging and showing patterns of grey, whitish grey, and relatively dark tone with cleared surrounding |
| Shrub | Light tone with open repetitive pattern but not clustered. |
| Fallow field | Cleared and well-defined edges. In few cases with few vegetative cover, light tone and smooth texture of surface condition. |
| Highland / mountain | Light tone reflectance (white) with few vegetative cover on the summits |

Source: a. Aerial Photograph interpretation Scheme (Lillesand & Kiefer, 1976)
b. Anderson *et al.* (1976)

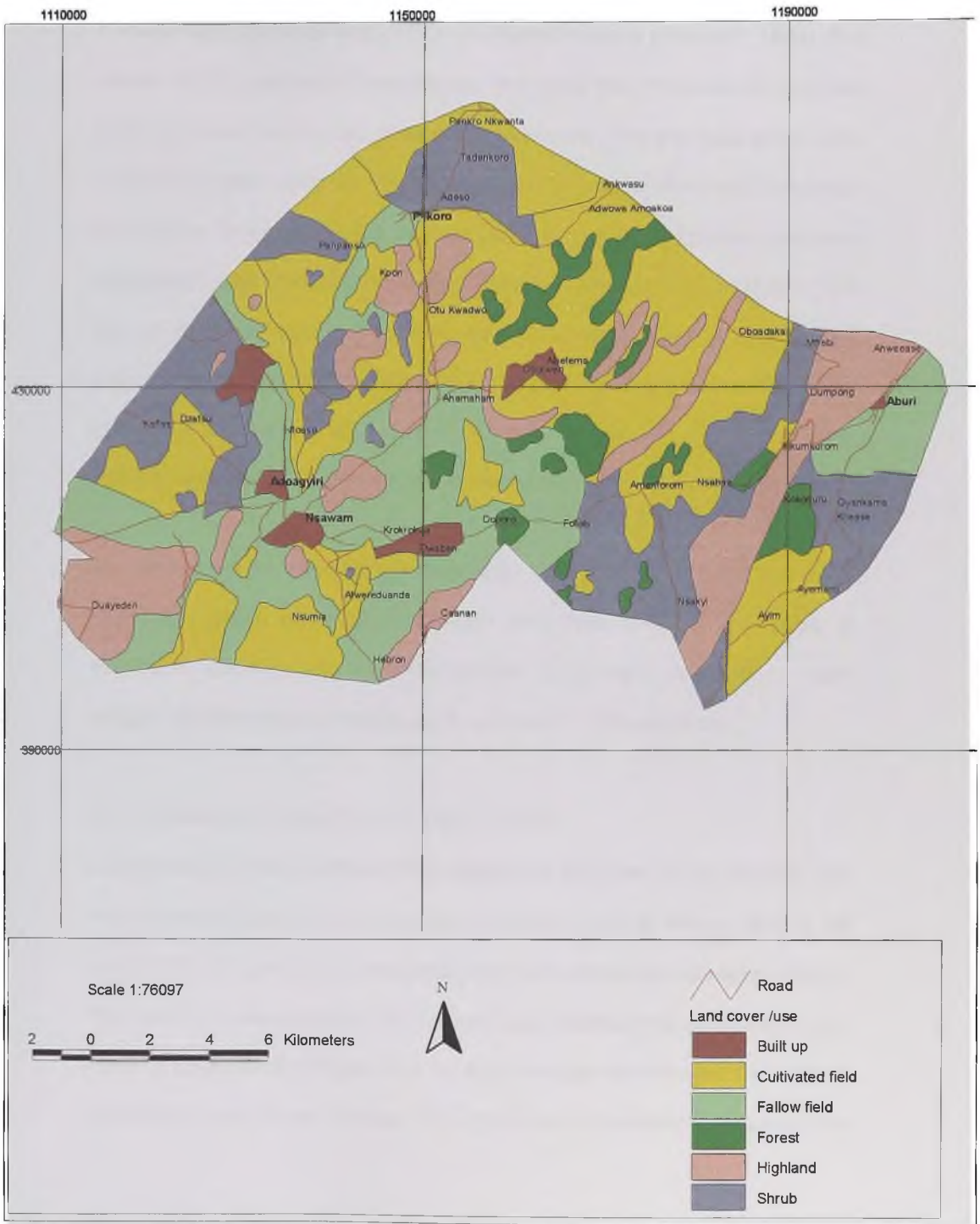
Figure 3.1

Processes of photo interpretation

Forests include patches of closed canopy forest, mature secondary regrowth, palm plantation, and fruit trees. Farm lands were identified by low plant cover and regular edges of farm plots. They include currently cropped and cleared lands. Fallow fields were also identified by their defined edges, but they were usually bare or cleared land. Shrubs include fallow fields and uncultivated lands with scattered, isolated standing trees.

The polygons created on the aerial photos were validated concurrently with the questionnaire. Some approximations were made in the delineation of the land use/cover boundaries because it was difficult to demarcate the exact boundary of any land use/cover class. The information gathered from the aerial photos was subsequently digitized.

Figure 3.2 Land use/cover classes derived from aerial photos



Source: Aerial Photographs of 1972, Survey Department, Accra

3.2 Image Processing

Land use/cover classification of remotely sensed data requires that homogeneous areas be segmented into distinct regions (Gyabaah, 1994). The choice of an appropriate classification technique that produces an accurate land use/cover classification is therefore necessary. The two main procedures used for the land use/cover classification are the unsupervised and supervised techniques. The fundamental assumption is that, each vegetation type exists separately in the multi-spectral band of satellite data, although in reality there are no clear boundaries. The main difference between the supervised and unsupervised classification techniques is that, in the former, information categories are first defined before their spectral separability, but in the latter, spectral separability classes are first defined before information categories.

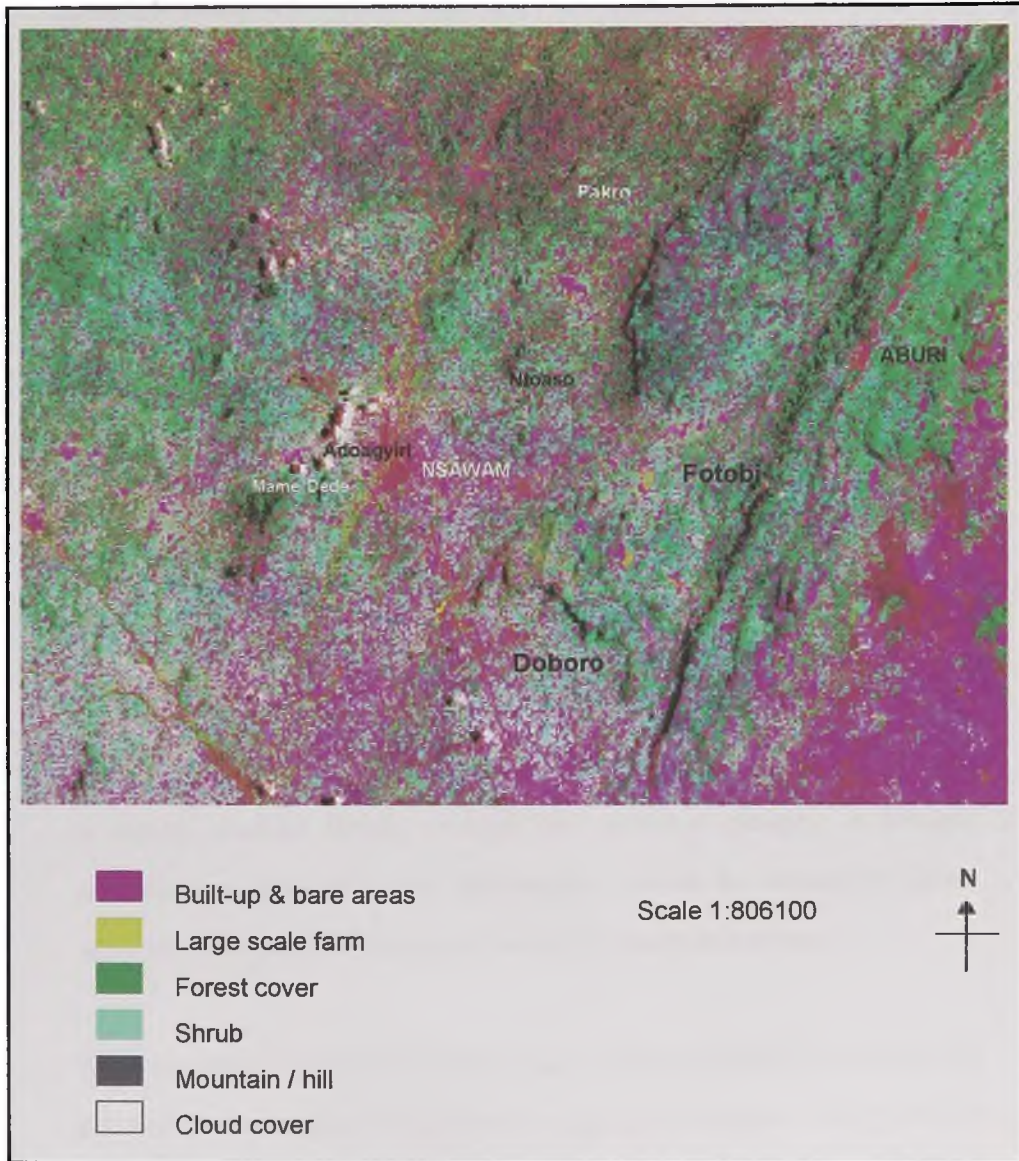
For the supervised classification technique, training areas of homogeneously identified surface types were selected and then used as examples in automated classification. Separate training sites were selected for each imagery because the two images were acquired on different dates.

3.2.1 Classification of Landsat TM 1985 Imagery

Using the WIN-CHIPS software, the image was displayed on the monitor, and various enhancement techniques were performed, using all the six Landsat TM bands (1,2,3,4,5 and 7), to emphasise the tonal differences between objects. This was done several times until the most appropriate band combinations (3, 4 and 5) were chosen (Figure 3.3). An unsupervised classification was initially performed, using the six classes. The result was unsatisfactory because of a

lot of overlaps. In view of this, training sites from the area were selected based upon field visits aided by aerial photographs and topographic maps.

Figure 3.3 False colour composition (band 3, red; band 4, green; band 5, blue) of Landsat TM Image 1985 of Akwapim South District and its environs (unclassified)



Source: Processed digital image data from CERSGIS, Legon

For instance, during the field work, vegetation characteristic and land use/cover types at known reference points, which could be identified on the aerial photos, were recorded. Histograms and training site statistics were displayed, using a Signature Editor (Appendixes I and III), to show the reflection values within the various bands. The statistical operation performed produced a covariance matrix, which was used to classify the images. Statistics of the training sites were generated and scatter plot ellipse of the classes were drawn (Appendixes II and IV). The scatter plots illustrate the separability or uniqueness of the various class signatures. Supervised classification, using maximum likelihood, was then performed to indicate the major land use/cover types within the sub-scene (Figure 3.4).

The land use/cover types delineated on the images included;

- built-up / bare areas,
- farms / fallow fields,
- forest / mountain vegetation / tree crops, and
- shrubs.

These classes were arrived at after several enhancements and classifications to ensure minimum overlap of each land use/cover category. A principal component analysis (PCA) was performed to indicate the reflectance values within the multi-band images, and to select the appropriate bands.

Table 3.3 shows that the first three principal components explain more than 95 per cent of the variables. For instance, in principal component (PC) 3, band 4 was heavily weighted (0.92) whereas in PC 4, band 3 was slightly weighted

(0.49), indicating more reflectance of vegetation. The value -0.41 for PC 5 and band 5 means reflectance was less in areas identified as built-up or bare. This reflectance served as a good contrast for the classification.

**Table 3.3 Principal component analysis of Landsat TM 1985
(six bands)**

| PC | Eigen value | Pct | C1 | C2 | C3 | C4 | C5 | C6 |
|----|----------------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 127.24 | 41.49 | 0.36 | 0.21 | 0.46 | 0.09 | 0.53 | 0.57 |
| 2 | 92.56 | 30.18 | 0.50 | 0.34 | 0.39 | 0.30 | -0.56 | -0.29 |
| 3 | 73.44 | 23.95 | -0.18 | 0.00 | -0.19 | 0.92 | 0.27 | -0.12 |
| 4 | 10.28 | 3.35 | -0.65 | -0.07 | 0.49 | 0.15 | -0.4 | 0.40 |
| 5 | 2.42 | 0.79 | 0.31 | -0.12 | -0.53 | 0.16 | -0.41 | 0.65 |
| 6 | 0.72 | 0.23 | -0.28 | 0.91 | -0.29 | -0.10 | -0.00 | 0.09 |

Source: CHIPS analysis of image

Both Jeffries-Matusita and Euclidean Distance were used for the classification (Tables 3.4 and 3.5), because they produce divergence values which have been shown to be very effective in other studies (eg. Mausel *et al.*, 1990). The separability analysis (Tables 3.4 and 3.5) shows that all the land use/cover classes were distinct from each other, with 1.4 being the highest separability level among the classes.

Table 3.4 **Separability for 1985 Landsat TM Image using Jeffries-Matusita Distance**

| Region | Built-up/bare areas | Farms/fallow fields | Forest/mountain vegetation/tree crops | Shrub |
|---------------------------------------|---------------------|---------------------|---------------------------------------|------------|
| Built-up/bare areas | 0.0 | 1.4 | 1.4 | 1.4 |
| Farms/fallow fields | 1.4 | 0.0 | 1.4 | 1.4 |
| Forest/mountain vegetation/tree crops | 1.4 | 1.4 | 0.0 | |
| Shrub | 1.4 | 1.4 | 1.4 | 0.0 |

Source: CHIPS analysis of image

Table 3.5 **Separability for 1985 Landsat TM Image using Euclidean Distance**

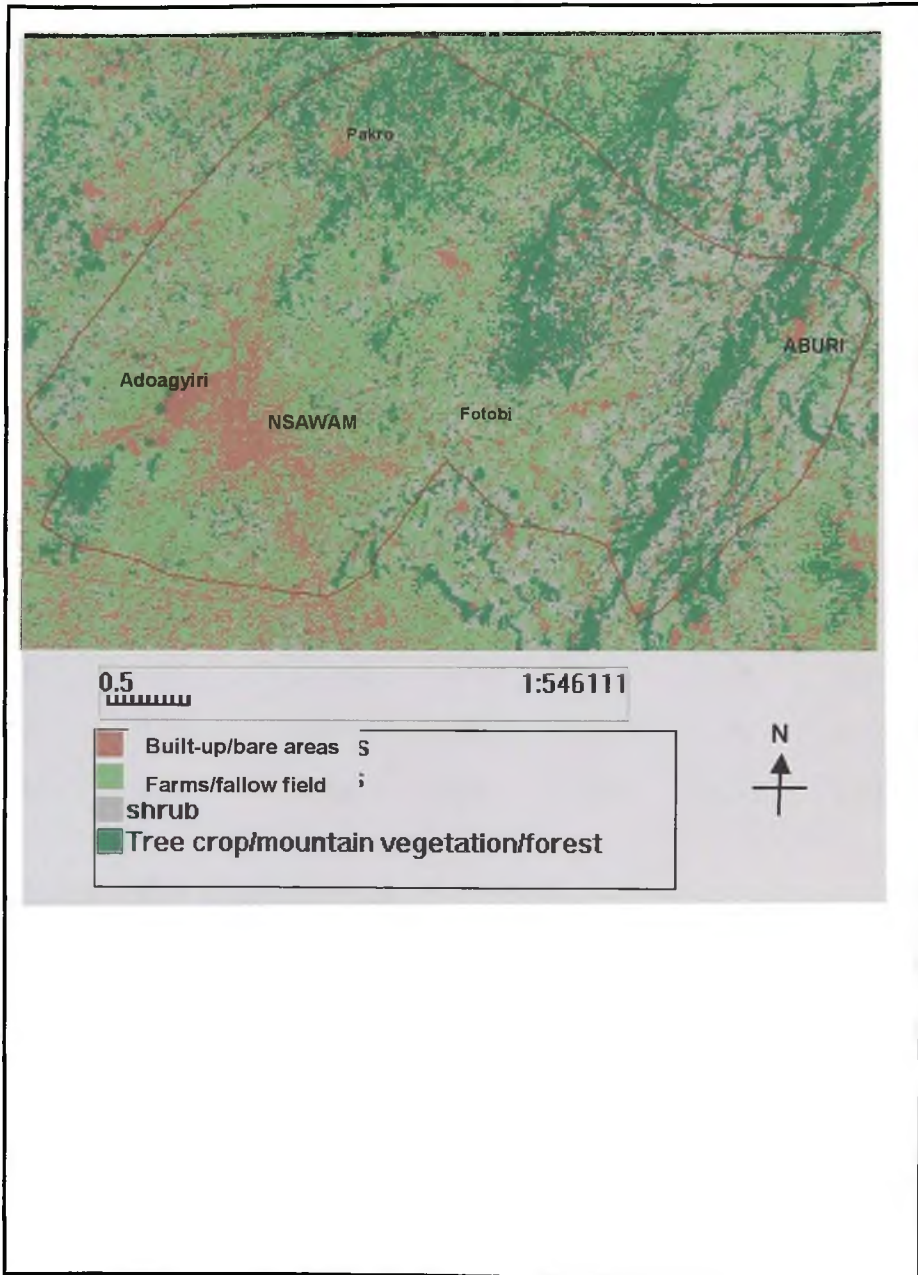
| Region | Built-up/bare areas | Farms/fallow fields | Forest/mountain vegetation/tree crops | Shrub |
|---------------------------------------|---------------------|---------------------|---------------------------------------|------------|
| Built-up/bare areas | 0.0 | 61.7 | 56.9 | 66.2 |
| Farms/fallow fields | 66.2 | 0.0 | 33.1 | 15.1 |
| Forest/mountain vegetation/tree crops | 56.9 | 33.1 | 0.0 | |
| Shrub | 66.2 | 15.1 | 72.7 | 0.0 |

Source: CHIPS analysis of image

To enhance the image and to give differential information on land use/cover types, the classified image was pseudo coloured. From this, it was possible to clearly identify the four distinct land use/cover types. The brown colour represents built-up and bare areas, with Nsawam and Adoagyiri shown in the central portion (Figure 3.4). Agricultural land, comprising current farms (mono and mixed cropping) and fallow fields, are shown in light green. The deep green colour describes tree crops, mountain vegetation and forest cover, and shrubs are shown in ash colour.

Tree crops, mountain vegetation and forest, according to the analysis (Figure 3.4), are more concentrated north and north-east, especially on the highlands.

Figure 3.4 **Classified & Filtered Landsat TM (1985) image of Akwapim South District and its Environs**



Source: Processed digital image data from RSAL

3.2.2 Classification of Landsat TM 1991 Imagery

This was done using the same procedure as in the classification of Landsat TM 1985 Image. Similar land use/cover types were identified (Figure 3.4). Table 3.6 shows the PCA which was used for the enhancement (Gillespie *et al.*, 1996). Tables 3.6, 3.7, and 3.8 show the statistics derived from the classified image. The land use/cover classes identified and depicted in Figures 3.5 and 3.6 are similar to those discussed for the 1985 Landsat Image. Variations observed in the magnitudes of each land use/cover type for the different periods have been discussed further in this chapter.

Table 3.6 Principal component Landsat TM 1991 Image

| PC | Eigenvalue | Pct. | C1 | C2 | C3 | C4 |
|-----------|-------------------|-------------|-----------|-----------|-----------|-----------|
| 1 | 2.14 | 53.53 | 0.45 | -0.62 | 0.07 | -0.64 |
| 2 | 1.22 | 30.48 | -0.46 | -0.28 | 0.84 | 0.04 |
| 3 | 0.53 | 13.14 | 0.76 | 0.24 | 0.49 | 0.35 |
| 4 | 0.11 | 2.86 | 0.06 | -0.69 | -0.23 | 0.68 |

Source: CHIPS analysis of image

The separability analysis in Tables 3.7 and 3.8 shows that the classes were distinct from each other as observed in the 1985 Landsat TM image. It also shows a good classification. Secondly, a classification accuracy assessment based on the original training sites showed that the percentage of training sites pixels that were correctly classified ranged between 94 and 100 per cent for both image dates.

Table 3.7 **Separability for Landsat TM 1991 Image using Jeffries-Matusita**

| Region | Distance | | | |
|---------------------------------------|---------------------|---------------------|---------------------------------------|------------|
| | Built-up/bare areas | Farms/fallow fields | Forest/mountain vegetation/tree crops | Shrub |
| Built-up/bare areas | 0.0 | 1.3 | 1.4 | 1.4 |
| Farms/fallow Fields | 1.3 | 0.0 | 1.4 | 1.3 |
| Forest/mountain vegetation/tree crops | 1.4 | 1.4 | 0.0 | |
| Shrub | 1.4 | 1.3 | 1.4 | 0.0 |

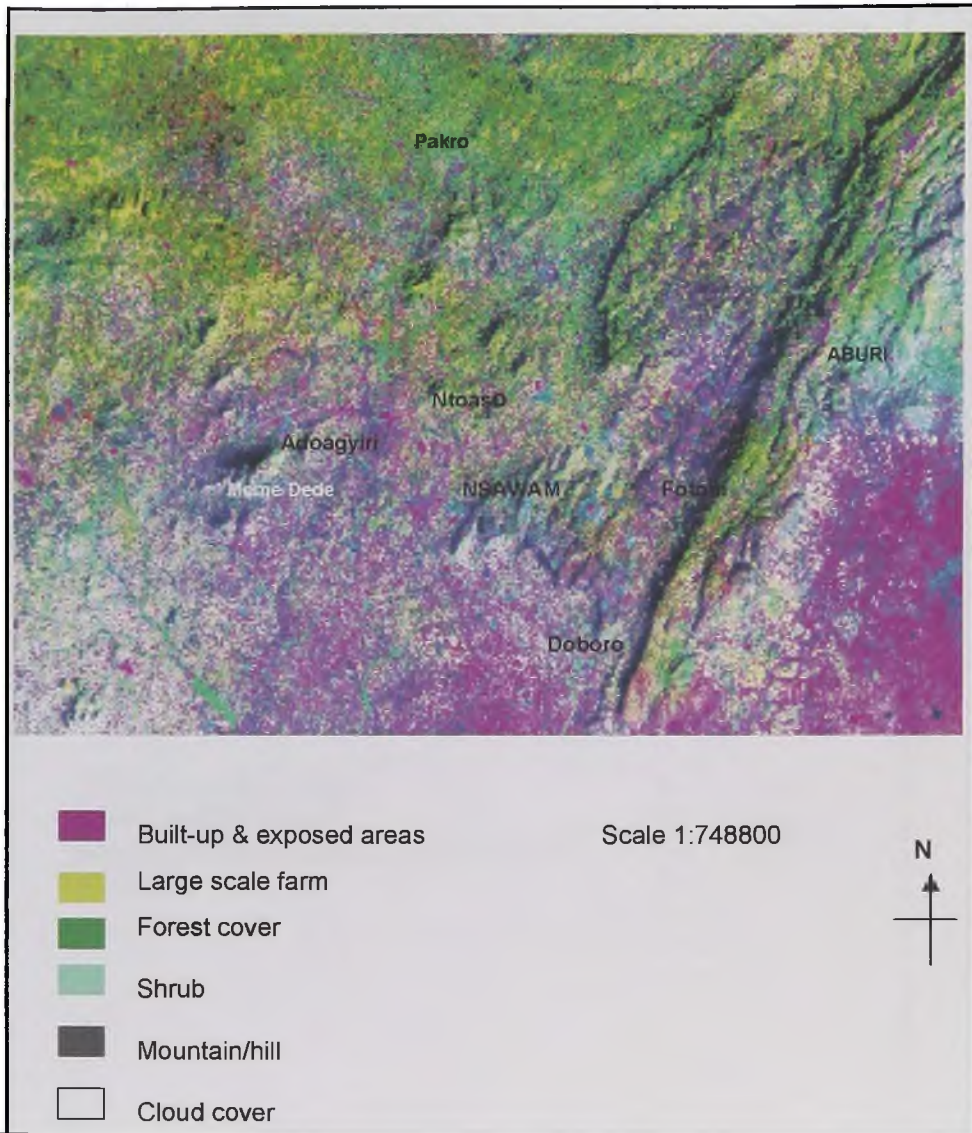
Source: CHIPS analysis of image

Table 3.8 **Separability for Landsat TM 1991 Image using Euclidean**

| Region | Distance | | | |
|---------------------------------------|---------------------|---------------------|---------------------------------------|------------|
| | Built-up/bare areas | Farms/fallow Fields | Forest/mountain vegetation/tree crops | Shrub |
| Built-up/bare areas | 0.0 | 27.8 | 53.8 | 29.4 |
| Farms/fallow Fields | 27.8 | 0.0 | 34.0 | 2.7 |
| Forest/mountain vegetation/tree crops | 53.8 | 34.0 | 0.0 | 33.5 |
| Shrub | 29.4 | 2.7 | 33.5 | 0.0 |

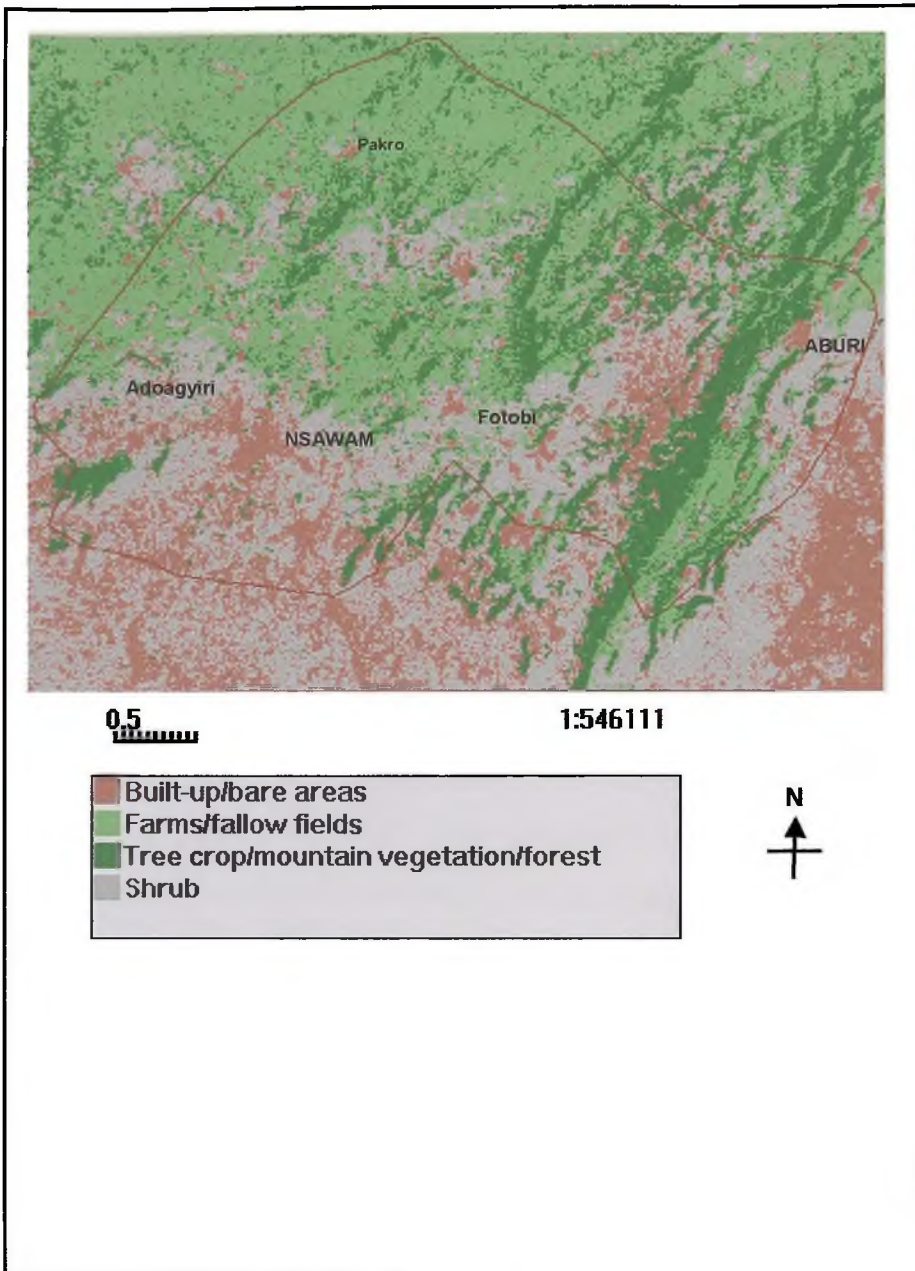
Source: CHIPS analysis of image

Figure 3.5 False colour composition (band 3, blue; band 4, green; band 5, red) of Landsat TM Image 1991 of Akwapim South District and its environs (unclassified)



Source: Processed digital image data from CERGIS, Legon

Figure 3.6 **Classified & filtered Landsat TM 1991 Image of Akwapim South District and its environs**



Source: Processed digital image data from RSAL

3.3 Changes in Land Use Pattern between 1972/74 and 1985

The aerial photo interpretation and the classification of the satellite images show a complex land use/cover pattern. Table 3.9 presents the distribution of land use/cover classes identified on the aerial photos as at 1972/74.

Table 3.9 Land use/cover classes as at 1972/74

| Land use/cover | Area (ha) | Percentage (%) |
|------------------------------|------------------|----------------|
| Built-up | 847.29 | 2 |
| Farm land / cultivated field | 13,762.00 | 37 |
| Fallow field | 7,848.44 | 21 |
| Forest | 1,886.26 | 5 |
| Highland | 5,909.00 | 16 |
| Shrub | 6,952.31 | 19 |
| Total | 37,202.01 | 100 |

The GIS analyses showed that, as at 1972/74, about 37 per cent (13,762 ha) of the total land was under cultivation or considered to be farms. The second most important land use was fallow fields, at various succession regeneration stages, occupying 21 per cent of the total land area. Land use/cover described as shrub was the third most important, occupying 19 per cent of the land. Settlements, both rural and urban, and forest, both tree crop and secondary forest, were rated the least land use/cover type, representing 2 and 5 per cent, respectively.

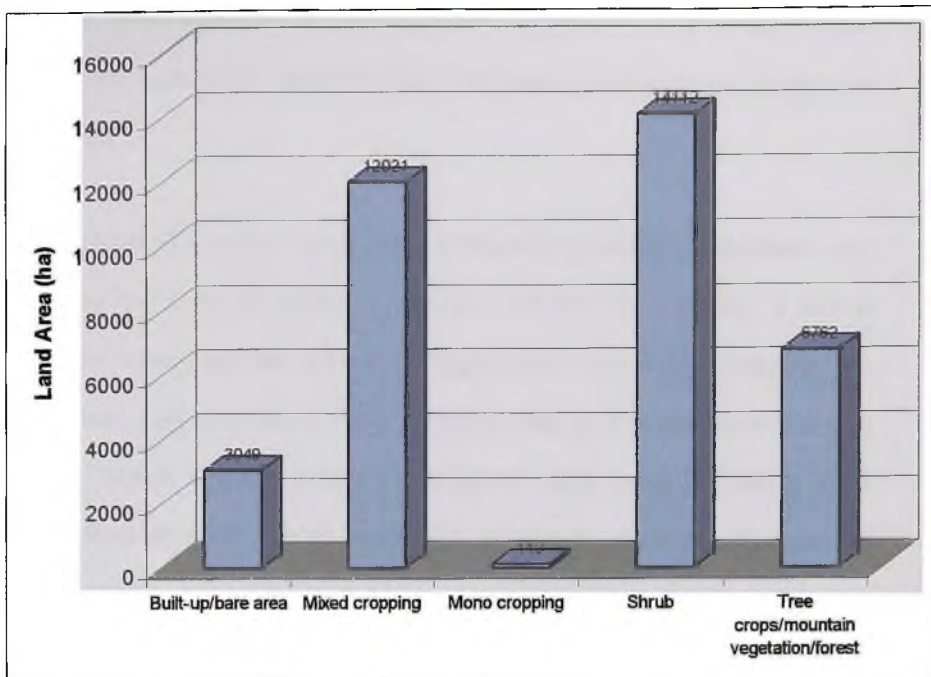
For harmonisation and comparison among the various satellite images and aerial photos, further field investigations were conducted and a second level of classification was generated (Table 3.10) within the GIS environment as a vector layer. Another GIS analysis showing the pattern of changes is discussed in Chapter Four.

Table 3.10 **Interpretation levels of remote sensing data integrated in the GIS**

| Imagery | Level 1 | Level 2 |
|--|---|---|
| Aerial photos | <ol style="list-style-type: none"> 1. Built-up 2. Cultivated field 3. Fallow field 4. Forest 5. Highland 6. Shrub | <ol style="list-style-type: none"> 1. Built-up/bare area 2. Mixed cropping 3. Mono cropping 4. Tree crop/mountain vegetation/forest 5. Shrub |
| 1985 Landsat TM (satellite image) | <ol style="list-style-type: none"> 1. Built-up / bare areas 2. Farms / fallow fields 3. Forest / mountain vegetation / tree crops 4. Shrubs | <ol style="list-style-type: none"> 1. Built-up/bare area 2. Mixed cropping 3. Mono cropping 4. Tree crop/mountain vegetation/forest 5. Shrub |
| 1991 Landsat TM (satellite image) | <ol style="list-style-type: none"> 1. Built-up / bare areas 2. Farms / fallow fields 3. Forest / mountain vegetation / tree crops 4. Shrubs | <ol style="list-style-type: none"> 1. Built-up/bare area 2. Mixed cropping 3. Mono cropping 4. Tree crop/mountain vegetation/forest 5. Shrub |

Source: Vectorisation of satellite data (Aerial photos and Landsat TM)

Table 3.10 shows that the most important land use/cover type was shrub, covering 14,112 ha of the total land area (Figure 3.7). The next important land use/cover was mixed cropping, made up of cassava, plantain, maize and cocoyam, occupying 12,021 ha of the land. Another important land use/cover that followed were areas classified as mixed cropping, covering about 12,024 ha. Tree crop, mountain vegetation, and forest also occupied 6,762 ha. Area classified as built-up or bare were 3,049 ha; and mono cropping, which included the cultivation of crops like pineapples and pawpaw, represented only 110 ha.

Figure 3.7 **Total areas of land use/cover types as at 1972/74**

Source: Aerial photographs, 1972/74

Comparing the classification result of the Landsat TM 1985 Image and aerial photos of 1972/74, it came to light that series of changes had taken place within a period of about 12 years.

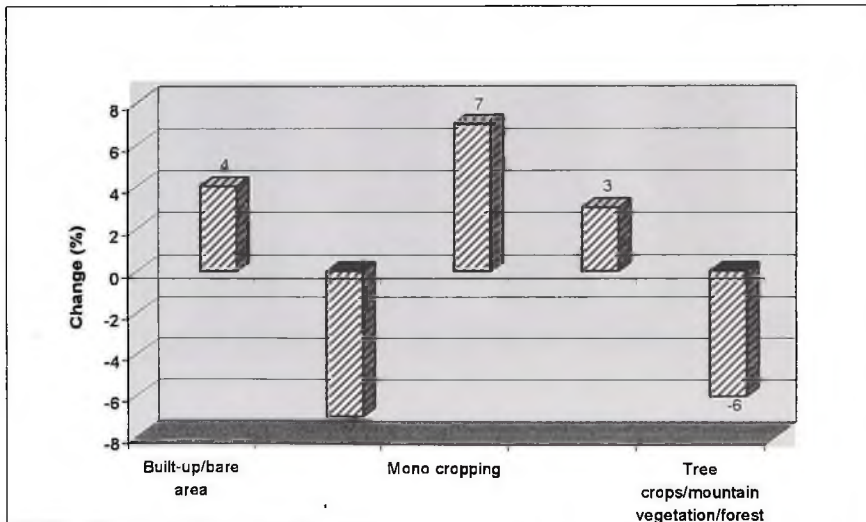
Table 3.11 Changes in land use/cover types between 1972/74 and 1985

| Land use/cover type | 1972/74 | 1985 | Change |
|---|------------|-----------|----------|
| | (%) | (%) | |
| Built-up/bare areas | 8 | 12 | 4 |
| Mixed cropping | 34 | 27 | -7 |
| Mono cropping | 5 | 12 | 7 |
| Tree crops / Mountain vegetation / forest | 19 | 13 | -6 |
| Shrub | 34 | 36 | 3 |
| Total | 100 | 13 | 1 |

Table 3.11 and Figure 3.8, show that three of the land use/cover had expanded. Areas classified as built-up/ bare expanded from 8 to 12 %, mono cropping from 5 to 12 %, and tree crop, mountain vegetation and forest from 33 % to 37%.

The expansion in built-up / bare areas indicates of population increase, and also shows the level of human interaction with the environment. It further shows how vulnerable the area is to degradation. For mono cropping, the increase was very significant (7%), probably due to the promotion of non-traditional export crops, especially pineapples and pawpaw, which were observed from the field. The increase of 4 per cent in areas classified as tree crop, mountain vegetation, and forest does not mean forest cover has increased; rather, it can be attributed to tree crops such as sugarcane and oil palm plantation observed on the field.

Figure: 3.8 **Changes in land use/cover types between 1972/74 and 1985**



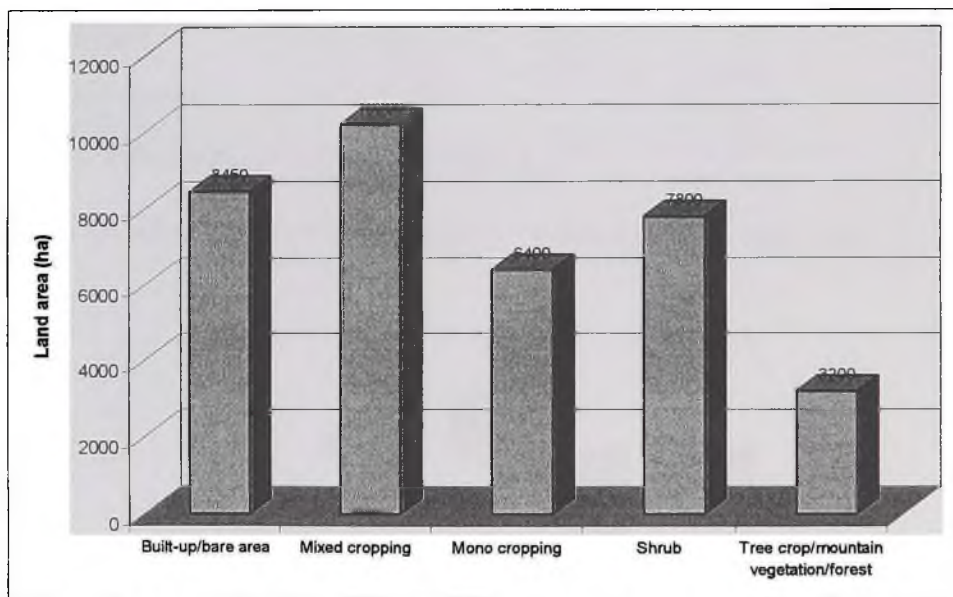
Source: Aerial photos 1972/74 and satellite image 1985

On the contrary, areas classified as mixed cropping reduced by 7 per cent (from 34 to 27%) over the period of 12 years. Some of the crops cultivated in mixed cropping are cassava, plantain, cocoyam, maize, and yam.

3.4 Changes in Land Use Pattern between 1985 and 1991

A different land use/cover pattern was observed in 1999 from the satellite image. Figure 3.9 shows that the highest land use/cover type was mixed cropping which covered 10,200 ha of the total land area. This was followed by built-up or bare areas (8,450 ha), then mono cropping areas (6,400 ha), and the least was tree crop, mountain vegetation and forest cover (3,200 ha).

Figure 3.9 Total areas of land use/cover types as at 1991



Source: Satellite image, 1991 Landsat TM

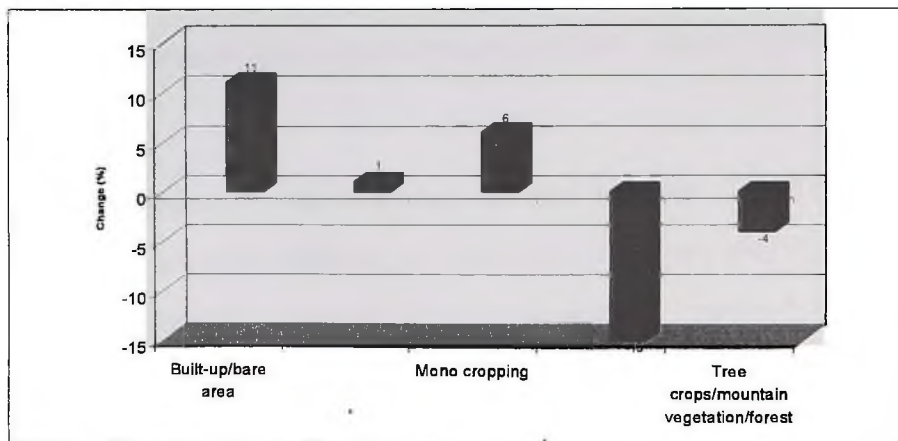
Table 3.12 and Figure 3.10 show the percentage change of the various land use classes. Between 1985 and 1991, areas classified as built-up or bare (exposed) expanded by 11 per cent (from 12 to 23%). Mixed cropping increased by only 1 per cent while mono cropping also showed an increase of 6 per cent (12 to 18%). The rate of increase in both built-up or bare areas and mixed cropping need much to be desired, because exposed or bare areas are under a serious threat of land degradation. Also, the low percentage increase in mixed cropping (1%) is a serious threat to food security in the area and the country at large.

Table 3.12 **Changes in land use/cover between 1985 and 1991**

| Land use/cover | Year | | Change % |
|--------------------------------------|------|------|----------|
| | 1985 | 1991 | |
| Built-up/bare area | 12 | 23 | 11 |
| Mixed cropping | 27 | 28 | 1 |
| Mono cropping | 12 | 18 | 6 |
| Shrub | 37 | 22 | -15 |
| Tree crop/mountain vegetation/forest | 13 | 9 | -4 |

Source: Satellite image, 1985 & 1991 Landsat TM

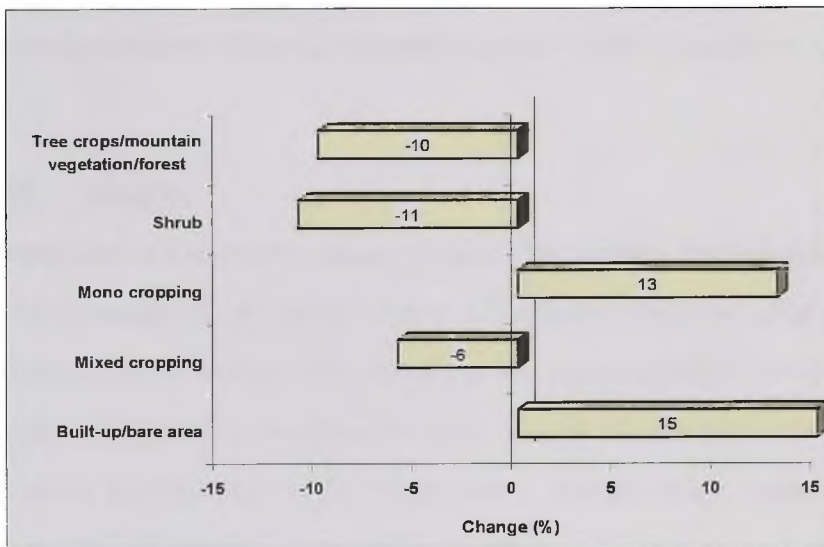
Figure 3.10 **Changes in land use/cover between 1985 and 1991**



Source: Satellite image of 1985 and 1991 Landsat TM

The total percentage change over the period of about 19 years was very high. The total land use/cover of built-up or bare areas expanded by 15 per cent Figure 3.11. Furthermore, areas classified as mono cropping has also expanded by 13 per cent. Meanwhile, areas classified as mixed cropping, shrub, and tree crops or mountain vegetation showed a reduction in their various land areas.

Figure 3.11 **Changes in land use/cover from 1972/74 to 1991**



Source: Aerial photos & satellite imagery (1972/74, 1985 and 1991)

The observations discussed so far had limitation. Firstly, supervised classification was performed on the images, which involved the selection of training sites. This was a great limitation because, as Lillesand & Kiefer (1979) noted, "the training effect is more of an art than science, referring close interaction between the image analyst and the image data and therefore

necessitates a thorough knowledge of the geographical area to which the data apply”.

Secondly, the satellite images were acquired in the dry season (April 1985 and January 1991) and this might have influenced the classification. Perhaps if the images had been acquired immediately after the major rainy season (July-August), the classification might have changed. Besides, the classification scheme used was very broad, due to the complexity of the land use / cover pattern in the area. Mapping crop pattern therefore, was not possible.

3.5 Summary

Aerial photos and satellite imagery were the main remote sensing data used. The photographs and satellite imagery were visually interpreted using various classification schemes at different levels, and then integrated into a GIS for further analysis. The four main land use/cover types identified and used for the analysis were built-up and bare areas; mono cropping; mixed cropping; tree crop, mountain vegetation, and forest; and shrub.

From 1972/74 to 1991, the analysis showed significant increase in areas classified as built-up or bare and mono cropping (13 and 15%, respectively), and a significant decrease in mixed cropping, shrub, and tree crop, mountain vegetation or forest (6, 11 and 10% respectfully). These changes have their socio-economic and environmental implications. The expansion in built-up or bare areas is evidence of environmental degradation as well as of increase in population in the study area. For mono cropping, it is expected that the

country's foreign exchange earnings from exports of pineapples and pawpaw will increase. However, the main issue is the cultural practices associated with mono cropping; trees that might shade the crops are cleared thereby causing deforestation. The decrease in mixed cropping, shrub, and tree crops or forest indicate a threat to the environment as well as to food security.

CHAPTER FOUR

4.0 INTEGRATION OF DATA IN GIS

4.1 Introduction

To be able to use information derived from the remotely sensed images in conjunction with maps, aerial photographs, and field-derived information, the data were geographically corrected and projected to the topographic map (transverse mecaton) for use in a GIS.

The database created was referenced to the location of Akwapim South District and specifically to the settlements. The database is to enable one to retrieve information as well as to manipulate multiple sets of geographic data (Said, 1993). The database consists of attribute data with information such as population tied to the various settlements (Table 4.1). The satellite data were stored initially as raster and later converted into vector format for the change detection.

Vector data are split into three types: polygon, line (or arc), and point data. Polygon data are used to represent areas (land use/cover). Line (or arc) data are used to represent linear features such as roads, rail, streams, and contours. The symbols used to distinguish these arc features are solid lines, dashed lines, and combinations using colours and line thickness. In this study, roads are represented in red lines, streams or rivers in blue, boundary as solid black line, and contours in brown. Points have been used to represent settlements. In addition to these definitions, metadata (Table 4.2) have been created to show the information needs of the system, data type, source format, and level of details, among others.

Table 4.1 **Organization of database using the relational model**

1. Settlement and population

| | | | | | |
|-------|---|---|-----|--------------|-----|
| Point | 0 | 0 | 39 | Oboadaka | 249 |
| Point | 0 | 0 | 44 | Nsakyeso | 185 |
| Point | 0 | 0 | 99 | Aburi Amanfo | 179 |
| Point | 0 | 0 | 104 | Anoff | 68 |
| Point | 0 | 0 | 117 | Noka | 190 |
| Point | 0 | 0 | 136 | Pakro | 513 |

2. Land use derived from aerial photos

| | | | | | |
|-----------|----------|----|-----|------------------|----------------|
| 42650160 | 39906 | 2 | 39 | Cultivated field | Mixed cropping |
| 66228940 | 44131.3 | 3 | 44 | Cultivated field | Mixed cropping |
| 115107600 | 51865.5 | 4 | 3 | Shrub | Shrub |
| 586565500 | 416603.8 | 6 | 4 | Cultivated field | Mono cropping |
| 48360690 | 59868 | 7 | 117 | Fallow field | Mixed cropping |
| 35682840 | 28623.8 | 8 | 6 | Shrub | Shrub |
| 31417970 | 34927.2 | 9 | 7 | Forest | Tree crop |
| 32611260 | 44902.8 | 10 | 8 | Forest | Tree crop |
| 22772870 | 21421.8 | 11 | 9 | Highland | Tree crop |
| 20070050 | 23167.8 | 12 | 10 | Cultivated field | Mixed cropping |
| 22687850 | 22026.2 | 13 | 75 | Highland | Tree crop |
| 48127220 | 65697.7 | 14 | 86 | Cultivated field | Mixed cropping |
| 8741919 | 12626.9 | 15 | 11 | Highland | Tree crop |
| 1905742 | 6481.2 | 16 | 12 | Shrub | Shrub |
| 15352150 | 22593.7 | 17 | 0 | Fallow field | Mono cropping |
| 5259259 | 9496.4 | 18 | 13 | Forest | Tree crop |

3. Land use derived from satellite imagery

| | | | | |
|------------------|--------------|----|-----|----------------|
| 116541000.000000 | 58190.090000 | 4 | 102 | Mono cropping |
| 67437300.000000 | 43625.290000 | 5 | 105 | Mixed cropping |
| 82285610.000000 | 64493.910000 | 7 | 98 | Mono cropping |
| 55597320.000000 | 49131.730000 | 8 | 37 | Shrub |
| 167847100.000000 | 62577.450000 | 9 | 100 | Tree crop |
| 38802750.000000 | 34456.850000 | 10 | 106 | Shrub |
| 17220440.000000 | 15653.670000 | 13 | 35 | Mixed cropping |
| 3262077.000000 | 7917.066000 | 14 | 97 | Mixed cropping |
| 93498050.000000 | 58346.490000 | 15 | 48 | Mixed cropping |
| 4621214.000000 | 11521.220000 | 16 | 46 | Mixed cropping |
| 58307330.000000 | 54143.500000 | 17 | 33 | Mono cropping |

Source: Adapted from Aronoff S. 1991

Table 4.2 Metadata information used

| Information needs of the system | Data description | Source | Format | Level of details | Quality | Utilisation |
|--|-----------------------|---------------------------|--------------------|-------------------------|-------------------------------------|--------------------|
| Agricultural land use information | District boundary | Town & Country Planning | Map: Analogue | District level | Not very accurate Scale 1:50,000 | General in GIS Map |
| | Road network | Survey Department | Topo map: Analogue | Administrative National | 1: 50000 Accurate | General in GIS Map |
| | Water bodies/ streams | Survey Department | Topo map: Analogue | Administrative National | Scale 1: 50000 Accurate | General in GIS map |
| | Contours | Survey Department | Digital, vector | Tile | Scale 1:50,000 Accurate | General in GIS Map |
| | Settlement | Survey Department | Topo map: Analogue | Administrative National | Scale 1:50,000 Accurate | General in GIS Map |
| | Aerial photos | Survey Department | Photographs | District | Scale 1: 40,000 | Land use/cover map |
| | Landsat imagery | Remote Sensing Laboratory | Digital | Tile | | Land use/cover map |

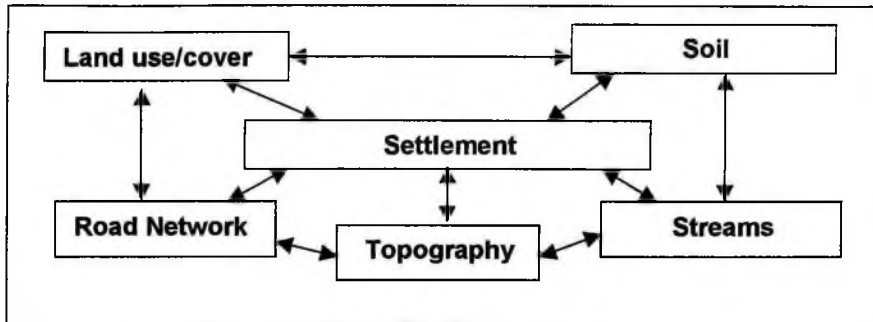
Source: Author's construct, 1999

4.2 Conceptual Data Modelling

Six entities – a settlement, land use, soils, streams, road network, and topography have been identified to establish relation within the database. Settlement is indicated as points together with its population. Land use is depicted as polygon, and shows the land use type as identified on both the aerial photos and satellite imagery, as well as the area coverage within which various settlements are located. Soil as an entity also describes the soil type as a polygon feature, and shows the settlements and other attributes that are associated with the settlement (Figure 4.1). Each arrow within the conceptual entity relations shows that many relationships can be drawn from many

entities. This relationship diagram (Figure 4.1) has been transferred into a computer and the entities and relationships mapped with their attributes.

Figure 4.1 **Conceptual entity relationship**



4.3 Data Integration and Analysis

To enhance GIS analysis and data harmonization using Arcview, all the images were vectorized and a common classification scheme generated. These classes are built-up/bare areas, mixed cropping, mono cropping, tree crop / mountain vegetation / forest, and shrub. The classes are more generalized, but in each case, the type of land use/cover forms more than 50 per cent of the complex vegetation pattern described in the area. For example, areas classified as built-up or bare have some shrubs as well as farms, but more than 50 per cent of the vegetation in these areas is built-up or bare.

The overlay principle was used to determine the actual pattern of land use/cover change between 1985 and 1991. Initially, the classified satellite image of 1985 was superimposed on the 1991 image in the GIS to observe various overlaps and for further analysis. Intersect and dissolve operations

were then performed. Originally, the 1991 land use map (polygon) was used as an input theme while the 1985 land use (polygon) was used as intersect (overlay). This was to integrate the two data sets while preserving those features falling within the spatial extent common to both themes. The attribute tables were also automatically updated.

Finally, the dissolve operation was then performed to remove boundaries between adjacent polygons with the same values for the 1991 land use attributes, and the results were used to create a new theme showing the change pattern (Figure 4.2). It also includes summaries of which land use type changed over the years under review (Table 4.3)

Table 4.3 **Types of agricultural land use/cover changes (1985 to 1991)**

| Initial state (1985) | Change (1991) |
|--------------------------------------|--------------------------------------|
| Built-up/bare area | Mixed cropping |
| Mixed cropping | Mixed cropping |
| Mono cropping | Shrub |
| Shrub | Shrub |
| Tree crop/mountain vegetation/forest | Tree crop/mountain vegetation/forest |

Source: Image analysis 1985 & 1991

It was observed that portions of built-up/bare areas changed into mixed cropping while portions of mono cropping also changed into shrub, but areas classified as mixed cropping, shrub and tree crop did not change.

Figure 4.2 Land use /cover pattern of 1985 & 1991

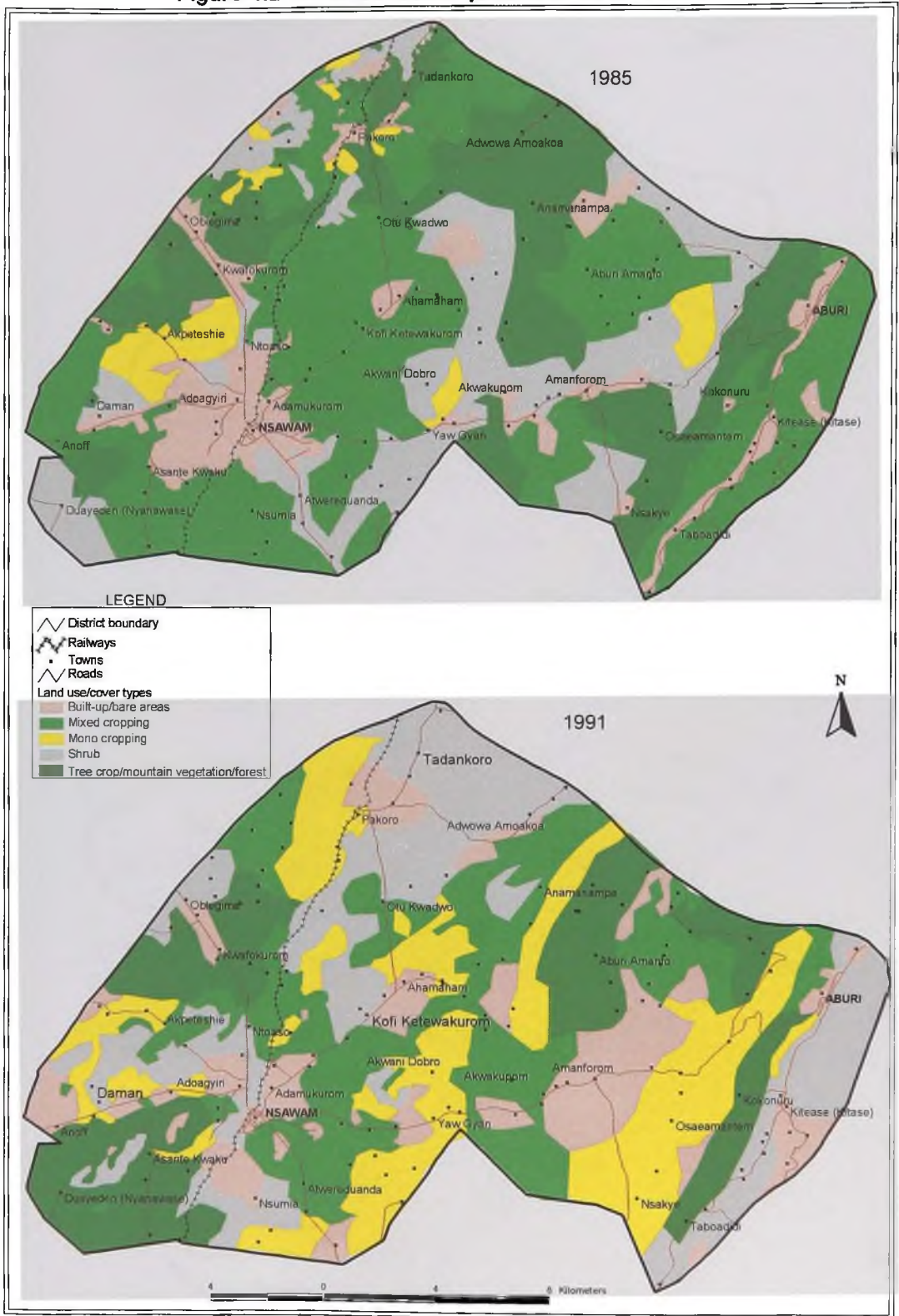
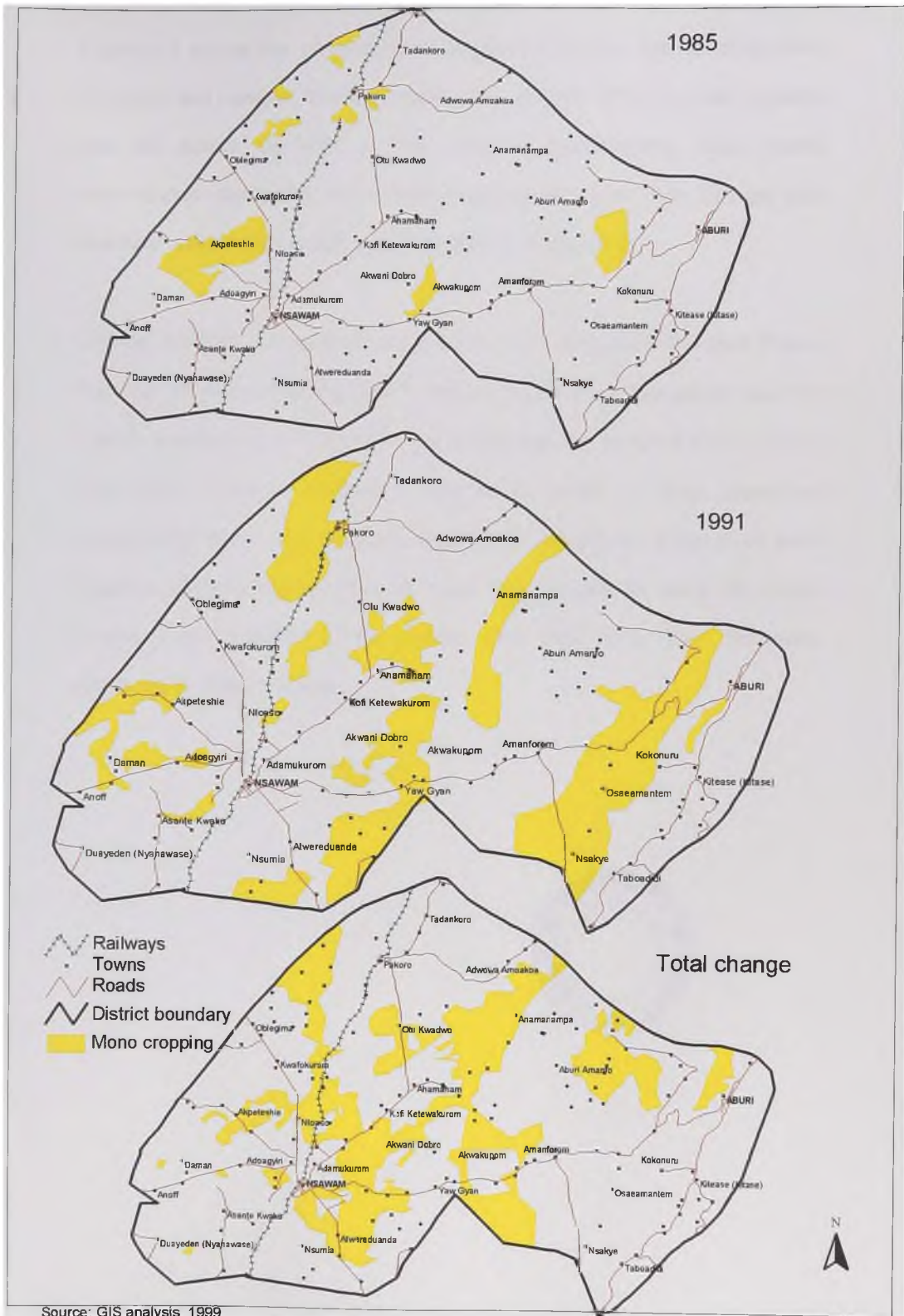


Figure 4.3 Akwapi District showing changing pattern of mono cropping

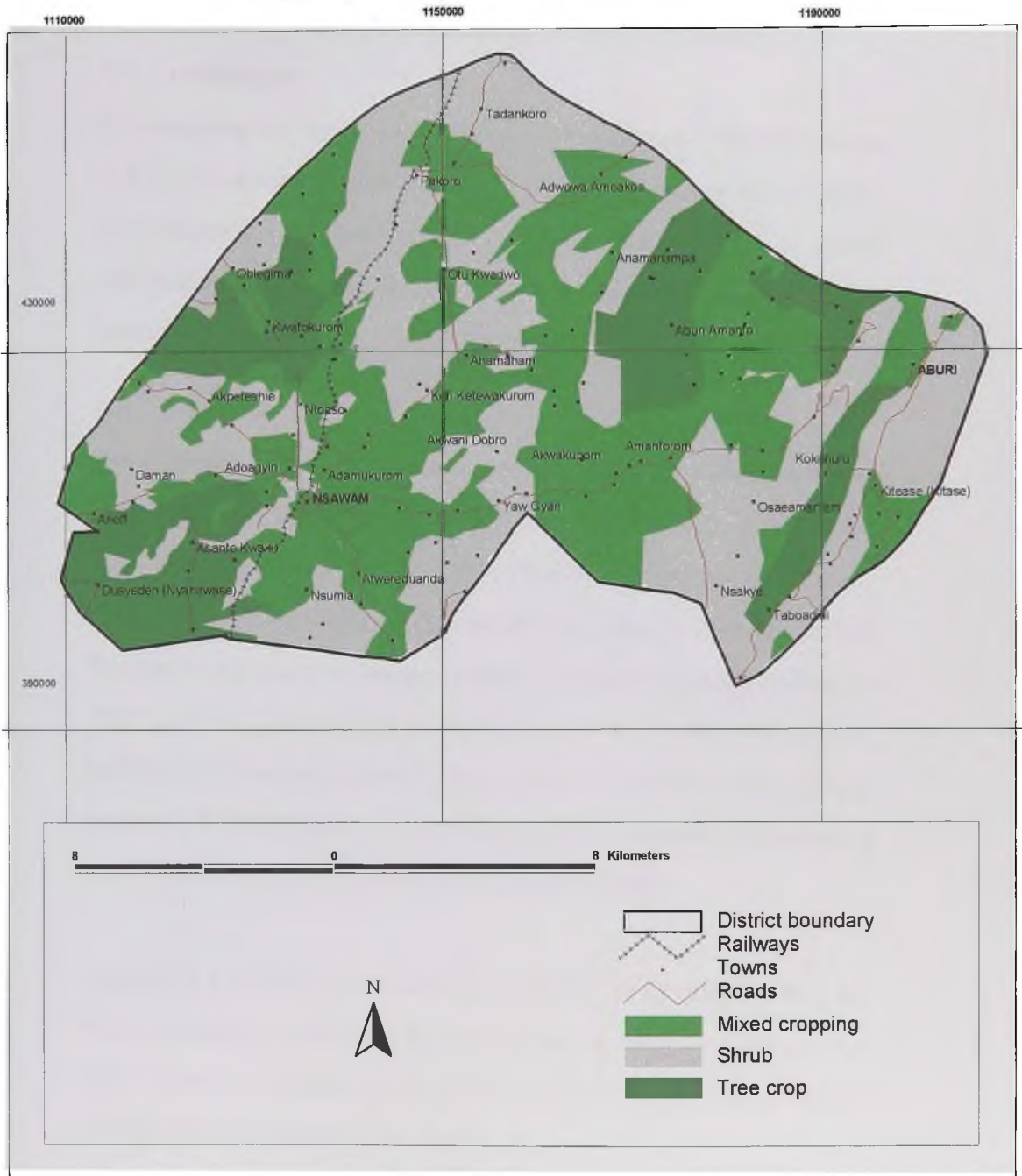


Source: GIS analysis, 1999

Figure 4.3 shows the general mono cropping activities, that is, commercial pineapple and pawpaw farming. It was not so much in 1985, and was scattered over the district. By 1991, it had increased tremendously, being mostly concentrated along the ridge from Nsawam to Aburi. The change was observed around the central part of the district (Figure 4.3).

Change detection among three of the land use/cover types in the area (Figure 4.4) also shows a different pattern. Mixed cropping is observed all over the district, especially concentrated in the central part as depicted in light green. Tree crops, mountain vegetation and forest shown in deep green are concentrated in the east and west, around hills and ridges. Areas which were originally shrub as well as other land uses that changed into shrub are shown in ash. The magnitude of the change from 1972/74 to 1991 has been discussed in Chapter Three.

Figure 4.4 Akwapim South District showing changes between three main land use/cover pattern from 1985 to 1991



Source: GIS analysis, 1999

CHAPTER FIVE

5.0 ASSESSMENT OF THE SOCIO-ECONOMIC EFFECTS OF THE CHANGES IN AGRICULTURAL LAND USE

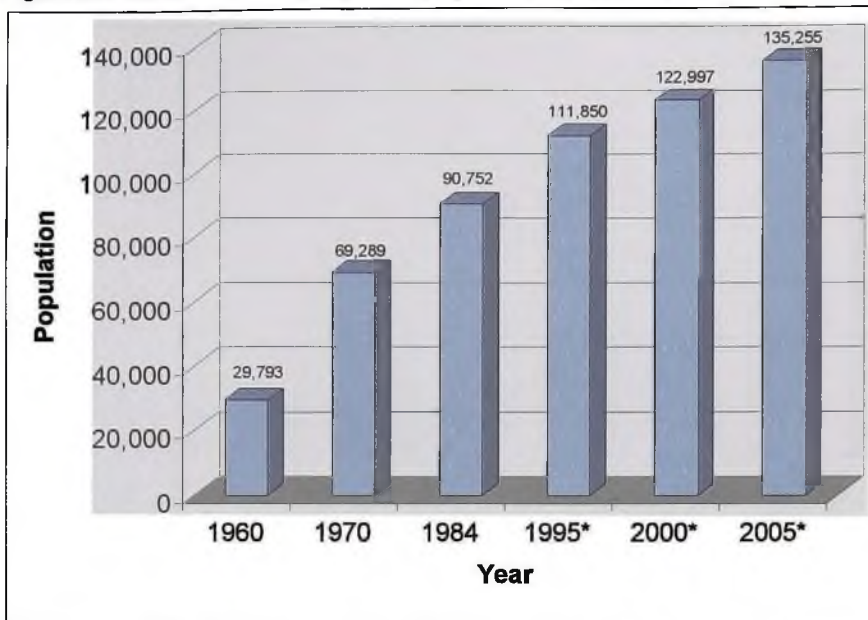
5.1 Introduction

To understand and appreciate the effects of the changes in agricultural land use, it is necessary to obtain evidence from the resource users themselves. Socio-economic data were gathered through field survey. This chapter examines the demographic and socio-economic effects of the land use change within the systems model.

5.2 Population

The population estimates for the district in 1960 and 1970, when it was known as Nsawam-Aburi Urban Council, 29,793 and 69,289, respectively. This shows that within 10 years, the population has increased by more than 100 per cent. The census report indicated that the district's population in 1984 was 90,752. Considering the rate of population increase in the area, it is projected that by 1995 and 2000, the district's population would be 111,850 and 122,997, respectively. It is again projected that by the year 2001, the total population would be 135,255 (Figure 5.1). The rate at which the population is increasing in the district is very alarming and calls for greater concern.

According to the 1984 population census report, out of 300 settlements in the district, only three can be classified as urban, namely, Nsawam, Adoagyiri, and Aburi. The three settlements accounted for 43.5 per cent of the total population (Medium Term Development Plan, 1995).

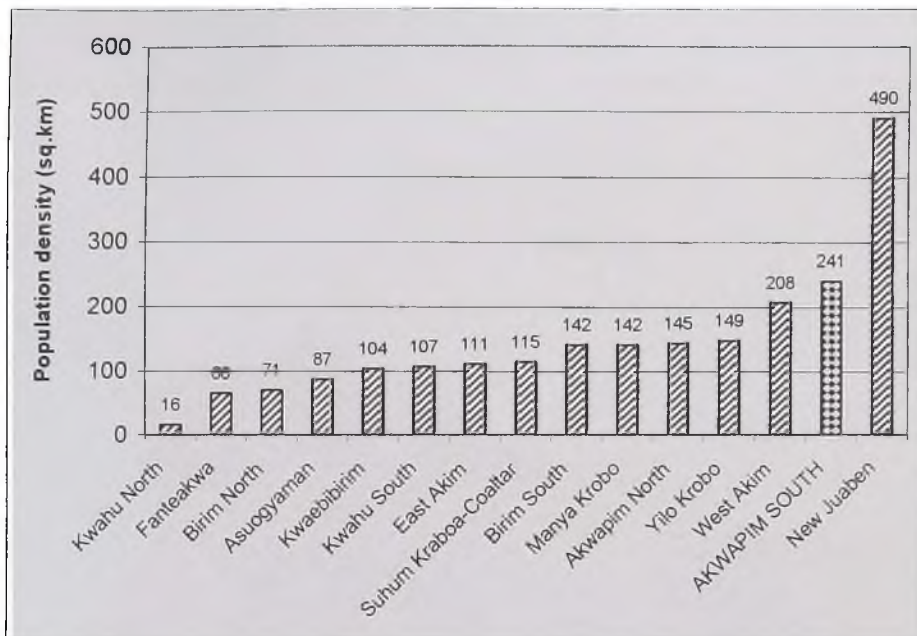
Figure 5.1 Historical and projected population of Akwapim South District

Source: 1. Ghana Population Census Reports 1960, 1970 and 1984
 2. Akwapim South District Development Plan 1996-2000 (*Estimates)
 3. Population Impact Project (PIP) Report (*Estimates)

For population density (Figures 5.2 and 5.3), the Akwapim South District happens to be the second highest with 241 persons per sq. km. after New Juaben District in the Eastern Region. The distribution is uneven and tends to concentrate in Nsawam, Adoagyiri, and Aburi.

The continuous growth of the district's population cannot be ignored, though the district population growth rate of 1.9 per cent is far below the estimated 5.3 per cent annual growth of agriculture in 1998 (ISSER, 1999). The high population density is evidence of population pressure on land.

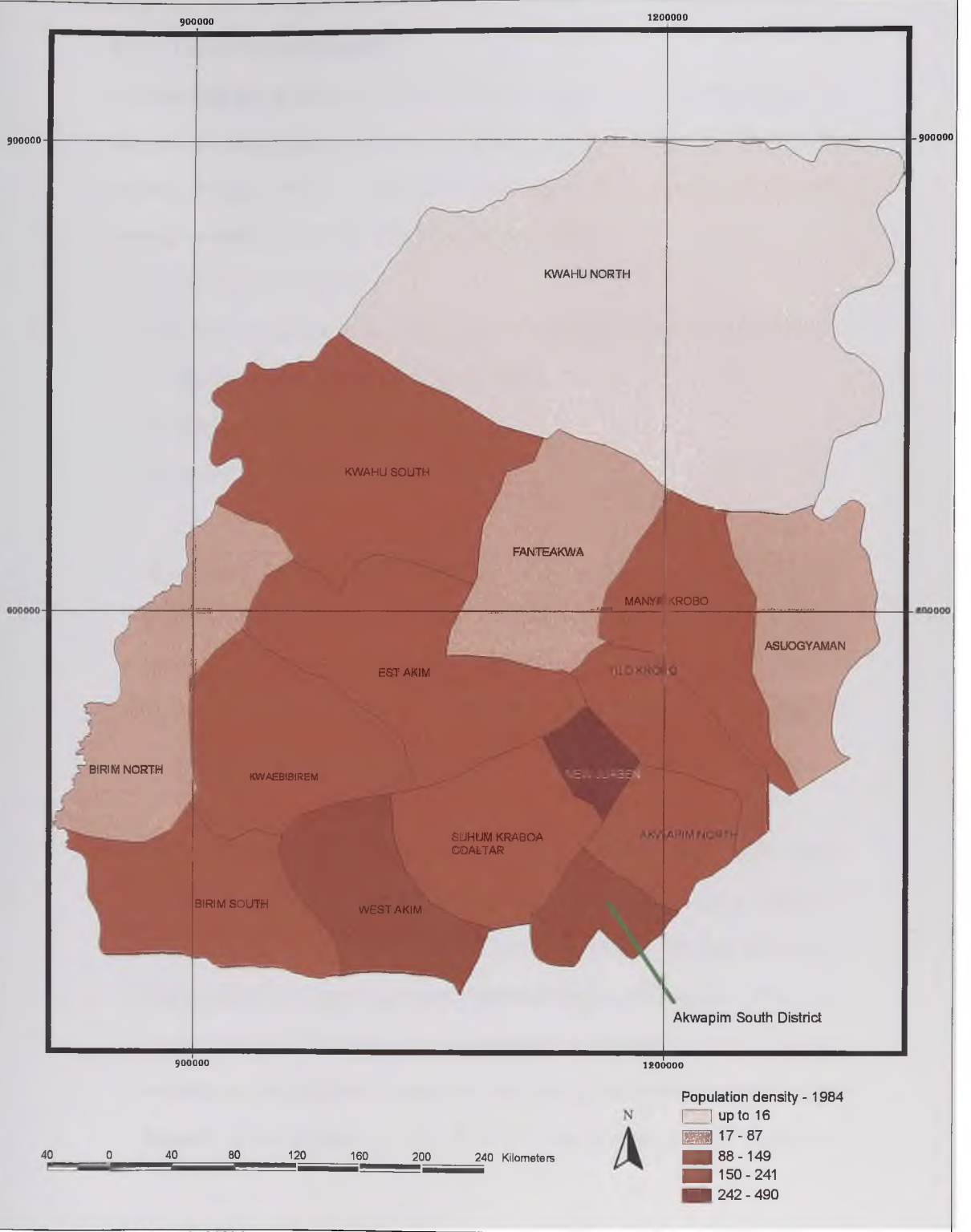
Figure 5.2 **Comparative analysis of population density in the Eastern Region**



Source: 1. Ghana Population Census Reports, 1984
2. National Commission on Democracy, 1992

This may compel people of an agrarian economy to over cultivate the land (Campbell, 1984). Secondly, rapid population growth adversely affects farmers' ability to adopt sustainable agricultural development, with the consequences of accelerated degradation as noted by Langemann (1977). Migration from the district to the city of Accra has been on the increase in recent times; therefore, population pressure is not a serious issue. The problem, as identified on the field, is associated with land ownership or tenancy. Large hectares of land are currently in the hands of commercial farmers, some of whom for over 10 years have not cultivated the land.

FIGURE 17 Population density in the Eastern Region - 1984



Source: Census report of 1984

5.3 Land Tenure Systems

Land tenure can be defined as the mode by which land is held or owned, or the set of relationships among people concerning the use of land and its product (Payne, 1997). According to Kasanga (1988), in Ghana there are varying tenurial systems with the following landholders:

- (1) individual landholders;
- (2) stools, sub-stools and skins - chiefs represent stools or skins which symbolize the community in certain areas;
- (3) 'tendamba' or clans; and
- (4) government (state).

According to the Akwapim customary practices, land is owned communally or by the extended family (Gyasi, 1991) and therefore, a member enjoys farming rights on the land. Migrant farmers could acquire a piece of land through negotiations with the chief or the land-owning groups. The tenant farmers focused on producing seasonal food crops for sustenance.

The communal land tenure system is not static, as most authors have contrarily postulated, because of the growing population pressure (Benneh, 1985). In the study area, an influx of many migrant farmers and their dependents from neighbouring countries like Togo and Cote d'Ivoire as well as other regions of Ghana have rendered land relatively scarce. Besides, increase in the value of land has encouraged an active land market, with tenancy arrangements in the form of sharecropping and rental or

leaseholds for a long duration. Table 5.1 shows the percentage of respondents in land acquisition.

Table 5.1 Mode of land acquisition over 30 years

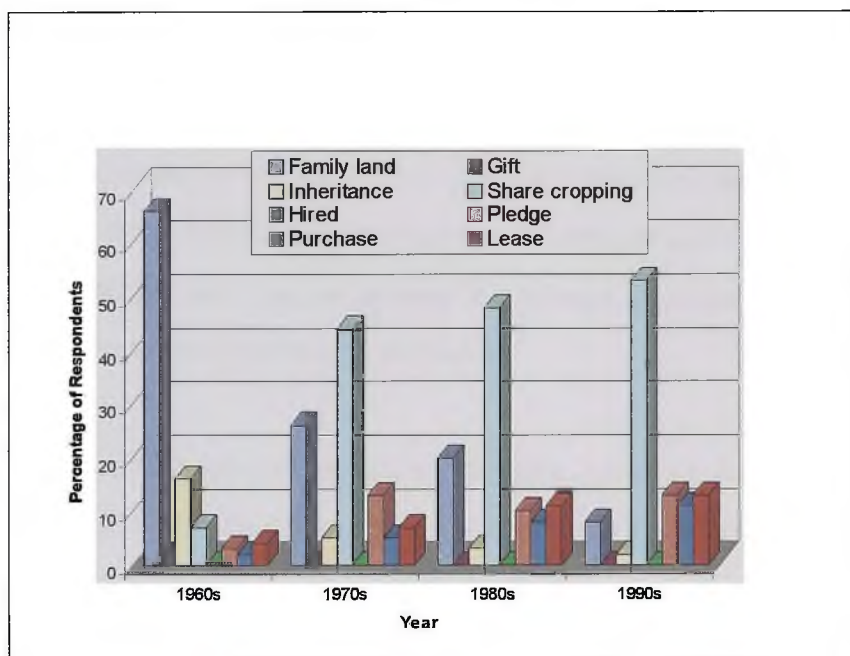
| | 1960s (%) | 1970s (%) | 1980s (%) | 1990s (%) |
|---------------|-----------|-----------|-----------|-----------|
| Family | 66 | 26 | 20 | 8 |
| Gift | 2 | 0 | 0 | 0 |
| Inheritance | 16 | 5 | 3 | 2 |
| Sharecropping | 7 | 44 | 48 | 53 |
| Hired | 0 | 0 | 0 | 0 |
| Pledge | 3 | 13 | 10 | 13 |
| Purchase | 2 | 5 | 8 | 11 |
| Lease | 4 | 7 | 11 | 13 |
| Total | 100 | 100 | 100 | 100 |

Source: Field survey, 1999.

According to the 130 respondents from eight settlements, 66 per cent of agricultural land used in the 1960s was family land, and so did not attract any rent as compared to sharecropping, hired, purchase, and lease which formed a small percentage (16%) of those that attracted payment. In the 1960's, only 2 per cent, according to the field survey, used lands that were offered to them as gifts. Generally, land acquisition has changed drastically over the years (Figure 5.4 and Table 5.1). The number of farmers in possession of family land has reduced, whereas that of sharecropping has

increased. For sharecropping, 89 per cent of the farmers interviewed paid two thirds (Abusa), while only 11 per cent paid half (Abunu) of their produce to the landlord for using the land. Generally, hired and lease land acquisition had increased (Figure 5.4) over the years, probably because of the high cost of living and the need to cater for the ever increasing population.

Figure 5.4 Mode of land acquisition for farming over a period of 30 years (1960s-1990s)



Source: Field survey, 1999

For land dispute, 95 per cent of the respondents said they had never been engaged in any land dispute, while 5 per cent reported some conflict. However, whatever dispute it was, had been settled more than 3 years ago.

This explains the peaceful co-existence of the migrant farmers and the land owners in the district.

5.4 Farm Size

Farm size can be expressed in two ways: the amount of land actually cultivated in a growing period, or the amount of land potentially under the control of the farmer, which includes fallow lands. In the study, farm size refers to the amount of land cultivated during the growing period.

The introduction of better implements, mechanization, and financial assistance were very crucial in developing of agriculture. However, most of the farmers lacked these things, and therefore their farm sizes tended to be smaller. During the survey, farmers were asked to provide information about the size, number of farms, and the type of crop being cultivated on each farm or land. This information was used to estimate the average size and number of individual farm holdings in the area (Table 5.2).

The average household was found to be 10 people, with average farm size of 5.6 acres (2.27 ha). Most farmers (25) had six different farm plots totalling between 5.5 and 6 acres (2.23 to 2.43 ha). Also, as many as 19 farmers had only three different farm plots with the total farm size of less than 3 acres (1.21 ha). On the average, total individual farm sizes were less than 4 ha.

Farm sizes vary with the topography, soil conditions, and crop types. At Fotobi, 47 per cent of farmers interviewed had their farms located along the ridge and

were cultivating cash crops, mainly pineapple, whereas 53 per cent were located in the Densu plain. The fragmented land, a holding in the valleys according to the survey, was attributed to the high demand for moist soil for sugarcane plantation and vegetable cultivation.

Table 5.2 Comparing farm size and the number of farms owned

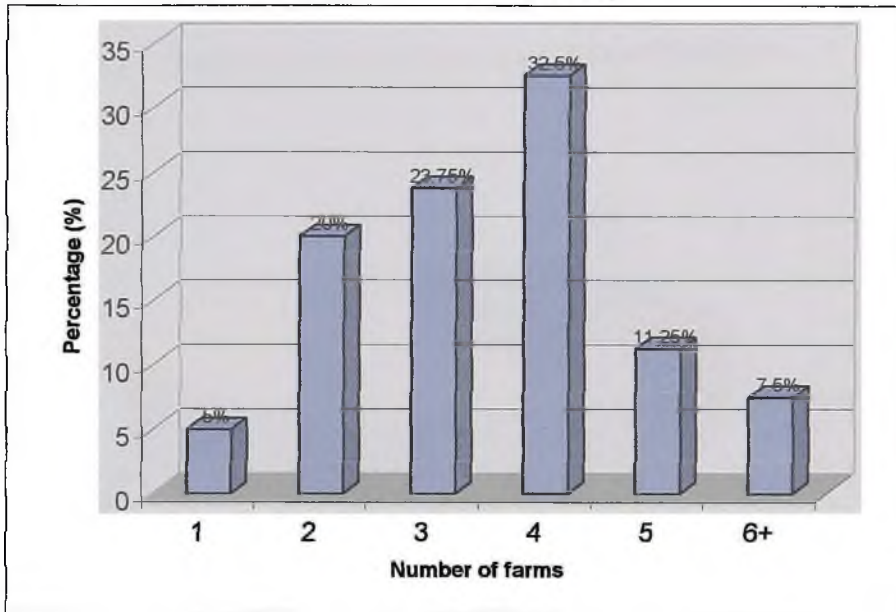
| Number of farmers (respondents) | Total farm size by owned by individual farmers | | Number of farms owned |
|------------------------------------|---|---------------|-----------------------------|
| | (acres) | (ha) | |
| 14 | Less than 1 | Less than 0.6 | 1 |
| 19 | 1.5 – 2 | 0.6 –0.8 | 3 |
| 9 | 2.5 – 3 | 1.0 -1.2 | 4 |
| 16 | 3.5 – 4 | 1.4 –1.6 | 6 |
| 21 | 4.5 – 5 | 1.8-2.0 | 10 |
| 25 | 5.5 – 6 | 2.2-2.4 | 6 |
| 12 | 6.5 – 7 | 2.6-2.8 | 5 |
| 6 | 7.5 – 8 | 3.0-3.2 | 6 |
| 8 | 8.5 – 9 | 3.4-3.6 | 5 |

Source: Field survey, 1999

Figure 5.5 indicates that at least each farmer had more than one farm plot and grew either the same or more than two different crops. The field investigation showed that about 33 per cent of the farmers owned four different farm plots of which at least one was for cash crop. Surprisingly, about 4 per cent of the farmers cultivated more than six different farm plots. Comparing the size of

each household and the number of farm plots owned, it was noted that there was no relationship; thus, the coefficient of linear correlation, $r = 0.32$.

Figure 5.5 **Percentage of farmers cultivating more than two acres of cash crop**

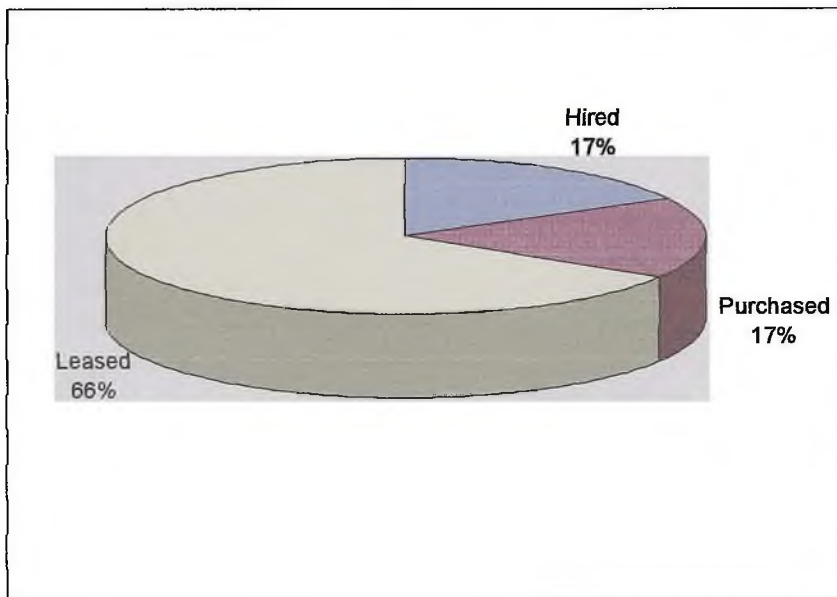


Source: Field survey, 1999

The size of households does not therefore determine the number of farm plots that a farmer owns. The average number of households according to the survey was nine people. Also, there was no relationship between the number of farms and respondent farm sizes. On the average, a household owns at least three farm plots, but the total farm sizes are never the same. These observations suggest that large households with more than three different farms may still be unable to supply their food requirements. They are therefore

compelled to purchase some foodstuffs to supplement whatever they produce. None of the commercial farmers interviewed belonged to any land-owning group in the district. Out of 10 commercial farmers interviewed, 17 per cent had purchased the land, 66 per cent were on leasehold, and 17 per cent hired the land (Figure 5.6).

Figure 5.6 **System of land acquisition by commercial farmers**



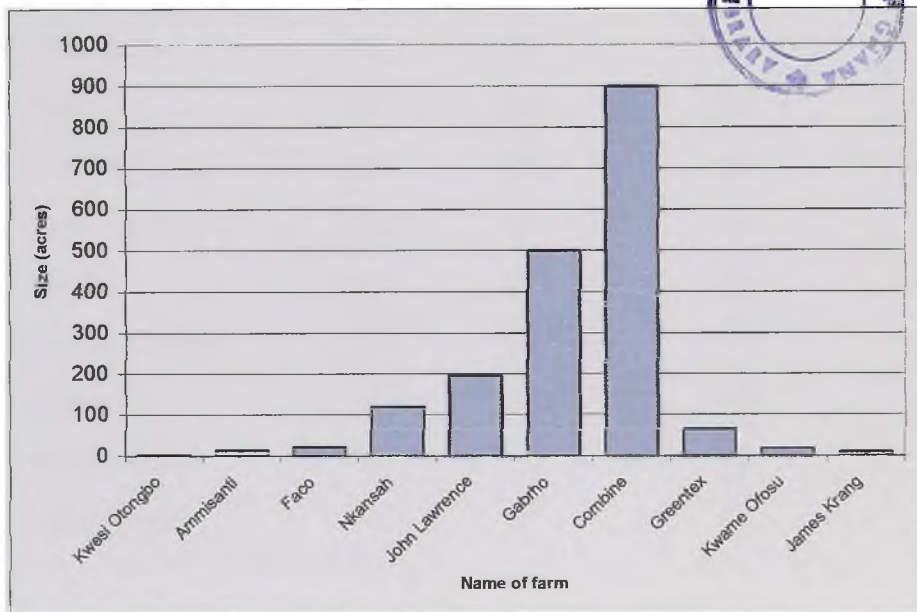
Source: Field survey, 1999

The duration of those on leasehold ranges from 50 to 70 years. This implies that if the land is owned by a family or clan, other members are deprived of it for such long periods. Secondly, if the land is not properly documented, the death of the landlord may lead to the annexing of the land by the farmer. Unlike urban areas where land is leased for as long as 70 years, it is cheating

for rural land to be leased for 70 years. It gives commercial farmers the opportunity to exploit the rural folks.

Considering farm sizes, Combine Farms, one of the largest commercial farms in the district cultivating pineapples, owns more than 700 acres (283.29 ha), while about 80 per cent of the same category of farmers own between 100 and 450 acres (40.47 and 182 ha) each (Figure 5.7).

Figure 5.7 **Commercial farm sizes**



Source: Field survey, 1999.

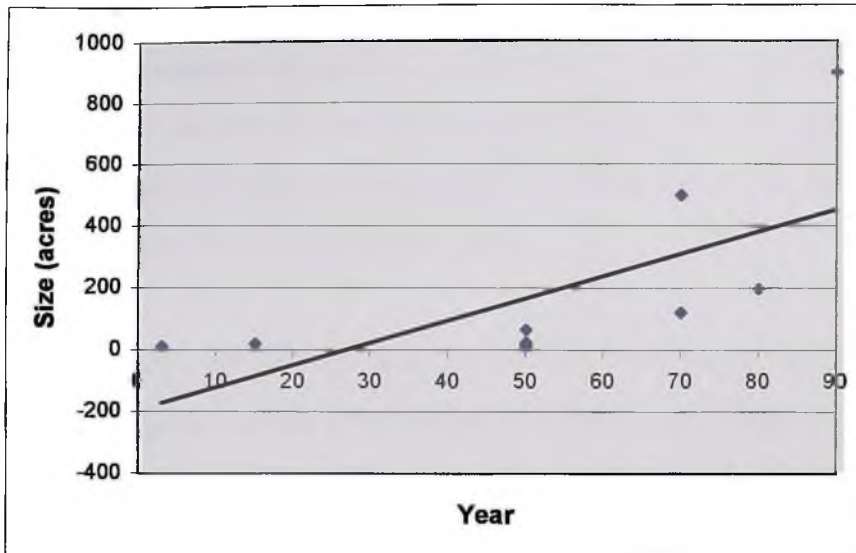
The survey indicated that there was a direct relationship between farm sizes and the duration of leasehold; thus, the larger the farm size, the longer the duration of lease (correlation coefficient, $r = 0.86$) (Table 5.3 and Figure 5.8).

Those with more than 50 acres (20 ha) enjoy between 50 to 70 years of lease. This permanent nature of tenancy serves as great incentive to commercial pineapple farmers, as it enables them to be in business for such a long period. Conversely, it is a disincentive to land owners, because they are deprived of the use of the land for such a long period.

Table 5.3 Farm size and duration of lease for commercial farmers

| Commercial farms | Farm size | | Duration of lease |
|------------------|-----------|-------|-------------------|
| | (acres) | (ha) | |
| Kwesi Otongbo | 3 | 1.2 | 10 |
| Ammisanti | 15 | 6.0 | 20 |
| Faco | 22 | 8.9 | 50 |
| Nkansah Farms | 120 | 48.5 | 70 |
| John Lawrence | 196 | 79.3 | 80 |
| Gabrho | 500 | 202.3 | 70 |
| Combine Farms | 900 | 364.2 | 90 |
| Greentex | 65 | 26.3 | 50 |
| Kwame Ofosu | 19 | 7.6 | 50 |
| James Krang | 10 | 4.0 | 50 |

Source: Field survey, 1999

Figure 5.8 **Commercial farm size and duration of lease**

Source: Field survey, 1999

Secondly, though non-traditional (pineapple, citrus, etc) export forms a significant proportion of the national income, the cultural practices associated with the cultivation of the crops threaten the environment. Pineapple does not like shade, so the farms are cleared of trees which would shade the crops. Consequently large hectares of pineapple farms are devoid of trees. Furthermore, the crops are cultivated along slopes which expose the area to high risk of erosion and therefore degradation.

5.5 Agricultural Production Systems

Farmers have been farming extensively to meet the increasing demand for their crops. Out of the 130 farmers from the eight settlements interviewed, 62%

responded as purely subsistence farmers, 28 per cent responded as practicing both subsistence and commercial farming, and a further 10 per cent practiced purely commercial farming, but on a small scale. The farmers who practiced both systems had two or more farms. This, according to 23 per cent of the farmers, helps in providing a constant supply of food crops for their families while the surplus is sold to earn some income.

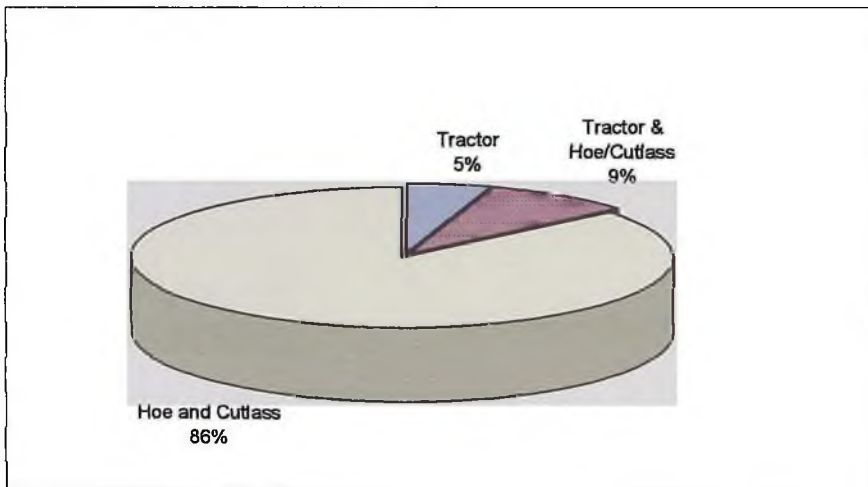
Mixed cropping and mono-cropping are the major farming systems in the district. Ninety-one per cent of the farmers interviewed usually practised mixed cropping on plots cultivated with food crops meant for home consumption. However, a sizeable proportion (averaging 65%) of the farm produce was sold for income. The dominant crop cultivated by those who practise mono-cropping is pineapple.

5.6 Technology

According to Mabogunje (1989), 'technologies are bodies of skills, knowledge and procedures for making, using and doing useful things. Technology is a cultural tradition developed in human communities for dealing with the physical and biological environment, including human and biological organisms'. From this definition, it is clear that virtually all human communities have developed technologies of one sort or the other to be able to cope with their physical and biological environment. Such technologies do not only determine how effectively they cope, but also what type of organization and settlement patterns they evolve in the process.

Weeding and soil preparations are known to be the most important bottlenecks in agricultural systems. In technology, farming implements have not improved much. The basic tools for cultivation include the traditional hoe and cutlass, most of which are locally manufactured. According to the survey, 86 per cent of the farmers still use the hoe and cutlass while 9% use tractors (Figure 5.9). Seventy per cent of the farmers who still use the hoe and cutlass explained that the terrain does not permit the use of tractors. Fifteen per cent could not afford hiring a tractor due to their low income, though they wish to use it. Other farmers explained that they have never used a tractor. Having lost their investments due to unfavourable weather conditions experienced over the past years, the farmers deem it inappropriate to hire a tractor with their little income. The emergence of commercial farming has led to an increased usage of tractors in ploughing, harrowing, and harvesting.

Figure 5.9 **Types of techniques employed in farming**



Source: Field survey, 1999

Family and hired labour constitute the most significant source of power for the farmers. Labour is engaged on daily basis and paid according to the farm size. Most of the hired labourers also own farms but they work for other farmers to earn income. Most sharecroppers rarely make use of hired labour, resulting in low yields and income. Table 5.4 shows that only 12 (9.2%) farmers did not use family labour; they used at least three hired labourers.

Table 5.4 **Average size of various categories of labour**

| Percentage of Farmers (Respondents) | Number of family labour per farming season | Number of hired labour |
|--|---|-------------------------------|
| 9.2 | 0 | 3 |
| 10.8 | 6 | 4 |
| 13.1 | 1 | 5 |
| 16.2 | 8 | 6 |
| 6.9 | 5 | 7 |
| 18.5 | 4 | 8 |
| 7.7 | 10 | 9 |
| 12.3 | 7 | 10 |
| 3.8 | 4 | 13 |
| 1.5 | 4 | 14 |

Source: Field survey, 1999

Technological change has led to the emergence of large scale non-traditional export-oriented production (pineapple, orange and pawpaw) and trade. The field investigations showed that all the commercial farms are mechanized. They use agro-chemicals, tractors for ploughing and harrowing, as well as

combine harvesters on their farms. They irrigate their farms, thus ensuring continuous cultivation throughout the year. As a result, they enjoy economic of scale.

5.7 Changes in Crop Production

Data gathered during the interview shows quite clearly that for most farmers, the economic motive of profit has been the major driving force for the change in agriculture land use. It is worth mentioning that it was not easy for farmers to give their production or out put level. However, they were able to tell which crops they have been producing over the period under review. In order to enhance the analysis of the data, the various crops produced were categorized into two namely; food crops and cash crops. Food crops include cassava, plantain, cocoyam and vegetables while pineapple, pawpaw and sugar cane are classified as cash crops.

Table 5.5 **Percentage change in amount of land to various crop production during the period under review**

| Settlement | Percentage of farmers | | | | | |
|------------|-----------------------|-----------|-----------|-----------|-----------|-----------|
| | 1970 | | 1980 | | 1990 | |
| | Food crop | Cash crop | Food crop | Cash crop | Food Crop | Cash crop |
| Fotobi | 63 | 37 | 22 | 78 | 13 | 87 |
| Pakro | 75 | 25 | 64 | 36 | 41 | 59 |
| Pampamso | 66 | 34 | 62 | 38 | 48 | 52 |
| Duayeden | 59 | 49 | 40 | 60 | 51 | 49 |
| Nsakyee | 55 | 45 | 36 | 64 | 30 | 70 |
| Doboro | 61 | 39 | 45 | 55 | 40 | 60 |
| Daman | 39 | 61 | 56 | 44 | 52 | 48 |
| Kofisa | 71 | 29 | 59 | 41 | 47 | 53 |

Source: Field survey, 1999

Table 5.5 indicates that out of the eight settlements sampled, each area produced food and cash crops. However, the percentage of production varied over the years under review. In the 1970s for example, almost all the settlements, except Daman, produced more than 50 per cent of food crops in the district. Surprisingly, in the 1980s, the percentage of farmers producing food crops in Fotobi reduced drastically from 63 to 22 per cent, while that for cash crop production increased tremendously from 37 to 78 per cent. This was due to Technoserve (a non-governmental organization) promoting the cultivation of cash crops (pineapple) in the area. The package offered by this NGO motivated more farmers to produce of pineapple. This change in focus in the area confirms the changes observed.

In Pakro, food crop production was high (64%) in the 1980s, but declined to 41 per cent. There was a shift from food crop to cash crop. Farmers at Pakro explained that there is always ready market for pineapple in recent times, and profit levels are higher than those for food crops. Secondly, most of those cultivating cash crops enjoy financial assistance and other benefits from various NGOs in the district. For Pampamso and Oblegima, the change from food crop to cash crop was not significant; nonetheless, cash crop production increased. These observed changes have their effect on the biophysical environment. For instance, large hectares of land are devoid of vegetation (Plates 1 & 2), and slopes are bare, exposing those areas to erosion.

Output per hectare is an important indicator of productivity and also of sustainability, since falling output might indicate deterioration in the resource

base (Tiffen *et al.*, 1995). Unfortunately, farmers were unable to give the output levels of their farms during the year under review. So to test the second hypothesis that, 'agricultural land use changes have resulted in a reduction in staple food crop production', secondary data on estimates for food crop production and farmers response to whether or not they have changed from food crops to cash crops were used (Appendix VI). In 1970, the proportion of change from food crop to cash crop was very significant ($t = 2.68$, $P < 0.05$), but the subsequent changes in 1980 and 1990 were not significant ($t = 0.383$, $P > 0.05$).

5.8 Summary

This chapter has discussed the various cultural and socio-economic effects of changes in agricultural land use in the district, by specifically examining population growth, land tenure system, farm size, production systems, and technology used in farming, among others. High population density, coupled with the influx of commercial farmers, rendered agricultural land scarce and thus put pressure on it. Farm sizes were generally small and fragmented. Simple farm tools, including the cutlass and hoe, were used. The cause of change in land use was more economical, as farmers argued that profit levels were higher for pineapple production.

CHAPTER SIX

6.0 ASSESSMENT OF THE ENVIRONMENTAL EFFECTS OF THE CHANGES IN AGRICULTURAL LAND USE

6.1 Introduction

Farmers in the Akwapim South District seem to recognise signs of degradation in their environment by examining several indirect factors which affect the quality and physical appearance of their crops, and fallow lands. This is not surprising because it is well known that in most traditional African communities, people have developed a remarkable stock of knowledge about their environment by using a range of indicators to make valid statements and predictions about the conditions of the physical world.

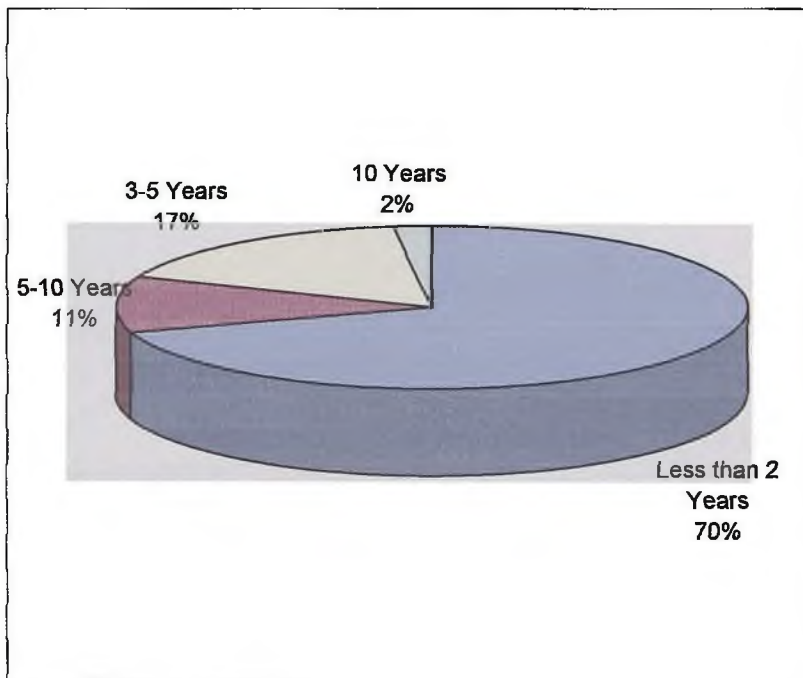
Some of the indicators identified are soil erosion, deforestation, loss of soil fertility, and decreasing duration of the rainy season. All these have affected the level of food crop production in the area. To determine the level of awareness of environmental deterioration, it is argued that the clearest evidence can be provided by only the resource users themselves. This chapter therefore discusses farmers' perception of what is happening to the micro-environment (i.e., soil fertility, erosion, and vegetation cover, among others), because the most fruitful causal explanation is available at the local level.

6.2 Soil Fertility

The pivot of every farming system is the fertility of the soil (Benneh, 1972). So the decreasing fallow period, as indicated during the interview and in Figure 6.1, implies that the sustained use of a fixed plot of land requires the adoption of an effective technique to maintain the fertility of the soil. Only 2 per cent of

respondents leave the land fallow for a period of about 10 years, while 70 per cent leave their land fallow for less than 2 years. Along the food plains of the Densu River, continuous moisture supply has promoted an intensive cultivation of sugarcane and vegetables. Elsewhere on the uplands and along slopes like Fotobi, Wangara and Kokonuru, declining yields have stimulated the need for effective means of replenishing lost nutrients by applying fertilizer. On the other hand, in some of the settlements, manure derived from goats and poultry was largely used for maintaining soil fertility on small farms.

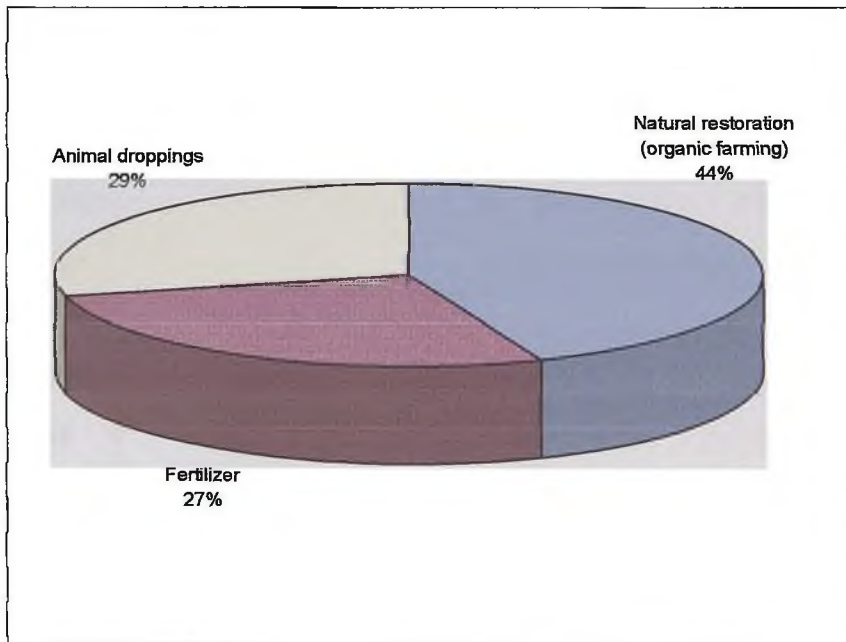
Figure 6.1 **Farmers and fallow periods**



Source: Field survey, 1999

Out of the 130 respondents, as high as 44 per cent leave their land fallow to restore fertility, 29 per cent use animal droppings, while only 27 per cent use chemical fertilizer (Figure 6.2). However, the natural restoration method would have been all right in the 1950's because the average fallow period of 10 years would have permitted the soil to recuperate. This method is now unsustainable due to population pressure on land and, most importantly, to the reallocation of land by landlords to commercial farmers. In Pakro, Pampamso, and Oblegima for example, some form of land rotation and mixed cropping has been adopted. Though leguminous plants such as beans were included in the cropping sequence, this practice, according to the farmers, failed to improve their yield.

Figure 6.2 **Method of fertility restoration**



Source: Field survey, 1999

Although fertilizer application became popular in the 1970s, the percentage of its use in the area, after much education and demonstration by extension officers, was very small (27%). Table 6.1 indicates that the number of farmers who applied fertilizer was highest (69%) at Fotobi, followed by Pakro (13%) because most of them were in pineapple production. Asked why the percentage of application was low, more than 90 per cent of farmers in the other six settlements complained about lack of finance, others said the fertilizers were unavailable when needed most, while about 5 per cent gave no reason.

Table 6.1 Percentage of farmers' response to fertilizer application

| Settlement | Percentage of farmers | Type of crop cultivated |
|-------------------|------------------------------|---|
| Fotobi | 69 | Pineapples and vegetables |
| Pakro | 13 | Cocoa, vegetables, cassava, and maize |
| Pampamso | 4 | Vegetables and pineapples |
| Duayeden | 7 | Cassava, maize, and vegetables |
| Nsakyee | 1 | Cassava, maize, pineapples, and cocoyam |
| Doboro | 2 | Cassava, maize, and vegetables |
| Daman | 6 | Cassava, maize, and oranges |
| Kofisa | 4 | Cassava, maize, and vegetables |

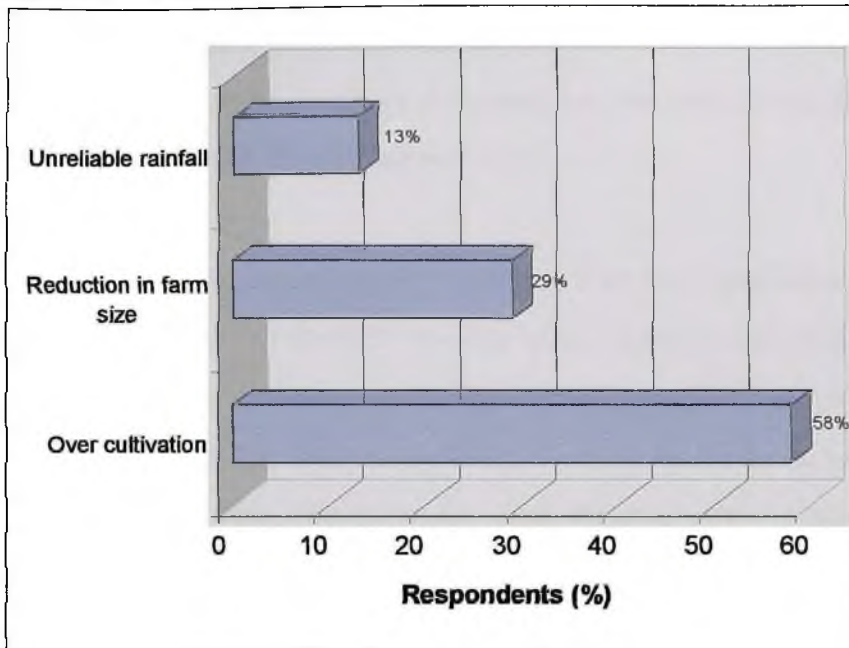
Source: Field survey, 1999

The loss of fertility is also reflected in the level of production. To determine the level of food crop production, the exploratory questions that were asked included:

- a) whether or not their yields had reduced over the last decade; and
- b) reasons for the decline, if any.

Farmers' responses were ranked and the results shown graphically (Figure 6.3). Surprisingly, 58 per cent of all the farmers interviewed in the district complained that their yields over the past 20 years had declined due to over cultivation. Other farmers (13%) attributed their low yields to unreliable rainfall rather than to declining soil fertility caused by over cultivation. Secondary data compiled by the Policy Planning, Monitoring and Evaluation Division (PPMED) of the Ministry of Food and Agriculture confirmed these results.

The data were also used to test and accept the null hypothesis that, changes in agricultural land use have reduced staple food crop production in the district (Appendix VII). Though the satellite images showed that there was an overall increase in cultivated land from 1972 to 1991, food crop production rather declined. The three major reasons given by farmers (Figure 6.3) might explain these observations.

Figure 6.3 Farmers responses to reduction in yield

Source: Field survey, 1999

6.3 Deforestation

In the traditional system, the inhabitants of Akwapim South District recognised the significance of trees in the following:

- i. restoration of soil fertility and control of erosion;
- ii. abode for some gods;
- iii. provision of wood for making stools, farm implements, etc; and
- iv. medicinal value.

Benneh & Agyepong (1990) observed that in societies where superstitions, beliefs' and taboos form part of life regarding the environment, environmental

resources such as forest and certain tree species are protected. For instance, about 98 per cent of pockets of forest cover left in the area are sacred places dedicated to the gods. Others are cemetery sites. As a result, most of the tree species are preserved. A sign of deforestation is the physical evidence of isolated forest trees in the area (Plates 3 and 5).

Deforestation in the district is attributed to felling of trees for fuel wood and the making of charcoal for domestic purposes. Also, modern farming methods, especially the use of tractors, commercial mechanized farming and the shift from food crops to non-traditional export crops, especially pineapple cultivation, have been blamed for the rapid depletion of the vegetation. Pineapple cultivation does not require tree shade and for that matter large hectares of land for cultivating pineapple are devoid of trees.

Deforestation is also accelerated in the district through annual bush burning as part of the farming practices among food crop farmers. Owing to lack of information on the amount of forest cover in the district over the years under review, assessment of deforestation was difficult. This notwithstanding, the results from the image gave an idea of deforestation in the area. The aerial photographs (Chapter 3) showed that in 1972, forest occupied a total of 1,886 hectares of the land, which formed about 5 per cent of the various land use/cover. By 1985, according to the satellite (Landsat TM) Imagery, there was an increase of more than 85 per cent in the forest cover. This result was disputed after field investigations and literature review on the state of the forest in the district.

Gyasi (1997) and Enu-Kwesi (1997) in a research undertaken in the forest savanna transitional zone, which happens to lie within the study area, concluded that, the forest had degraded. Enu-Kwesi (1978) for example, in a study of floral and faunal diversity, observed *Chromolaena odorata* as herbaceous plant species which had once invaded forested land.

6.4 Soil Erosion

Soil erosion by water is the most conspicuous form of land degradation in the district. This can be attributed to the farming activities in the area, though population increase, and therefore urbanization, has a part to play. Most importantly, the cultivation of pineapple has rendered a greater part of the area bare. As shown by the remote sensing data (Chapters 3 & 4), between 1985 and 1991, bare areas increased from 13.5 to 15.5 per cent. Sheet erosion is widespread in the upland while rill erosion occurs along the slopes where most of the pineapple farms are located. In rill erosion, soil is detached mainly by scouring and is transported by run-off concentrated in rills.

In the Akwapim South District, erosion in cropland is commonly associated with lack of cover. Annual crops are grown where ground cover is normally little for the first month after planting, and this is generally the time when the heaviest rains can be expected (Fisher, 1978). Erosion on cropland is therefore associated mainly with annual crops on sloping land with terraces incorrectly laid out, poorly constructed or not stabilised with grass. The

increment from 13.5 per cent in 1985 to 15.5 per cent in 1991 in areas classified as bare on the two satellite images, (chapter 3) implies that the risk of erosion is high, especially on the sloping land which is more pronounced in the eastern part of the district (Plate 3).

Another socio-cultural tendency that facilitates degradation of the environment is bush burning. Annual bush burning as part of the farming practices among food crop farmers constitutes a major cause of environmental degradation. It is accepted that bush fire depletes and destroys the vegetation, particularly grass and some tree species which are not fire resistant. In the interview, most of the farmers complained of the extinction of some tree species in the area.

6.5 Summary

Environmental degradation in an agrarian economy like the Akwapim South District is a very serious problem that needs painstaking attention. Loss of soil fertility, deforestation, and soil erosion were the major forms of land degradation identified in the district (Plates 1, 2, 3 and 4). Spatially, these problems were more pronounced in the north and northeast of the district as identified both on the field and on the satellite images. It was noticed that the problem of environmental degradation is associated with socio-cultural and economic activities, including the land tenure system, overcropping due to high population density, and technology used by the farmers. To boost agriculture, these environmental problems need to be addressed.



Plate 1 Extensive land cleared for food crop and pineapple cultivation



Plate 2 Burial site around the village, Kojo Fosu, showing little forest tree species left



Plate 3 Fallow land covered by shrub



Plate 4 Commercial pineapple farm around Fotobi



Plate 5 Typical subsistence farm with portions of the land eroded



Plate 6 Orange plantation belonging to one of the fruit-processing industries in the district

CHAPTER SEVEN

7.0

CONCLUSION

7.1 Summary

The objective of the study was to assess the socio-economic, cultural, and environmental effects of the changes in agricultural land use in the Akwapim South District, using Remote Sensing and Geographic Information Systems technique. Data used included aerial photographs of 1972/74, topographic maps of 1974, soil map and Landsat TM satellite images of 1985 and 1991. In all, five land use/cover classes were identified using the classification scheme developed by Lillesand & Kiefer (1976) and Anderson *et al.* (1976), combined with field investigation. The land use/cover classes included built-up and bare areas, mixed cropping, mono cropping, shrub, and tree crop, mountain vegetation and forest.

Through visual interpretation, the images showed changes in land use/cover patterns in the Akwapim South District from 1972/74 to 1991. As at 1972/74, the aerial photographs showed that land use/cover described as shrub and mixed cropping formed 34 per cent each of the total land area of the district. This was followed by areas classified as tree crop, mountain vegetation and forest (19%), and the least was built-up or bare areas (8%).

A comparative analysis of the remotely sensed data namely, aerial photos of 1972/74 and satellite images of 1985 and 1991, showed evidence of changes in the agricultural land use/cover in the area. From 1972/74 to 1985, areas classified as mixed cropping and tree crop, mountain vegetation and forest were reduced (7

and 6%, respectively). On the contrary, there were various degrees of expansion in built-up or bare areas (4%), monocropping (7%) and shrub (3%). A different situation emerged between 1985 and 1991; thus shrub, and tree crop, mountain vegetation and forest were reduced. On the whole, the total changes observed from 1972/74 to 1991 were as follows: built-up and bare areas increased by 15 per cent, mono cropping increased by 13 per cent, mixed cropping decreased by 6 per cent, shrub decreased by 11 per cent, and tree crop, mountain vegetation and forest decreased by 10 per cent. The reduction in areas classified as tree crop, mountain vegetation and forest confirmed earlier observations made elsewhere in the district by Agyepong *et al.* (1997), Gyasi *et al* (1995), and Enu-Kwesi (1997) that forest cover had depleted.

Apart from showing the magnitude and rate of change, the GIS analysis further showed the pattern of change in the study area. From 1985 to 1991, the change patterns observed were as follows: built-up/bare areas changed to mixed cropping, and mono cropping areas changed into shrub while no change pattern was observed in the other land use classes.

The changes in land use/cover in the Akwapim South District have socio-cultural implications. For land tenure, the study showed that share-cropping is on the ascendancy. Large hectares of land leased to commercial farmers have denied most subsistence farmers access to land. For example, the field data confirmed leasehold of up to 70 years, which seems to be a form of rural exploitation. The introduction of non-traditional export crops, especially pineapples, and the

economic motive of maximizing profit has become a more dynamic force of agricultural land use change instead of population pressure as observed elsewhere (Gyasi, 1976; Songsore, 1996). According to the literature review, about 50 years ago, settlements like Fotobi, Pakro, and Pampanso were major food crop-producing areas, but the study showed that more than 60 per cent of food crop producers in these areas are currently in cash crop production. This has actually affected the total level of food crop production in the district.

The systems model was used to assess the environmental effects of the land use/cover. Loss of soil fertility, soil erosion, and above all deforestation were identified as the major forms of degradation in the area.

The changes in agricultural land use have not been uniform over the entire landscape of the Akwapim South District. The changes are more pronounced towards the central, north and east, and also along the slopes of the hills where most commercial farms are sited. The commercial farmers have adopted highly mechanized techniques to increase and sustain their yield, but to the detriment of the environment.

The combination of sequential aerial photos, satellite images, and GIS analysis has made it possible to generate agricultural land use database for planning district agricultural land use. The database, stored on computer memory for easy access, will also provide essential guidelines for future research, particularly for in-depth analysis of the agricultural performance in the district. Furthermore, it

constitutes a data bank which is relevant to agricultural land use modeling and predicting environmental effects of land use change and to ensure food security in the Akwapim South District. Also, the data could be used together with other appropriate information such as soil quality and economic activities to estimate concerns such as protection of water bodies (Densu River), population numbers, budgetary allocation, and development activities in the district.

It is worth mentioning that there were some limitations to the study. The first is the classification scheme used. Considering the resolution of the satellite images (30 m sq) and complexity of the vegetation cover, it was impossible to map out various farms. Therefore a generalized land use of mixed cropping and mono cropping was used as part of the classes. Secondly, some of the aerial photos were covered with clouds, and it was therefore impossible to interpret them.

7.2 Recommendations

The problem of fragmented land holdings, changes from food crop to cash crop, lack of security of tenure, scarcity of land due to increasing commercial farming activities, low financial resource, and land degradation constitute serious bottlenecks to agricultural development in the Akwapim South District. In addition, the office of the Ministry of Food and Agriculture in the district lacks proper and consistent data organization. The following are therefore recommended in the light of the study:

1. The land tenure system is essential in determining to a large extent, the level of capital investment and the type of agricultural system practised. The share-croppers, who constitute a majority of the farming population in this area, operate mainly under the *Abusa* and the *Abunu* tenancy arrangement. However, the increasing value and scarcity of land due to the influx of commercial farmers in response to high demand for non-traditional export crops has led to the traditional land owners indiscriminately reclaiming land from food crop producers. Commercial farmers have acquired large hectares of land under the pretence of engaging in cash crop farming, but the land had remained uncultivated for more than 10 years

Clearly, if farmers are to adopt improved and sustained methods, then there should be a way to ensure some reasonable degree of security for tenant farmers. Land reforms aimed ultimately at land redistribution are obviously too far-fetched in view of the traditional land tenure system. In the short run, some form of compromise can be reached by entreating the traditional custodians of the land to offer land to tenant farmers on long-term agreements or lease. Secondly, there is the need to ensure that land is leased to commercial farmers who are ready to cultivate the land. They can be granted a period of one year within which they must cultivate the land or have it taken from them. If anything at all, the tenancy agreement should be renewed after every 20 years.

2. The decline in yield due to over cropping can be corrected through regular application of chemical fertilizers. The mineral nutrients, especially phosphorous,

potassium and calcium, are essential for all crops. Regular and improved imports of fertilizer can be distributed effectively through co-operatives, as the farmers at Fotobi and Pokroma are doing under Technoserve, an NGO. It is recommended that poor farmers organise themselves into groups with the help of the chiefs in each settlement. Extension officers should be provided with the necessary logistics to enable them reach out to all the farmers in the district to provide the necessary advice.

3. The farmers must decide to change the land use practices or to introduce new techniques in the light of the prevailing physical and socio-economic attributes of any particular locality and time. The need for speedy operations where the planting season is short and where labour is scarce, calls for the use of agricultural equipment. Consequently, farmers need effective technical advice, demonstration and education by extension officers of the Ministry of Food and Agriculture. Out of more than 60 farming villages in the district, extension officers concentrate only on 23 villages. This therefore, calls for the deployment of more agricultural officers. Since poor farmers are a common sight in our agricultural system, farm inputs should, as much as possible, be highly subsidised.

4. To reduce the rate of deforestation, the inhabitants must be educated on the importance of forest cover and afforestation and tree planting duly encouraged. The people should be introduced to alternative sources of energy. The use of liquefied petroleum gas (LPG) which has been promoted as an alternative source

of energy would be appropriate. However, it has become very expensive these days, making it impossible for the poor to afford.

5. Erosion can be checked through mulching, and adoption of crop rotation. To reduce soil exposure to the vagaries of the weather, planning fallow should be encouraged. Building of dams should also be encouraged as few of the cash crop farmers are doing. Though it is expensive, the government can collaborate with co-operative farmers. This would ensure continuous cultivation all year round.

6. Credit facilities are essential for increasing farmers' capacity to adjust to changes in the physical and socio-economic environment. In Ghana, the Agricultural Development bank and the Rural Banks are mandated to grant loans to farmers, but the total amount of loans to be given out depends on the sectoral allocation from the year's budget. Unfortunately, over the years, the percentage allocation of credit to the agricultural sector has been inadequate (ISSER, 1999). Most farmers have no collateral and others, from experience, have been unable to pay back loans granted to them. This scenario makes it difficult for farmers to be granted loans. On the whole, more than 85 per cent of the farmers from the eight sampled settlements complained of lack of finance. From this, only 23 per cent had heard of financial assistance being offered to farmers in the district, but never bothered to pursue it. In addition, 44 per cent expressed their desire for loans but lacked collateral security. There is the need to restructure the requirements for loans, bearing in mind the status of farmers in the country. This would constitute a vital prelude towards streamlining the functions of the financial institutions to benefit the farmers.

7. Finally, effective planning is frequently rendered difficult owing to lack of up-to-date information on agricultural land use and of the means of acquiring such information. The method used in this study and the results, suggest strongly that the combination of remote sensing techniques, especially the interpretation of sequential aerial photographs, satellite imagery and GIS, offers the most promising tool for assessing and monitoring agricultural land use. It is recommended that similar research be carried out in other districts not only in environmental resources, but also in natural resources to help agricultural extension officers in planning effectively for sustainable agriculture land use in the country.

Acronyms

| | |
|------------------|--|
| CERSGIS - | Centre for Environmental Remote Sensing and Geographic Information Services |
| Chips - | Copenhagen Image Processing System |
| CSIR - | Centre for Scientific and Industrial Research |
| FAO - | Food and Agriculture Organization |
| GEMS - | Global Environmental Monitoring System |
| GERMP - | Ghana Environmental Resource Management Project |
| GEPC - | Ghana Export Promotion Council |
| GIS - | Geographic Information Systems |
| GPS - | Global Positioning System |
| GRID - | Global Resource Information Database |
| ISSER - | Institute of Statistics Social and Economic Research |
| MSS - | Multi-spectral Scanner |
| NARP - | National Agricultural Research Programme |
| PC - | Personal Computer |
| PPMED - | Policy Planning, Monitoring and Evaluation Department |
| RSAL - | Remote Sensing Applications Laboratory |
| SPSS - | Statistical package for Social Science |
| SSS - | Sub-Saharan Africa |
| TM - | Thematic Mapper |

REFERENCES

- Abbiw, D. K. (1990): Useful Plants of Ghana. West African Uses of Wild and Cultivated Plants. Intermediate technology publications and the Royal Botanic Gardens, Kew, UK.
- ADC (1983): Economic Developments, Oxford Pergamon District Councils London.
- Adu., S. V. and Asiamah, R. D. (1992): Soils of the Ayensu-Densu Basin, Central, Eastern and Greater Accra Regions, Ghana. Memoir NO. 9 Soil Research Institute (Council for Scientific and Industrial Research)
- Africa GIS'95 (1995): Travaux Document, UNSO, GTZ, Abidjan March.
- Agyepong, G. T. (1977): 'Aerial Photography and Aerial Photograph Utilization in Ghana' The Bulletin of Ghana Geographical Association, Vol. 19, pp 48-54
- Agyepong, G. T. (1988): Remote Sensing and Land Use Planning in the Onchocerciasis and Tsetse Free Zones of Northern Ghana. FAO Seminar on Land Use in Onchocerciasis and Tsetse Free Zones of Ghana, Tamale.
- Agyepong, G. T. and Kufogbe, S. K. (1997): Land Use and Land Cover Patterns, Environment, Biodiversity and Agricultural Change in West Africa, Perspectives from Ghana. Gyasi E. A. and Uitto, J. I. (ed). United Nations University. Pp 52-56
- Agyepong, G. T. and Kufogbe, S. K. (1997): Land Use and Cover Change in the Southern Forest-Savannah Transition Zone in Ghana: A sequence Model in Environment, Biodiversity and agricultural Change in West Africa (Perspective from Ghana) Edited by Gyasi, E. A. and Uitto J. I. United Nations, University Press, Tokyo-New York-Paris pp 52-57
- Alexandratos, N. (ed) (1988): World Agriculture Toward 2000. An FAO Study. Blue haven Press, London
- Alhassan, O.A-R (1998): Land Cover Change in the Densu Basin: Implications for Woodfuel Resources in Ghana. Proceedings of the 27th International Symposium on Remote Sensing of Environment. Tromso, Norway, June 8th 12th 1998. pp.688-691
- Allan, J. A. (1980): Remote Sensing in Land and Land Use Studies.
- Amankwah, H. A.Q. (1989): The legal Regime of Land Use in West Africa; Ghana and Nigeria, Pacific Law Press, Australia.
- Amamoo-Otchere, E. (1986): "Visual Interpretation of MSS-FCC Manual Cartographic Integration of Data" Proceedings of the seventh International Symposium on Remote Sensing for Resource Development and Environmental Management. Enschede.

Amatekpor J. K. (1999): Soils and Land – Use in the Volta Basin, State of the Art. The Sustainable Integrated Development of the Volta Basin in Ghana. Volta Basin Research Project, University of Ghana, Legon Accra. Gold Type Press, Ghana. pp 91-106

Amatekpor, J. K. and Kufogbe, S. K. (1997): Remote Sensing Evaluation of Urban Encroachment on Sakumuo Coastal Wetland in the Accra-Tema Metropolitan Area in Ghana. Bulletin of the Ghana Geographical Association, No. 20. pp 18-28.

Anderson, J. R. and Roach, J. T. (1977): Agriculture Decision Analysis. Ames Low State University Press.

Anderson, J. R., Hardy, E. E., Roach, J. T. and Witmer, R. E. (1976): A Land Use Cover Classification System for Use With Remote Sensing Data. Geological Survey Professional Paper 964, United States Government Printing Office, Washington.

Aronoff Stan (1991): Geographic Information Systems. A Management Perspective. WDL Publications Ottawa, Canada

Asenso-Okyere, W. K., Benneh, G. and Tims, W. (1997): "The Status of Food Security in West Africa". Sustainable Food Security in West Africa (Edited by Asenso-Okyere, W. K., Benneh, G. and Tim, W.) Kluwer Academic publishers, Dordrecht.

Avery, T. E. (1977): Interpretation of Aerial Photographs. (3rd Edition) Burgess Publishing Company, Minneapolis Minnesota

Barrett E. C. and Curtis L. F. (1976): Introduction to Environmental Remote Sensing London Chapman and Hall. New York. John & Sons Inc. A Hasted Press Book

Benneh, G. (1972): Systems of Agriculture in Tropical Africa. Economic Geography Vol. 48 No. 3 July 1972, pp244-257.

Benneh, G. (1997): 'Indigenous African Farming Systems. Their Significance for Sustainable Environmental Use (Keynote Address). Environment, Biodiversity and Agricultural Change in West Africa: Perspectives from Ghana. (Edited by Gysai, E. A. & Uitto, J. I.) United Nations University Press, Tokyo. New York. Paris

Benneh, G. and Agyepong, G. T. (1990): Land Degradation in Ghana. Commonwealth Secretariat/University of Ghana. London

Blaikie, P. and Brookfield, H. (1987): Land Degradation and Society, New York, Methuen pp 27-37

Board Christopher, Chorley, J. R., Haggett, P and Stoddart, R. D. (eds) (1976): "Progress in Geography". International Reviews of Current Research Vol. 8 pp 12-17

Boserup, E. (1965): The Conditions of Agricultural Growth. The Economics of Agrarian Change Under Population Pressure, Allen and Unwin, London. (Republished 1993: Earth Publications, London).

Bowers, D. S. (1988). From Data to Database. Van Nostrand Reinhold (UK) Co. Ltd. Berkshire, England.

Brain J. (1981): " Air Photo and Agricultural Land Use Studies" ITC Publication Vol. 14 pp 16.

Burrough, P. A. (1986): Principals of Geographic Information Systems for Land Resouces Assessment. Monographs on Soil and Resources Survey NO. 12. Carendon Press. Oxford Science Publications pp194

Campell D. J. (1984): "Response to Drought Among Farmers and Herders in Southern Kajiado District, Kenya". Human Ecology 12 (1) pp 35-63

Campell James B. (1996): Introduction to Remote Sensing (2nd Edition) London,

Carr P.M., Carlson G.R., Jacobson J.S., Nielson G.A., Scogley E.O. (1991). Farming soils, not fields: a strategy for increasing fertiliser profitability. Journal of Production Agriculture 4: 57-61.

Chauvaud S., Bouchon, C. and Manieres R. (1998): "Remote Sensing Techniques Adopted to High Resolution Mapping of Tropical Coasttal Marine Ecosystems (Coral Reef, Seagrass Beds and Mangrove)" International Journal of Remote Sensing Volume 19, Number 18, pp 3625-3631

Clark, C. (1967): Population Growth and land Use. London, Macmillan. Pp 406

Clark, K. C. (1977): Getting Started with Geographic Information Systems. University of California, Santa Barbra

Cleaver, K. M. and Schreiber, G. A. (1994): Reversing the Spiral. the Population, Agriculture, and Environment Nexus in Sub-Saharan Africa. The World Bank, Washington D. C.

Colby, J. D. and Keating, P. L. (1998): "Land Cover Classification Using Landsat TM Imagery in the Tropical Highlands: The Influence of Anisotropic Reflectance". International Journal of Remote Sensing Volume 19 Number 8. 20May 1998. pp 1479-1496

Commonwealth Secretariat (1989): Report of Consultation on Promoting

Conservation for Sustainable Agricultural Development in Sudano-Sahelian Regions Of Africa. Banjul, The Gambia 27 May - 2 June 1989.

CSIR (1975): A Survey of Water Quality of River Densu. Accra, Ghana. October 1975.

Dale, P. F. and McLanghlin, J. D. (1988): Land Information Management, An Introduction with Special Reference to Cadastral Problems in Third World Countries, Oxford: Oxford University Press.

Dickson, K. B. (1969): A Historical Geography of Ghana. London, Cambridge University Press

Dickson, K. B. and Benneh, G. (1988): A New Geography of Ghana. Longman U. K. pp7-39

Enu-Kwesi, L. (1997) 'Floral and Faunal Diversity' Environment, Biodiversity and Agricultural Change in West Africa (Perspectives from Ghana) Edited by Gyasi E. A. and Uitto J. I. United Nations, University Press, Tokyo-New York-Paris pp 64-74

F A O (1972): Developed Countries Share of Food Production. Rome pp 26-32

F A O (1995): Food, Agriculture and Food Security: The Global Dimension, WFS 96/TECH/1. Food and Agriculture Organisation of the United Nations Rome.

Foresman, T. W. The Baltimore-Washington Regional Collaboratory Land-Use History Research Program. <http://biology.usqs.gov/luhna/chap5.html>

Fisher, N. M. (1978): 'Cropping Systems for Soil Conservation in Kenya,' Soil and Water Conservation, in Kenya. Report of a Workshop, University of Nairobi, 21-23 September 1977. Occasional Paper NO 27, pp 47-55, Institute for Development Studies, University of Nairobi, Nairobi

Floyd, F. and Sabins, Jr. (1987): Remote Sensing, Principles and Interpretation Second Edition, W. H. Freeman and Company New York.

GARMIN Corporation (1997): Garmin GPS 12XL Operator's Manual. Kansas USA pp 1-58

GEPC (1994): News Letter No.3, June 1994

Gillespie, A. R., Kahile, A. B. and Walker, R. E. (1996) 'Color Enhancement of Highly Correlated Image. Decorrelation and HIS Contrast Stretch. Remote Sensing of the Environment. NO. 20, pp 209-235

Gleave, M. B. and White, H. P. (1996): 'Population Density and Agricultural System in West Africa' In Thomas, M. F. and Whittington, G. W. Editors, Environment and Land Use in Africa, London; Methuen, pp 275-300

Grigg, D. B. (1976): Population Pressure and Agricultural Change. Longman

Gyabaah, K. N. (1994): Environmental Degradation and Desertification in Ghana. A Study of the Upper West Region. Bureau of Integrated Rural Development, University of Science and Technology, Atheneum Press Ltd, Newcastle upon Tyne, Great Britain.

Gyasi, E. A. (1976): Population Pressure and Changes In Traditional Agriculture: Case study of Farming in Sekesua-Agbelitsom, Ghana. Bulletin of the Ghana Geographical Association. Vol. 18 pp 68-87

Gyasi, E. A. (1991): Communal land Tenure and the Spread of Agroforestry in Ghana's Mampong Valley in Ecology and Farming. International IFOAM Magazine, (Second Quarter) pp. 16-17

Gyasi, E. A. (1997): Ability of the Farming Systems to Cope and Strategies for Sustaining Farming in Environment, Biodiversity and Agricultural Change in West Africa (Perspectives from Ghana) Edited by Gyasi E. A. and Uitto J. I. United Nations, University Press, Tokyo – New York-Paris pp 84-88

Gyasi, E. A., Agyepong, G. T., Ardayfio-Schandorf, E., Enu-Kwesi, L., Nabila, J. S and Owusu-Bennoh, E. (1995): ' Production Pressure and Environmental change in the Forest savanna Zone of Southern Ghana' Global Environmental Change, Vol 5, No. 4, pp 355-366. Great Britain

Haefner Harold (1989): Remote Sensing Thematic, Methodological and Technical Perspectives. Applied Geography and Development. A Biannual Collection of Recent German Contributions Vol. 34 pp 68-88

Harvey, D. (1966): Theoretical Concepts and the Analysis of agricultural land use patterns in Geography. Annals of American Geography. Vol 56, pp 138-140

Hill Polly (1963) The Migrant Cocoa-Farmers of Southern Ghana. A Study in Rural Capitalism. Cambridge University Press

ISSER (1991): The State of the Ghanaian Economy in 1991, The Institute of Statistical, Social and Economic Research, University of Ghana, Legon, July 1992

ISSER (1992): The State of the Ghanaian Economy in 1991, The Institute of Statistical, Social and Economic Research, University of Ghana, Legon, July 1995

ISSER (1995): The State of the Ghanaian Economy in 1994, The Institute of Statistical, Social and Economic Research, University of Ghana, Legon, July 1995

ISSER (1998): The State of the Ghanaian Economy in 1997. The Institute of Statistical, Social and Economic Research, University of Ghana, Legon, July 1998

ISSER (1999): The State of the Ghanaian Economy in 1998. The Institute of Statistical, Social and Economic Research, University of Ghana, Legon, July 1999

Jensen, J. R. (1986): Introductory Digital Image Processing. A Remote Sensing Perspective (2nd Edition) Upper Saddle River, New Jersey.

Kasanga, R. K. (1988): Land Tenure and the Development Dialogue. Department of Land Economy, University of Cambridge pp. 29-33.

Kinnear, P. R., and Gray, C. D. (1999): SPSS for Windows Made Simple (3rd Edition) Psychology Press Ltd. Hove UK

Langemann, J. (1977): Traditional African Farming Systems in Eastern Nigeria. Munchen .

Lapin, L. L. (1982): Statistics for Modern Business Decision (Third Edition), San Jose State University, U.S. A. pp 597-614

Li yingcheng, Chu liangcai, Guo tongying, Xue Yanli, Li xueyou, Ding xiaobo and Liu xiaolong (1999) Landuse Change and Urban Growing Monitoring in China <http://www.gisdevelopment.net/aars/acrs/1999/ts5/ts5250pf.htm>

Liverman, D. Moran, E. F., Rindfuss, R. R. and Stern P. C. (Editors) (1998): People and Pixels. Linking Remote Sensing and Social Science. National Academy Press. Washington, D. C.

Lo, C. P (1976): Geographical Applications of Aerial Photographs. Crane, Russak & Company, Inc. New York, pp.137-175

Lo, C. P. (1986): Applied Remote Sensing. University of Georgia Longman Scientific and Technicals.

Lawrance Richard, stinner Benjamin R. & House Garfield, J. (Editors) (1976): Agricultural Ecosystems. Unifying Concepts. New York

Mannion, A. M. (1995): Agriculture and Environmental Change. Temporal and spatial Dimensions NewYork

Martin, D. (1996): Geographic Information Systems (2nd Edition). Socio-Economic Applications. London and New York

Malthus T. R (1798, First Edition, 7th Ed. 1872): An Essay on Population with Introduction by M. P. Fogarty Vol. 1 & 2. Dent & Sons Ltd. London, Dutton & Co. New York

- Mabogunje, A. L. (1989): The Development Process, A Spatial Perspective 2nd Edition London pp 206-207
- Mather, A. S. (1989): Land Use. Longman Scientific & Technical, New. York
- Mausel, P. W., Kramber, W. J. and Lee, J. K. (1990): Optimum Band Selection for Supervised Classification of Multispectral Data. Photogrammetric Engineering and Remote Sensing, 56 pp 55-60
- Mellor, J. W., Delgado, C. L., and Malcolm, B. (Editors) (1988): Accelerating Food Production in Sub-Saharan Africa. London .
- Ministry of Food and Agriculture (1998): Performance of the Agricultural Sector 1987. Accra. Policy Planning, Monitoring and Evaluation Department.
- Moller-Jensen, L. (1999): Post Processing of Remote Sensing Data Using GIS. Remote Sensing and Geographic Information Systems (GIS) in Ghana: Research, Applications and Collaborations (Edited by Yankson, P. W. K. and Rasmussen, M. S.). Department of Geography and Resource Development, University of Ghana, Legon pp.29
- NARP (1994): National Agricultural Research Strategic Plan, Final Report, Ghana
- Odingo (1981): Land Evaluation, Land Use and Development in Developing Countries: The Potential Contribution of Remote Sensing in The Contribution of Geoscience in Development. *Proceedings of the United Nations University. The Tokyo Geographical Society Joint Symposium Tokyo*
- Okigbo, B. N. (1997): 'Criteria for Designing Sustainable Farming Systems in Tropical Africa' Environment, Biodiversity and agricultural Change in west Africa. Perspective from Ghana. (Edited by Gyasi, E. a. and uitto, J. I) United Nations University Press, Tokyo. York. Paris. pp 19-37
- Ozemony, V. M. Smith, D. R., and Sicherman, A. (1981): Evaluating Computerized Geographic Information Sysytems Using Decision Analysis. *Interfaces*, 11: 92-8
- Payne Geoffrey (1997): Urban Land Tenure and Property Right in Developing Countries.
- Peng, w., Qu, X., Wang, Y. and Lui, Z. (1998): A Study on Monitoring the Farmland of High, Middling and Low Yield Using Remote Sensing Data. Proceedings of the 27th International Symposium on Remote Sensing of Environment. Tromso, Norway, June 8th - 12th 1998. pp.830-833
- Planconsult Ltd (1996): Medium Term Development Plan (MTDP) Akwapim South District Assembly, University of Science and Technology, Kumasi February 1996.

Prakash, P. G., and Natarajan (1998): Remote Sensing-A Tool for Soil Resource Appraisal and Sustainable Agriculture. Proceedings of the 27th International Symposium on Remote Sensing of Environment, Tromso, Norway, June 8th - 12th 1998. pp.822-825

Ghana Census Report (1984): Population Census of Ghana, Special Report on Localities by Local Authorities, Eastern Region. Statistical Service, Accra. Eddy Williams Accra

Ronald Abler, F., Marcus, G., Melvin and Judy Olson M. (Eds) (1992): Geography's Inner World. Pervasive Themes in Contemporary American Geography Rutgers University Press New Brunswick, New Jersey.

Russel, N. C. and Dowswell, C. R. (Editors) (1992): Policy Options for Agricultural Development in Sub-Saharan Africa. CASIN/SAA/Global 2000.

Said, M. Y., (1993): Modelling Relationships Between Large Herbivores, Vegetation, Soils and Climate in the Mara Ecosystem: a GIS Approach. M.Sc. thesis International Institute for Aerospace Survey and Earth Science (ITC), Enschede, The Netherlands.

Singh A., Dieye A. M., Finco M., Chenoweth, M. S., Fosnight, E. A. and Allotey A. (1999): Early Warning of Selected Emerging Environmental Issues in Africa: Changing Correlation from a Geographic Perspective. Environmental Information and Assessment Technical Report, UNEP/DEIAEW/TR. 99-2, USGS.

Smith, T. R., Menon, S., Starr, J. L., and Estes, J. E. (1987) Requirements and Principles for the Implementation and construction of Large-Scale Geographic Information Systems. International Journal of Geographical Information Systems, 1:13-31

Songsore Jacob (1996): Population Growth and Ecological Degradation in Northern Ghana: Myths and Realities, Research Review (New Series) Vol. 12, N01&2. Institute of African Studies University of Ghana, Legon.

TAC (1988): Sustainable Agricultural production: Implications for International agricultural Research. TAC, Rome

Thomson, A. G., Fuller R. M. and Eastwood, J. A. (1998): Supervised Versus Unsupervised Methods for Classification of Coasts and River Corridors From Airborne Remote Sensing. International Journal of Remote Sensing Vol. 19 Number 17 20 November 1998.

Till Roger (1985): Statistical Methods for the Earth Scientist an Introduction, Macmillan London pp 117-127

Tivy Joy (1990): Agricultural Ecology. Longman Group UK

Toe Elisabeth (1993): Monitoring and Evaluation of Temporary Protection of Vegetation for the Restoration of Semi Arid Land: A Case Study of Bayend Foulgo, Bam Province/Burkina Faso ITC

Toll, D. L. (1984): An Evaluation of Simulated Thematic Mapper Data and Landsat MSS Data for Discriminating Suburban and Regional Land Use and Land Cover. Photogrammetric Engineering and Remote Sensing, 50, 1713-1724

Tsukasa Hosomura (2000) Accuracy Improvement of the Land Cover Classification by using Truncated Normal Distribution
<http://www.gisdevelopment.net/aars/acrs/2000/ts9/imqp0023pf.htm>

UNEP (1990): GEM-Global Environment Monitoring System. Nairobi: UNEP

United Nations (1992): Agenda 21. United Nations Conference on Environment and Development. The Earth Summit, Rio de Janeiro.

Vegetation and land Use Change Analysis "Assesment of Vegetation and Land Use Chnages in Nigeria Between 1976/78 and 1993/95"
<http://www.geoniger.com/luv.htm>

Wigton, W., Mkandawire, V., Burger, K. and Hutchinson C. (1998): Food Security Information for Malawi. Proceedings of the 27th International Symposium on Remote Sensing of Environment. Tromso, Norway, June 8th 12th 1998. pp.826-829

Wills, J. B.(1962): Agriculture and Land Use in Ghana. Oxford University Press

World Bank (1995): World Development Report, 1995

World Bank (1996): Africa Can Compete in Europe. Findings, Africa Region, No. 64

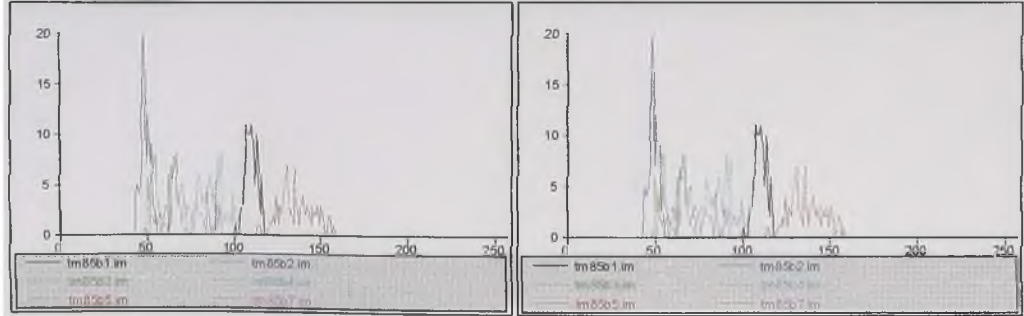
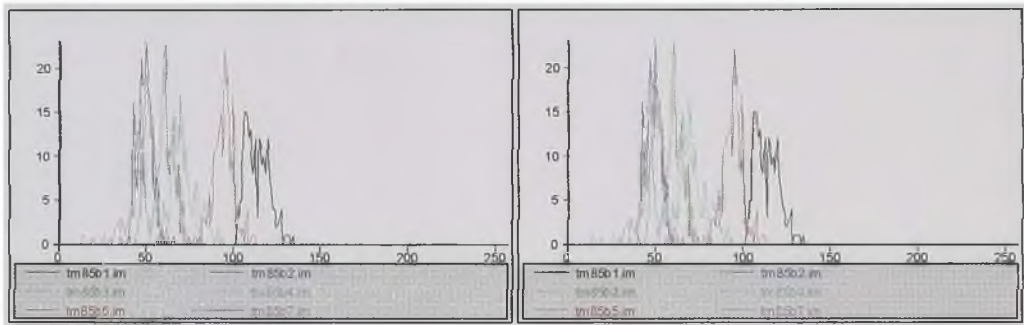
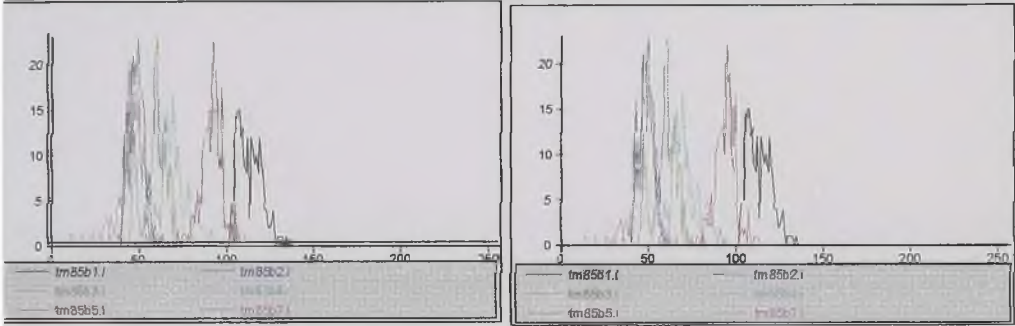
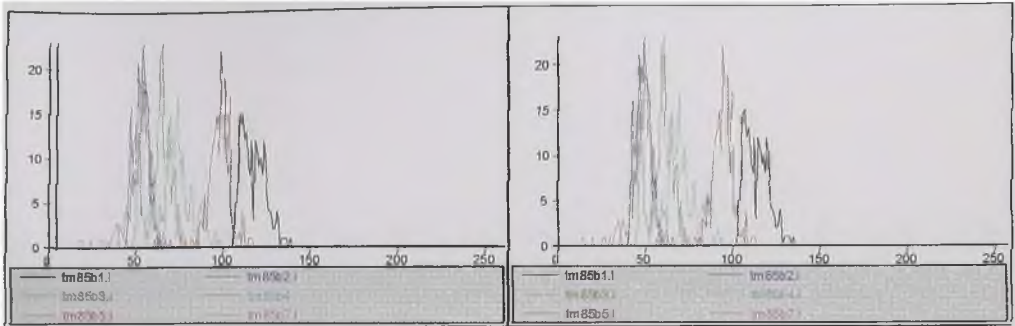
Yang Bangjie and Liu Haiqi (1999) Development of A National Operation System for Crop and Resources Monitoring using Remote Sensing in China Ministry of Agriculture
<http://www.gisdevelopment.net/aars/acrs/1999/radarsat/agriculture/aqri001.shtml>

Yesou, H., Besnus, Y., Rolet, J., Pion, J. C. and Aing, A. (1993): Merging Seasat and Spot Imagery for the Study of Geological Structures in Temperate Agricultural Region. Remote Sensing of Environment. 43, 265-279

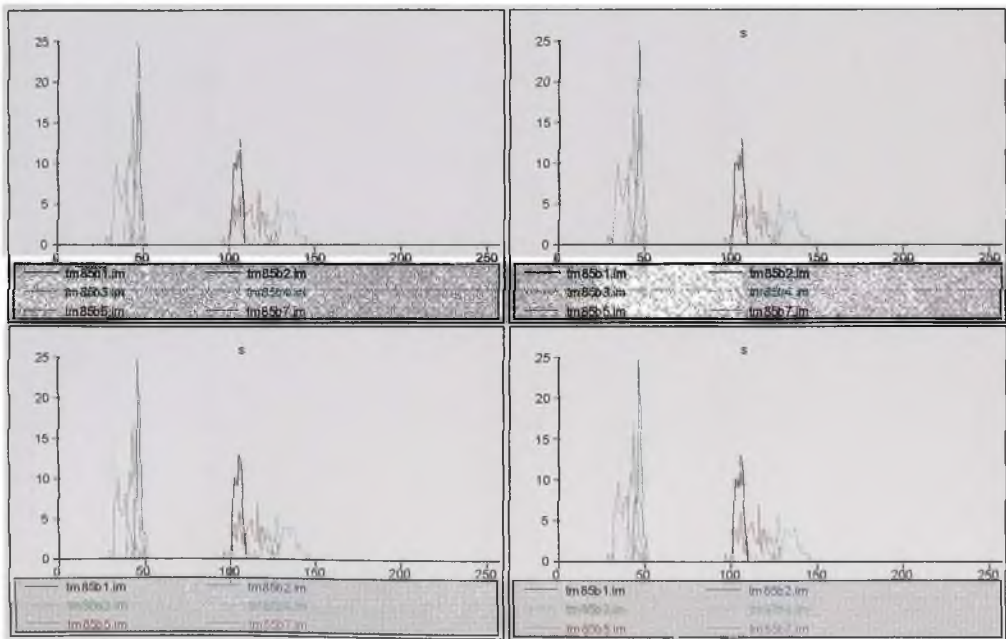
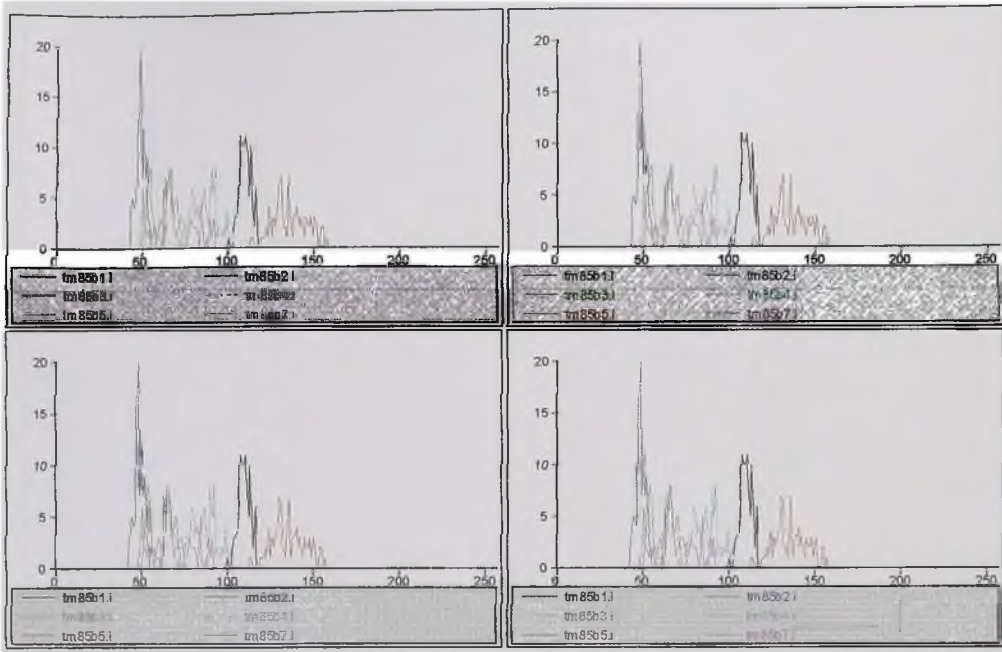
Zhongchao Shi. Liu Haiqi and Ryouzuke Shibasaki (1999) A practical model for estimating the arable land change of China using remotely sensed imagery
<http://www.gisdevelopment.net/aars/acrs/1999/ps1/ps1129.shtml>

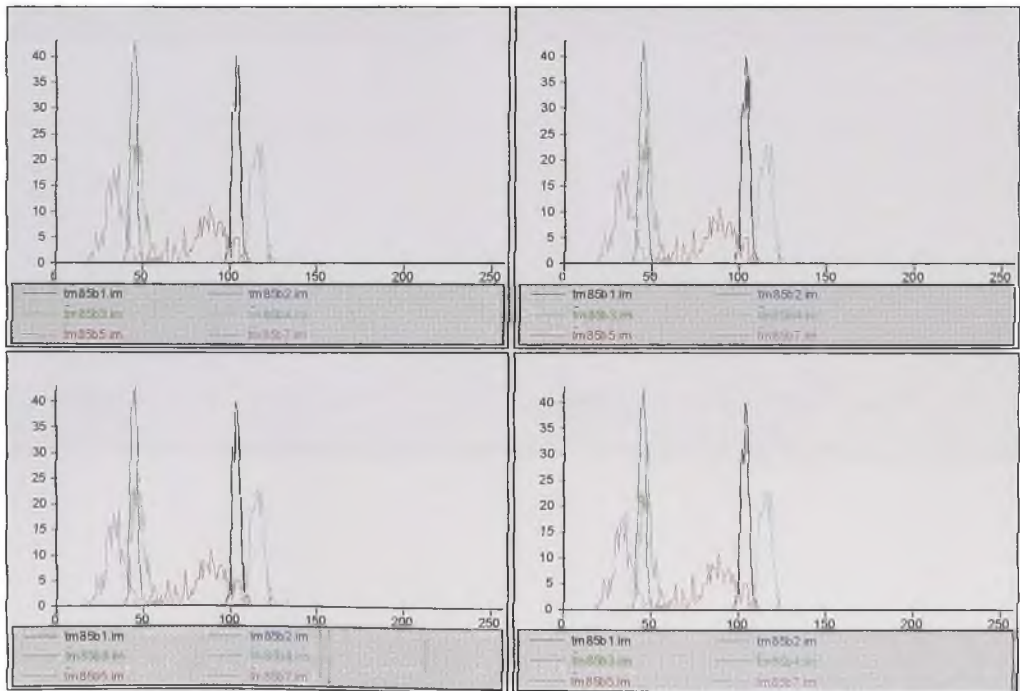
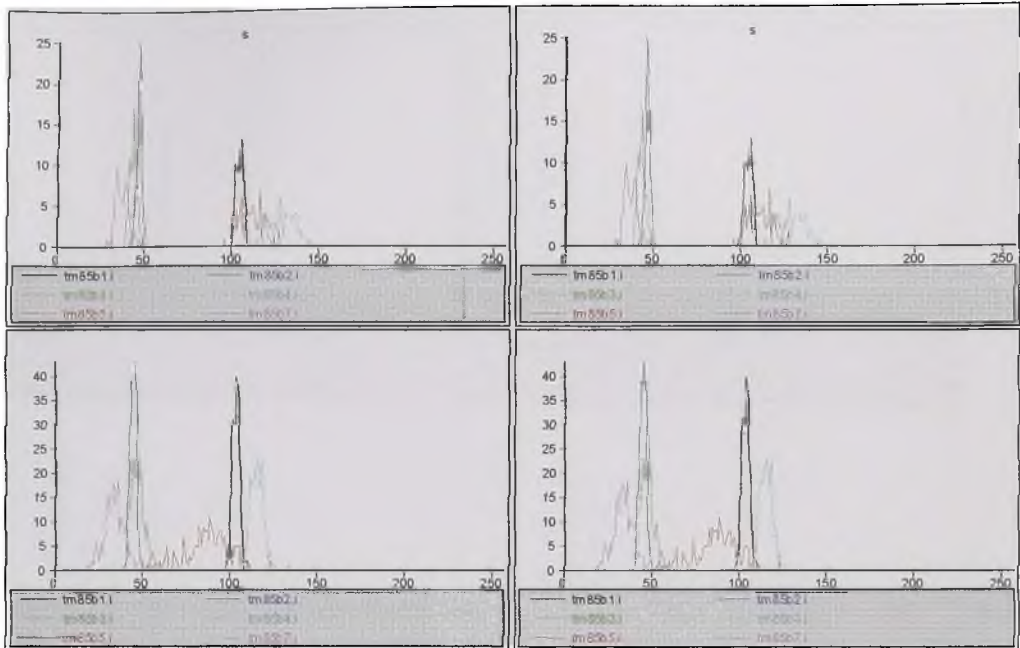
ZHU L. and TATEISHI R. (2000) Integration of Multisensor Multitemporal Satellite Data for Agricultural Vegetation Mapping
<http://www.gisdevelopment.net/aars/acrs/2000/ps1/ps105.shtml>

Appendix I **spectral Signature Graph for Landsat TM 1985 Image**
Band(s) by region of interest – built-up/bare areas

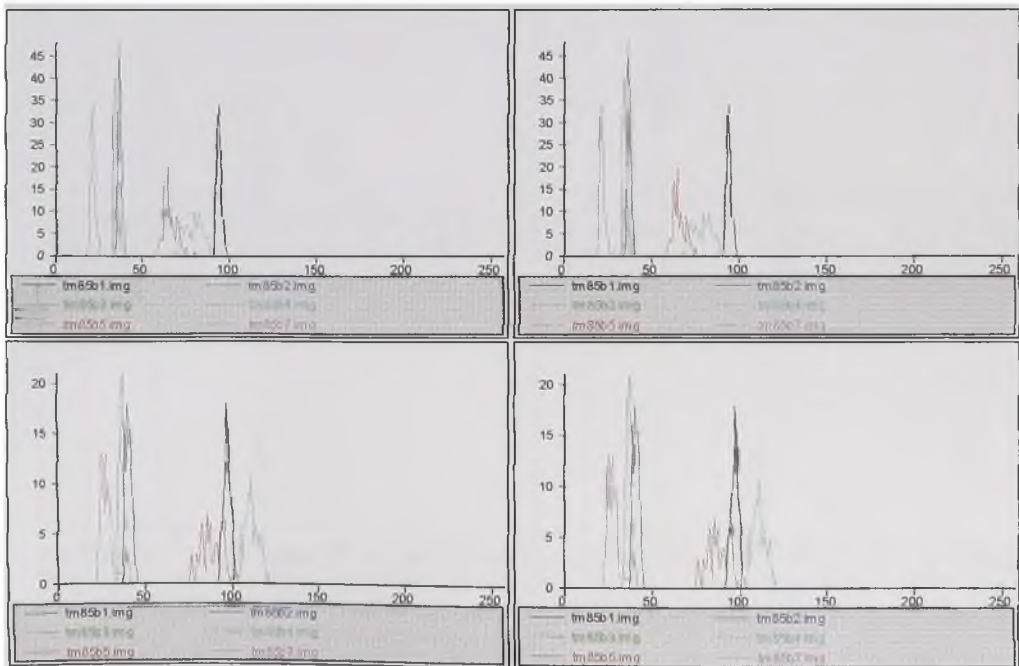
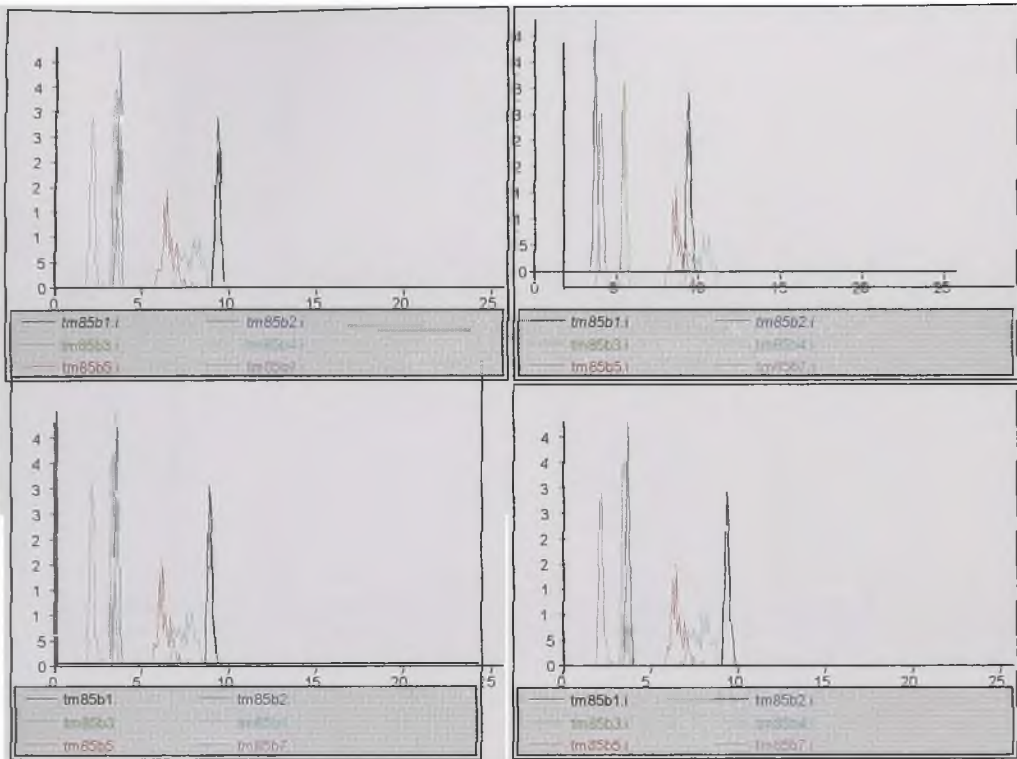


Band(s) by region of interest – shrub

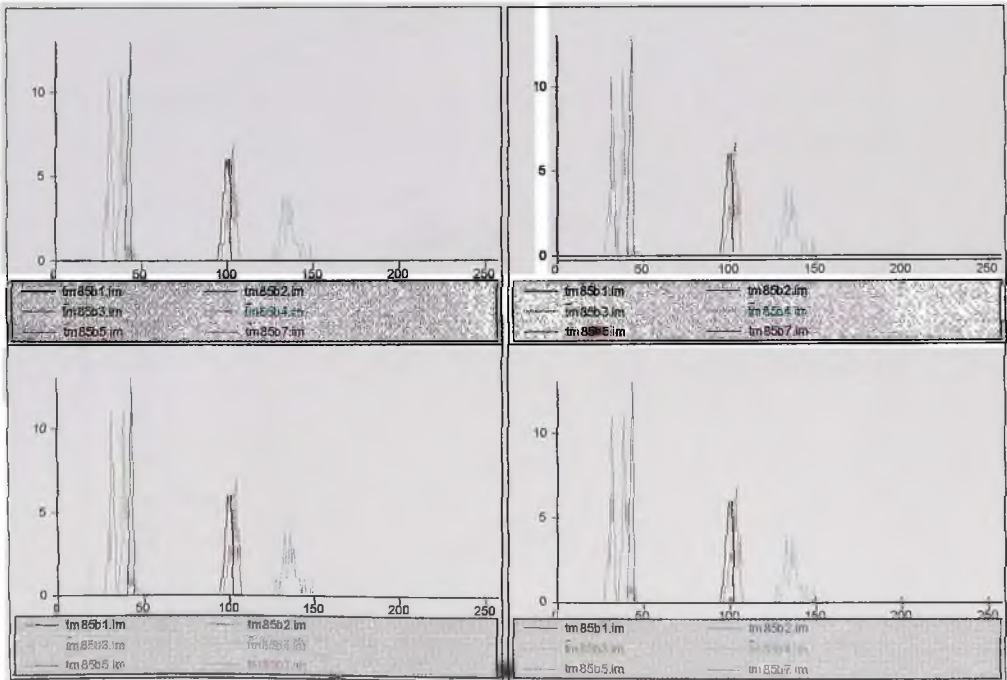
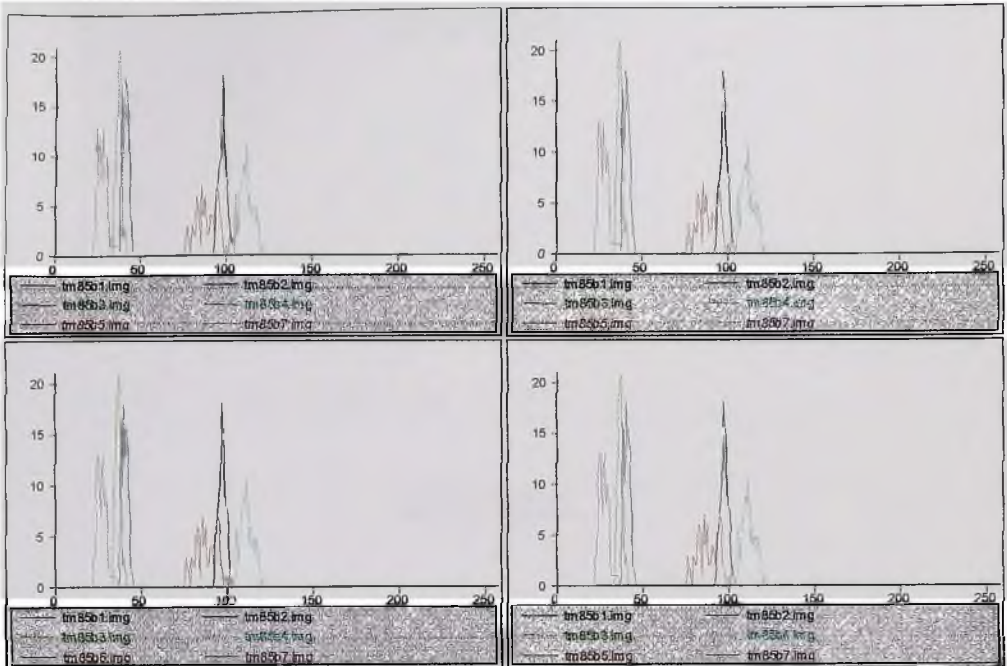


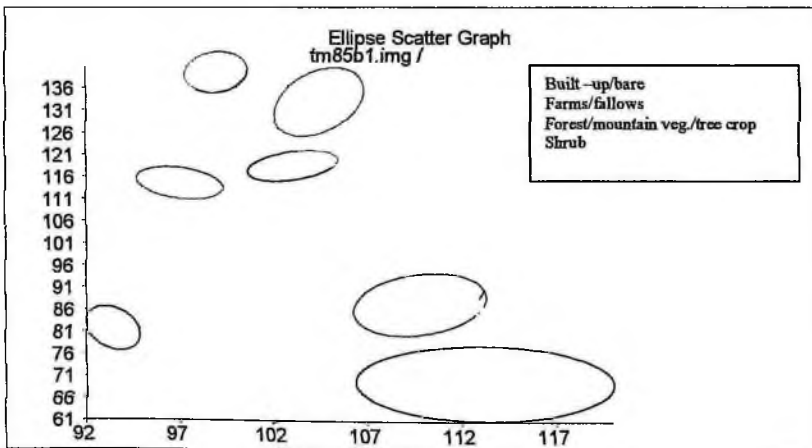
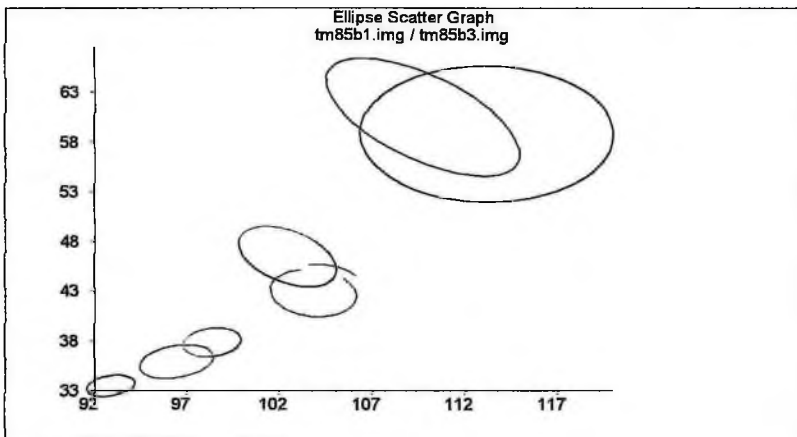
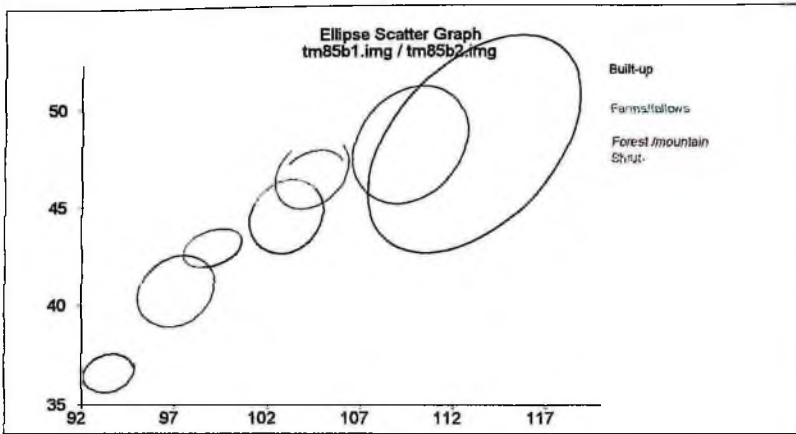


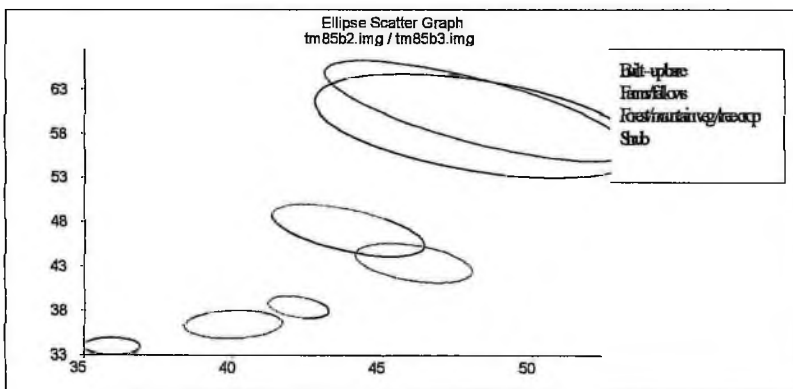
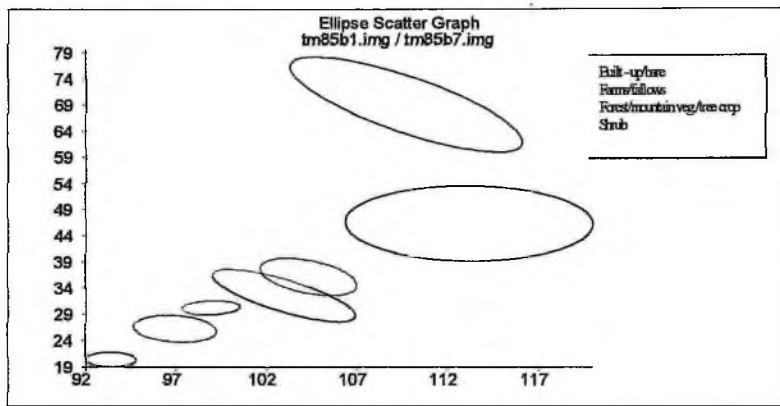
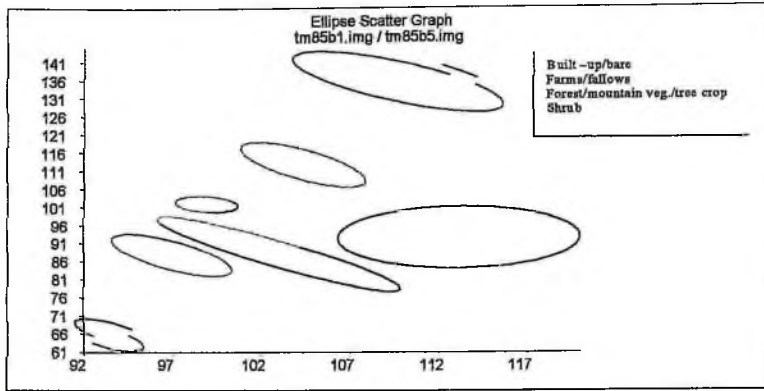
Band(s) by region of interest – Forest/mountain vegetation, tree crop

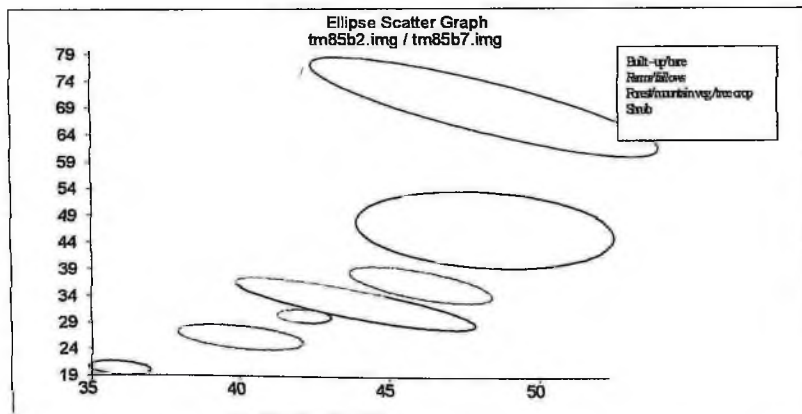
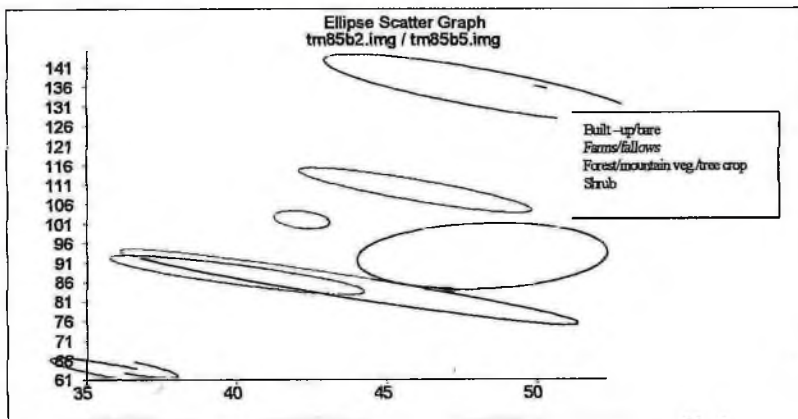
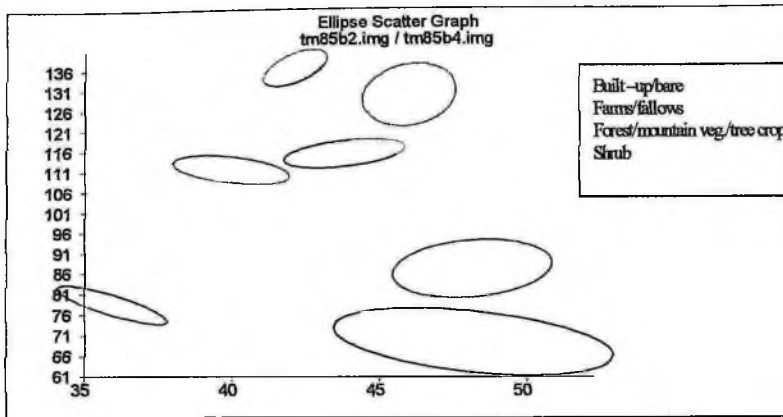


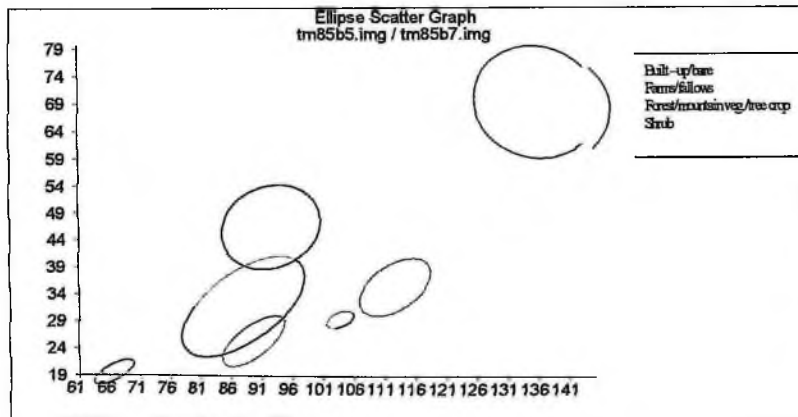
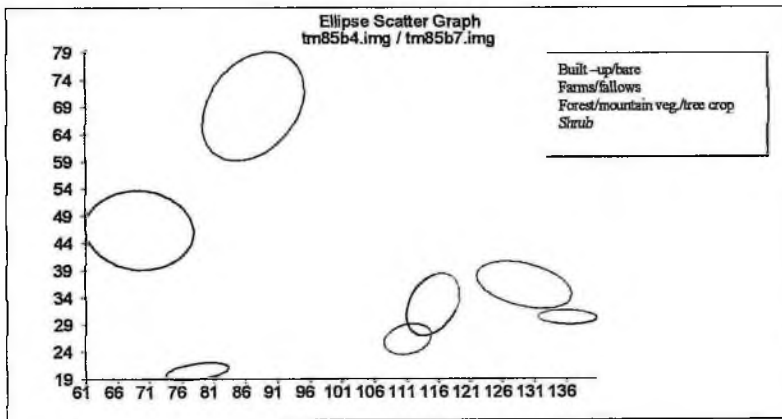
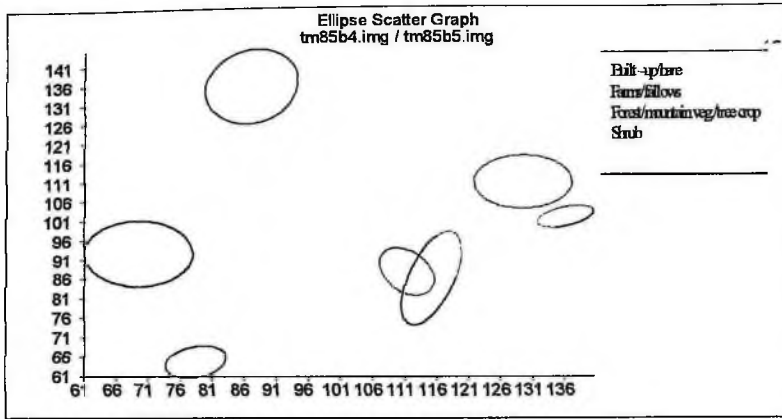
Bands by region (s) of interest – farms/fallow field





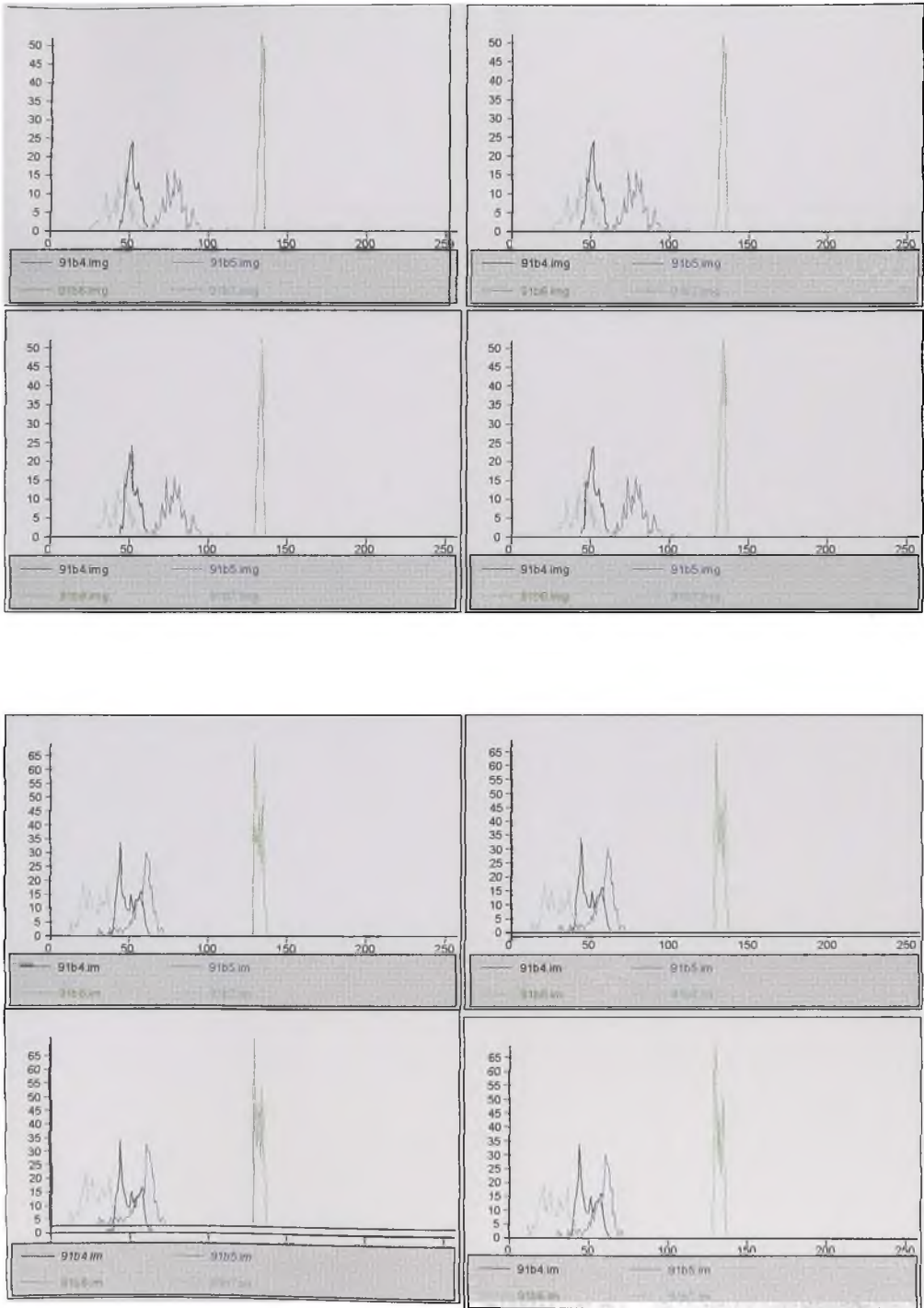




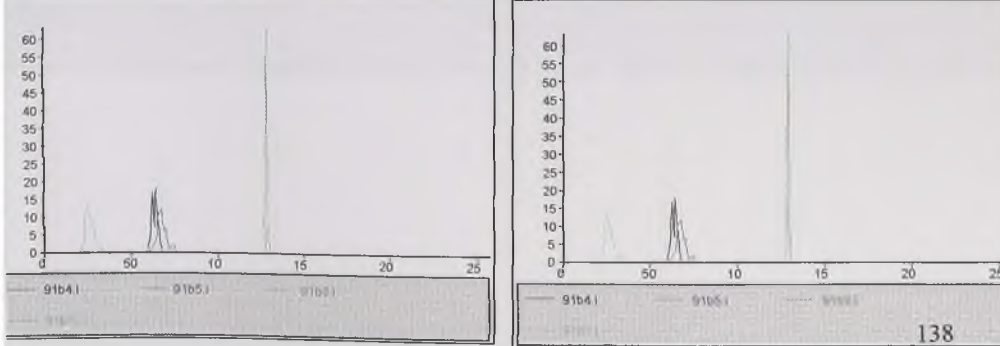
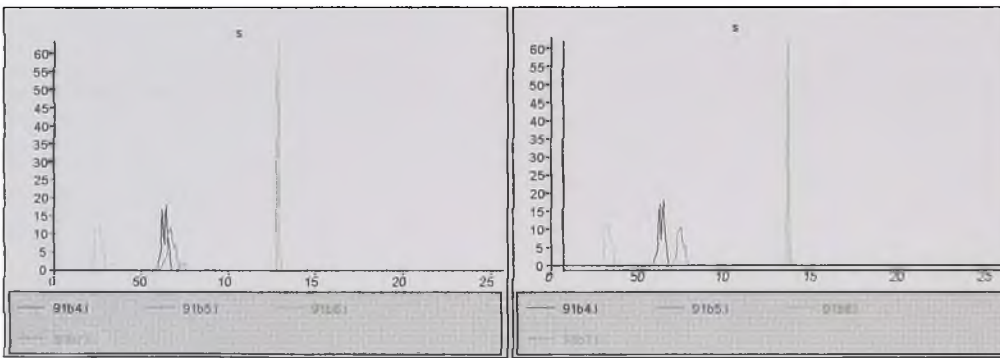
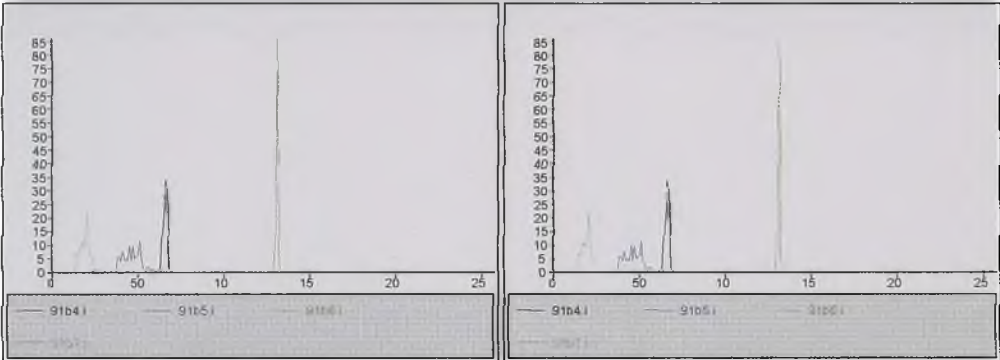
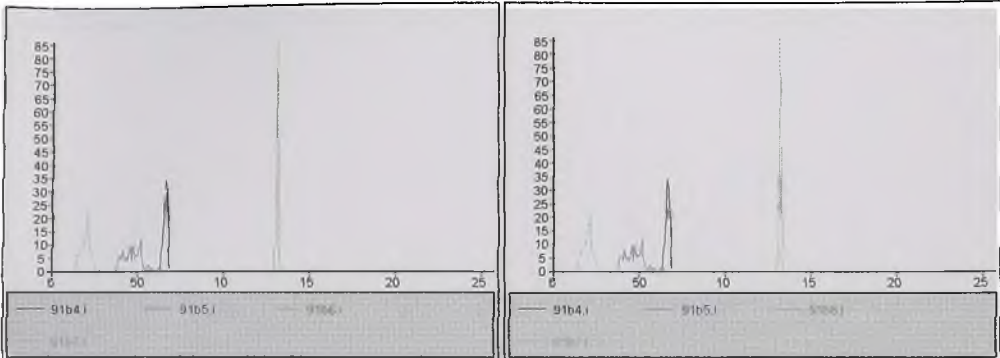


Appendix III Spectral Signature Graph for Landsat TM 1991 Image

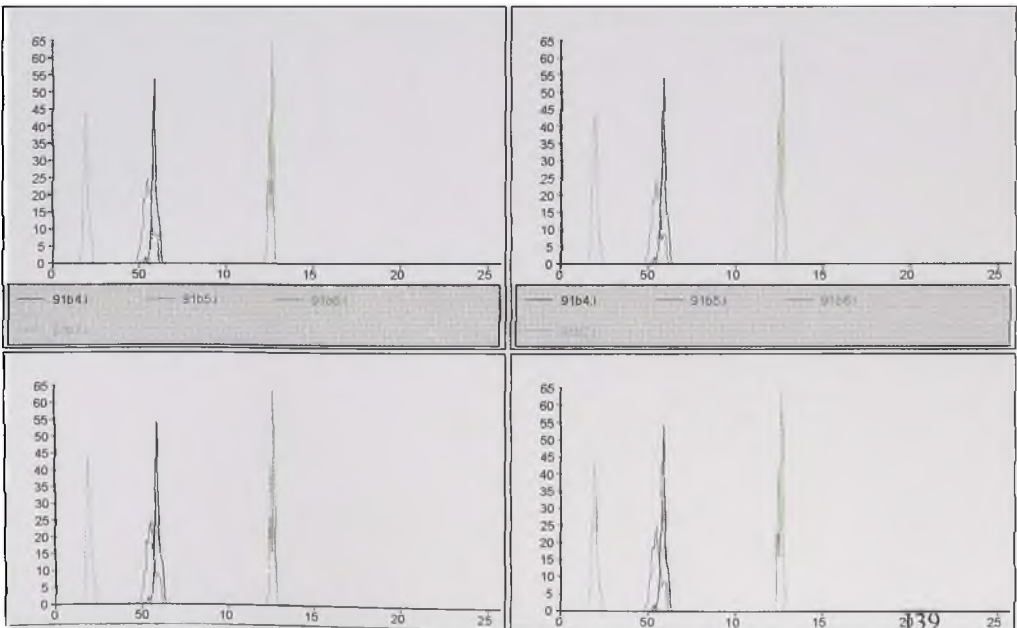
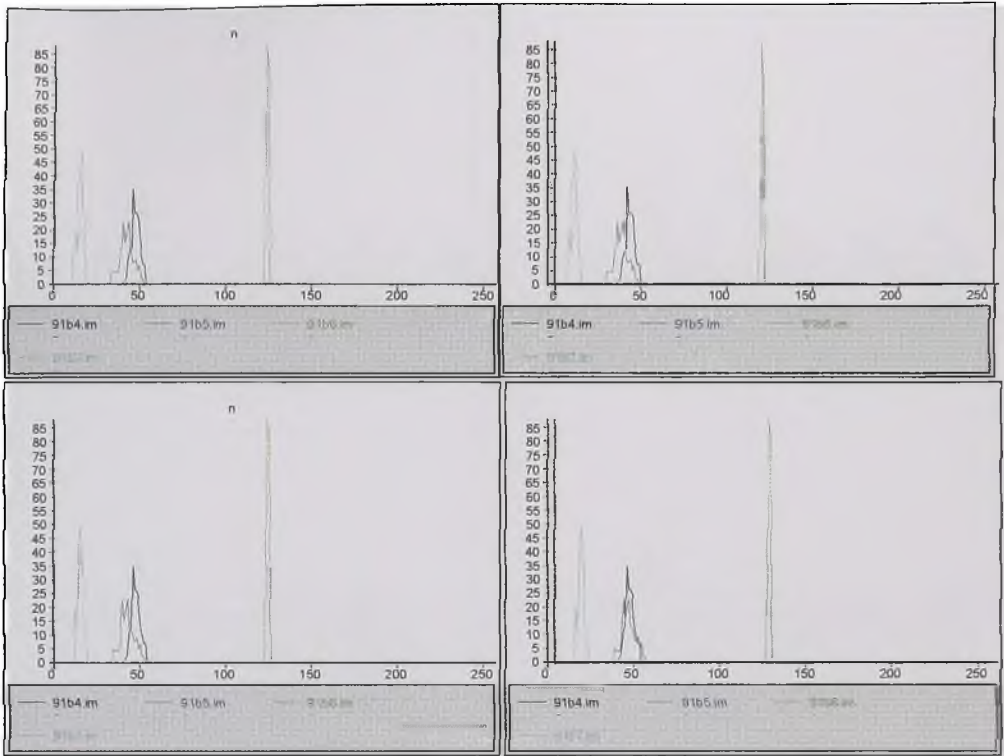
Band(s) by region of interest – Built-up/bare areas



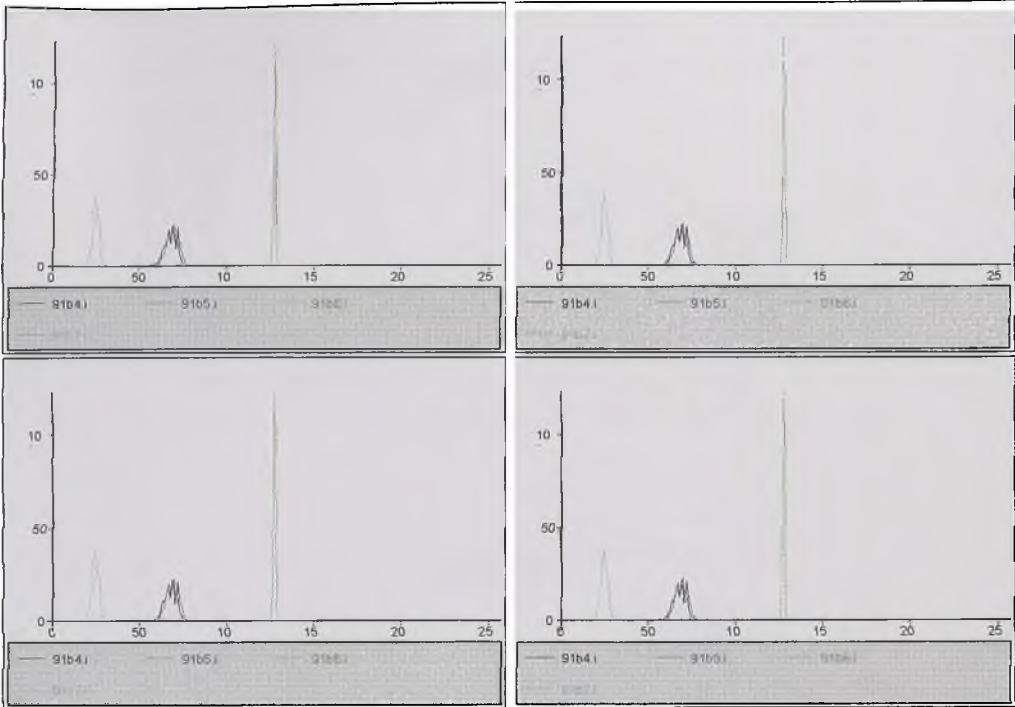
Band(s) by region of interest – farms/fallow field



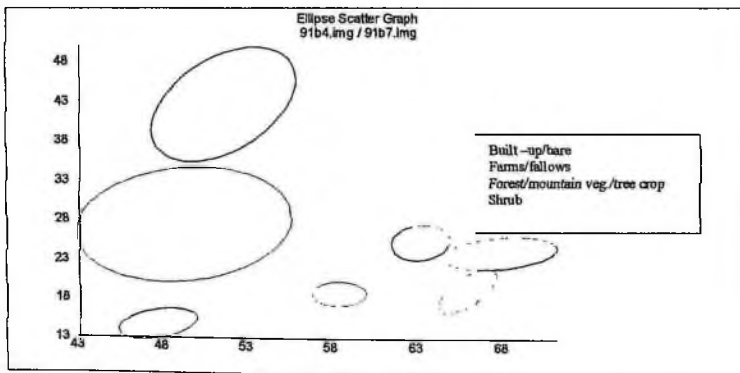
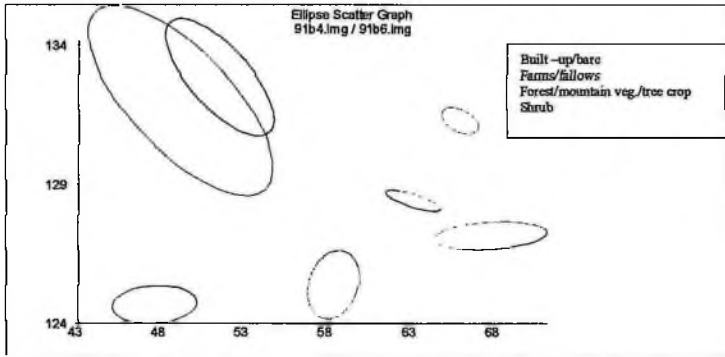
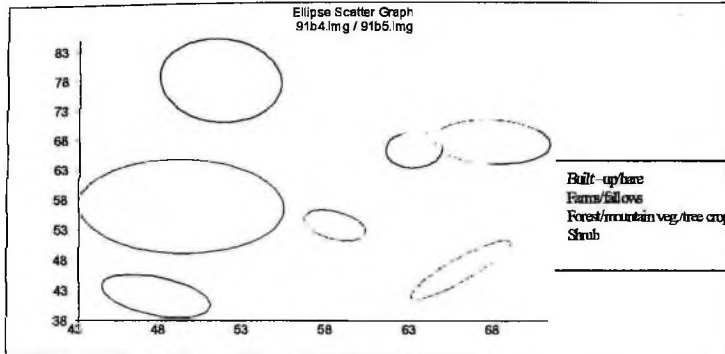
Band(s) by region of interest – forest/mountain veg./tree crop



Band(s) by region of interest – shrub



Appendix IV Training field Ellipses of Landsat Tm 1991 Image



Appendix V

Principal component transformation is a linear transformation of the original bands. The transformation coefficients are found as **eigenvectors** of the correlation or covariance matrices for the selected bands. The principal components are computed using the following method:

$$PC_1 = SC_1(a_{11}IM_1 + a_{12}IM_2 + \dots + a_{1n}IM_n + M_1)$$

$$PC_2 = SC_2(a_{21}IM_1 + a_{22}IM_2 + \dots + a_{2n}IM_n + M_2)$$

...

...

$$PC_n = SC_n(a_{n1}IM_1 + a_{n2}IM_2 + \dots + a_{nn}IM_n + M_n)$$

Where

$$a_{11} \ a_{12} \ \dots \ a_{1n}$$

$$a_{21} \ a_{22} \ \dots \ a_{2n}$$

...

$$a_{n1} \ a_{n2} \ \dots \ a_{nn}$$

is the matrix containing the transformation coefficients. IM_n is the pixel value of image n (typically band n of a multispectral or temporal image). SC_n is the adjustable scale factor used to distribute the principal components and M_n is the adjustable mean value of principal component n .

Appendix VI**CHI-SQUARE ANALYSIS**

$$\text{General Formula: } X^2 = \sum_{i=1} \sum_{j=1} \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$$

Where: O_{ij} = is the observed value in the i^{th} row of the j^{th} column of the contingency table

E_{ij} = is the expected value in the i^{th} row of the j^{th} column of the contingency table

$\sum \sum$ = Sum values over all rows and all columns i.e. sum expression for all cells of the contingency table

$$E_{ij} = \frac{T_i \times T_j}{n}$$

Where: T_i = marginal total for row i

T_j = marginal total for column j

n = the total number of observations

Hypothesis testing (a); that changes in agricultural land use in Akwapim South District is due to a shift in emphasis to monocropping (pineapple)

(a) YEARS

CONTINGENCY TABLE 2 X 2

| | (1) | 1974 | |
|-------------------------|--------------------------|----------------------------|-------|
| | Traditional or Food crop | Non-tradition or pineapple | Total |
| Proportion of Land size | 63.68 (63.34) | 36.32 (36.66) | 100 |
| Number of Farmers | 63 (63.34) | 37 (36.66) | 100 |
| Total | 126.68 | 73.32 | 200 |

Hypothesis 1

H_0 ; there was no significant difference between traditional (food crop) and non-traditional (pineapple) crop production in terms of land allocation and the number of farmers engaged in 1974.

H_1 ; there was significant difference between traditional (food crop) and non-traditional (pineapple) crop production in terms of land allocation and the number of farmers engaged in 1974.

Significant level: 95%

$$df = (n_1 - 1) (n_2 - 1) = (2 - 1) (2 - 1) = 1$$

$$\text{From Tables } X^2 = 0.05 (1) = 3.841$$

$$\text{Calculated } X^2 = 0.999737 \text{ (significant level is 0.05)}$$

$\therefore H_0$ rejected; H_1 accepted.

Where: df represents the degree of freedom
 n_1 represents the number of rows
 n_2 represents the number of columns

| (2) | 1985 | | Total |
|-------------------------|--------------------------|----------------------------|-------|
| | Traditional or Food crop | Non-tradition or pineapple | |
| Proportion of Land size | 47.08 (62.54) | 52.92 (37.46) | 100 |
| Number of Farmers | 78 (62.54) | 22 (37.46) | 100 |
| Total | 125.08 | 74.92 | 200 |

Hypothesis 2

H_0 ; there was no significant difference between traditional (food crop) and non-traditional (pineapple) crop production in terms of land allocation and the number of farmers engaged in 1985.

H_1 ; there was significant difference between traditional (food crop) and non-traditional (pineapple) crop production in terms of land allocation and the number of farmers engaged in 1985.

Significant level: 95%

$$df = (n_1 - 1) (n_2 - 1) = (2 - 1) (2 - 1) = 1$$

$$\text{From Tables } X^2 = 0.05 (1) = 3.841$$

$$\text{Calculated } X^2 = 0.00014 \quad (\text{significant level is } 0.05)$$

$\therefore H_0$ rejected; H_1 accepted.

(3) 1991

| | Traditional or Food crop | Non-tradition or pineapple | Total |
|-------------------------|--------------------------|----------------------------|-------|
| Proportion of Land size | 51.6 (32.3) | 48.4 (67.7) | 100 |
| Number of Farmers | 13 (32.3) | 87 (67.7) | 100 |
| Total | 64.6 | 135.4 | 200 |

Hypothesis 3

H_0 : there was no difference between traditional (food crop) and non-traditional (pineapple) crop production in terms of land allocation and the number of farmers engaged in 1991.

H_1 : there was difference between traditional (food crop) and non-traditional (pineapple) crop production in terms of land allocation and the number of farmers engaged in 1991.

$$df = (n_1 - 1) (n_2 - 1) = (2 - 1) (2 - 1) = 1$$

$$\text{From Tables } X^2 = 0.05 (1) = 3.841$$

$$\text{Calculated } X^2 = 1.91627E-07 \text{ (significant level is 0.05)}$$

$\therefore H_0$ rejected; H_1 accepted.

(b) Number of Farmers

CONTINGENCY TABLE 3 X 2

| | Traditional or Food crop | Non-tradition or pineapple | Total |
|-------|--------------------------|----------------------------|-------|
| 1974 | 29 (56) | 71 (44) | 100 |
| 1985 | 78 (56) | 22 (44) | 100 |
| 1991 | 61 (56) | 39 (44) | 100 |
| Total | 168 | 132 | 300 |

Hypothesis

H_0 ; there is no significant difference in the proportion of land devoted to non-traditional (pineapples) and traditional (food crop) crops from 1974 – 1991

H_1 ; there is difference in the proportion of land devoted to non-traditional (pineapples) and traditional (food crop) crops from 1974 – 1991

$$df = (n_1 - 1) (n_2 - 1) = (3 - 1) (2 - 1) = 2$$

$$\text{From Tables } X^2 = 0.05 (2) = 5.991$$

$$\text{Calculated } X^2 = 1.23556E-09 \quad (\text{significant level is } 0.05)$$

$\therefore H_0$ rejected; H_1 accepted.

Appendix VII

Testing of Hypothesis that (b); agricultural land use changes have resulted in a reduction in staple food crop production.

H_0 ; there is no significant change in staple food crop production

H_1 ; there is a significant change in staple food crop production

Using Production Estimates;

Production Estimates for Some Major Crops in Akwapim South District

| CROP | YEAR (Metric Tonnes) | | | | |
|-----------------|-------------------------|-------|-------|-------|-------|
| | 1992 | 1993 | 1994 | 1995 | 1996 |
| MAIZE | 7800 | 11500 | 9900 | 8400 | 8000 |
| CASSAVA | 78100 | 84700 | 84700 | 70000 | 62000 |
| COCOYAM | 1200 | 700 | 2010 | 2300 | 1900 |
| PLANTAIN | 4200 | 800 | 10080 | 9500 | 820 |

Source: Ministry of Food and Agriculture, PPMED, 1998

ANOVA

| | N | Mean | Std. | Std. Error | 96% Confidence Interval for Mean | | Minimum | Maximum |
|--------------|-----------|-----------------|-----------------|----------------|----------------------------------|-----------------|------------|--------------|
| Year | | | | | Lower Bound | Upper Bound | | |
| 1992 | 4 | 22825.00 | 36948.65 | 18474.32 | -35968.54 | 81618.54 | 1200 | 78100 |
| 1993 | 4 | 24425.00 | 40501.64 | 20250.82 | -40022.14 | 88872.14 | 700 | 84700 |
| 1994 | 4 | 26672.50 | 38867.54 | 19433.77 | -35174.43 | 88519.43 | 2010 | 84700 |
| 1995 | 4 | 22550.00 | 31791.46 | 15895.73 | -28037.30 | 73137.30 | 2300 | 70000 |
| 1996 | 4 | 18180.00 | 29383.85 | 14691.93 | -28576.27 | 64936.27 | 820 | 62000 |
| Total | 20 | 22930.50 | 31893.72 | 7131.65 | 8003.78 | 37857.22 | 700 | 84700 |

| | Sum of Squares | df | Mean Square | F | Sig. |
|----------------|------------------------|-----------|----------------|------|------|
| Between Groups | 155837020.000 | 4 | 38959255.000 | .030 | .998 |
| Within Groups | 19171135275.000 | 15 | 1278075685.000 | | |
| Total | 19326972295.000 | 19 | | | |

To test the same hypothesis using percentage of respondents

H_0 ; there is no proportionate change in staple food crop production

H_1 ; there is proportionate change in staple food crop production

Percentage changes in the amount of land to various crop production during the period under review

| Settlement | Percentage of Farmers | | | | | |
|------------|-----------------------|-----------|-----------|-----------|-----------|-----------|
| | (1970) | | (1980) | | (1990) | |
| | Food Crop | Cash Crop | Food Crop | Cash crop | Food Crop | Cash Crop |
| Fotobi | 63 | 37 | 22 | 78 | 13 | 87 |
| Pakro | 75 | 25 | 64 | 36 | 41 | 59 |
| Pampamso | 66 | 34 | 62 | 38 | 48 | 52 |
| Duayeden | 59 | 49 | 40 | 60 | 51 | 49 |
| Nsakyee | 55 | 45 | 36 | 64 | 30 | 70 |
| Doboro | 61 | 39 | 45 | 55 | 40 | 60 |
| Daman | 39 | 61 | 56 | 44 | 52 | 48 |
| Kofisa | 71 | 29 | 59 | 41 | 47 | 53 |

Source: Field Survey, 1999.

T-Test**Paired Samples Statistics**

| | | Mean | N | Std. Deviation | Std. Error Mean |
|---------------|-----------|-------|---|----------------|--------------------|
| Pair 1 | Food crop | 61.13 | 8 | 11.01 | 3.89 |
| | Cash crop | 39.88 | 8 | 11.58 | 4.09 |
| Pair 2 | Food crop | 48.00 | 8 | 14.78 | 5.23 |
| | Cash crop | 52.00 | 8 | 14.78 | 5.23 |
| Pair 3 | Food crop | 40.25 | 8 | 13.13 | 4.64 |
| | Cash crop | 59.75 | 8 | 13.13 | 4.64 |

Paired Samples Test

| | | Paired Differences Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference | | t | df | Sig. (2- tailed) |
|--------|--------------------|-------------------------------|-------------------|-----------------------|---|-------|--------|----|---------------------|
| | | | | | Lower | Upper | | | |
| Pair 1 | FOOD70 - CASH70 | 21.25 | 22.42 | 7.93 | 2.50 | 40.00 | 2.680 | 7 | .032 |
| Pair 2 | FOOD80 - CASH80 | -4.00 | 29.57 | 10.45 | -28.72 | 20.72 | -.383 | 7 | .713 |
| Pair 3 | FOOD90 - CASH90 | -19.50 | 26.27 | 9.29 | -41.46 | 2.46 | -2.100 | 7 | .074 |

In 1970 the proportion of change from food crop to cash crop was very significant ($t=2.68$, $P < 0.05$), but the subsequent changes in 1980 and 1990 were not at all significant ($t=0.383$, $P > 0.05$).

Appendix VIII**USING REMOTE SENSING/GIS FOR A STUDY OF AGRICULTURAL LAND USE
CHANGE IN AKWAPIM SOUTH DISTRICT**

This exercise is purely an academic research towards the fulfilment of the requirements of an M.Phil. programme in Geography by Albert N. M. Allotey, Department of Geography and Resource Development, University of Ghana, Legon. Information given on this form will therefore not be attributed to any particular individual for the sake of confidentiality. Your co-operation is thus of immense help to the success of this survey.

SCHEDULE (B)**QUESTIONNAIRE
FOR COMMERCIAL FARMERS**

1. Name of farm.....
2. Town / Settlement located.....
3. In what year did you establish your farm.
4. What was the initial size of your farm (in hectares) when you started at first.....
5. Has there been any change in the farm size over the years. Yes [] No []
6. If Yes, which of these is applicable (a) An increase [] (b) A decrease []
- 7 How many times has the changes occurred.
 - (a) Once [] (b) twice [] (c) thrice []
 - (d) four times [] (e) others (State).....
8. Give the Year and Amount of change in farm size.
 - (i) Year.....and by what size (hectares).....
 - (ii) Year.....and by what size(hectares).....
 - (iii) Year.....and by what size (hectares).....
 - (iv) Year.....and by what size (hectares).....

LAND

9. How did you acquire the land:

i. Purchased [] ii. Lease [] iii. Hired [] iv. Inherited []

v. Family Property []

10. If **Leased**, for how long. i) 10yrs [] ii) 15yrs [] iii) 20yrs [] iv. 25yrs []

v. 30yrs [] vi. 35yrs [] vii) 40yrs. [] viii. 45yrs [] ix) 50yrs []

x) 55yrs [] xi) 60yrs [] xi) others (state).....

11. What was the land use/cover type before acquisition?

a) Farm []

b) Shrub []

c) Fallow []

d) Forest []

e) Others (state).....

12. Do you own other farms outside this vicinity? Yes [] No []

13 If Yes to question 12, give the **location**, **size** and **crops** cultivated

a) Locationsize..... crops.....

b) Locationsize..... crops.....

c) Locationsize..... crops.....

d) Locationsize..... crops.....

Labour

12. How many people are employed on your present farm.....

13. Do they come from the nearby villages? Yes [] No []

13. If No to question 13, then where do they come from?

14. Which is the target market?

a) Local (Ghana) []

b) Export []

c) Both []

Thank You

Appendix VIII

**USING REMOTE SENSING/GIS FOR A STUDY OF AGRICULTURAL LAND USE
CHANGE IN AKWAPIM SOUTH DISTRICT**

This exercise is purely an academic research towards the fulfilment of the requirements of an M.Phil. programme in Geography by Albert N. M. Allotey, Department of Geography and Resource Development, University of Ghana, Legon. Information given on this form will therefore not be attributed to any particular individual for the sake of confidentiality. Your co-operation is thus of immense help to the success of this survey

**SCHEDULE (A) QUESTIONNAIRE
FOR SUBSISTENCE & SEMI-SUBSISTENCE FARMERS**

Section 'A' Socio-Economic Characteristics

1. Name of respondent..... 2. Sex M.[] F []
2. Name of settlement.....
3. Age (Tick) a/. below 20yrs, b/. 21 - 40 yrs, c/. 41 - 55yrs., d/. above 55 yrs.
4. Educational status (tick) a/ No formal education [] b/ Primary / middle []
c/ Secondary [] d/ Tertiary / higher institution []
5. What is the size of your household.....
6. Major occupation.....6. Subsidiary occupation.....

Section 'B' LAND

- 7 What is the mode of land acquisition (tick)

| <u>a / 20years ago (1970s)</u> | <u>10years ago (1980s)</u> | <u>Presently (1990)</u> |
|----------------------------------|-------------------------------|-------------------------------|
| 1. Abusa [] | Abusa [] | Abusa [] |
| 2. Abunu [] | Abunu [] | Abunu [] |
| 3. Family Land / Inheritance [] | Family Land / Inheritance [] | Family Land / Inheritance [] |
| 4. Pledge [] | Pledge [] | Pledge [] |
| 5. Hire /purchase [] | Hire /purchase [] | Hire /purchase [] |
| 6. Gift <input type="checkbox"/> | Gift <input type="checkbox"/> | Gift <input type="checkbox"/> |

7. others others.....others.....

8. What has brought this (these)changes.....

.....

9. Have you experienced any form of dispute or litigation in respect of your access or title to land or farm? Yes [] No. []

10. If Yes to question '9', state the year(s).....

11. Give details in respect to question '9'.

.....

Section 'C' FARM

12. What has been the size of your farm over the following periods ;

a. 30yrs ago (1960s)..... 20yrs ago (1970s).....10yrsago(1980s).....

present (1990s).....

13. What type(s) of crops do you cultivate?

a. 30yrs ago (1960s).....

b. 20yrs ago (1970s).....

c. 10yrs ago(1980s).....

d. present(1990s).....

14. Since you started farming, is the present plot of land the only one you have been farming on? Yes [] No []

15. If no to question 14, then how many others have you?

16. Name where they are **located**, **size** and **crop cultivated** on each.

i. Location Size (acres)..... Crops.....

ii. Location Size (acres)..... Crops.....

iii. Location Size (acres)..... Crops.....

iv. Location Size (acres)..... Crops.....

14. Do you produce for consumption, sale or both ;

| 20yrs ago (1960s) | 10yrs ago (1970s) | 20yrs ago(1980s) |
|--|-------------------------------|-------------------------|
| a./ home consumption only [] only [] | home consumption only [] | home consumption |
| b/ home consumption and sell [] and sell [] | home consumption and sell [] | home consumption |
| c/ sell only [] | sell only [] | sell only [] |
| Present (1990s) | | |
| a./ home consumption only [] | | |
| b/ home consumption and sell [] | | |
| c/ sell only [] | | |

15. Have you in any way increased your land area that you are cultivating. Yes [] No []

a. If Yes to question 15, Why.....

b. If No to question 15, Why.....

16. Why did you decide to change the crops you were cultivating.....

17. Which times (season) of the year do you farm ?.....

18. What technique do you use for clearing the land?

a. Tractor [] b. Hoe and Cutlass [] c. Tractor, hoe & cutlass []

19. Averagely, considering your farm size, what is the size of your labour force?

a. Farm size..... (acres) (b) Size of labour

20. Have you been receiving the services of Agricultural extension officers Yes [] No []

21. If yes to 20, how often.....

22. If No to question 20, why.....

23. How do you restore the fertility of the soil.

- a. Follow (natural restoration) []
- b. Chemical Fertilizer []
- c. Compost manure []
- d. animal droppings []
- e. Others.....

Section 'D' FINANCE

24. Have you over the years received any financial assistance Yes [] No []

25. If yes to question 20, state the years or periods

26. Which Agency provided this financial support.

27. If No to question 20, have you sought for any Yes [] No []

28. If No to question 23, Why?.....

Section 'E' ENVIRONMENTAL DEGRADATION

29. Over the years, what type of degradation have you observed
a/ water erosion

b/ deforestation

c/ overgrazing

d/ lost of fertility

e/ others.....

30. Have you taken any measure: Yes [] No []

31. If yes to question 26, have you care to take any corrective action? Yes [] No []

32. If yes to question 27, explain the measures

33. If No to question 26, state why?

Thank You