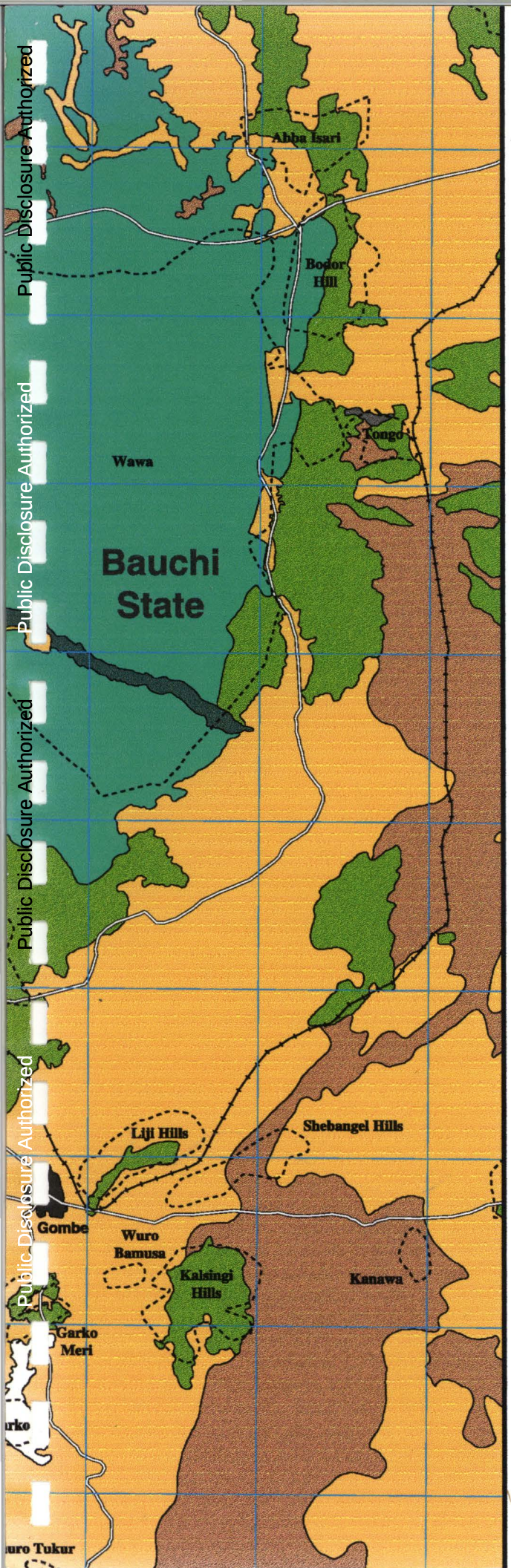
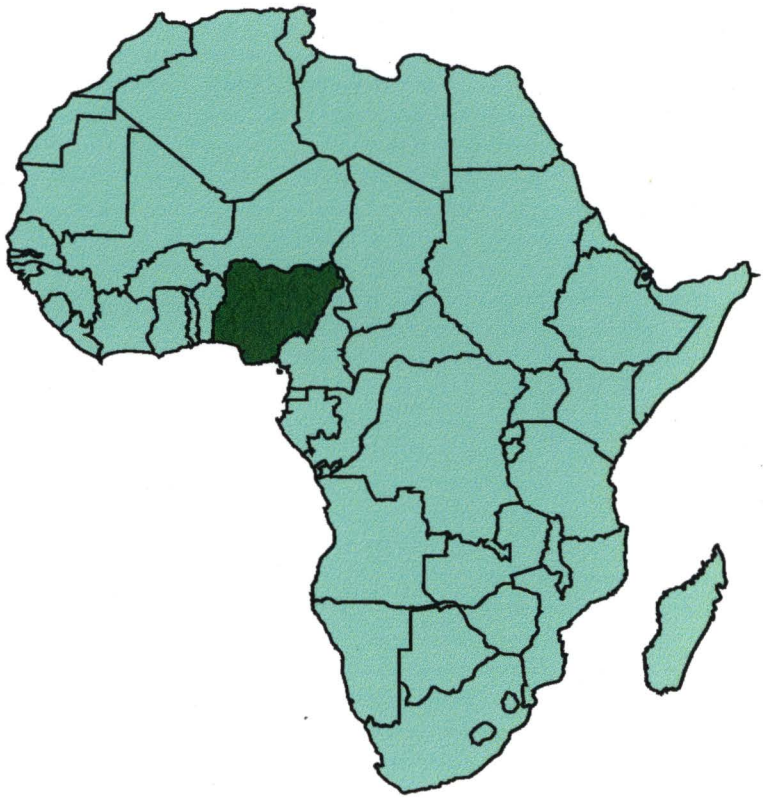


THE ASSESSMENT OF

Vegetation and Land Use Changes in Nigeria

BETWEEN 1976/78 AND 1993/95



Submitted to:

The Forestry Management, Evaluation and Co-ordinating Unit

FORMECU

Federal Department of Forestry

Part of the World Bank - Funded

Environmental Management Project (EMP)

For Nigeria

Submitted by:

Geomatics International Inc.

Member of the SSG Group

1998

ACKNOWLEDGEMENTS

Geomatics International Inc. would like to acknowledge all of the representatives from FORMECU, counterpart staff, World Bank task managers, the members of the consulting consortium and contract consultants, who were essential to the success of this study. Acknowledgements are also extended to the Canadian International Development Agency who provided supplemental funding for training aspects of this project.

TABLE OF CONTENTS

FIGURES

TABLES

1.0 Introduction

On November 7, 1994, a contract was signed by the Forestry Management, Evaluation and Coordinating Unit (FORMECU) with the consortium of Geomatics International Inc. of Canada, Beak Consultants Limited of Canada and Unilag Consult of Nigeria, to prepare an "Assessment of Vegetation and Land Use Changes in Nigeria between 1978 and 1993". Due to the project award date and material availability, the assessment period was revised to be between 1976/78 and 1993/95. For ease of coordination, Geomatics International was assigned the lead role for the contractors.

1.1 PROJECT OBJECTIVES

The objectives of this project were to:

1) assess and evaluate the available data on land use and vegetation changes and their interrelationships
2) identify data gaps
3) develop programs for the production of reliable and up-to-date information on vegetation changes and degradation over time
4) develop and implement a GIS database for the country of Nigeria - this database would contain polygon and point information in raster and vector formats that could be used in the analysis of trends in the extent and intensity of changes in vegetation and land use and to evaluate the socio-economic effects of these changes over time

In order to achieve these objectives, three separate but related tasks were implemented. These tasks included:

1) the establishment of an historical record on the status of vegetation and land use in 1976/78 to be used as baseline information from which the assessment of change would begin
2) the establishment of current information on vegetation and land use for 1993/95, based on the same classification scheme and the general format of the 1976/78 baseline information
3) the analysis of trends identifying extent and intensity of the changes in vegetation and land use over this 18-year period

2.0 Study Area

2.1 LOCATION

The Federal Republic of Nigeria, one of the countries in West Africa, is bounded by Niger to the north, by Chad and Cameroon to the east, by the Gulf of Guinea on the south, and by Benin on the west (Figure 2.1). The most populous country in Africa, Nigeria has a total area of 923 768 km^2, with a land area of 910 770 km^2 and marine claims to 200 nautical miles, extending from 4 to 14° North latitude and 2 to 14° East longitude. Its name is derived from that of its major river, the Niger. Abuja is the capital and Lagos is the largest city and main commercial centre.

2.2 RELIEF AND MAIN PHYSICAL FEATURES

Much of Nigeria's surface consists of ancient crystalline rocks of the African Shield. Subject to weathering and erosion for long periods, the landscape of this area is characterized by extensive level plains interrupted by occasional granite mountains. These features are a major landscape type in Nigeria and West Africa as a whole. Smaller areas of younger granites are also found, for example, on the Jos Plateau.

Sedimentary strata overlie the older rocks in many areas. The sedimentary areas typically consist of flat-topped ridges, dissected plateaus and a characteristic landscape of extensive plains with no major rocky outcrops. This landscape is generally found in the basins of the Niger and Benue rivers as well as the depressions of the Lake Chad and Sokoto River basins. In southeastern Nigeria, thick sedimentary beds from the Abakaliki Uplift to the Anambra Basin have been tilted and eroded. This process has resulted in a rugged scarp with east-facing cliffs in the Udi Hills, north of Enugu and in the area around Nanka and Agulu.

Volcanic rock occurs in only two areas in Nigeria, the Biu Plateau in the northeast extending into some localized volcanic areas along the eastern border with Cameroon, and the Jos Plateau.

Relief in Nigeria generally consists of a gradual rise from the coastal plains to the northern savanna regions, reaching an elevation of 600 to 700 m. Altitudes of more than 1200 m are found in the Jos Plateau and in parts of the eastern highlands along the Cameroon border. The coastal plain extends inland for approximately 10 km and rises to an elevation of 40 to 50 m above sea level. Its east and west sections are separated by the Niger Delta, which extends over an area of approximately 10 000 km^2 and is characterized by mangrove and freshwater swamp separated by numerous islands. The coastal plain region penetrates inland approximately 75 km in the west but extends farther inland in the east. This region is gently undulating, with elevation increasing northward and a mean elevation of about 150 m above sea level.

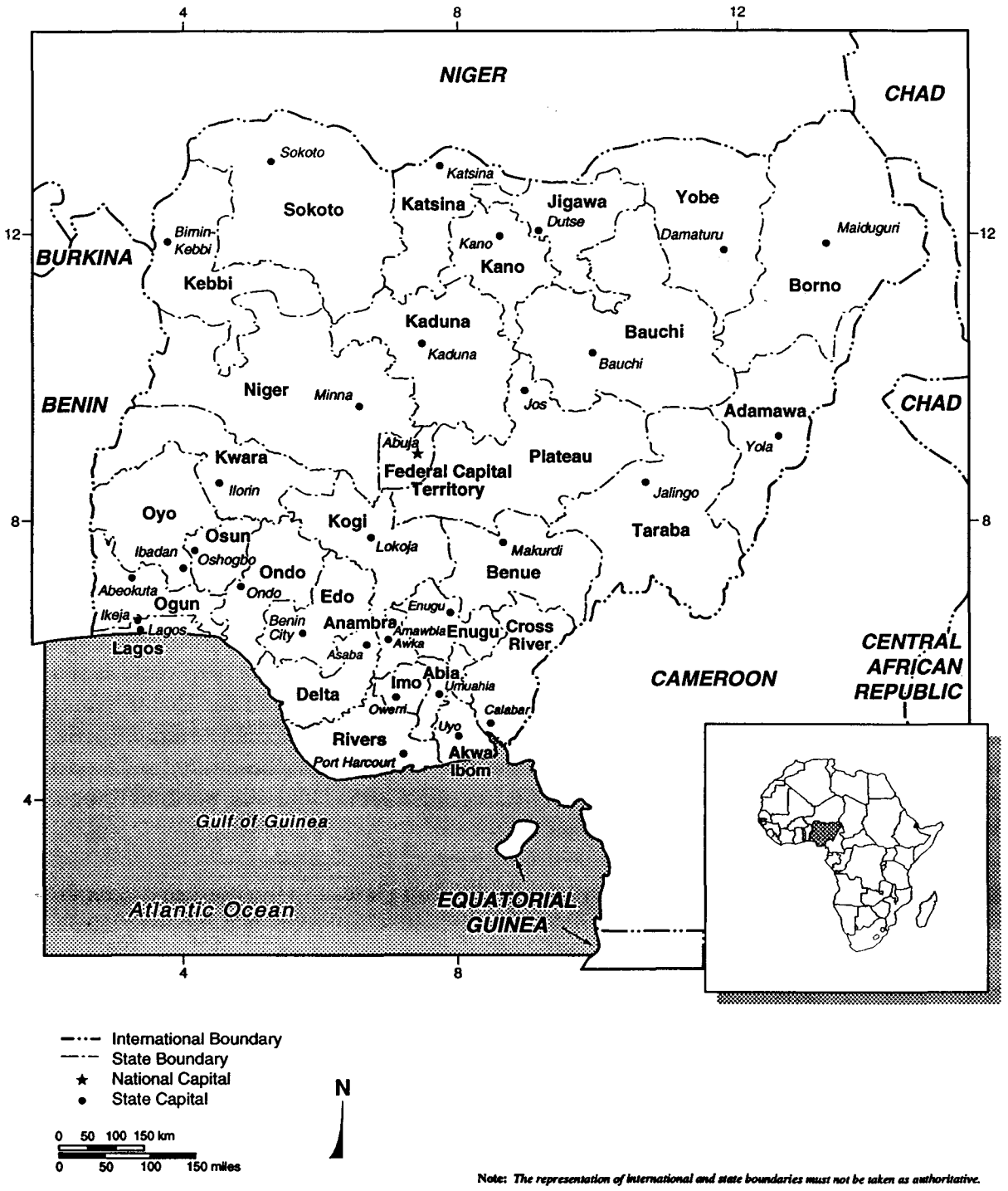


Figure 2.1 Nigeria Administration Boundaries (1991).

Extending to the northwest and northeast are the broad river basins of the Niger and Benue rivers. To the north of the Niger and Benue river basins are the broad, stepped plateau and granite mountains that characterize much of northern Nigeria. Such mountains are also found in the southwest, in the region between the western coastal plains and the upper Niger Basin. The western wedge between Abeokuta and Ibadan and the Niger Basin reaches an elevation of 600 m or more, whereas the extensive northern savanna region, stretching from Kontagora to Gombe and east to the border, includes extensive areas with elevations of more than 1200 m at its centre. The mountainous zone along the middle part of the eastern border, the Cameroon Highlands, includes the country's highest point (2042 m). Elevations fall to below 300 m in the Sokoto and Chad basins in the far northwest and northeast, respectively.

2.3 CLIMATE

Nigeria's climate is characterized by strong latitudinal zones which become progressively drier as one moves north from the coast. Rainfall is the key climatic variable and there is a marked difference between wet and dry seasons in most areas. By April or May the rainy season is underway in areas south of the Niger and Benue river valleys. Farther north, rains do not commence until June or July with August being the peak of the rainy season. From December through February northeast trade winds, called harmattan, sweep across the country bringing moderate temperatures and lower humidity across the country. In addition, these winds are often laden with dust particles from the Sahara giving rise to characteristic harmattan haze which reduces visibility.

The regularity of drought periods has been among the most notable aspects of Nigerian climate in recent years, particularly in the drier regions of the north. Experts regard the twentieth century as having been among the driest periods of the last several centuries; the well publicized droughts of the 1970s and 1980s were only the latest of several significant such episodes to affect West Africa (Metz 1992). At least two of these droughts have severely affected large areas of northern Nigeria and the Sahel region farther north (Metz 1992).

2.4 POPULATION

The most populous country in Africa, Nigeria has virtually no reliable demographic information (U.S. Library of Congress 1991). The World Bank has given various estimates over the years, including approximately 119 million in 1990 with an annual growth rate of 3.3% (U.S. Library of Congress 1996) while the Nigerian census in 1991 provided a population estimate of 90 million. The CIA World Factbook estimated the population at 104 million in 1996 (CIA 1996). In the state reports of Section 8, the census data are used as this was the only source found with estimates of population for individual states. The Nigerian population is divided among 478 different ethnic groups (Grimes

1996). Population densities in the country vary considerably from 25 to 1500 persons per km². Table 2.1 shows some of the characteristics of the Nigerian population.

Table 2.1 Population Characteristics of Nigeria (CIA 1996).

Population Variable	Unit
Total Population(1996)	104 million (estimate)
Population Density	114 persons per km²
Population Annual Growth	3.05%
GDP/Capita	$1300 US
Primary Education • Combined (male/female) • Female Only	 93% of school-age population 82% of school-age population
Infant Mortality	72.4 per thousand live births
Life Expectancy	54 years of age
Average No. of Persons per Household	5.4 people
Access to Safe Water	40% of population
Access to Health Care	67% of population

2.5 PREVIOUS WORK - VEGETATION AND LAND USE

The United Nations Food and Agriculture Organization (FAO) conducted a large-scale inventory of Nigeria's high forest area between 1973 and 1977. The purpose of the study was to determine the merchantable forest base and prepare forest management plans for the country. As an extension to this, the Federal Government of Nigeria, through the Federal Department of Forestry, awarded a contract for acquiring Side Looking Airborne Radar (SLAR) images of Nigeria to Motorola Aerial Remote Sensing Incorporated (MARS). SLAR imagery was obtained between October 1976 through March 1977. A British firm, Hunting Technical Services, was contracted to interpret the SLAR imagery for mapping vegetation and land use.

This study, termed the Nigeria Radar (NIRAD) Project, commenced in September 1976 and was completed in September 1978. Sixty-nine, 1:250 000 scale, colour vegetation and land use maps and a report were delivered. An extensive field survey was undertaken to verify and correct classification results of the SLAR interpretation. These NIRAD vegetation and land use maps and the related indicative forest inventory constituted the only nationwide database on the Nigerian environment and they required an update in order to study environmental degradation trends and propose action programs.

3.0 Data Acquisition

Landsat Multispectral (MSS) imagery was used to derive vegetation and land cover information for the 1976/78 time period and SPOT imagery was used for most of the 1993/95 time period. Where the desired imagery was either not available or obscured by cloud cover, ERS-1, or JERS-1 imagery was used to complete the coverage of the country. NOAA data was acquired in order to provide imagery for a regional scale trend analysis of vegetation and land cover change for the time period of the study. Therefore, the types of satellite data acquired for the project and included:

- Landsat Multispectral (MSS) (1975/1976/1977/1978)
- SPOT Multispectral (1993/1994/1995)
- Landsat Thematic Mapper (TM) (1993)
- ERS-1 Radar (1994/1995)
- JERS-1 Radar (1995)
- National Oceanic Atmospheric Administration(NOAA) Advanced Very High Resolution Radiometer (AVHRR) (1978, 1983, 1986, 1990, 1995)

3.1 LANDSAT MULTISPECTRAL SATELLITE DATA

Ideally, a total of 55 Landsat MSS scenes would have given complete coverage of Nigeria. However, because of persistent cloud cover in southern Nigeria, a total of 69 scenes were acquired in order to maximize cloud-free area (Table 3.1). Scene locations are shown in Figure 3.1.

Table 3.1 Landsat Multispectral (MSS) Satellite Data Acquired.

Path	Row	Date (year/month/day)
198	52	77/11/02
199	50	78/12/31
199	51	78/12/13
199	52	76/01/25
199	53	75/12/20
199	54	75/12/20
199	55	77/11/21
200	50	76/01/08
200	51	76/01/08
200	52	76/01/08
200	53	76/01/08
200	54	76/01/09
200	55	78/11/17
200	56	78/11/17
201	51	78/11/18
201	52	78/11/18
201	53	76/02/14
201	54	76/01/09
201	55	76/01/09
201	56	76/01/09
201	57	78/11/27
202	51	78/11/19
202	52	78/11/19
202	53	76/01/10
202	54	76/01/10
202	55	76/01/10
202	56	76/01/10
		72/12/29
		76/05/15
		79/01/30
		72/01/29
202	57	76/05/15
		79/01/30
		79/01/03
203	51	78/11/20
203	52	78/11/20
203	53	76/01/29
203	54	76/01/29
203	55	75/01/06
		73/12/07
		76/01/29
203	56	75/12/ 24
		79/01/31
203	57	75/12/24
		79/02/09
204	50	76/01/12
204	51	75/12/07
204	52	75/12/07
204	53	75/12/07
204	54	76/01/30
204	55	79/01/14
		75/12/07
		72/11/07
204	56	79/03/18
		79/02/28
205	50	78/12/28
205	51	78/03/15
205	52	78/03/15
205	53	78/03/15
205	54	78/03/15
205	55	75/11/02
		79/01/24
205	56	79/02/02
206	50	78/18/ 25
206	51	78/09/30
206	52	76/01/14
206	53	76/02/01
206	54	79/02/03
206	55	74/01/15

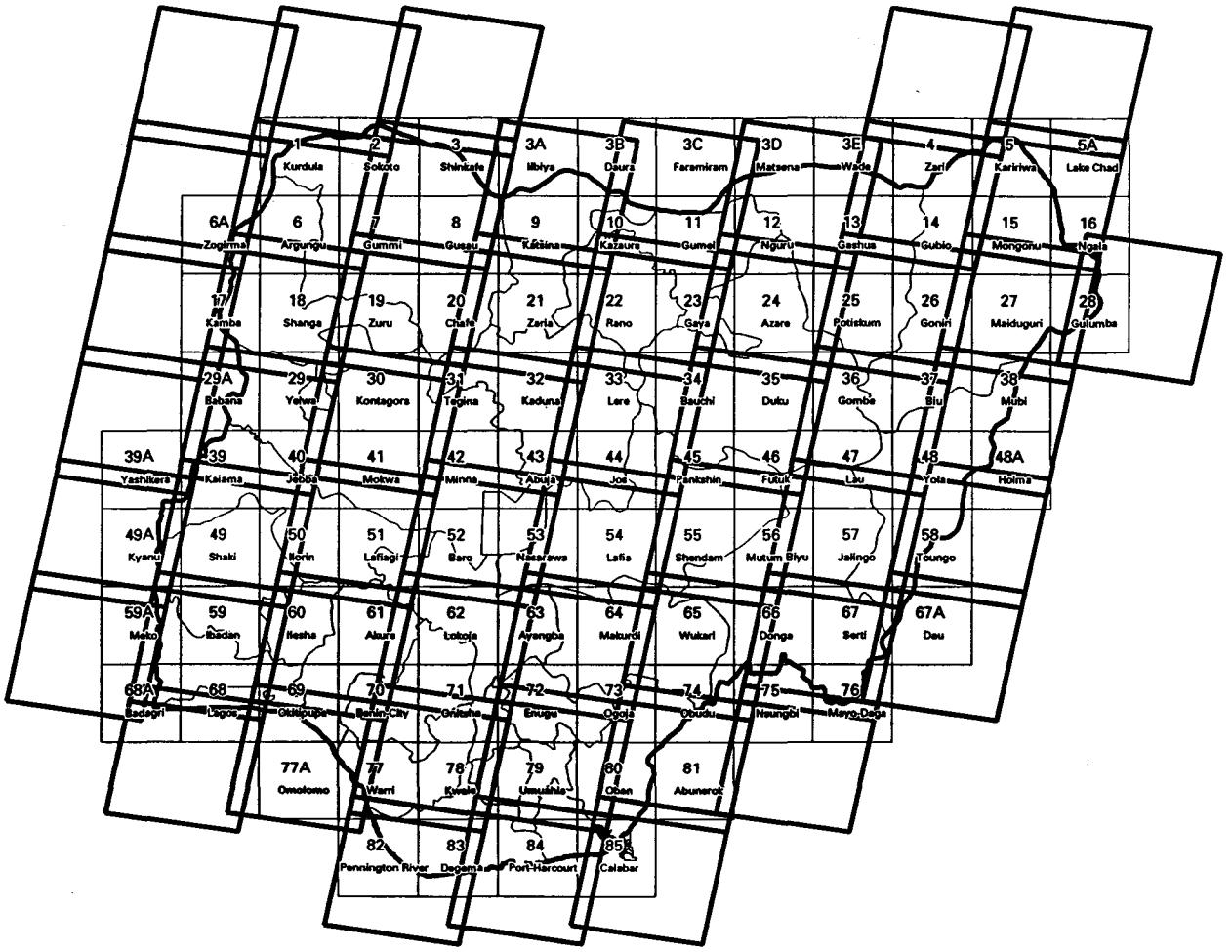


Figure 3.1 Landsat MSS Data.

The majority of cloud-free scenes were acquired during 1976, 1977 and 1978. In areas where cloud cover was persistent, there was little choice in available data and several scenes were required to create mosaics with minimal cloud cover. In order to identify suitable scenes in cloud persistent areas, Geomatics personnel travelled to the EROS Data Centre to examine archived microfiche. It soon became apparent that for some path and row coordinates up to four scenes would be required and for other path and row coordinates only 1975 data was available. Although this data was acquired, it should be noted that the use of this older data was kept to a minimum and where used, land use information was updated according to the existing NIRAD maps.

3.2 SPOT MULTISPECTRAL AND LANDSAT THEMATIC MAPPER SATELLITE DATA

Imagery required for the second time period could not be older than 1993, in accordance with the project contract. Only three Landsat Thematic Mapper (TM) (Table 3.2 and Figure 3.2) and 43 SPOT Multispectral (XS) dated 1993 were in archive. Landsat data was no longer available for Nigeria because the communications links on Landsats 4 and 5 were no longer in operation. SPOT-XS data was the next best option and a programmed mission was requested. The 1994/1995 dry season was a particularly dry one with almost no harmattan. The 1994/95 SPOT-XS images are of excellent quality and far more coverage was acquired than expected (Figure 3.3). It should be noted that the 1993 SPOT-XS images are mostly cloud free, however, when compared to the 1994/95 images they appear to be out of focus because of airborne sand particles from the harmattan. A listing of the SPOT-XS images used in the 1993/1995 vegetation and land use mapping is found in Table 3.3.

The southern Niger Delta area remained cloud covered throughout the data acquisition period. Radar satellite imagery was acquired for this area.

Table 3.2 Landsat Thematic Mapper (TM) Data Acquired for the 1993/95 Maps.

Path	Row	Date (year/month/day)
185	51	93/01/23
185	52	93/01/23
185	53	93/01/23

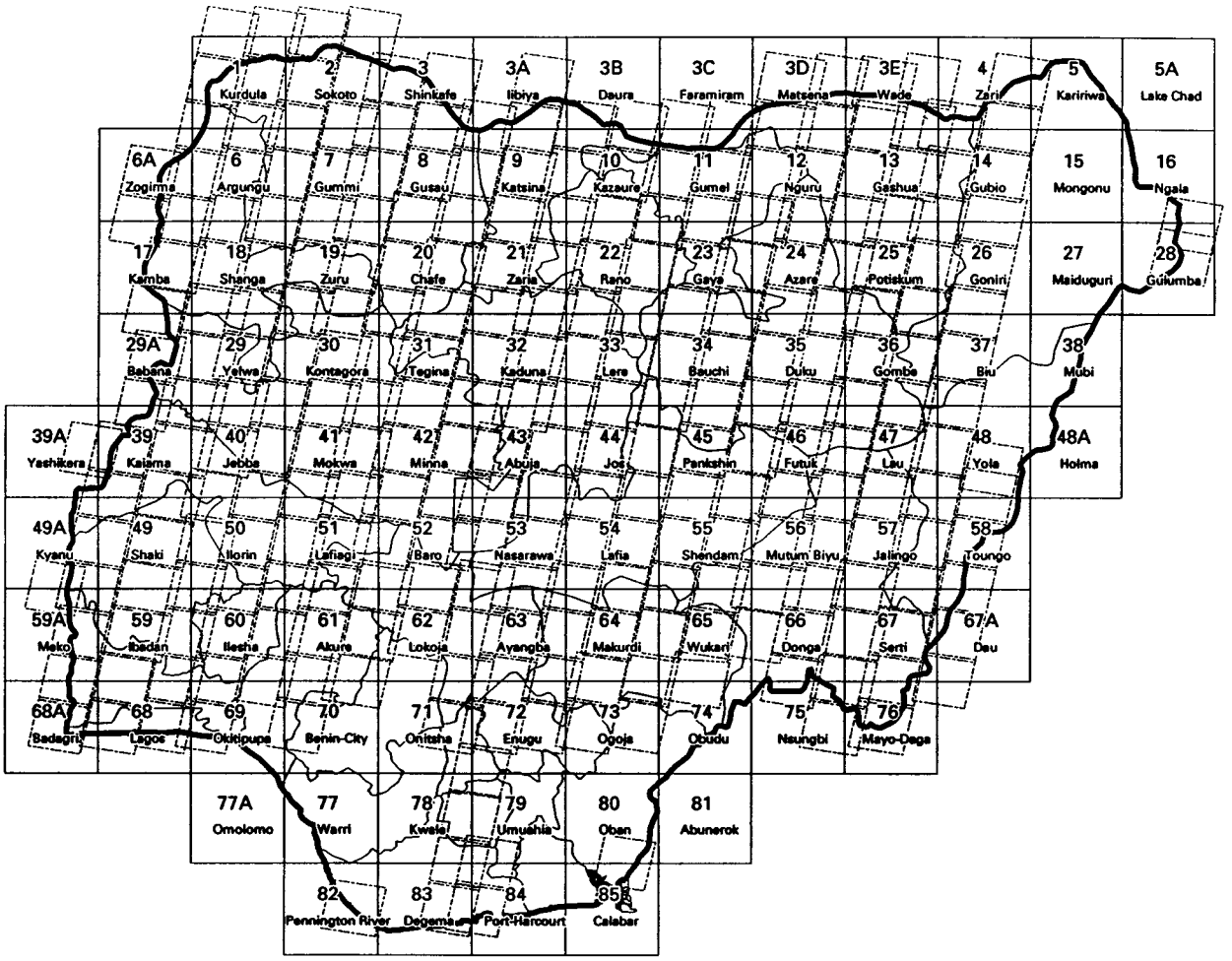


Figure 3.2 SPOT Data.

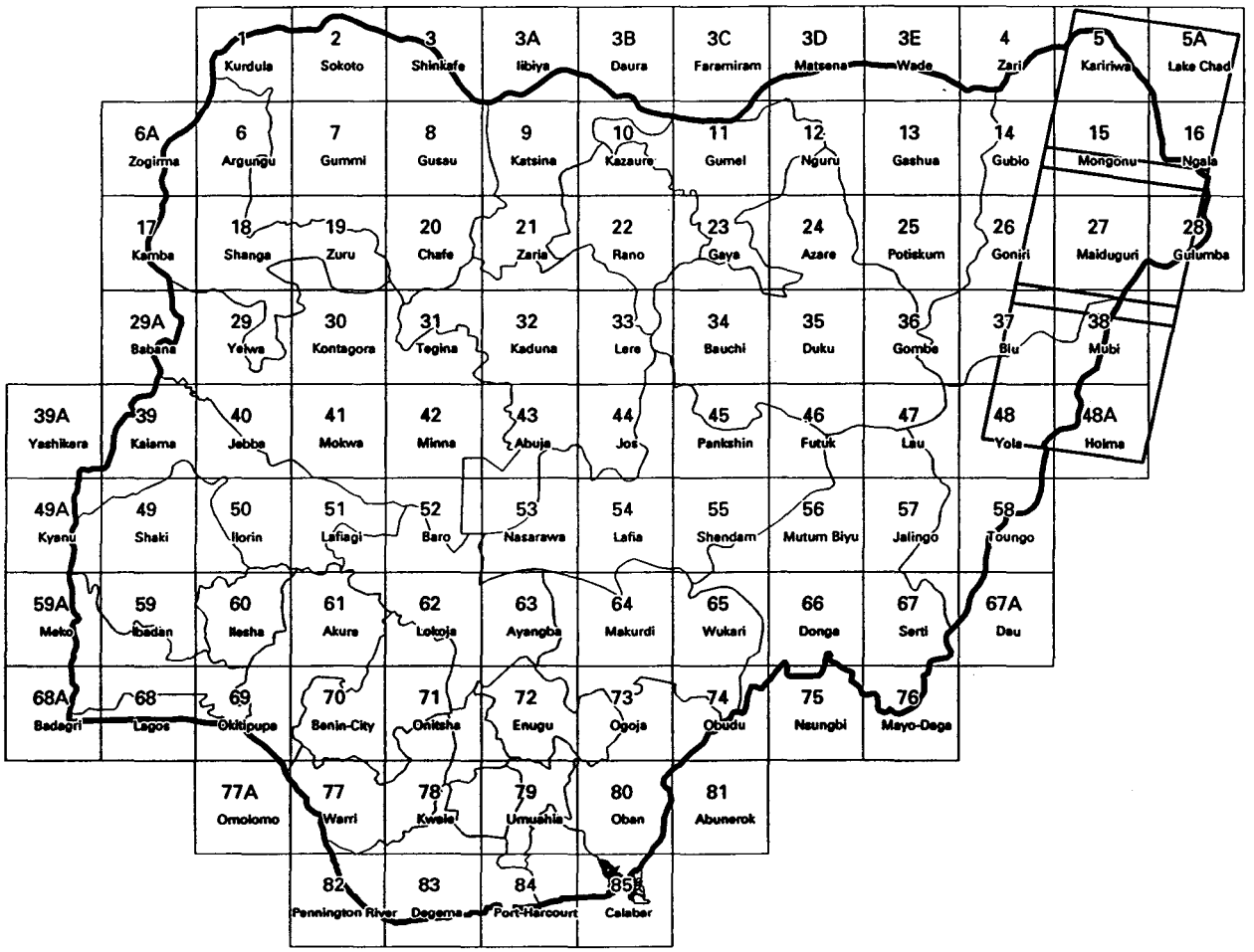


Figure 3.3 Landsat TM Data.

Table 3.3 SPOT Multispectral (XS) Data Acquired for the 1993/95 Maps.

Path (K)	Row (J)	Date (year/month/day)	CD Number
64	325	93/05/12	5
64	326	93/05/12	5
64	331	93/04/16	5
64	334	93/03/21	5
65	322	93/05/07	5
65	323	93/05/07	5
65	324	93/05/07	5
65	325	93/05/07	5
65	326	93/05/07	5
65	327	94/11/23	17
65	328	94/11/22	16
65	329	93/04/11	5
65	330	93/04/11	6
65	331	94/11/22	16
65	332	94/11/22	17
65	333	94/11/22	17
65	334	94/11/22	17
65	335	94/12/13	29
65	336	94/12/13	29
65	337	94/12/13	29
66	322	93/06/02	6
66	323	93/06/02	6
66	324	93/06/02	6
66	325	93/06/02	6
66	326	93/06/02	6
66	327	93/06/02	6
66	328	94/11/22	23
66	329	94/11/22	23
66	330	94/11/22	23
66	331	94/11/22	23
66	332	94/11/22	23
66	333	94/11/22	23
66	334	94/11/22	23
66	335	94/11/22	23
66	336	94/12/13	29
66	337	94/12/13	29
67	322	93/04/06	6
67	323	93/04/06	6
67	324	93/04/06	6
67	325	93/04/06	7
67	326	93/04/06	7
67	327	93/04/06	7
67	328	93/04/06	7
67	329	93/04/06	7
67	330	94/11/28	19
67	331	94/11/28	19
67	332	93/04/06	7
67	333	94/11/28	19
67	334	94/11/28	19
67	335	94/11/28	19

Path (K)	Row (J)	Date (year/month/day)	CD Number
74	327	93/12/10	1
74	327	94/11/18	37
74	328	93/12/10	1
74	328	94/11/18	37
74	329	93/12/10	1
74	329	94/11/18	37
74	330	94/12/20	28
74	331	94/12/20	28
74	332	94/12/20	28
74	333	94/12/20	28
74	334	94/12/20	28
74	335	94/12/20	28
74	336	94/12/20	28
74	337	94/12/20	28
74	338	95/01/25	34
74	339	95/01/25	33
74	340	95/01/25	33
74	341	95/01/25	33
75	324	94/11/13	11
75	325	94/11/13	11
75	326	94/11/13	11
75	327	94/11/29	26
75	328	94/11/29	26
75	329	94/11/29	26
75	330	94/11/29	26
75	331	94/11/29	26
75	332	94/11/29	26
75	333	94/11/29	26
75	334	94/11/29	26
75	335	94/11/29	27
75	336	94/11/29	27
75	337	94/11/29	27
75	340	93/12/26	4
75	341	93/12/26	4
76	324	94/11/03	11
76	331	94/12/20	28
76	332	94/12/30	31
76	333	94/12/30	31
76	334	94/12/30	31
76	335	94/12/30	31
76	336	94/12/20	33
76	337	94/12/20	33
77	325	94/11/03	11
77	326	94/11/03	11
77	327	94/11/03	11
77	328	94/11/03	11
77	329	94/11/03	11
77	330	94/11/03	11
78	323	94/11/14	12
78	324	94/11/14	12

Path (K)	Row (J)	Date (year/month/day)	CD Number
67	336	94/11/28	19
67	337	94/11/28	19
68	322	93/04/06	7
68	323	93/04/06	7
68	324	93/04/06	7
68	325	93/04/06	7
68	326	93/04/06	3
68	327	93/04/06	3
68	328	93/04/06	3
68	329	94/11/28	22
68	330	94/11/28	22
68	331	94/11/28	22
68	332	94/11/28	22
68	333	94/11/28	22
68	334	94/11/28	22
68	335	94/11/28	22
68	336	94/11/28	22
68	337	94/11/28	22
69	323	94/10/18	10
69	324	94/10/18	10
69	325	94/10/18	10
69	326	94/11/02	9
69	327	93/06/18	3
69	328	94/11/02	12
69	329	94/12/24	30
69	330	94/12/24	30
69	331	94/12/24	29
69	332	94/12/24	30
69	333	94/12/24	29
69	334	94/12/24	30
69	335	94/12/24	29
69	336	94/12/24	30
70	323	94/10/18	10
70	324	94/10/18	10
70	325	94/10/18	10
70	326	94/11/02	14
70	327	94/11/02	14
70	328	94/11/02	14
70	329	93/06/18	3
70	330	93/06/18	3
70	331	93/06/18	3
70	332	94/12/24	30
70	333	94/12/24	30
70	334	94/12/24	30
70	335	94/12/24	30
70	336	94/12/24	33
70	337	94/12/24	33
71	324	94/10/28	20
71	325	94/10/28	20
71	326	94/10/28	20
71	327	94/12/03	20

Path (K)	Row (J)	Date (year/month/day)	CD Number
78	325	94/11/14	12
78	326	94/11/14	12
78	326	94/10/29	14
78	327	94/11/19	16
78	328	94/11/19	16
78	329	94/11/19	16
78	330	94/11/19	16
78	331	94/11/19	16
78	332	94/11/19	16
78	333	95/01/20	31
78	334	95/01/20	31
78	335	95/01/31	34
78	336	95/01/31	34
78	337	95/01/31	34
78	340	93/01/24	8
79	323	94/01/16	35
79	324	94/01/16	1
79	325	94/01/16	1
79	326	94/01/16	1
79	327	94/01/16	1
79	328	94/11/19	25
79	329	94/11/19	25
79	330	94/11/19	25
79	331	94/11/19	25
79	332	95/01/20	31
79	333	95/01/20	31
79	334	95/01/20	31
79	335	95/01/20	31
79	336	95/02/10	34
80	323	95/03/13	36
80	324	94/01/16	4
80	325	94/01/16	4
80	326	94/01/16	4
80	327	94/01/16	4
80	328	94/01/16	4
80	329	94/11/14	12
80	330	94/11/14	12
80	331	94/11/14	12
80	332	94/11/14	14
80	333	95/01/21	32
80	334	95/01/21	32
80	335	95/01/30	34
81	323	94/11/14	14
81	324	94/10/09	9
81	324	94/11/09	12
81	325	94/11/09	12
81	326	94/10/24	9
81	327	94/10/24	9
81	328	94/10/24	9
81	329	94/11/14	14
81	330	94/11/14	15

Path (K)	Row (J)	Date (year/month/day)	CD Number
71	328	94/12/03	20
71	329	94/12/03	20
71	330	94/12/03	20
71	331	94/12/03	20
71	332	94/12/03	20
71	333	94/12/03	20
71	334	93/01/24	2
71	335	93/01/24	2
71	336	94/12/03	24
72	323	94/11/18	16
72	324	94/11/18	16
72	325	94/10/28	15
72	326	94/10/28	15
72	327	94/10/28	14
72	328	94/12/03	24
72	329	94/12/03	24
72	330	94/12/03	24
72	331	94/12/03	24
72	332	94/12/03	24
72	333	94/12/03	24
72	334	95/01/25	34
72	335	95/01/25	34
72	341	95/01/19	33
73	324	94/11/03	10
73	325	94/11/03	10
73	326	94/11/03	10
73	327	94/11/03	10
73	328	94/11/29	21
73	329	94/11/29	21
73	330	94/11/29	21
73	331	94/01/15	4
73	332	94/01/15	4
73	333	94/01/15	4
73	334	94/11/29	21
73	335	94/11/29	21
73	336	94/11/29	33
73	337	94/11/29	33
74	324	94/11/18	25
74	325	94/11/18	25
74	326	93/12/10	1
74	326	94/11/18	37

Path (K)	Row (J)	Date (year/month/day)	CD Number
81	331	94/11/14	15
81	332	94/11/14	13
81	333	94/11/14	13
81	334	94/11/14	13
81	335	94/11/14	13
81	336	95/01/31	34
82	325	94/10/19	9
82	326	94/10/19	9
82	327	94/10/24	15
82	328	94/10/24	15
82	329	94/10/24	15
82	330	94/11/24	17
82	331	94/11/24	17
82	332	94/11/24	17
82	333	94/11/24	17
82	334	95/01/21	32
82	335	95/01/21	32
82	336	95/02/05	35
82	337	95/02/05	35
83	323	94/10/09	18
83	324	94/10/09	18
83	325	94/10/09	18
83	326	94/10/30	18
83	327	94/10/30	18
83	328	94/11/30	18
83	329	94/11/30	18
83	330	94/11/30	18
83	331	94/11/30	18
83	332	94/11/30	18
83	333	94/11/30	18
83	334	94/11/30	18
83	335	94/11/30	18
83	336	94/11/30	18
83	337	94/11/30	18
84	331	94/11/30	37
84	332	94/11/30	21
84	333	94/11/30	21
84	334	94/11/30	21
84	335	94/11/30	21
84	336	94/11/30	21
87	326	94/11/30	35
87	326	94/11/30	35

3.3 ERS-1 AND JERS-1 SATELLITE RADAR DATA

The southernmost parts of Nigeria are persistently cloud covered and therefore do not lend themselves to the acquisition of optical data. 1993/95 ERS-1 radar data (Table 3.4) was acquired for most of southern Nigeria (Figure 3.4). ERS-1 radar imagery did not cover two small areas, one near Port Harcourt the other near Oban. JERS-1 radar data (Table 3.5) was acquired to fill these gaps (Figure 3.5).

Table 3.4 ERS-1 Satellite Radar Imagery Acquired for the 1993/95 Maps.

Orbit	Frame	Date (year/month/day)
15732	3501	94/07/19
15775	3501	94/07/22
15775	3519	94/07/22
15818	3465	94/07/25
15818	3483	94/07/25
15926	225	94/08/01
15933	3465	94/08/02
15933	3483	94/08/02
15933	3501	94/08/02
15976	3465	94/08/05
15976	3483	94/08/05
15976	3501	94/08/05
16976	3519	94/08/05
16070	171	94/08/11
16177	3465	94/08/19
16177	3483	94/08/19

Orbit	Frame	Date (year/month/day)
16199	81	94/08/20
16199	99	94/08/20
16199	117	94/08/20
16220	3465	94/08/22
16220	3483	94/08/22
16220	3501	94/08/22
16242	99	94/08/23
16242	117	94/08/23
16242	135	94/08/23
16263	3483	94/08/25
16263	3501	94/08/25
16263	3519	94/08/25
16285	139	94/08/26
16306	3465	94/08/28
16306	3483	94/08/28
16306	3501	94/08/28

Table 3.5 JERS-1 Satellite Radar Imagery Acquired for the 1993/95 Maps.

Path	Row	Date (year/month/day)
290	290	93/08/26
291	289	93/08/27
293	293	95/05/07
294	291	95/03/25
294	292	95/03/25
294	293	95/03/25

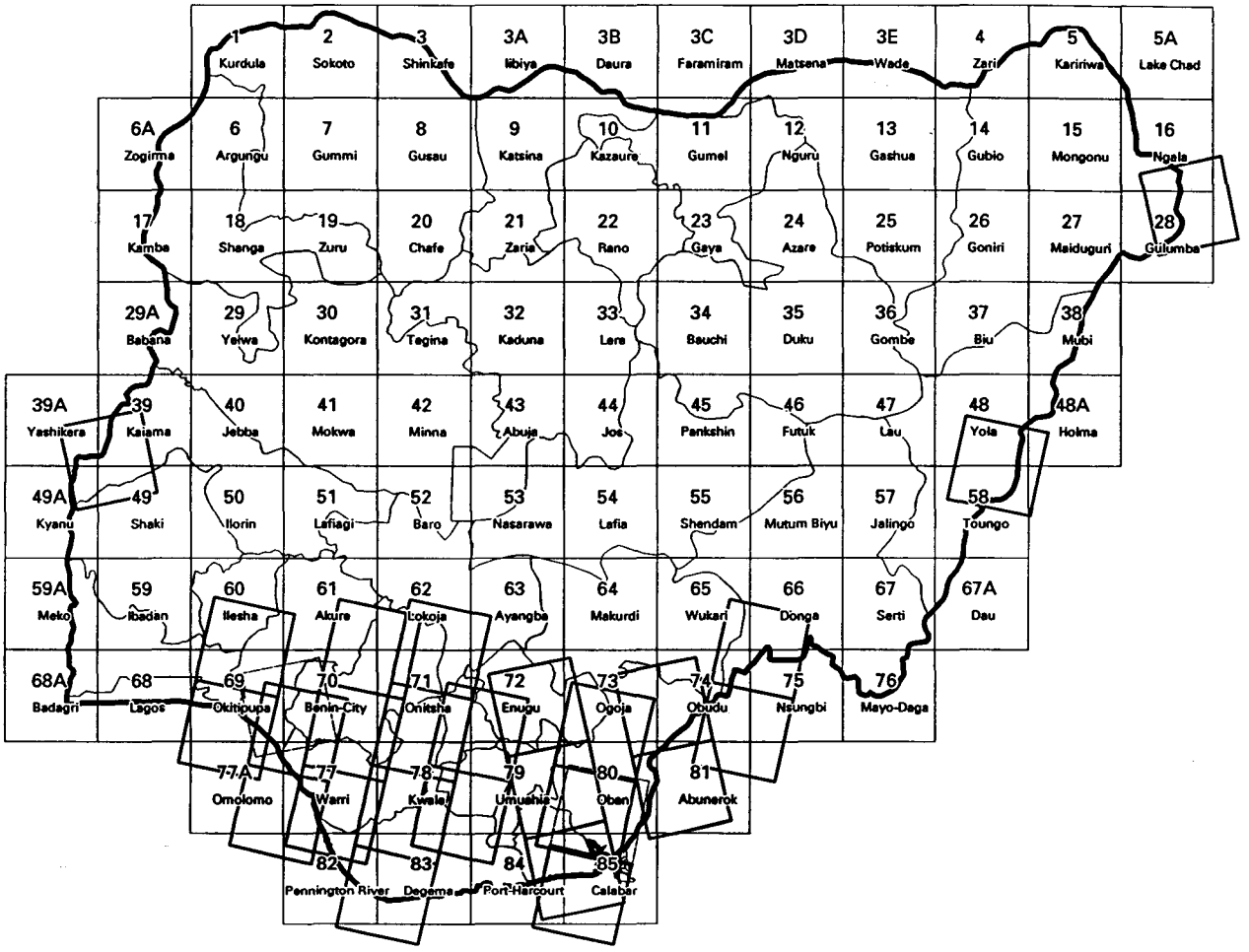


Figure 3.4 ERS-1 Data.

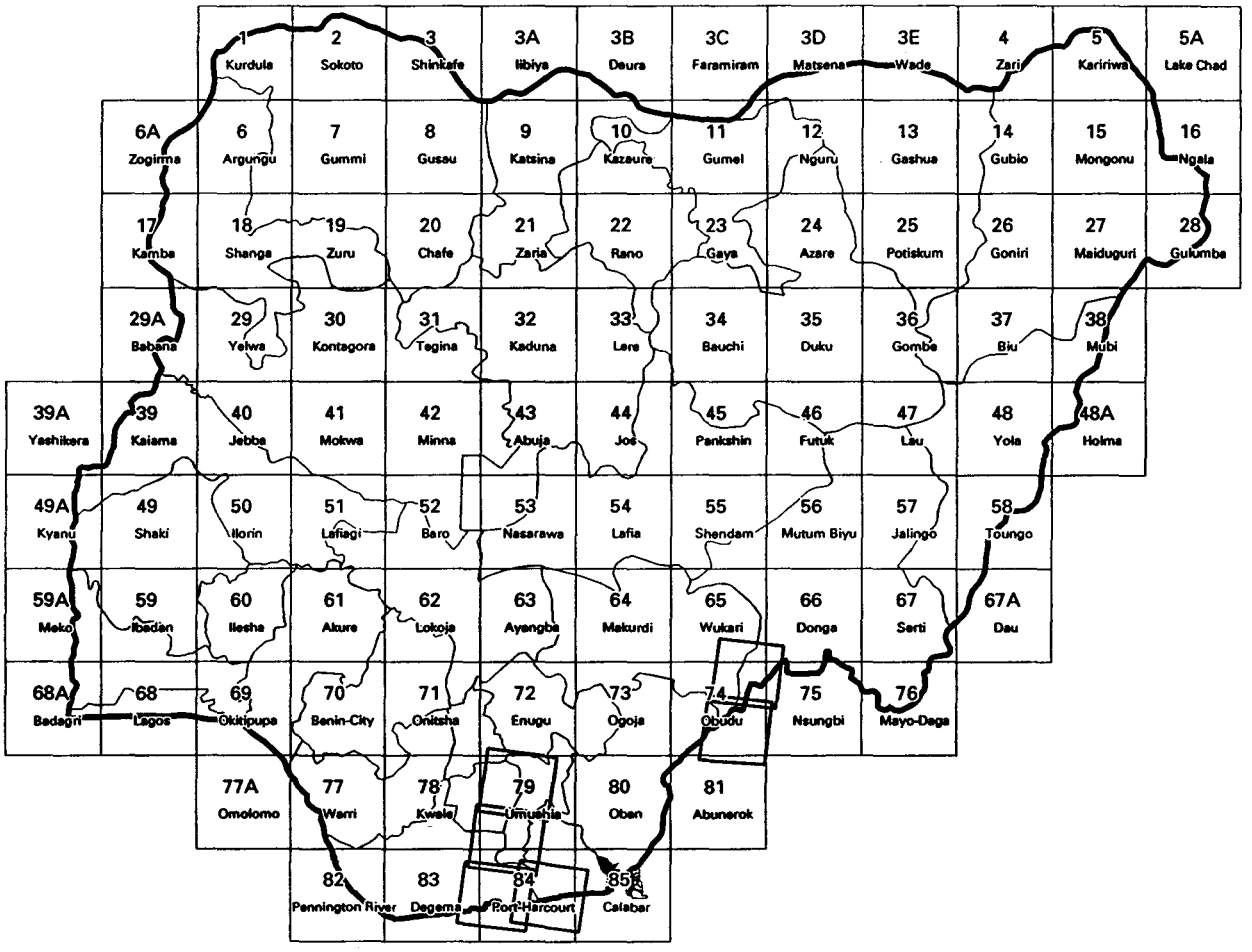


Figure 3.5 JERS-1 Data.

3.4 NOAA AVHRR SATELLITE DATA

In order to monitor changes in vegetation and land use between 1976/78 and 1993/95, on a national basis, National Oceanic Atmospheric Administration (NOAA) Advanced Very High Resolution Radiometer data (AVHRR) was acquired for the time periods 1978, 1983, 1986, 1990 and 1995. Early AVHRR data (1978 and 1983) has a ground resolution of 4 km per pixel and is termed Global Area Coverage (GAC). AVHRR data from 1983 through to present has a ground resolution of 1 km per pixel and is referred to as Local Area Coverage (LAC). LAC data is not available in the early years.

One AVHRR scene is enough to cover the entire country of Nigeria. However, in order to get maximum cloud-free coverage, two or more scenes were required. A listing of NOAA AVHRR scenes is found in Table 3.6.

Table 3.6 NOAA AVHRR Images Acquired.

Date (year/month/day)	Resolution
78/11/26	4 km (GAC*)
79/01/06	4 km (GAC)
79/01/06	4 km (GAC)
79/01/07	4 km (GAC)
82/01/16	4 km (GAC)
83/01/30	4 km (GAC)
83/02/02	4 km (GAC)

*Global Area Coverage

Date (year/month/day)	Resolution
86/12/08	1 km (LAC*)
86/11/15	1 km (LAC)
90/11/23	1 km (LAC)
90/12/18	1 km (LAC)
95/02/19	1 km (LAC)
95/02/21	1 km (LAC)

**Local Area Coverage

3.5 ANCILLARY DATA

Several additional national data sets (maps) from other sources were digitized and incorporated into the database. These data sets included:

- soils
- geology
- relief and drainage
- groundwater provinces (hydrogeology)
- mean annual rainfall, mean annual temperature
- population density
- cultural areas

4.0 Legend And Ecological Zones

4.1 BACKGROUND TO LEGEND DEVELOPMENT

Early in this study, Geomatics International in cooperation with Unilag Consult and FORMECU assessed the suitability of the legend classification used in the 1978 Nigerian Radar (NIRAD) maps for the present project. A reconnaissance 10 day field survey was undertaken in October 1994 to identify the range of vegetation and land use categories that would need to be mapped. The field team traversed Nigeria by car, making numerous stops (Figure 4.1). Observations and discussions with respect to the vegetation and land use were noted as were features that were most important to quantifying change. During the survey, a preliminary legend was developed that could be applied to the various ecological zones and also mappable using Landsat MSS and SPOT-XS imagery. This legend was later refined during the interpretation of the 1976/78 Landsat MSS imagery and at a nationwide workshop. Geomatics also plotted several 1978 Landsat MSS scenes of the study area and compared the ability to interpret these images with the results of the existing NIRAD vegetation and land use maps.

It was concluded that, although the NIRAD vegetation and land use map series was invaluable, it was not an adequate base from which to monitor vegetation and land use change. Both the map polygons and map legend required redefinition due to the many complex map classes used for this series. Therefore, it was deemed necessary for Geomatics to create a new land use and vegetation map series for both the 1976 and the 1995 time period in order to provide a consistent database with which to assess country and state land use and vegetation changes.

Another reason for the new legend classification was to ensure consistency in interpretation between time periods which would greatly improve the quality of the final land use change analysis required by the project. When creating a map using remotely sensed imagery, it is important that the legend classes be directly relatable to patterns and tones on the imagery. This ensures repeatability of results as well as consistency for a quantification of change over time.

The final legend provides the ability to discriminate vegetation and land cover as well as the relationship between natural and disturbed land cover. It provides a consistent, country-wide legend with which vegetation and land use change can be assessed. The legend also can be interpreted from Landsat MSS, Landsat TM and SPOT-XS data and it adheres to international mapping standards. The final vegetation and land use legend is shown in Table 4.1 with descriptions of the classes presented in Section 4.3.

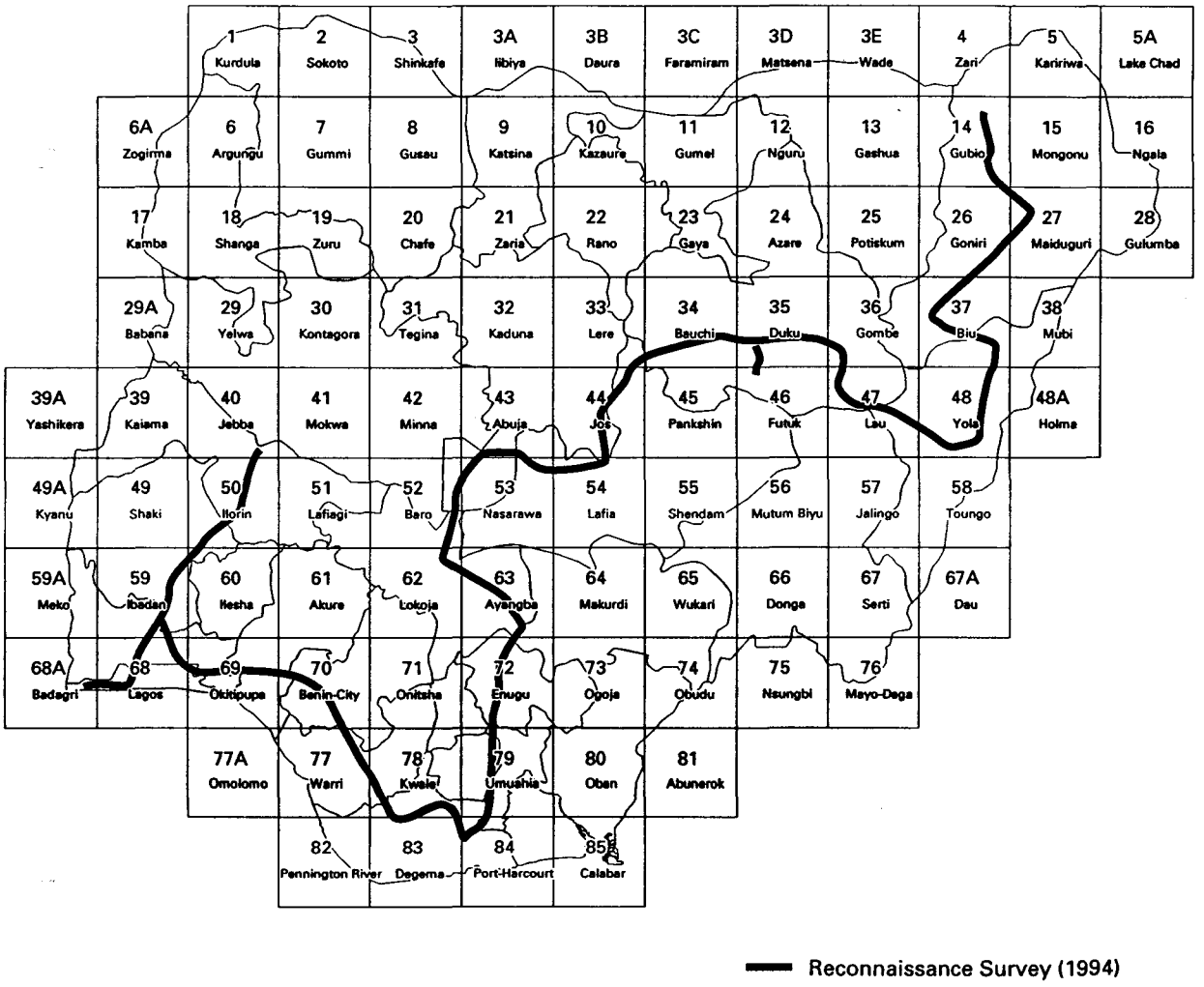


Figure 4.1 Reconaissance Survey Path.

Table 4.1 Vegetation and Land Use Legend.

Legend Codes		Vegetation and Land Use Legend
Urban	11	major urban
	12	minor urban
Agriculture	211	intensive (row crops, minor grazing) small holder rainfed agriculture
	212	extensive (grazing, minor row crops) small holder rainfed agriculture
	213	extensive small holder rainfed agriculture with denuded areas
	23	floodplain agriculture
	22	rainfed arable crops
	24	irrigation project
	26	livestock project
	25	agricultural tree crop plantation
Woodland/	41	dominantly trees/woodland/shrubs with a subdominant grass component
Shrub /	42	dominantly shrubs and dense grasses with a minor tree component
Grassland	43	dominantly grasses with discontinuous shrubs and scattered trees
	31	grassland
	32	discontinuous grassland dominated by grasses and bare surfaces
	33	montane grassland
Forest	52	undisturbed forest
	51	disturbed forest
	53	riparian forest
	55	montane forest
	54	forest plantation
	541	teak/Gmelina plantation
Wetlands	62	graminoid/sedge freshwater marsh
	63	shrub/sedge/graminoid freshwater marsh/swamp
	61	forested freshwater swamp
	65	mangrove forest
	64	saltmarsh/tidal flat
Water	71	natural waterbodies: ocean, river, lake
	73	canal
	74	reservoir
Bare	81	rock outcrop
Surfaces	82	sand dunes/aeolian
	83	alluvial
	84	gullies
	85	mining areas
Infrastructure		main roads
		railways
Other Map Elements		international boundary
		state boundary
		forest reserves
		national parks
		game reserves
		ecological boundary
		airport
		sea port
		oil field and/or terminal

4.2 LEGEND DEVELOPMENT

In developing the legend classes for this study, two key prerequisites had to be satisfied: (1) the derived classes had to be interpretable using satellite data (spectral and radar); and (2) the land cover classes developed needed to reflect both human activities (land use) and natural vegetation in order to assess factors relating to environmental impact.

Any attempt to map vegetation and land use requires a simplification of reality. On the maps distinct lines are drawn between classes, whereas in reality often there is a gradation between the two legend classes. This gradation is a transition zone which will be larger between some classes than others. Every attempt was made to delineate the class boundaries at the most distinct area of change between the two classes. Areas where the transition zone is indistinct are discussed in the legend description (Section 4.3).

4.2.1 Compatibility With Satellite Data

When using remote sensing data to create thematic maps, it is important that the legend classes be directly relatable to patterns and tones on the imagery. This ensures repeatability of results (same data reinterpreted); consistency in application to a broad area; and consistency for a quantification of change over time (sequential data with statistically compatible information). The legend defined for this study is one that can be interpreted from Landsat MSS, TM and SPOT data.

Each of the legend classes is defined by differences in its physical attributes and characteristics. These differences can be discriminated in a false colour composite satellite image. Vegetation and land use classes are identified through pattern, colour, tone and texture recognition, size, shape and class relationships, and location both at a local and national scale.

Patterns, colours, tones and textures, used for class discrimination, may change for a single land use class particularly because of differences in: season (wet versus dry); soil and/or bedrock type; and, in some cases, cultural practices. This was clearly seen in mosaics of imagery where the individual scenes were acquired at different dates. Each image was optimally enhanced for interpretation, so that within the mosaic a single class could appear quite different in terms of its colour and tone.

4.2.2 Reflection of Vegetation and Land Use

An important product for this study is assessment of human-induced change over time and its impact on water vegetation and soils. Hence, the legend must also reflect the degree of human induced impact as well as type of impact. For this study, it was conducted primarily on a qualitative basis. The qualitative assessment relates human activities to the relative intensity of vegetation modification (species composition as well as structure) and manipulation or management of soils and water.

Natural vegetation classes are assigned based on the visual interpretation of images and from ground truth. Basically, these areas are defined structurally (woody, shrubby, forest) and represent areas having the least disturbance to human activities. Species are not directly mapped but the vegetation structure relates to their origin as types of savanna (Sudan, Guinea, Sahel) or forest (lowland, mangrove, riparian). The dominant species occurring within any given map unit can be determined from comparing the location of the unit with the ecological zonation for the specified time period which is also shown on each map (*see* Section 4.4)

4.3 LEGEND CLASS DESCRIPTIONS

All legend classes are described in terms of the following three categories: 1) definition; 2) appearance on spectral imagery; and 3) appearance on radar images (where appropriate). It is necessary to note that the appearance of a legend class within each ecological zone may be different but this is described separately where relevant.

4.3.1 Urban

Major Urban

Definition

- densely populated city core
- includes residential, industrial, commercial, administration and educational areas of both traditional and modern cities
- present in any ecological zone

Appearance on Spectral Imagery

- identified by the relatively large size of the city
- appears as solid area of very bright cyan blue
- examples found on the Ilesha (sheet 60) and Kaduna (sheet 32) maps

Appearance on Radar Imagery

- identified by the relatively large size of the city
- appears as solid area of white
- examples found on the Benin City (sheet 70) map

Minor Urban

Definition

- smaller urban centres and the outskirts of large cities which are less densely populated than the city core
- includes larger rural, nucleated settlements, villages, small towns, airports, oil terminals and any other features associated with industrial development
- present in any ecological zone

Appearance on Spectral Imagery

- identified by the relatively small size of the city
- appears as areas of mottled cyan blue - mottling may include tones of red, orange or pink which indicate the presence of sporadic vegetation
- industrial sites are identified by their distinctive manmade structures
- examples found on the Kaduna (sheet 32) and Akure (sheet 61) maps

Appearance on Radar Imagery

- identified by the relatively small size of the city
- appears as areas of very bright white
- industrial sites are identified by their distinctive manmade structures
- examples found on the Umuahia (sheet 79) map

4.3.2 Agriculture

Agricultural systems vary significantly within Nigeria due to the wide range of climate, soils, cultural characteristics and population patterns. Generally, agricultural systems are correlated to the major ecological zones. However, there is usually a gradual change from one agricultural system to the next.

Intensive (row crops, minor grazing) Small Holder Rainfed Agriculture

This type of agriculture refers to a vegetation and ground management regime which includes slash and burn clearing, non-mechanized planting and fertilization, replacement of all ground vegetation and most or all replacement of natural tree and shrub cover. Shrubs/trees include only those with agricultural products/use. Shrubs are usually absent in this class. Methods of planting, fertilizing, fallow and field management vary within the country.

Sahel Savanna Ecological Zone

Definition

- characterised by fragmented, small plot farms growing row crops combined with minor amount of grazing activity
- crops such as millet and sorghum are grown
- includes grazing of cattle, goats, sheep, donkeys and in some areas horses and camels

Appearance on Spectral Imagery

- identified by the irregular shape of the fields and association with urban areas
- appears as a patchwork of yellow to white
- pinkish tones (indicating vegetation) may be present if the imagery was collected towards the end of the wet season
- examples found on the Daura (sheet 3B) map

Sudan Savanna Ecological Zone

Definition

- characterised by fragmented, small farms growing rainfed cereals and food crops with minor grazing activity
- crops include millet, Guinea corn (sorghum), maize, rice, ground nuts, cassava, yams, beans and cowpeas
- the main cash crops include ground nuts, cotton and tobacco
- migratory tribes from the north move their cattle into this zone during the wet season

Appearance on Spectral Imagery

- identified by the irregular shape of the fields, often found in association with populated areas and extensive agriculture
- appears as a patchwork of yellows, oranges and shades of white with minor speckling of reds (scattered trees and shrubs)
- examples found on the Gombe (sheet 36), Gaya (sheet 23) and Argungu (sheet 6) maps

Derived and Guinea Savanna Ecological Zones

Definition

- characterised by fragmented, small farms growing a combination of grain and root crops with minor grazing activity
- crops include maize, guinea corn, millet, rice, beans, yams, cassava, cashews and cowpeas
- cash crops include benniseed (*Sesamun indicum*) and cotton
- in the Derived Savanna Ecological Zone the principal tree crops are oil palm and plantain

Appearance on Spectral Imagery

- identified by the irregular shape of the fields, often found in association with populated areas or extensive agriculture
- appearance varies significantly depending on soil, rock and climatic composition as well as variations in cropping practices (fallow) and crops grown
- identified more by texture and pattern than by distinctive spectral signature
- appears as a patchwork mosaic of: reds and pinks mixed with shades of yellow to white and light blue indicating the combination of tree, root and grain crop activity plus scattered patches of woodland; dark greens, greys and reds indicating areas of shallow rocky soils; discontinuous red patches with yellowish patches indicating areas of tree and root crop agriculture; or patches of blueish white, yellow and reds indicating grain and root crops with exposed bare soil
- examples in the Derived Savanna Ecological Zone found on the Enugu (sheet 72) and Akure (sheet 61) maps
- examples in the Guinea Savanna Ecological Zone found on the Abuja (sheet 43) and Tegina (sheet 31) maps

Appearance on Radar Imagery

- identified by the irregular shape of the fields, often found in association with populated areas or extensive agriculture

- appears as an uneven, heterogeneous texture, with dark to mid grey tones
- example in the Derived Savanna Ecological Zone found on the Onitsha (sheet 71) map

Lowland Rain Forest Ecological Zone

Definition

- characterised by small farms growing tree crops with root crops in the understorey
- crops include yams, rice, cocoyams, cassava, maize (moisture tolerant variety), plantains, kola nut, citrus fruits, beans and various types of vegetables
- the principal cash tree crops include oil palm, rubber, mango and cocoa

Appearance on Spectral Imagery

- identified by the irregular shape of the fields and association with populated areas
- appears as a discontinuous, uneven pattern of mostly red, mottled flecks of yellow and white indicating trees with varying degrees of canopy closure showing exposed or poorly vegetated soil
- example found on the Port Harcourt (sheet 84) map

Appearance on Radar Imagery

- identified by the irregular shape of the fields, often found in association with populated areas or extensive agriculture
- appears as an uneven, heterogeneous texture, with dark to mid grey tones
- example found on the Port Harcourt (sheet 84) map

Extensive (grazing, minor row crops) Small Holder Rainfed Agriculture

Extensive small holder rainfed agriculture is characterised by areas where grazing is the predominant agricultural activity with minor areas of fragmented, small holder row crop agriculture. In general the native grasses, shrub and tree layer are intact but have been impacted on by grazing animals and fuelwood collection. This type of agriculture is not commonly associated with southern areas of the country where the population and pressures on the land base are greater.

Sahel Savanna Ecological Zone

Definition

- characterised by disturbed areas of grasses with scattered shrubs
- dominantly used for grazing of cattle, goats, sheep, donkeys and in some areas horses and camels
- very small-scale, fragmented farming may occur within the range land areas due to the nomadic and semi-nomadic nature of the herdsmen

Appearance on Spectral Imagery

- identified by the irregular shape of the fields and association with relatively undisturbed vegetation
- appears as gently mottled grey tones (grasses) with scattered reddish areas (shrubs)
- examples found on the Zari (sheet 4) and Gubio (sheet 14) maps

Sudan Savanna Ecological Zone

Definition

- characterised by disturbed areas of shrubs, grasses and scattered trees
- dominantly used for grazing of cattle and goats as well as fuelwood collection
- very small-scale, fragmented farming may occur within the range land areas due to the nomadic and semi-nomadic nature of the herdsmen

Appearance on Spectral Imagery

- identified by the irregular shape of the fields, often found in association with relatively undisturbed areas
- appears as gently mottled grey tones (grasses) with scattered reddish areas (shrubs or trees)
- in areas of rocks and shallow soils, appears as speckled dark green to grey tones (minimal grasses and bare ground)
- example found on the Zuru (sheet 19) map, example on rocky shallow soils found on the Argungu (sheet 6) map

Guinea Savanna Ecological Zone

Definition

- characterised by disturbed area of trees, woodland and shrubs
- dominantly used for cattle grazing and fuelwood collection
- very small-scale, fragmented farming may occur within the range land areas

Appearance on Spectral Imagery

- identified by the irregular shape of the fields, often found in association with relatively undisturbed areas
- appearance varies significantly depending on soil, rock and climate conditions as well as variations in the density and/or predominance of the tree or shrub component
- in general, the area has more yellow tones (bare or thin vegetation) than relatively undisturbed areas
- in areas of rocks and shallow soils, appears as speckled dark green to grey tones (minimal grasses and bare ground)
- examples found on the Jos (sheet 44) and Abuja (sheet 43) maps, example on rocky, shallow soils found on the Kontagora (sheet 30) map

Extensive Small Holder Rainfed Agriculture with Denuded Areas

Definition

- characterised by disturbed areas of grasses and shrubs with areas of exposed bare soil
- dominantly used for cattle, goats, sheep and poultry as well as fuelwood collection
- only applied to areas within the Sahel Savanna Ecological Zone where increasing pressure on the land base and reduced ground moisture levels have resulted in degraded grazing lands
- very small-scale, fragmented farming may occur within the range land areas

Appearance on Spectral Imagery

- identified by the irregular shape of the fields and association with erosion features, intensive agriculture and/or areas of grasses
- in general, areas of exposed soil appear white with vegetated areas appearing yellowish to pinkish toward the end of the wet season
- examples found on the Daura (sheet 3B) and Kazaure (sheet 10) maps

Floodplain Agriculture

Definition

- characterised by fragmented agricultural activity located within a river's floodplain
- this class includes fadama-style agriculture with walled fields
- crops grown include tobacco, rice, sorghum, maize, sugar cane, okra and other vegetables
- may include minor irrigation activity, however the water level is mostly maintained through high water tables and seasonal overbank flooding
- found in all of the ecological zones

Appearance on Spectral Imagery

- identified by proximity to a river and sinuous shape of fields
- appears as browns, greys or muted green colours with a smooth texture, darker and more even than adjacent intensive or extensive agriculture
- the area includes many small areas of dark red tone which are riparian vegetation or wetland
- the tone varies throughout the year depending on the stage of growth of the crops and the amount of flooding
- fadamas could not be confidently identified in the early dry season imagery acquired for this project
- examples found on the Sokoto (sheet 2), Lau (sheet 47) and Shanga (sheet 23) maps

Rainfed Arable Crops (Plantation)

Definition

- characterised by large individual fields (>25 ha)
- mostly grain cropping, which is not irrigated
- mechanized farming techniques are used
- found in Sudan Savanna and Guinea Savanna ecological zones

Appearance on Spectral Imagery

- identified by the shape – polygons with some straight edges marking individual fields
- colour varies between fields from white to pink depending on the stage of crop growth, or dark green for bare/cleared areas
- examples found on the Mokwa (sheet 41) and Abuja (sheet 43) maps

Irrigation Project

Definition

- characterised by large individual fields, separated by manmade irrigation canals
- usually a monoculture such as tobacco, rice, sorghum, maize, okra and other vegetables
- mechanized farming techniques are used
- found throughout Nigeria but are most common in the northern areas where precipitation is limited

Appearance on Spectral Imagery

- identified by the shape – polygons with some straight edges marking individual fields
- irrigation channels within the project have a grid-like appearance on the imagery
- close to a large water body
- fields are large and appear smooth in texture and homogeneous in colour
- colour varies between fields from white to pink depending on the stage of crop growth, or dark green for bare/cleared areas
- examples found on the Sokoto (sheet 2), Mongonu (sheet 15), Jebba (sheet 40) and Lau (sheet 47) maps

Livestock Project

Definition

- characterised by uniform grassy fields with minor shrub areas
- large herds of cattle or goats are intensively grazed and fed in these locations
- cattle markets and large dug-out water holes for cattle are often associated with livestock projects
- particularly common in the Sudan Savanna, Sahel Savanna and Guinea Savanna ecological zones

Appearance on Spectral Imagery

- identified by their irregular, polygon shape
- appear as even textured grey-brown areas indicative of grasses
- examples found on the Jos (sheet 44) and Mokwa (sheet 41) maps

Agricultural Tree Crop Plantation

Definition

- characterised by a large area under cultivation
- usually single species
- oil palm, rubber, cocoa and citrus in southern Nigeria and mango in the north
- usually located near major cities

Appearance on Spectral Imagery

- identified by regular-shaped polygons with some straight edges
- usually homogeneous red colour and texture

- tree species were not discernable therefore, ground truth was required to distinguish tree crop plantation from forest plantation
- examples found on the Badagri (sheet 68A) and Benin City (sheet 70) maps

Appearance on Radar Imagery

- identified by regular-shaped polygons with some straight edges
- homogeneous texture contrasts with adjacent agriculture, brighter or darker tone may contrast with adjacent forest class
- ground truth was required to distinguish tree crop plantation from forest plantation
- example found on the Kwale (sheet 78) map

4.3.3 Woodland/Shrub/Grassland

Dominantly trees/woodlands/shrubs with a subdominant grass component

Definition

- typically located in the Guinea Savanna Ecological Zone
- characterised by woodland savanna (trees and shrubs) and tree savanna (trees and shrubs are scattered)
- woodland savanna species are generally found in the southern areas covered by this legend class
- trees usually have short boles and broad leaves and range from 12 to 30 m in height
- common tree species include *Daniellia oliveri* (most abundant), *Lophira lanceolata, Terminalia glaucescens, Hymenocardia acida, Vitex doniana, Detarium microcarpum* and *Afzelia africana*
- tall savanna grasses include *Andropogon, Hypatthenia* and *Pennisetum*
- tree savanna species, generally found in the northern areas covered by this class may be 9 to 14 m high
- the most abundant tree types include *Isoberlinia doka* and *Isoberlinia dalzielii* (further north) in almost pure communities, *Monotes kerstingii* in pure open stands on sandy or eroded slopes, and *Uapaca togoensis* on low hills or slopes of ironstone boulders
- rocky hills are dominated by sprawling shrubs such as *Acacia ataxacantha* and *Canthium venosum* and several trees not commonly found elsewhere in the Guinea Savanna Ecological Zone (i.e., *Steganotaenia araliacea, Bombax costatum* and *Ficus spp.*)
- under natural conditions this vegetation burns annually in the dry season, therefore fire-resistant species tend to dominate

Appearance on Spectral Imagery

- characterised by a wide range of colours and textures based on the density of woody shrubs and trees
- closed canopy trees and/or shrubs vary from vibrant red to brownish red
- the textures of treed areas range from a curved, cloud-like texture to a smoother texture to very irregularly shaped patterns which follow bedrock jointing

- open grassy areas appear greenish grey to brownish grey
- burn scars, which are common, appear black to dark greenish grey in colour with very irregular or elongated shapes (result of wind)
- smoke from ongoing fires is a rich, royal blue colour
- examples found on the Mokwa (sheet 41) and Baro (sheet 52) maps

Dominantly shrubs and dense grasses with a minor tree component

Definition

- typically located in the Sudan Savanna Ecological Zone
- characterised by a dense shrub and grass layer with a minor tree component
- distribution of trees, shrubs and grasses vary depending on location and soil/bedrock types (e.g., trees are more prominent on sandy soils whereas in areas of shallow soils over bedrock, grasses and shrubs are the more dominant vegetation)
- thorny shrubs such as *Xeromphis nilotica* and woody climbers (or spreading shrubs) such as *Combretum micranthum,* and *Capparis corymbosa* are abundant in more open savanna
- woody climbers are abundant, often suppressing the herb layer, on rocky hills which are not grazed
- grasses are short (1 to 1.5 m tall) and feathery in contrast to the tussocky Guinea Savanna grasses
- two distinct tree types occur: (1) large trees (8 to 15 m tall) with wide spreading crowns (e.g., *Anogeissus leiocarpus, Sclerocaraya spp., Balanites aegyptiaca, Lannea microcarpa* and *Prosopis africana*), (2) smaller trees (5 or 6 m tall) with short boles (e.g., *Combretum glutinosum, Strychnos spinosa, Acacia senegal, A. seyal* and several other Acacia)
- under natural conditions this vegetation burns annually in the dry season, therefore fire resistant species tend to dominate

Appearance on Spectral Imagery

- colour varies from an orangish to brownish-red
- the texture tends to be smooth and homogeneous
- open grassy areas tend to appear as varying shades of grey to brown
- burn scars, which are common, appear black to dark greenish grey with very irregular or elongated shapes (result of wind)
- examples found on the Duku (sheet 35) and Gombe (sheet 36) maps, in northwestern Nigeria, grasses take on light green colours as seen on the Argungu (sheet 6) map

Dominantly grasses with discontinuous shrubs and scattered trees

Definition

- typically located in the Sahel Savanna Ecological Zone
- characterised by a dominant grass layer with thorny shrubs
- typical grasses include *Aristida stipoides, Schoenefelidia gracilis* and *Chloris prieuri*

- grasses in eastern Borno State are dominantly sorghum grasses
- shrub layers are more prevalent on high ground
- typical shrubs include *Salvadora persica, Leptadenia pyrotechnica* and four species of *Grewia (G. villosa, G. bicolor, G. flavescens* and *G. tenax)*
- trees on areas of high ground may be widely distributed, 5 to 9 m high, fine leaved and thorny
- trees tend to have a spreading branch pattern (to maximize interception of rain)
- typical tree species include *Acacia raddiana* (most abundant on sandy soil), *A. senegal, A. laeta* and *Commiphora africana*
- under natural conditions this vegetation burns annually in the dry season, therefore fire resistant species tend to dominate

Appearance on Spectral Imagery

- colour varies from light reddish (bushes) to light grey brown (grasses) with reddish specks (trees)
- the texture can appear quite patchy as the grass cover can have scattered trees and shrubs throughout
- burn scars, which are common, appear black to dark greenish grey with very irregular or elongated shapes (result of wind)
- examples found on the Mongonu (sheet 15) and Matsena (sheet 3D) maps

Grassland (Continuous)

Definition

- typically scattered throughout the country, from the northern edge of the Lowland Rain Forest Ecological Zone northward through the Sahel Savanna Ecological Zone
- characterised by dense grass cover with the shrub and tree component removed as a result of human activity
- indicates an area of degraded natural environment or very stony soils
- significantly affected by human activity such as grazing, fuelwood collection and the creation of forest and game reserves or abandoned areas of poor farmland
- often found on the perimeters of reserves
- includes areas left fallow

Appearance on Spectral Imagery

- appear as large, irregular areas that are relatively homogenous in tones of medium to light grey
- since the tree and shrub component have been removed, specks of red (trees) or brownish red (shrubs) are not present
- examples in the Sudan Ecological Zone found on the Goniri (sheet 26) and Pankshin (sheet 45) maps, in the Guinea and Derived Savanna ecological zones example found on the Ilorin (sheet 50) map and in the Lowland Rain Forest Ecological Zone example found on the Ibadan (sheet 59) map

Discontinuous Grassland

Definition

- typically located in the Sahel Savanna and Sudan Savanna ecological zones
- characterised by grasses interspersed with patches of bare soil
- indicates an area of degraded grass-dominated vegetation which has been negatively affected by human activity (e.g., overgrazing, fuelwood collection)
- the result is exposed sandy soils and permanent dunes which are susceptible to erosion

Appearance on Spectral Imagery

- appear as large, irregular patches of medium to light grey (grasses) and bright white (bare soil)
- examples in the Sahel Savanna Ecological Zone found on the Nguru (sheet 12) map and in the Sudan Savanna Ecological Zone examples found on the Katsina (sheet 9) and Kazaure (sheet 10) maps

Montane Grassland

Definition

- typically located at altitudes of approximately 1800 m or higher, in the southeastern mountainous region of Nigeria
- generally dry grasses that are susceptible to fire
- characterised by tussocky, flat-leaved grasses (0.6 to 1 m high) such as *Andropogon distachyos* and shrubs in crevices or stream channels
- large gaps between the tussocks are filled with annual herbs, ferns and bushy perennials [*Blaeria mannii*, members of the *Compositae* family (particularly *Coreopsis monticola* and *Lactuca capensis)* and several species of *Helichrysum* (particularly *H. globosum*)]

Appearance on Spectral Imagery

- appear as distinctive shades of yellow with green to blue tones
- red, fine, dendritic patterns (low shrubs) tend to dissect the area and create a unique pattern
- burn scars in shades of dark green are also present
- examples found on the Serti (sheet 67) and Mayo-Daga (sheet 76) maps

4.3.4 Forest

Undisturbed Forest

Lowland Rain Forest Ecological Zone

Definition

- characteristically stratified into three layers: 1) the upper or emergent layer (40 to 50 m high) consists of scattered, very tall trees that do not form a continuous canopy, 2) the middle layer (16 to 40 m high) is also discontinuous, but taken together with the upper layer forms a

continuous canopy, and 3) the lower tree layer (10 to 16 m high) forms a more or less continuous canopy
- below the tree layers are the shrub and herb layers that contain more young trees and seedlings than mature shrubs
- the drier northern areas are characterised by the presence of the *Sterculiaceae* family (e.g., *Triplochiton scleroxylon, Sterculia tragacantha, S. rhinopetala, S. oblonga, Nesogordonia papaverifera, Mansonia altissima, Cola gigantea, C. millenii, Pterygota macrocarpa, Hildegardia barteri)* and *Terminalia superba, Ricinodendron heudelotii, Aubrevillea kerstingii* and *Khaya grandifoliola*
- the families *Ulmaceae* and *Moraceae* are also well represented by *Celtis brownii, C. mildbraedii, C. zenkeri, Holoptelea grandis, Trema guineensis, Morus mesozygia, Chlorophora excelsa, Antiaris africana, Ficus spp.* and *Bosqueia angolensis*
- some species (i.e., *Triplochiton scleroxylon* and *Terminalia superba*) also extend into the wetter parts of the Lowland Rain Forest where they usually behave as serval species colonizing open abandoned farmland
- in the wetter, more southern areas of the Lowland Rain Forest Ecological Zone, the families *Meliaceae* and *Leguminosae* are predominant
- common species are the valuable mahogany timbers (*Khaya ivorensis, Entandrophragma spp., Lovoa trichilioides, Guarea cedrata* and *G. thompsonii)* and leguminous trees such as *Cylicodiscus gabunensis, Gossweilerodendron balsamiferum, Hylodendron gabunense, Distemonanthus benthamianus* and *Piptadeniastrum africanum*
- in wetter coastal areas the family *Sapotaceae (*i.e., *Mimusops spp., Omphalocarpum spp.)* assumes an important place, and the timber trees *Lophira alata* and *Nauclea diderrichii* are often abundant

Appearance on Spectral Imagery
- appears as mottled reds to pinks
- the mottled texture is in tones of grey/red/brown
- associated with forest reserves, national parks, game reserves and along river valleys in southern Nigeria
- examples found on the Okitipupa (sheet 69) and Port Harcourt (sheet 84) maps

Appearance on Radar Imagery
- appears as an even, fine texture with little variation in tone
- the tone is slightly lighter than adjacent forested freshwater swamp or tree crop agriculture
- often found along river valleys in southern Nigeria
- examples found on Ogoja (sheet 73) and Port Harcourt (sheet 84) maps

Freshwater Swamp Forest Ecological Zone

Definition
- consist entirely of slender trees (30 to 50 m high) many of which have stilted roots
- species assemblages are found in the description for the forested freshwater swamp legend class

Appearance on Spectral Imagery

- appears smooth, near homogeneous tones of pink or reddish pink
- only observed in the 1976/78 imagery just north of mangrove forest
- example found on the Okitipupa (sheet 69) map

Guinea Savanna Ecological Zone

Definition

- areas where the trees form a very dense, closed canopy
- species assemblages are listed in the description for the dominantly trees/woodland/shrubs legend class

Appearance on Spectral Imagery

- appears as bright red areas
- example found on the Nasarawa (sheet 53) map

Sudan Savanna Ecological Zone

Definition

- areas where the trees form a very dense, closed canopy
- species assemblages are listed in the description for the dominantly shrubs and dense grasses legend class

Appearance on Spectral Imagery

- appears as irregular areas showing a smooth, homogeneous texture of orange red colours
- example found on the Gombe (sheet 36) map

Montane Region Ecological Zone

Definition

- areas where the trees form a very dense, closed canopy, usually in the valleys or lower lying mountainous areas
- species assemblages are listed in the description for the montane forest legend class

Appearance on Spectral Imagery

- appears as dense dark red areas with a texture that mimics the rugged ridges of the mountainous terrain
- found in association with montane forest
- example found on the Serti (sheet 67) map

Disturbed Forest

Definition

- characterised by areas of native forest with open canopies that are a result of human disturbance
- human activity commonly includes removal of wood for fuelwood or saw timber or sporadic clearing for farm plots

- species assemblages in each of the ecological zones are listed in the description for the undisturbed forest legend class

Appearance on Spectral Imagery

- appears as dull red areas with some gentle mottling
- found in association with undisturbed forest and agricultural areas
- examples found on the Akure (sheet 61) and Oban (sheet 51) maps

Riparian Forest

Guinea Savanna Ecological Zone

Definition

- characterised by its location adjacent to watercourses and its dense, closed canopy
- common species assemblages in the north Guinea Savanna Ecological Zone include *Terminalia glaucescens*, often with *Anogeissus leiocarpus* in narrow strips along the sides of streams
- species assemblages in the southern Guinea Savanna Ecological Zone include *Pterocarpus santalinoides, Cola laurifolia, Brachystegia eurycoma* and *Berlinia grandiflora*

Appearance on Spectral Imagery

- appears as bright red strips that assume the dendritic pattern of the stream course
- examples found on the Mokwa (sheet 41) and Yelwa (sheet 29) maps

Sudan Savanna Ecological Zone

Definition

- characterised by dense tangles of deciduous climbers and scandent shrubs that alternate with open patches of tall grass, larger trees are more or less isolated
- common species assemblages are *Combretum micranthum, Acacia ataxacantha, Bauhinia rufescens* and *Mimosa pigra*

Appearance on Spectral Imagery

- appears as red strips that assume the dendritic pattern of the stream course
- the red patches of riparian forest may alternate with brown to grey patches (grass)
- may be confused with the wetland shrub class because of similar discontinuous characteristics and the difficulty in distinguishing tree height
- found in association with streams or rivers
- examples found on the Futuk (sheet 46) and Chafe (sheet 20) maps

Sahel Savanna Ecological Zone

Definition

- characterised by tangles of deciduous climbers and scandent shrubs that alternate with open patches of tall grass, larger trees are more or less isolated
- common species assemblages are *Combretum micranthum, Acacia ataxacantha, Bauhinia rufescens* and *Mimosa pigra*

- more open than in the Sudan Savanna Ecological Zone with smaller trees

Appearance on Spectral Imagery

- appears as bright red strips that assume the dendritic pattern of the stream course
- red patches of riparian forest with brown to grey patches (grass)
- may be confused with the wetland shrub class because of the discontinuous characteristics and the difficultly in distinguishing tree height
- found in association with streams or rivers
- example found on the Nguru (sheet 12) map

Montane Forest

Definition

- located above altitudes of 1000 m
- characterised by a tree canopy that is often irregular and discontinuous
- composed of such species as *Polyscias ferruginea, Entandrophragma angolense, Turraeanthus africanus* and at higher altitudes *Schefflera hookeriana*, and species of *Ficus* and *Conopharyngia*
- may be referred to as "mist forest" because it is commonly enveloped in mist for long periods of time which results in a profusion of mosses and various kinds of epiphytes such as orchids and begonias
- tree fern (*Cyathea manniana*) is abundant especially in more open areas
- at 1500 to 1800 m the forest is drier and more stunted – *Syzygium staudtii, Schefflera abyssinica, S. mannii, Lachnopylis mannii* and *Pittosporum mannii* are typical trees
- lichens beard the tree branches
- tall, shrubby Acanthaceous plant *Mimulopsis violacea*, plus one or two other *Acanthaceae*, form an extensive understorey
- this class also includes the transition area between true forest and montane grasslands, where marginal forest and thickets are more dominant than grassland
- marginal forest occurs in clumps and along old lava streams
- in marginal forest *Lasiosiphon, Hypericum* and *Agauria* cover considerable areas - all trees are covered with masses of white lichen
- the shrub *Mimulopsis* is often dominant in the marginal forest
- dense 2 m high thickets of *Adenocarpus mannii* are extremely common and are associated with *Indigofera atriceps, Hypericum, Philippia* and *Myrica*
- thickets of *Philippia*, up to 3 m high, mixed with stunted *Hypericum, Agauria* and *Myrica* also occur along old lava streams

Appearance on Spectral Imagery

- occurs only in the southeastern, mountainous region
- appears as irregularly shaped areas of red (forest) covering 80 to 90% of an area with small areas of yellow (montane grass) scattered throughout
- marginal forest appears as irregularly shaped bright red clumps or strips of red in a fine,

dendritic pattern with less than 50% of the areas appearing yellowish (montane grasses)
- the fine dendritic patterns mimic old lava streams
- examples of both types of montane forest found on the Serti (sheet 67) map

Forest Plantation

Definition
- large plantations of both exotic and indigenous tree species
- the majority of the plantations are devoted to exotic species such as *Eucalyptus spp.* and *Azadirachta indica* (*neem* or *Dogon-Yaro*)

Appearance on Spectral Imagery
- identified by their shape (polygons with some straight edges), homogenous colour (red) and texture
- areas of blue to yellow may be present (harvested areas)
- tree species are not discernable
- ground truth information is necessary to distinguish between forest and tree crop plantations
- examples found on the Kaduna (sheet 32) and Benin City (sheet 54) maps

Teak/Gmelina Plantation

Definition
- large plantations of exotic tree species with pure and intermixed plantations
- used for pulp (primarily *Gmelina arborea*) and saw logs *(Tectona grandis*)
- largest plantations are found in southern Nigeria

Appearance on Spectral Imagery
- identified by their shape (polygons with some straight edges), homogenous colour (red) and smooth texture
- ground truth information is necessary to distinguish tree species in plantations
- areas of blue to yellow (harvested areas) may be present
- examples found on the Ilesha (sheet 60) and Benin City (sheet 70) maps

4.3.5 Wetlands

Graminoid/Sedge Freshwater Marsh

Definition
- characterised by freshwater wetland communities that occur in flood plains; on or adjacent to islands in large rivers; and in shallows of major lakes and rivers
- dominated by tall emergent graminoids and/or sedges
- few trees may be found within the Guinea Savanna Ecological Zone
- most extensive graminoid/sedge freshwater marsh occurs within Lake Chad

- other extensive communities occur in portions of the Niger Delta and along the banks of the Niger and Benue rivers
- many emergent marshes on floodplains have been converted to rice or sugarcane production areas

Appearance on Spectral Imagery

- identified by a brilliant red to pink colour with a smooth texture
- located within a floodplain or in Lake Chad
- examples found on the Nguru (sheet 12), Ngala (sheet 16), Lau (sheet 47) and Lake Chad (sheet 5A) maps

Shrub/Sedge/Graminoid Freshwater Marsh/Swamp

Definition

- characterised by freshwater wetland communities that occur in floodplains, on or adjacent to islands in large rivers, and in shallows of major lakes and rivers
- dominated by shrubs or stunted trees
- in the Sudan Savanna and Sahel Savanna ecological zones, almost pure stands of *Acacia seyal* comprise the shrub component
- in the Guinea Savanna Ecological Zone, on flatter and poorly drained parts of streams *Syzygium* and the palm *Raphia sudanica* are frequently dominant, and in permanently swampy parts *Mitragyna inermis* occurs
- most extensive shrub/sedge/graminoid freshwater marsh/swamp occurs along the shoreline of Lake Chad
- other less extensive communities occur in portions of the Niger Delta and along the banks of the Niger and Benue rivers

Appearance on Spectral Imagery

- identified as a combination of rough textured, dark red areas (shrubs) and vibrant red to pink areas (sedge grasses)
- recognized by its association with streams, floodplains and Lake Chad
- at the end of the dry season, grassy areas appear medium brown and shrubby swamps are mottled shades of brown and dark grey
- this class was difficult to discriminate from riparian forest, particularly in the north where riparian forest tends to be shrubby in nature and tree/shrub height cannot be detected on the imagery
- examples found on the Gummel (sheet 11), Ngala (sheet 16), Lau (sheet 47) and Mutum Biyu (sheet 56) maps

Forested Freshwater Swamp

Definition

- most extensive freshwater wetland type found in Nigeria

- typically, the main canopy is rather open and in the gaps, dense tangles of shrubs and lianes form an almost impenetrable undergrowth
- climbing palms (*Ancistrophyllum, Eremospatha* and *Calamus*) with hooked spines are particularly characteristic as are clumps of aroids such as *Cyrtosperma senegalense*
- large trees (up to 45 m tall) such as *Mitragyna ciliata, Spondianthus preussii, Lophira alata,* (on better drained parts only), *Anthostema aubryanum,* and *Alstonia congensis* occur together with smaller trees (up to 20 m tall) such as *Nauclea gilletii, Berlinia auriculata, Grewia coriacea, Uapaca spp.* and *Carapa procera*
- a number of the trees have stilt roots
- the outer fringe vegetation is less than 14 m high and is composed mostly of *Raphia* palm with *Lonchocarpus griffonianus*
- in creeks and lagoons the waterlily *Nymphaea lotus* is often abundant, so too are floating communities of *Pistia stratiotes, Lemna, Salvinia* (a tiny water fern), *Jussiaea repens var. diffusa*, species of *Ipomoea* and *Impatiens,* and grasses

Appearance on Spectral Imagery

- primarily identified by its location in southern Nigeria, mostly in the upper reaches of the Niger Delta and along major rivers to the west of the delta
- exhibits a high degree of colour variation from dark red and pink through to mottled brown and blue tones
- texture appears fuzzy, almost out of focus, with smooth gradations between the various colours
- example found on the Degema (sheet 83) map

Appearance on Radar Imagery

- primarily identified by its location in southern Nigeria
- homogenous, medium to dark grey speckled texture with little variation
- examples found on the Warri (sheet 77), Kwale (sheet 78) and Degema (sheet 83) maps

Mangrove Forest

Definition

- occurs on the muddy banks of creeks and in tidal channels in the upper portion of the zone of saltwater influence where the water is brackish
- three species of *Rhizophora* (red mangrove) with their stilted roots are dominant and include: *R. mangle, R. racemosa* and *R. harrisonii*
- white mangrove *(Avicennia nitida)* and the shrub *Laguncularia racemosa* are much less abundant
- each species requires different growing conditions to thrive, thus forming separate communities
- *Rhizophora racemosa* is the most common species, it is usually found at the edge of the alluvial salt swamp and may reach a height of 45 m
- often cut for fuelwood, *R. racemosa* rarely reaches maturity and forms a dense tangle, up to

9 m in height
- *R. harrisonii* prefers the wetter areas of the mangrove forest
- *R. mangle* is found only on the drier, inner limit of the *Rhizophora* zone and grows as a healthy shrub, up to 5 m high

Appearance on Spectral Imagery
- primarily identified by its location in southern Nigeria, particularly the outer reaches of the Niger Delta
- exhibits a unique, tangled-like texture with a network of sinuous lines (creeks)
- colours range from dark, mottled bluish grey/black through to mixed shades of browns, blue-grey, pinks and reds
- small sinuous tidal channels are also mimicked by colour differences
- examples found on the Pennington River (sheet 82) and Degema (sheet 83) maps

Appearance on Radar Imagery
- primarily identified by its location in southern Nigeria, particularly the outer reaches of the Niger Delta
- appears bright white to grey with a texture resembling the tangled nature of the forest
- wetter areas are slightly darker grey in colour
- the network of sinuous tidal channels is visible
- examples found on the Warri (sheet 77), Pennington River (sheet 82) and Degema (sheet 83) maps

Saltmarsh/Tidal Flat

Definition
- occurs at the uppermost limit of the tidal zone immediately inland of the *Rhizophora* mangrove forest
- flooded by saltwater only during the highest spring and neap tides
- grasses, mostly *Paspalum vaginatum*, are most common in a saltmarsh although in the vicinity of Port Harcourt it is being invaded by the dwarf palm (*Nepa fruiticans*)
- also includes areas within the Niger delta currently undergoing subsidence and inundation by saltwater

Appearance on Spectral Imagery
- appears as small, reddish orange, irregularly shaped areas usually occurring with dark blue/grey mangrove swamp, mostly in the Lagos area
- tidal flats appear light blue and are found along the coast
- examples found on the Port Harcourt (sheet 84) and Degema (sheet 83) maps

Appearance on Radar Imagery
- areas of saltwater inundation are best observed in the radar imagery
- show very good contrast to adjacent vegetation
- very dark grey to black appearance due to water, but still exhibit remnant textures characteristic of the forested freshwater swamp and/or mangrove forest

- examples found on the Okitipupa (sheet 69), Omolomo (sheet 77A) and Warri (sheet 77) maps

4.3.6 Water

Natural Waterbodies: Ocean, River, Lake

Definition

- includes lakes, rivers, large streams, and the Atlantic Ocean

Appearance on Spectral Imagery

- rivers are identified through pattern recognition, their varying shades of blue, or in cases of intermittent streams, the bright white colours of alluvial sands and/or red, vegetated stream beds
- lakes are identified by their irregular shape and dark to light blue colour
- ocean is identified by its dark blue to black colour and location
- examples found on the Mutum Biyu (sheet 56), Gummi (sheet 7) and Port Harcourt (84) maps

Appearance on Radar Imagery

- while pattern recognition and association are also useful with radar imagery, water appears solid black in sharp contrast to the shoreline
- example found on the Warri (sheet 77) map

Canal

Definition

- manmade waterways used for transportation or irrigation
- the majority of canals are located along the coast, in the Niger Delta

Appearance on Spectral Imagery

- identified as a "straight" edged, water feature
- example of irrigation canal on the Mongonu (sheet 15) map

Appearance on Radar Imagery

- identified as a "straight" edged, water feature
- water appears black
- example of transportation canals on the Warri (sheet 77) map

Reservoir

Definition

- lakes created by damming rivers and streams

Appearance on Spectral Imagery

- identified as a lake, in varying shades of blue, with a straight edge (the dam), occurring on

a river or stream
- examples found on Yelwa (sheet 29) and Jebba (sheet 40) maps

4.3.7 Bare Surfaces

Rock Outcrop

Definition
- exposed rock outcroppings with little to no vegetation

Appearance on Spectral Imagery
- identified by their rounded or elongated shapes and three-dimensional appearance
- most are bluish in colour due to lack of vegetation but colour may vary depending on rock type
- the exposed, weathered slopes of northwest Nigeria, contain iron-rich bedrock which appear as dark green gray, irregular, elongated areas (Sokoto, map sheet 2)
- examples found on the Chafe (sheet 20), Bauchi (sheet 34) and Shaki (sheet 49) maps

Sand Dunes/Aeolian

Definition
- exposed sand dunes formed by wind (aeolian) processes and susceptible to further erosion and movement
- includes the extensive beach sands on the Atlantic coast where the term "beach" was used as a qualifier and placed on the appropriate land use maps
- only includes exposed sand dunes undergoing active erosion/deposition processes

Appearance on Spectral Imagery
- identified by their patterns and shapes
- bare dune surfaces are mostly white however, patchy grasses may give a light grey-green, or sometimes a yellowish colour depending upon the enhancement
- in northeast Nigeria, once stable, parabolic dune fields are becoming exposed – recognized by their shape and by the presence of vegetation in low lying, somewhat triangular areas between the dunes
- examples in northeast Nigeria on the Matsena (sheet 3D) and Wade (sheet 3E) maps
- examples of exposed longitudinal dunes found on the Goniri (sheet 26) and Kaririwa (sheet 5) maps

Alluvial

Definition
- sand and gravel deposits found within and adjacent to major rivers
- generally not vegetated as the areas are frequently inundated by rapidly flowing water

Appearance on Spectral Imagery

- appear as bright white areas within a major river
- examples are found on the Yola (sheet 48), Nasarawa (sheet 53) and Lokoja (sheet 62) maps

Gullies

Definition

- areas substantially eroded by runoff following the removal of natural vegetation

Appearance on Spectral Imagery

- recognized by the whitish (with blue, grey or green tones) feathery dendritic patterns along creeks
- in some areas the erosion is so severe that large areas are riddled with numerous gullies
- examples found on the Gusau (sheet 8) and Katsina (sheet 9) maps

Mining Areas

Definition

- characterised by open pits
- not possible to discriminate at the resolution available
- ground truth information must be used

Appearance on Spectral Imagery

- tin and rare earth elements pits appear as white almost circular shapes (bare soil), which may have small blue circular (waterbodies) associated with them
- examples found on the Jos (sheet 44) and Rano (sheet 22) maps

4.4 ECOLOGICAL ZONES

The ecological zones delineated in this study are based on those defined by Keay (1949). Keay's ecological zones are primarily based on species assemblages and the amount of rainfall. Careful analysis of the optical imagery and field study results confirmed that updated ecological zones could be delineated based on interpretation of vegetation from satellite imagery and field work. It was found that northern and southern Guinea Savanna could not be visually differentiated, therefore they have been collapsed into a single zone. Moving from north to south, the ecological zones were mapped as follows:

- Sahel Savanna
- Sudan Savanna
- Guinea Savanna
- Jos Plateau
- Montane Region
- Derived Savanna

- Lowland Rain Forest
- Freshwater Swamp Forest
- Mangrove Swamp and Coastal Vegetation

On each of the map sheets a map of the ecological zones for either 1976/78 or 1993/95 is provided in the map index.

The extent of the ecological zones was determined by observing the type and density of vegetation. Due to the increase in population and associated agricultural activity since Keay originally delineated the ecological zones in 1949, the modern delineation of ecological zones was based on the type and density of remnant natural vegetation. The increased intensity of land use has resulted in a less clear definition between ecological zones. Field work helped to clarify zone delineation where there were only small pockets of natural vegetation. In areas of intensive agriculture where very little natural vegetation remains, the determination of the ecological zone boundary was more subjective.

4.4.1 Sahel Savanna Ecological Zone

Keay's definition of the Sahel Savanna Ecological Zone is based on the 50 cm isohyet and less. The Sahel Zone is seen along the northeastern border of the country and is influenced by the presence of Lake Chad and the Komadugu Yobe river systems. Typically the vegetation consists of grasses, open thorn shrub savanna with scattered trees, 4 to 9 m in height most of them fine leaved and thorny, and extensive sparse grasses.

Typical species are the trees *Acacia raddianna, A. Senegal, A. Laeta* and *Commiphora africana*, the shrubs *Salvadora persica, Leptadenia pyrotechnica* and four species of Grewia, and the grasses *Aristida stipoides, Schoenefeldia gracilis* and *Chloris priean.*

The legend class "dominantly grasses with discontinuous shrubs and scattered trees " was the primary class used to delineate this ecological zone. The class "extensive small holder rainfed - agriculture with denuded areas" was also common in this ecological zone.

4.4.2 Sudan Savanna Ecological Zone

Keay's definition of the Sudan Savanna Ecological Zone is based on the 50 cm isohyet which divides the Sudan and Sahel zones. Most of the zone is covered by a drift of sand. The Sudan Zone is seen in the northern areas of the country encompassing three geological regions which influence the vegetation in each of these areas. In the centre (Eastern Sokoto, Katsina and Kano states) gneisses and other igneous rocks form the basement complex, often protruding to form low outcrops. To the west (Sokoto State), sedimentary rocks, mostly sandstones, shales and clays with boulders

of ironstone are abundant and are exposed on high ground. Low flat-topped hills capped with ironstone are a conspicuous feature of this area and parts of Bauchi State. The eastern part of the zone (Borno, Yobe, Jigawa and the north area of Bauchi states) is occupied by the Chad Group of Quaternary deposits, overlain by desert drift sand.

The vegetation of the Sudan Zone has been interfered with by man and for a long period of time. Overall, the number of thorny shrub plants (mostly *Acacia*) in the Sudan Zone is noticeably greater than in the Guinea Zone. Grass is shorter and more feathery than in the Guinea Zone. Relatively mature woodland on high level sites has a fairly uniform structure and appearance, but the floristic composition varies as described in the "dominantly shrubs and dense grasses with minor tree component" legend class.

The legend class "dominantly shrubs and dense grasses with minor tree component" was the primary class used to delineate this ecological zone. The classes "extensive small holder rainfed - agriculture with denuded areas" and "sand dunes" were also common on the sandy soils in this ecological zone.

4.4.3 Guinea Savanna Ecological Zone

Keay's definition of the Guinea Savanna Ecological Zone is based on the mean annual rainfall as well as the severity of the dry season. The southern limit of Guinea Savanna Ecological Zone is based on a mean annual rainfall of at least 120 cm and lowest mean monthly relative humidity at 9 a.m. of not less than 70%. The northern limit of Guinea Savanna Ecological Zone is at approximately 100 cm mean annual rainfall, with the lowest mean monthly relative humidity at about 29%. Guinea Savanna is found throughout the middle belt of Nigeria. The typical vegetation is an open woodland with tall grasses (1 to 3 m high) in open areas and trees (up to 15 m high) usually with short boles and broad leaves. This vegetation is burnt almost annually by fierce fires in the dry season, therefore fire-resistant species predominate.

Many of the species in the southern areas of the Guinea Savanna zone are closely related to high forest species. Such species as *Lophira lanceolata* and *Terminalia glaucescens* are good examples. Other typical species are *Daniellia oliveri, Hymenocardia acida, Vitex doniana, Detarium microcarpum* and *Afzelia africana.* All these species have thick bark capable of resisting grass fires, and they typically send up a dense sucker growth after the fires have passed.

Species of the northern Guinea Savanna show close affinities with the east African "myombo" woodlands but there are much fewer species. *Isoberlinia doka, I.dalzielli, Monotes kerstingii* and *Uapaca togoensis* are the most abundant and characteristic trees of the northern Guinea Zone in Nigeria. Wherever the canopy is open, grass is dominant though usually shorter than in the wetter

southern Guinea Zone. Erect shrubs (e.g., *Gardenia spp.* and *Protes elliottii*) are frequent but woody climbers (e.g., *Opilia celtidifolia* and *Uvaria chamae*) are locally present.

The legend class "dominantly trees/woodland/shrubswith a subdominant grass component" was the primary class used to delineate this ecological zone.

4.4.4 Jos Plateau Ecological Zone

Keay's definition of the Jos Plateau Ecological Zone is based on the distinctness of the vegetation. The vegetation of the plateau (altitude about 1200 m) is distinct for two reasons. First, the high plateau has suffered widespread degradation by man so that only relics of Guinea woodland remain. The plateau is now almost totally treeless. Second, the flora on the plateau is peculiar with many species of woody and herbaceous plants not found elsewhere in West Africa, alongside many typical Guinea Savanna species.

Species peculiar to the Jos Plateau include *Terminalia brozenii, Morea zambesiaca* and the orchids *Disperis johnstoni* and *Disa hircicornis.*

This ecological zone, which is located in the central part of the county within the treed Guinea Savanna Ecological Zone, was delineated on the imagery by the ridges of the plateau as well as the absence of treed vegetation.

4.4.5 Montane Region Ecological Zone

Keay's delineation of the Montane Region is based on altitude as well as other important factors that influence vegetation such as slope, aspect, drainage and fire. This region is found along the southeastern bounder of Nigeria in the Cameroon mountains. Forest vegetation extends as high as 1600 to 2400 m where the forest stops abruptly and is replaced by mountain grassland.

There are two main types of montane forest. From about 1000 to 1800 m altitude the forest is enveloped in mist for long periods and is referred to as Mist Forest. The tree canopy is irregular and is composed of species such as *Polyscias ferruginea, Entandrophragma angolense, Turreanthus africanus* and at higher altitudes *Schefflera hookeriana* and species of *Ficus* and *Conopharyugia.* The high humidity results in a profusion of mosses and various kinds of epiphytes. Above the mist zone the forest is drier, more stunted, and more susceptible to fire. Typical trees include *Syzygium standtii, Schefflera abyssinica, Schefflera mannii, Lachnopylis mannii* and *Pittosporum mannii.* Masses of lichens beard the branches of the trees.

At the upper limit of the forest there is a scrubby zone of *Rapanca neurophylla*, *Agauria saheifolia* and *Laisiosiphon glaucus*. This fire swept area is characterised by *Hypericum* and *Lasiosiphon*. In the lower grasslands most of the grasses are tussocky, have flat leaves, and reach 0.6 m in height, or slightly more. The family *Compositae* is well represented in this grassland. At about 3000 m there is a marked change, the flat-leaved tussocky grasses, such as *Andropogon distachvus* are replaced by grasses with more compact shorter tussocks of narrow rolled leaves, such as *Festuca abyssinica*. Trees are absent from this upper grassland, with only a few bushy plants such as *Blaeria mannii, Senecio clarenceanus* and *Helichrysum mannii*. Vegetation of the scrubby lower grassland is often found along old lava flows within the highland grasslands.

The legend classes "montane forest" and "montane grassland" were used to delineate this ecological zone.

4.4.6 Derived Savanna Ecological Zone

The northern limit of the Derived Savanna Ecological Zone is the probable climatic limit of the Lowland Rain Forest Ecological Zone. The impact of man has been so intense in this area that areas left to regrow tend to grow savanna type grasses that are susceptible to fire and therefore they limit the lowland species that can regenerate in this area, creating a "derived savanna". Remnants of the high forest may be present in upland or rocky areas that are not suitable for agriculture. This zone is found in a densely populated east-west band between the Guinea Savanna and the Lowland Rain Forest ecological zones.

The appearance and composition of derived savanna, apart from the vestiges of lowland rainforest, are much the same as in the southern areas of Guinea Savanna.

The positioning of the boundary between the Guinea and Derived Savanna ecological zones was based mainly on the boundary of increased row cropping with the southern extent of grazing agricultural activity. The presence of the legend class "intensive agriculture" and the absence of "extensive agriculture" was used to delineate this ecological zone. Small areas of the classes "disturbed forest" or " undisturbed forest" were also useful. The presence of the class "discontinuous grassland" was also common in this zone. Data provided from the field studies was also useful.

4.4.7 Lowland Rain Forest Ecological Zone

Keay's describes Lowland Rain Forest as a drier type of forest north of the 160 cm isohyet, with a number of subtypes that are difficult to classify, therefore they have been grouped into this one class. This zone is located between the Freshwater Swamp Forest and Mangrove Forest and Coastal Vegetation ecological zones to the south and the Derived Savanna Ecological Zone to the north.

The lowland rain forest is a complicated mosaic of communities. The forest structure can be used to describe the vegetation of this zone. In mature lowland rain forest there are three stratum. The first, or top stratum, is 36 m or more in height with wide spreading, often isolated crowns called emergents. The second, or middle stratum, 15 to 36 m high, consists of a great variety of species with relatively small crowns, in lateral contact with each other. These trees form the upper canopy of mature forest. The third stratum, or understorey, consists of trees up to 15 m high with spreading crowns and short boles which are often bound together with woody climbers. Beneath the understorey is a shrub stratum composed of single-stemmed shrubs.

The forest in the northern parts of the zone is characterised by a number of species belonging to the *Sterculiaceae* family. The families *Ulmaceae* and *Moraceae* are also common. Characteristic species of the lowland rain forest are *Terminalia superba, Ricinodendron spp. , Aubrevillea kerstingii* and *Khaya grandifloria.* The families *Meliaceae* and *Leguminosae* make up a large proportion of the tree species in the wetter southern areas of this zone. In still wetter areas the *Sapotaceae* are prominent and the timber trees *Lophira alata* and *Nauclea diderrichii* are often abundant.

Due to high population and farming activities, mature rain forest occurs only within forest reserves, national parks and game reserves and borders rivers in southern Nigeria. The boundary between the Derived Savanna and Lowland Rain Forest ecological zones was placed where row crop agriculture is replaced by tree crop agriculture interspersed with remnant patches of lowland rain forest. Row crop and tree crop agriculture are not separate legend classes, however they could be visually distinguished in the spectral imagery. The legend classes "disturbed forest" and "undisturbed forest" were also used in the delineation of this zone.

4.4.8 Freshwater Swamp Forest Ecological Zone

Tropical lagoons and streams with freshwater are not surrounded by mangroves but by freshwater swamp communities. This zone is located in extensive areas south of the Lowland Rain Forest but inland from the Mangrove Forest and Coastal Vegetation ecological zones.

The main canopy, which may reach 45 m in height, is rather open with gaps that are tangles of shrubs and lianes which form an almost impenetrable undergrowth. Climbing palms with hooked spines are particularly characteristic as are clumps of large aroids such as *Cyrtospernia senegalense.* Large trees such as *Mitragyna ciliata, Spondianthus preussii, Lophira alata, Anthostema aubryanum* and *Alstonia congensis* occur with smaller trees such as *Nauclea gilletii, Berlinia spp., Grewia coriacea,* and *Uapaca spp.* A number of trees have stilted roots.

The *Raphia* palm and *Lonchocarpus griffonianus* are usually abundant in the outer fringe vegetation which seldom exceeds 14 m in height. Behind the fringe, the trees of the freshwater swamp may reach 30 m in height.

The presence of the legend class "forested freshwater swamp" was used to delineate this ecological zone.

4.4.9 Mangrove Forest and Coastal Vegetation Ecological Zone

Mangrove forest grows along the coast and delta areas of Nigeria where the water is brackish. Mangrove is a transitory community continually colonising new ground, terrestrialising it and then being replaced by other more permanent vegetation.

The most prominent feature of the mangrove forest is the stilt roots of *Rhizophora* which do not penetrate the ground but divide immediately below the water surface to form a thick felt raft of its own making. There are three species of *Rhizophora* (red mangrove) each with different ecological requirements. *R. racemosa* is the most common species and is found at the edge of the alluvial swamp. *R. harrisonii* is dominant in the middle areas of the mangrove. *R. mangle* is found only on the drier areas of the mangrove and grows as a shrub up to about 5 m high.

The presence of the legend class "mangrove forest" was used to delineate this ecological zone.

5.0 Methodology and Procedures

5.1 INTRODUCTION - MAPPING STANDARDS

The results of the land use and vegetation interpretation conducted for this project were presented in a set of 1:250 000 scale maps covering the entire country. A set of maps was produced for each of the two time periods included in the study, 1976/78 and 1993/95. The standards established by the Survey Division, Ministry of Works, Lagos (Ministry of Works 1976) were used throughout this project. The standards established dictated that the 1:250 000 maps be bounded by one degree of latitude by one degree of longitude. One hundred, 1:250 000 scale maps sheets were required for complete coverage of Nigeria (Figure 5.1). The 1:250 000 scale maps sheets were numbered and named as shown in Table 5.1.

Table 5.1 Index of 1:250 000 Scale Map Sheets for Nigeria.

Map Sheet No.	Map Sheet Name	Map Sheet No.	Map Sheet Name	Map Sheet No.	Map Sheet Name	Map Sheet No.	Map Sheet Name
1	Kurdula	19	Zuru	42	Minna	64	Makurdi
2	Sokoto	20	Chafe	43	Abuja	65	Wukari
3	Shinkafe	21	Zaria	44	Jos	66	Donga
3A	Jibiya	22	Rano	45	Pankshin	67	Serti
3B	Daura	23	Gaya	46	Futuk	67A	Dau
3C	Faramiram	24	Azare	47	Lau	68A	Badagri
3D	Matsena	25	Potiskum	48	Yola	68	Lagos
3E	Wade	26	Goniri	48A	Holma	69	Okitipupa
4	Zari	27	Maiduguri	49A	Kyanu	70	Benin City
5	Kaririwa	28	Gulumba	49	Shaki	71	Onitsha
5A	Lake Chad	29A	Babana	50	Ilorin	72	Enugu
6A	Zogirma	29	Yelwa	51	Lafiagi	73	Ogoja
6	Argungu	30	Kontagora	52	Baro	74	Obudu
7	Gummi	31	Tegina	53	Nasarawa	75	Nsungbi
8	Gusau	32	Kaduna	54	Lafia	76	Mayo-Daga
9	Katsina	33	Lere	55	Shendam	77A	Omolomo
10	Kazaure	34	Bauchi	56	Mutum Biyu	77	Warri
11	Gumel	35	Duku	57	Jalingo	78	Kwale
12	Nguru	36	Gombe	58	Toungu	79	Umuahia
13	Gashau	37	Biu	59A	Meko	80	Oban
14	Gubio	38	Mubi	59	Ibadan	81	Abunerok
15	Mongonu	39A	Yashikera	60	Ilesha	82	Pennington
16	Ngala	39	Kaiama	61	Akure	83	Degema
17	Kamba	40	Jebba	62	Lokoja	84	Port Harcourt
18	Shanga	41	Mokwa	63	Ayangba	85	Calabar

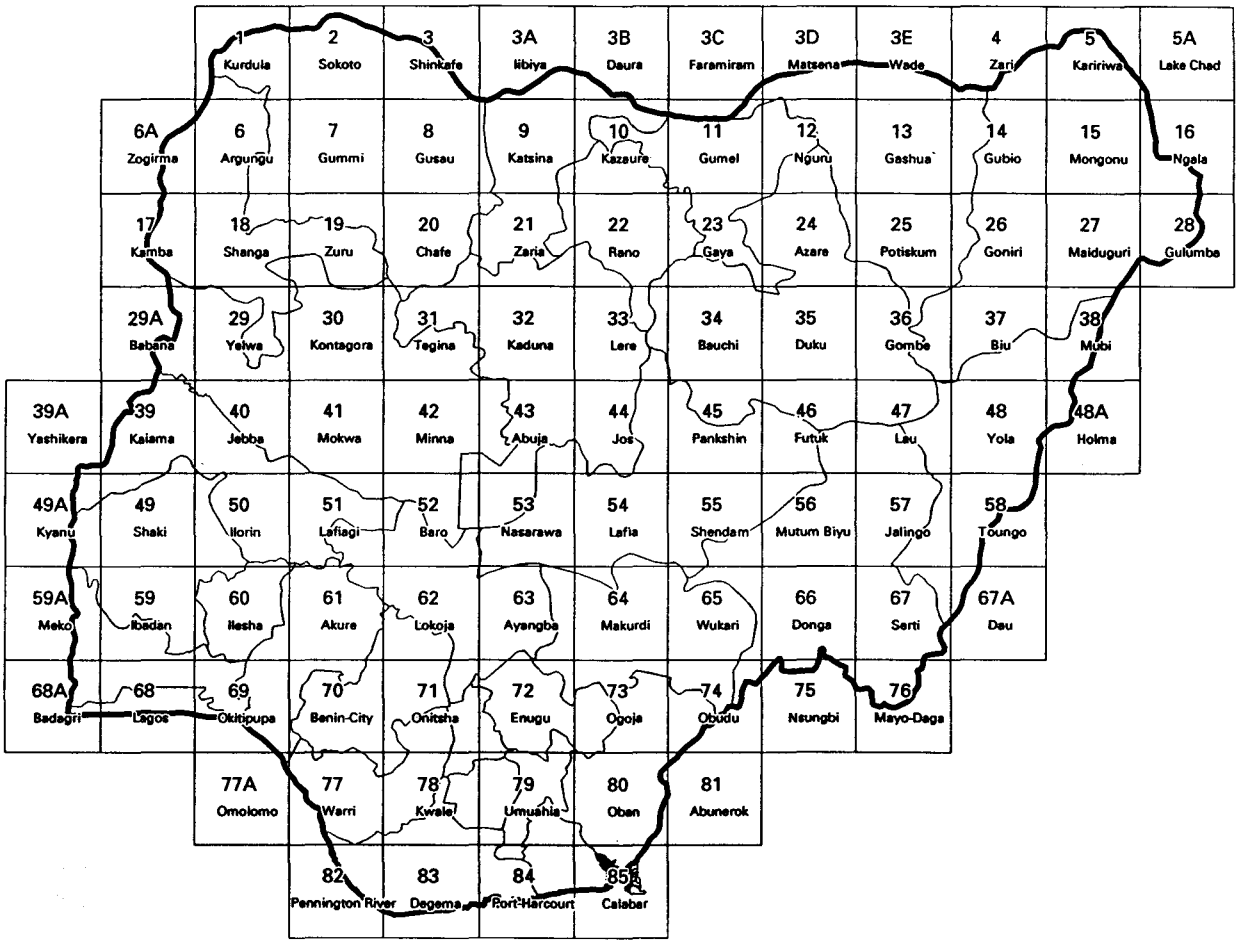


Figure 5.1 National Index of 1:250 000 Maps.

In order to conserve disk space and simplify data storage, it was determined that all imagery, regardless of type, would be mosaicked and stored in files defined by map sheet boundaries. Therefore, all data was interpreted, printed, stored and retrieved with reference to the map sheet number and name.

All image analysis work was done using PCI's EASI/PACE image analysis software. Data input and creation of the GIS database was done using ESRI's ARC/INFO and ArcView. Some ancillary map data was input using Tydac's SPANS GIS software.

Methodology details are provided below and summarized in Figure 5.2.

5.2 1976/78 VEGETATION AND LAND USE MAPS

5.2.1 Geometric Correction and Mosaicking, Landsat MSS

Random geometric distortions and residual unknown systematic distortions found in raw Landsat Multispectral Scanner (MSS) data were corrected by collecting ground control points. This procedure pairs a point on the satellite image with a point on a surveyed base map. Generally these points are features that are easily identified on both the imagery and surveyed maps. Ground control points included features such as road intersections, stream intersections, coastal features or well-defined landforms. Up to 100 ground control points were collected for each MSS image. Points were also collected from adjacent corrected imagery to provide a means of edge matching adjacent image map sheets.

One of the first problems encountered in the project was the lack of complete topographic map coverage of Nigeria for georeferencing. Some areas of the country have either never been mapped or it was not possible to acquire the topographic maps. The only "complete" set of maps available that could be used as a surveyed base map was the United States Joint Operations Graphics (J.O.G.) 1:250 000 scale series, reproduced on the NIRAD maps (Hunting Technical 1976). These maps are not survey perfect, however, they provided the only consistent and complete source of map information for the country.

Geometric corrections were performed using cubic convolution resampling and a second order polynomial transform equation. The MSS data, when resampled was transformed from an 80 to 50 m spatial resolution.

The image map sheets each required a mosaic of 1 to 4 Landsat MSS images depending upon where the satellite path and row occurred with respect to the map sheet. When more than 1 MSS scene was required to make an individual map sheet, vectors were drawn where the scenes met. Criteria

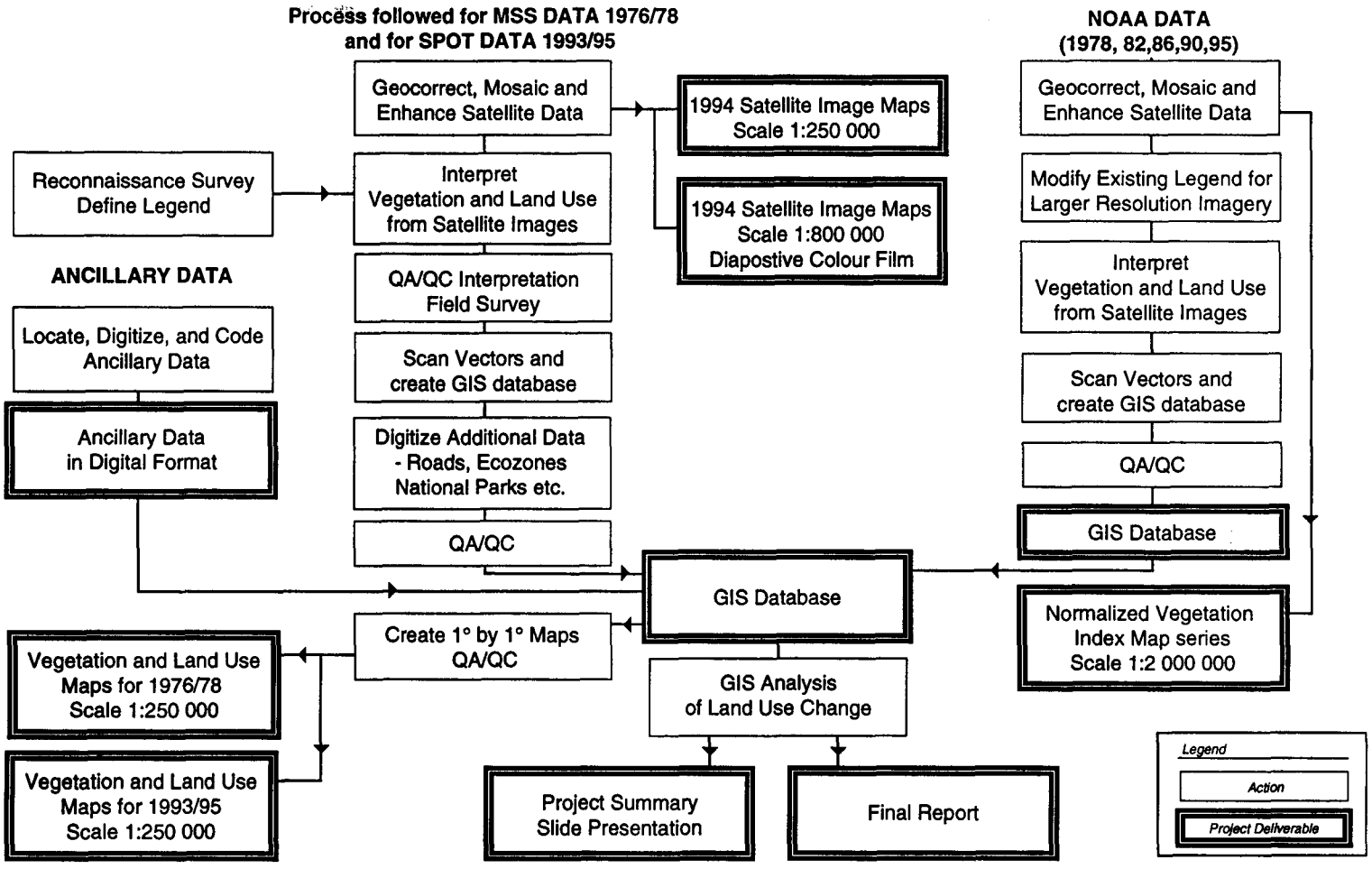


Figure 5.2 Methodology Flowchart.

considered for determining overlap priorities are defined as follows:

- absence of cloud cover
- most recent scene for the time period (i.e., a 1978 image would take precedence over a 1976 image)
- early dry season imagery was preferable for interpretation over late dry season imagery
- best image quality

Regarding enhancements, histogram matching between scenes was done when scenes were similar in date. Matching data from differing years could not be successfully done because detail would have been lost. In this case each scene was enhanced separately and then mosaicked in order to achieve maximum enhancement across the map sheets. Enhancements are very important in determining how well the interpreter can see the variation and changes in a scene.

For interpretation purposes, all image map sheets were printed at a scale of 1:150 000 in the MSS band combination 7, 5 and 4 as red, green and blue respectively. The infrared band (Band 7) viewed as red, results in vigourous vegetation being red in the images. A hard copy map was produced for each of the 100 map sheets and used for the vegetation and land use interpretation.

The scale at which the imagery was interpreted was a decision made by Geomatics and FORMECU. A standard scale had to be chosen that would allow consistent interpretation of imagery with ground resolutions of 20 m (SPOT-XS, 1993/95) to 80 m (Landsat MSS, 1976/78). An interpretation scale of 1:150 000 was chosen because it was stretching the limit of the MSS data yet the majority of the SPOT data would be seen at this scale. Thus, the vegetation and land use data within the GIS database would be stored at the scale of interpretation (1:150 000) and the final map products would be produced at a scale of 1:250 000 as stated in the terms of reference.

5.2.2 Visual Interpretation of 1976/78 Satellite Data

The interpretation of vegetation and land use was done visually using the 1:150 000 scale, hard copy image maps. Transparent acetate film was taped in place on the maps and corner registration marks were drawn and labelled with the UTM coordinates and appropriate zone. Fine, black ink drafting pens were used to delineate the polygons representing the different legend classes. The polygons were then labelled with red film markers.

Before interpretation could begin a familiarisation process with the imagery and ground truth information was conducted. For example, all photo and station locations from the October 1994, reconnaissance survey had GPS coordinates and hence could be marked on the appropriate map. This allowed for the interpreters to become familiar with the appearance of each class on the imagery and identify differences, similarities and relationships between classes.

Several representatives from FORMECU and one from Unilag Consult were at Geomatics for training and participated in the commencement of the interpretation process. The individual from Unilag Consult was experienced in remote sensing and had done extensive work throughout Nigeria with satellite imagery. Map sheets covering areas that were familiar to each individual were discussed and interpreted both for familiarization and as an interpretation training exercise.

The NIRAD maps were used as a source of information during the MSS interpretation. Although the legends were different, the main map elements were the same and a year-long, extensive ground survey was used to assist in the interpretation of these maps. Therefore it was assumed that information such as the plantation type and divisions between natural vegetation and agricultural activity were correct.

The interpretation process conducted for the 1976/78 Landsat MSS imagery emphasized some of the problems that can occur. The main issue resolved was one of interpretation consistency. Geomatics discovered that different individuals, depending upon how they viewed the legend and enhancements, interpreted the same image differently. Neither interpretation is wrong because many of the class boundaries are subjective. For example, two individuals, working independently, will differently judge the intensive row crop agriculture class and the extensive (grazing activity) agriculture class in areas where both are mixed in varying, small amounts and only the dominant land use can be mapped.

It was found that the best way to ensure interpretation consistency was to have no more than two individuals work closely together so that subjective class issues could be discussed and resolved. Each person would learn to recognize the same set of visual criteria for interpretation not only for differences between classes but they learn to recognize differences within a class resulting from seasonal and yearly changes, increased cultural activity, and varying image enhancements.

Another critical issue to address was that of edge matching between map sheets and viewing the "big picture" in an area during the interpretation process. Care was taken to ensure that classes and their boundaries were interpreted across map sheets. This was done by laying out 6 to 10 map sheets to not only check edges but to view how the dominant class or land use appeared overall in an area and to check if seasonal and enhancement differences were properly taken into account. In one example, up to 30 map sheets were laid out together in order to determine the location of the ecological zone boundary.

Thirty map sheets from the northwest corner of Nigeria (bounded by 3° to 10° East longitude and 9° to 14° North latitude) were interpreted by Unilag Consult in Nigeria. Mapping differences among several interpreters from Unilag Consult and those at Geomatics were apparent and required some modification. Subsequent adjustments were made to maps interpreted by both Unilag and Geomatics in order to ensure interpretation consistency throughout the entire country. At this stage, laying out up to 12 adjacent maps and examining the big picture was very important for checking consistency.

5.2.3 Input of Vegetation and Land Use Interpretation (1976/78) to the GIS Database

All the interpreted acetates were scanned using a Tangent 500-50TF drum scanner at 250 dots per inch (dpi), 1 bit, black and white mode. Each scanned map sheet was then converted into a 20 megabyte TIFF file using the Tangent software. As mentioned earlier, all land use class polygons were labelled using a red film marker. During the scanning process red lines were not recorded. Geomatics found that it took less time to manually enter the polygon label into the database than to remove polygons and dangles resulting from label placement on the map.

TIFF files were converted to an ARC/INFO grid coverage, then transformed to a vector or line coverage. Spatial coordinates were then assigned to the registration marks which allowed all other vector data to be georeferenced to the same grid. All registration coordinates were in the Universal Transverse Mercator (UTM) projection.

A mathematically generated latitude/longitude grid was projected for the proper UTM zone and Spheroid (Clarke 1880) to establish individual neatlines for each of the map sheets. Vector coverages were brought into their corresponding neatlines and run through a series of clean-up routines developed by Geomatics. These routines removed dangles, added polygon centroids, and removed small, false polygons that were created when ARC/INFO converted the file from grid to vector. Each of the polygons was manually identified and labelled accordingly.

Each neatline map sheet was edge matched with its four adjacent maps. Maps bordering UTM zone boundaries were projected to the adjacent UTM zone to allow edge matching. After across-zone edge matching was complete, maps were reprojected back to the correct UTM zone.

Quality assurance/quality control (QA/QC) procedures required each map to be plotted in colour with polygon codes and with a portion (approximately 5 cm) of the four adjacent maps sheets. All check plots were checked for correct labelling of polygons, georeferencing, and edge matching. Once all four adjacent maps had gone through the same QA/QC process, they were prepared for final map production.

5.2.4 Digitizing Infrastructure and Other Map Elements

The input of additional data sets to the GIS database was done concurrently with the vegetation and land use interpretation. Several coverages were required as components to the final vegetation and land use maps.

Dominant road and rail networks, part of the **infrastructure**, was digitized from the J.O.G.survey for the 1976/78 vegetation and land use maps. Although infrastructure information was digitized

from 69 map sheets it was merged to produce a seamless road and rail vector coverage. In this arc vector (line) coverage, attributes were used to distinguish roads from railways. Road class priority was not coded. This road and rail coverage was used only for the 1976/78 maps. Infrastructure for the 1993/95 vegetation and land use maps was identified from the SPOT and radar imagery and is discussed in Section 5.3.4.

Forest reserves were digitized from the NIRAD maps. Within the GIS database this coverage is a polygon layer with a centroid that contains the name of the forest reserve.

Urban and/or built-up areas that were large enough to delineate at the scale of interpretation were coded as urban in the land use layer. The **text** (town or city name) associated with the centroid of urban polygon classes was input from several existing maps which include: J.O.G. maps (Hunting Technical Services Limited 1978); a 1992 administrative map (Satode Cartographic Consultants 1992); and a 1994 road map (Spectrum Books Limited 1994). In addition, smaller urban areas were also input as point data with associated text. **Hydrologic annotation** (names for rivers, lakes, reservoirs) was entered as text information and derived from the J.O.G. maps, 1992 administrative map and 1994 road map.

State boundaries were digitized from the J.O.G. maps and updated using the 1992 administrative map. Within the GIS database this coverage is a polygon layer with a centroid that contains the state name.

The **international boundary** was derived from several sources that included: J.O.G. maps, a 1992 administration map, and satellite imagery in the north where Nigeria borders Niger. It should be noted that the boundaries, colours, denominations and any other information shown on the maps do not imply any judgement on the legal status of any territory, or any endorsement or acceptance of such boundaries.

Additional **point data** included sea ports, oil fields and/or terminals, and airports derived from the J.O.G. maps.

5.2.5 Final Map Creation

The digital files used for preparing the final 1976/78 vegetation and land use maps were prepared at Geomatics International. Information incorporated on each map included the following:

- map sheet name and number
- vegetation and land use derived from satellite data
- index map indicating the map location and current position of ecological zones
- legend
- satellite data index

- north arrow
- projection information and UTM zone
- scale
- copyright information
- list of companies involved in the mapping project

The map layout was designed at Geomatics with the assistance of representatives from FORMECU. An example of a final map and its layout are shown in Figure 5.3. The fonts, line weights and colours were chosen and applied to the GIS files. Two fonts, Times Roman and Helvetica, were used throughout the map and the legend. Thirty-four colours were chosen to represent the seven major land use categories and their subcategories. All colours were tested at the printer in order to verify maximum differentiation for visual class discrimination. Six lines and four symbols were used to represent the infrastructure and other map elements, such as airports, sea ports, oil fields and towns. Draft maps were approved by FORMECU before final printing.

All map surround information, for each of the one hundred 1:250 000 map sheets, was created using Adobe Illustrator 5.5 software. All ARC/INFO files, at a scale of 1:250 000, were imported into Adobe Illustrator 5.5 by using a map import filter provided by Avenza's Map Publisher software. The ARC/INFO lines (vectors), polygons, and point information were changed to conform to the graphic legend format and the text was placed on the map.

Quality assurance/quality control (QA/QC) procedures involved the printing of check plots on the HP Design Jet plotter. Up to 3 check plots were printed for each map during the QA/QC process. All text names for towns, rivers and forest reserves were checked against existing road maps, publications, J.O.G. maps and the NIRAD maps. All details, including edge matching were rigorously checked for consistency. This included checks by both FORMECU and the Surveyor General's Office.

Completed digital map files were sent to a printing house for the preparation of films and plates for printing. Before the final printing, test plots were produced for confirmation of colour. One hundred (100) copies of each map were printed, packaged, and shipped to FORMECU.

5.3 1993/95 VEGETATION AND LAND USE MAPS

The methodology used in the preparation of the 1976/78 vegetation and land use maps was repeated, with some differences, for the preparation of the 1993/95 vegetation and land use maps. These differences are described below.

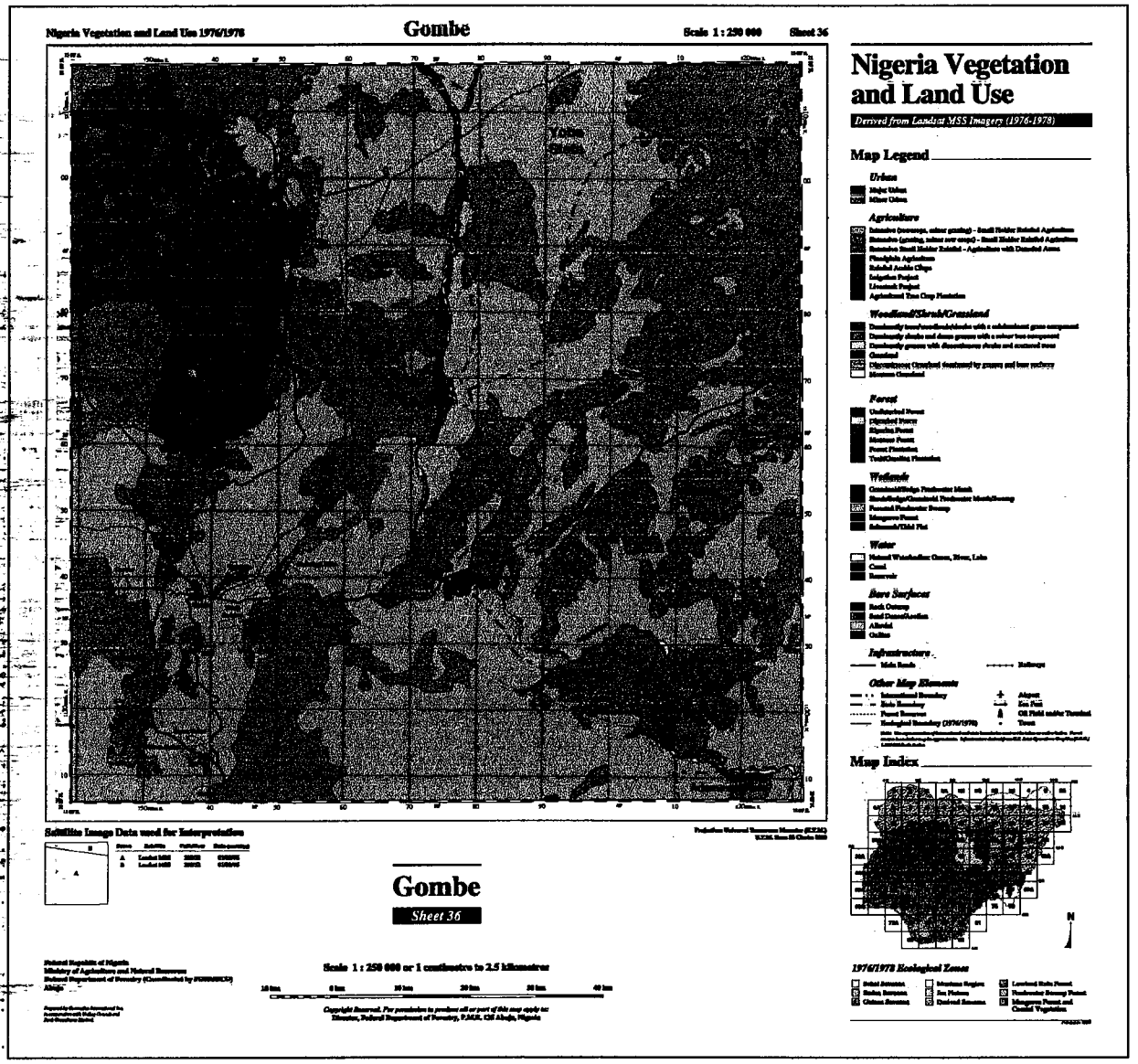


Figure 5.3 1976/78 Vegetation and Land Use Map.

Four types of satellite data were used to create the 1993/95 vegetation and land use maps. Data sets included:

Landsat TM, 1993 (3 scenes)
SPOT-XS, 1993/95 (285 scenes)
ERS-1 radar, 1993/95 (28 scenes)
JERS-1 radar, 1993/95 (6 scenes)

The dates chosen to represent the second time period were 1993 through 1995. An examination of archived imagery showed that only 3 Landsat TM scenes and 43 SPOT scenes were available for 1993. It was obvious that data would have to be collected through a mission specifically requested for this project. An investigation regarding the current satellites' capable of collecting optical data over Nigeria showed the Landsat satellites could no longer collect data over Nigeria because their links to communication satellites had failed. The only other options were SPOT and JERS-1 optical. Because the SPOT image satellite passed over Nigeria more often than the JERS-1 satellite, and because the price of imagery was less, it was decided to collect SPOT-XS data over Nigeria. The mission was programmed to start at the beginning of October, 1994 through to the end of March 1995.

In the Niger Delta area of Nigeria where there is persistent cloud cover, it was anticipated that the SPOT optical data of this area would not be useful due to cloud cover obscuring the earth's surface. However, the dry season of 1994/95 turned out to be an excellent year for collecting data. There were virtually no harmattans and the SPOT imagery collected was of superior quality. Therefore more data in southern Nigeria was collected than was anticipated. ERS-1 and JERS-1 radar data was ordered to fill in the areas were land cover was obscured by cloud cover.

5.3.1 Geometric Correction and Mosaicking (Landsat TM, SPOT-XS, ERS-1 and JERS-1 Radar Data)

Landsat TM

The three Landsat TM scenes were located in the Lake Chad area, northeastern Nigeria. Ground control points were collected using three sources: (1) J.O.G. maps; (2) georeferenced MSS images from 1976/78; and (3) overlapping areas in corrected TM scenes. More than 100 ground control points were collected per Landsat TM scene. Geometric correction was done using cubic convolution resampling from 30 to 20 m and a second order polynomial equation.

SPOT-XS

Geometric correction of the SPOT-XS imagery involved a two-step process where a quasi- corrected image was produced first, followed by the final, more precisely corrected image.

SPOT-XS scenes are provided with coordinate information that reference the sensor's relative ground position during the time of data capture. Reference coordinates are provided for the four corners and the centre point of the image. Although the coordinates are not always 100% precise, they provide a good geometric approximation. Therefore, for the first step of the correction process, the five points were used by the EASI/PACE program "SORTHO" to produce the quasi-corrected image. This process uses a nearest neighbour resampling (no change in pixel values) and a first order polynomial transform equation.

In the second step of the correction process, ground control points on the quasi-corrected SPOT-XS image were matched to points on: (1) georeferenced MSS images from 1976/78; (2) overlap areas on adjacent corrected SPOT-XS and Landsat TM imagery; and (3) J.O.G. maps. Approximately 130 ground control points were collected for each SPOT scene. The correction of the scenes was done using cubic convolution resampling and a second order polynomial transform equation. The 20 m spatial resolution was retained.

ERS-1 and JERS-1 Radar Data

Georeferencing the radar data was more complex than that of the optical imagery. A three-step procedure was required in order to process the information to make it suitable for vegetation and land use interpretation.

First, before the radar data could be geometrically corrected, Geomatics had to develop a methodology for reducing speckle and enhancing the textural differences between the vegetation and land cover categories within the scene. This process not only made the images easier to interpret but also aided in the collection of ground control points. The procedure developed by Geomatics adapted processes used for airborne radar data and applied them to the satellite radar data. This procedure is summarized as follows:

(1) apply three filters (F-gamma, high pass, and low pass) to the radar imagery resulting in the production of three channels of radar data
(2) apply an intensity, hue and saturation (IHS) transform to the filtered images to produce three new IHS images
(3) convert the IHS images back to red, green, and blue (RGB) and print as an enhanced colour composite

The second stage of the radar geometric correction process is similar to that used for SPOT. ERS-1 and JERS-1 radar data are also provided with coordinate information that reference the sensor's position during the time of data capture. These reference coordinates represent the four corners and the centre point of the image, approximately. These coordinates were used as ground control points to correct the imagery to an approximate ground location thus a quasi-corrected image was produced.

In the third step of the correction process, ground control points on the quasi-corrected SPOT-XS image were matched to points on: (1) georeferenced MSS images from 1976/78; (2) overlap areas

on adjacent corrected SPOT-XS and Landsat TM imagery; and (3) J.O.G. maps. Approximately 130 ground control points were collected for each radar scene. The correction of the scenes was done using cubic convolution resampling and a second order polynomial transform equation. The spatial resolution of the radar imagery was resampled from 25 to 20 m.

Mosaicking

In order to simplify the mosaicking of the wide variety of data sets used for the 1993/95 time period, all image data was resampled to a spatial or ground resolution of 20 m.

Depending on the position of the path and row of the satellite data, up to 9 scenes were used to produce a map sheet. Criteria used to determine image overlap priority included:

- absence of cloud cover or harmattan
- most recent scene for the time period (i.e., a 1995 image would take precedence over a 1993 image)
- early dry season imagery was preferable for interpretation than late dry season imagery
- SPOT-XS data always took precedence over radar data because it provided data from multiple electromagnetic bands which provided more information for interpreting vegetation and land use and provided easier comparison to the interpretation from the 1976/78 time period
- best image quality

Enhancement of the data involved histogram matching when scenes within a mosaic were collected from about the same time period. Mosaicking scenes from different years required each image to be enhanced on its own before it was mosaicked.

All image maps for 1993/95 were printed at a scale of 1:150 000. Landsat TM data was printed in the band combination of 4, 2, 1 as red, green, blue. SPOT-XS data was printed as bands 3, 2, 1 as red, green and blue. Processing of the radar imagery resulted in three final bands of radar being produced that were labelled as red, green and blue. These enhanced colour composite images still retained the appearance of a black and white image when plotted.

When printing a data set with a spatial resolution of 20 m, the optimal scale for discrimination of information in every pixel is about 1:80 000. When printing this data at a scale of 1:150 000, information is just dropped out. Geomatics did some experimenting in order to determine the best process for retaining the majority of the spatial information for interpretation at a scale of 1:150 000. Testing showed that the 20 m data had to be resampled to 50 m using cubic convolution resampling and then printed at a scale of 1:150 000.

5.3.2 Visual Interpretation of 1993/95 Satellite Data

The interpretation of 1993/95 vegetation and land use was done visually using 1:150 000 scale. Transparent acetate film was taped in place on the maps and corner registration marks were drawn and labelled with the UTM coordinates and appropriate zone. Fine, black ink drafting pens were used to delineate the polygons representing the different legend classes. The polygons were then labelled with red film markers.

Prior to interpretation, acetates with the 1976/78 vegetation and land cover interpretation were placed on top of the 1993/95 images to gain an understanding of the vegetation and land use and how it had changed over the time period of the study. This created consistency of interpretation between time periods. The interpretation of the 1993/95 time period then was done with the 1976/78 set aside for reference. Ideally, in areas where there was no change, the delineation of polygons from the second time period should be exactly the same as the first time period. However, due to human error with the method of manual interpretation used, this was not always the case. It was decided that this type of error was minimal and acceptable when looking at land use change on a state- and nation-wide basis.

Another source of error created during the interpretation phase was the fact that the SPOT-XS imagery used for the 1993/95 time period was a finer resolution than the MSS imagery used for the 1976/78 time period. The finer resolution allowed for a slightly finer detailed interpretation overall, but significantly improved the ability to interpret a few of the classes. In particular, urban areas and gully erosion were more evident and easier to delineate in the 1993/95 time period than they were in the 1976/78 time period. Between the two time periods, other studies have shown that there was an increase in area for these two land use classes, however, the results of our study will tend to exaggerate this increase due to the difference in resolution of the data. Since gully erosion in particular is of interest to environmental managers in Nigeria, it was decided that interpretation would take full advantage of this improved data source and provide the optimal interpretation of all classes even though this would create some error due to increased resolution of the data in the second time period.

During interpretation, the field survey results were used as a method of QA/QC to ensure interpretation accuracy. The data collection locations and legend classes were marked directly onto the mylar and taken into account during interpretation.

As another means of interpretation verification, Geomatics engaged Unilag Consult to verify interpretation completed by Geomatics. Sixteen, adjacent, 1:150 000 SPOT image maps, located on the western side of Nigeria, were sent to Unilag Consult for interpretation. Unilag's interpretation was then compared to that done by Geomatics. Overall, the vegetation and land use interpretation was very similar. Some differences did exist due primarily to different interpretations of the legend classes, these ideas were discussed and changes made where appropriate.

Interpretation of the radar data followed a slightly different procedure. For many of the areas there was significant overlap between the radar imagery and the spectral imagery. For these areas both the areas of spectral imagery and radar imagery were enhanced and printed on two different images. The spectral imagery, which the interpreters were very familiar with, was fully interpreted. Then the mylar from the interpreted area was placed on top of the overlapping radar image, so that the interpreter could identify the tone and texture that characterize each of the classes. This allowed the interpreter to confidently delineate the classes for the remaining area of the radar imagery.

As a further means of verifying the radar interpretation, Geomatics sent the interpreted maps sheets to Unilag Consult. Unilag conducted a small field survey to check the interpretation of the radar images. Results were sent back to Geomatics and only a few changes were required.

5.3.3 Input of Vegetation and Land Use Interpretation (1993/95) to the GIS Database

All the interpreted acetates were scanned using a Tangent 500-50TF drum scanner at 250 dpi, 1 bit, black and white mode. Each scanned map sheet was then converted into a 20 megabyte TIFF file using the Tangent software. As mentioned earlier, all land use class polygons were labelled using a red film marker. During the scanning process red lines were not recorded. Geomatics found that it took less time to manually enter the polygon label than to remove polygons and dangles resulting from label placement on the map.

TIFF files were converted to an ARC/INFO grid coverage, then transformed to a vector or line coverage. Spatial coordinates were then assigned to the registration marks. This allowed all the other vector data to be georeferenced in the same grid. All coordinates were in the Universal Transverse Mercator (UTM) projection.

A mathematically generated latitude/longitude grid was projected for the proper UTM zone and Spheroid (Clarke 1880) to establish individual neatlines for each of the map sheets. Vector coverages were brought into their corresponding neatlines and run through a series of clean-up routines developed by Geomatics. These routines removed dangles, added polygon centroids, and removed small, false polygons that were created when ARC/INFO converted the file from grid to vector. Each of the polygons was manually identified and labelled accordingly.

Each neatline map sheet was edge matched with its four adjacent maps. Maps bordering UTM zone boundaries were projected to the adjacent UTM zone to allow edge matching. After across zone edge matching was complete, maps were reprojected back to the correct UTM zone.

Quality assurance/quality control (QA/QC) procedures required each map to be plotted in colour with polygon codes and with a portion (approximately 5 cm) of the four adjacent maps sheets. All check plots were checked for correct labelling of polygons, georeferencing, and edge matching. Once

all four adjacent maps had gone through the same QA/QC process, they were prepared for final map production.

5.3.4 Infrastructure and Additional Map Elements

Infrastructure, which includes dominant roads and railways, was digitized from the 1993/95 SPOT-XS, Landsat TM and radar imagery. Canals through the Niger Delta area were also digitized from the recent imagery. A seamless road and rail vector (line) coverage, with attributes to identify roads from railways, was produced.

Game Reserves, National Parks, and Strict Nature Reserves were captured from the World Conservation Monitoring Centre database as a point or polygon coverage with the centroid or label point containing the name of the reserve or park.

Other map elements, such as state and international boundaries, were digitized from the 1992 administrative map and used on both the 1976/78 and 1993/95 maps. Hydrologic and urban annotation was updated using the 1994 road map.

5.3.5 Final Map Creation

The digital files used for preparing the final 1993/95 vegetation and land use maps were prepared at Geomatics International. Information incorporated on each map includes the following:

- map sheet name and number
- vegetation and land use derived from satellite data
- index map indicating the map location and current position of ecological zones
- legend
- satellite data index
- north arrow
- projection information and UTM zone
- scale
- copyright information
- list of companies involved in the mapping project

The map layout was designed at Geomatics with the assistance of representatives from FORMECU. An example of a final map and its layout are shown in Figure 5.4. The fonts, line weights and colours were chosen and applied to the GIS files. Two fonts, Times Roman and Helvetica, were used throughout the map and the legend. Thirty-five colours were chosen to represent the seven major land use categories and their subcategories. All colours were tested at the printer in order to verify maximum differentiation for visual class discrimination. Nine lines and five symbols were used to

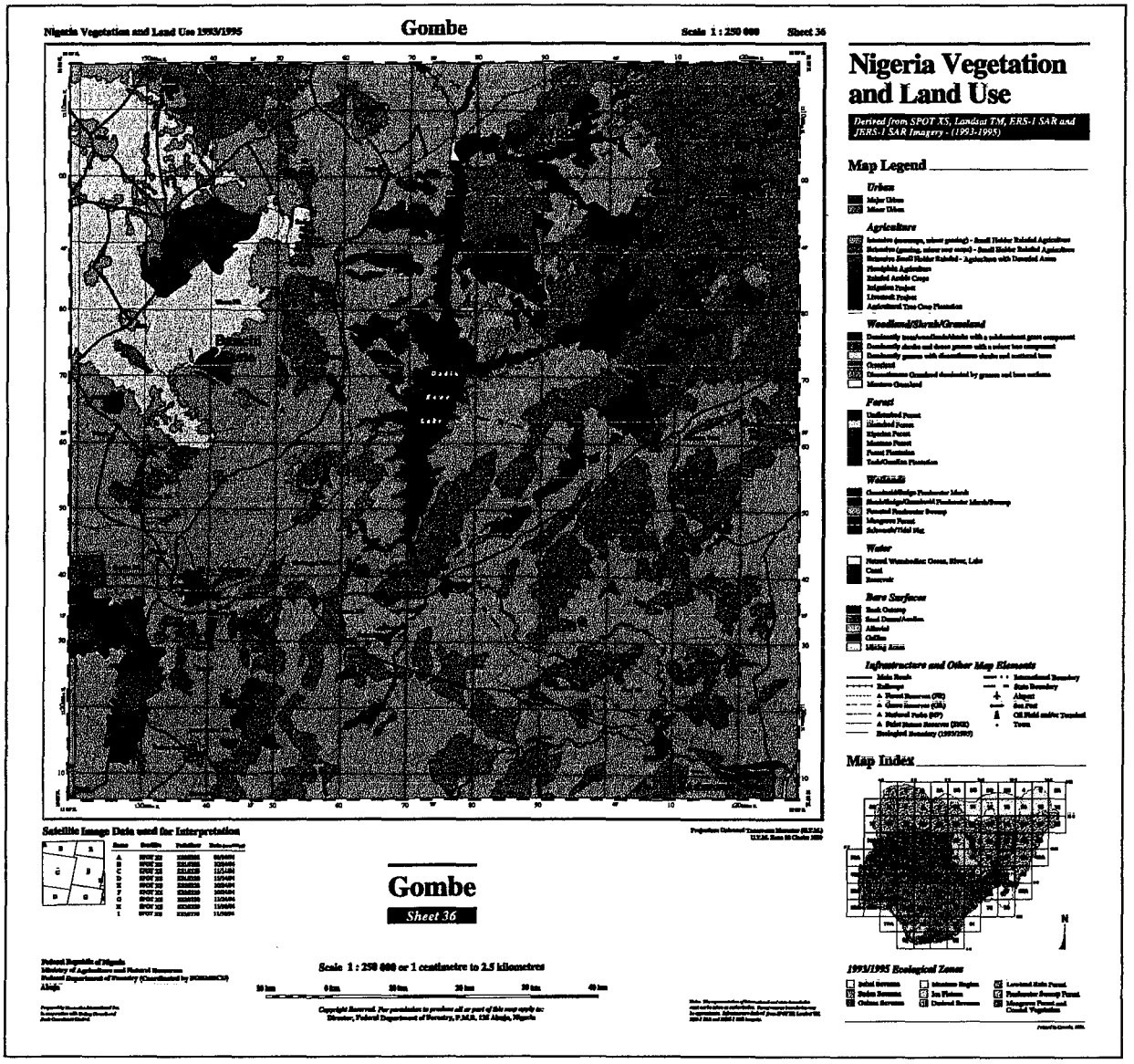


Figure 5.4 1993/95 Vegetation and Land Use Map.

represent the infrastructure and other map elements, such as airports, sea ports, oil fields and towns. Draft maps were approved by FORMECU before final printing.

All map surround information, for each of the one hundred 1:250 000 map sheets were created using Adobe Illustrator 5.5 software. All ARC/INFO files, at a scale of 1:250 000, were imported into Adobe Illustrator 5.5 by using a map import filter provided by Avenza's Map Publisher software. The ARC/INFO lines (vectors), polygons, and point information were changed to conform to the graphic legend format and the text was placed on the map.

Quality assurance/quality control (QA/QC)procedures involved the printing of check plots on the HP Design Jet printer. Up to 3 check plots were printed for each map during the QA/QC process. All text names for towns, rivers and reserves were checked against existing road maps, publications, J.O.G. maps and the NIRAD maps. All details, including edge matching were rigorously checked for consistency.

Completed digital files were sent to a printing house for the preparation of films and plates for printing. Before the final printing, test plots were produced for confirmation of colour. One thousand copies of each map were printed, packaged, and shipped to FORMECU.

5.4 NOAA AVHRR DATA

National Oceanographic Atmospheric Administration (NOAA) Advanced Very High Resolution Radiometer (AVHRR) data was acquired for five time periods. The years included: 1978, 1983, 1986, 1990 and 1995. Two types of AVHRR data were acquired. For the first two time periods, 1978 and 1983, only Global Area Coverage (GAC) data was available. GAC imagery has a ground resolution of 4 km by 4 km. Local Area Coverage (LAC) data, with a ground resolution of 1 km by 1 km, was acquired for 1986, 1990 and 1995. Although the entire country is covered by one AVHRR scene, two to six scenes were acquired for each time period to get as much cloud-free coverage as possible.

A trend analysis was undertaken based on the results of this process. This trend analysis is summarized in Section 7.3 and details major trends associated with vegetation and land use classes.

5.4.1 Geometric Correction and Mosaicking, AVHRR

Images from all the years were examined in order to find an image where most of the country was located towards the centre of the scene. This becomes important because the edges of the scene are increasingly distorted due to the curvature of the Earth. Also, imagery approaching the sides of the scene will not contain all the information (because of the Earth's curvature) and when corrected to

a flat surface, existing pixels are spread out to cover the area of interest.

In the majority of the AVHRR scenes, Nigeria was located within the right half of the scenes, thus earth curvature distortions are present. One 1986 AVHRR scene showed Nigeria to be in a more central location so this image was chosen to start the ground control point collection process.

Ground control points were collected matching the AVHRR image to the corrected SPOT-XS imagery. Once the first AVHRR scene was corrected, additional ground control points were collected from the corrected data. In order to georeference the images from different years, ground control points were also collected from images from different years. However, some scenes had too many curvature distortions that could not be removed. As a result it was not possible to perfectly correct all the AVHRR data sets to match one another. Therefore, the trend analysis was done on a visual basis rather than digitally calculated areas.

The images were georeferenced using cubic convolution resampling and a third or fourth order polynomial equation depending upon the amount of Earth curvature distortion. All of the images were resampled to a spatial resolution of 1 km.

5.4.2 Preparation of Normalized Vegetation Indices

NOAA AVHRR data have been used extensively for vegetation monitoring of large areas. Typically, the spectral bands used for this purpose are the channel 1 (Ch1) visible band (wavelength 0.58 to 0.68 μm) and the channel 2 (Ch2) near-infrared band (wavelength 0.73 to 1.1 μm). A mathematical combination of these two channels, termed the Normalized Vegetation Index (NVI) has been found to be a sensitive indicator of the presence and condition of green vegetation. The NVI is derived using the equation:

$$NVI = Ch2 - Ch1 / Ch2 + Ch1$$

This index is best suited for large areas because it compensates for changing illumination conditions, due to surface slope, aspect and other conditions.

This NVI ratio was applied to the corrected data to generate a range of digital numbers where the highest values represented the most vigourous vegetation. The lower values represented areas with little or no vegetation and the lowest values represented water. Cloud cover will also result in low values.

The next step was to group the NVI digital numbers to create an index of vegetation vigour. In order to do this Geomatics compared the 1993/95 vegetation and land use maps derived from the SPOT-XS data with the 1995 NVI data. The 1995 NVI digital numbers were grouped to coincide with the corresponding, detailed 1993/95 vegetation and land use maps. This resulted in a legend with 9

levels of vegetation vigour plus a water class. Level 1 represents the most vigourous vegetation and decreases to level 9 which is indicative of either no vegetation and/or wet soil.

Areas of undisturbed and disturbed forest and abundant tree crop agriculture in southern Nigeria had the highest NVI values and were represented in the vigour levels 1 to 3. Areas of remaining natural Guinea and Sudan vegetation were also represented by the higher vegetation vigour levels. Freshwater marshes, such as those within Lake Chad and along the Hadejia floodplain showed high vegetation vigour. The northern two-thirds of Nigeria, where agricultural activity is intense, was represented by NVI levels 4 through 6 because of less vegetation vigour. Areas of exposed sand dunes in the Lake Chad area and alluvial sands along the Niger and Benue rivers were represented by NVI levels 8 and 9. Areas where scattered patches of bare soil dominate the landscape were assigned to level 7.

Once a meaningful vegetation vigour legend had been defined, the NVI images from the earlier years were grouped accordingly. Scattered cumulous cloud cover was manually removed and vegetation vigour was interpolated for cloud-covered areas.

5.4.3 Preparation of Normalized Vegetation Index Maps

Normalized Vegetation Index maps were prepared at scale of 1:2 000 000 for each of the five years. Information on each map included:

- map title and scale
- vegetation vigour classes derived from AVHRR data
- legend
- marginal notes describing the NVI map series, ratio process and comments specific to each map
- projection information and latitude/longitude grid
- satellite image index
- major city, river and lake names
- copyright information

A scale of 1:2 000 000 was chosen because this represented the coarse resolution of the data well and the entire country could be presented on a single manageable size map which is useful for visually comparing time periods. An example of an NVI map is shown in Figure 5.5.

Producing these maps with the proper grid coordinates, and surrounding titles and indexes involved the use of four different software packages. First, using EASI/PACE image analysis software, the image file for each NVI map was used to create a TIFF file at 150 dpi. This file also included the surrounding Transverse Mercator and the latitude/longitude coordinates in a border. Next, this TIFF file was converted to an Encapsulated Postscript File (EPS) using Adobe Photoshop software. Then,

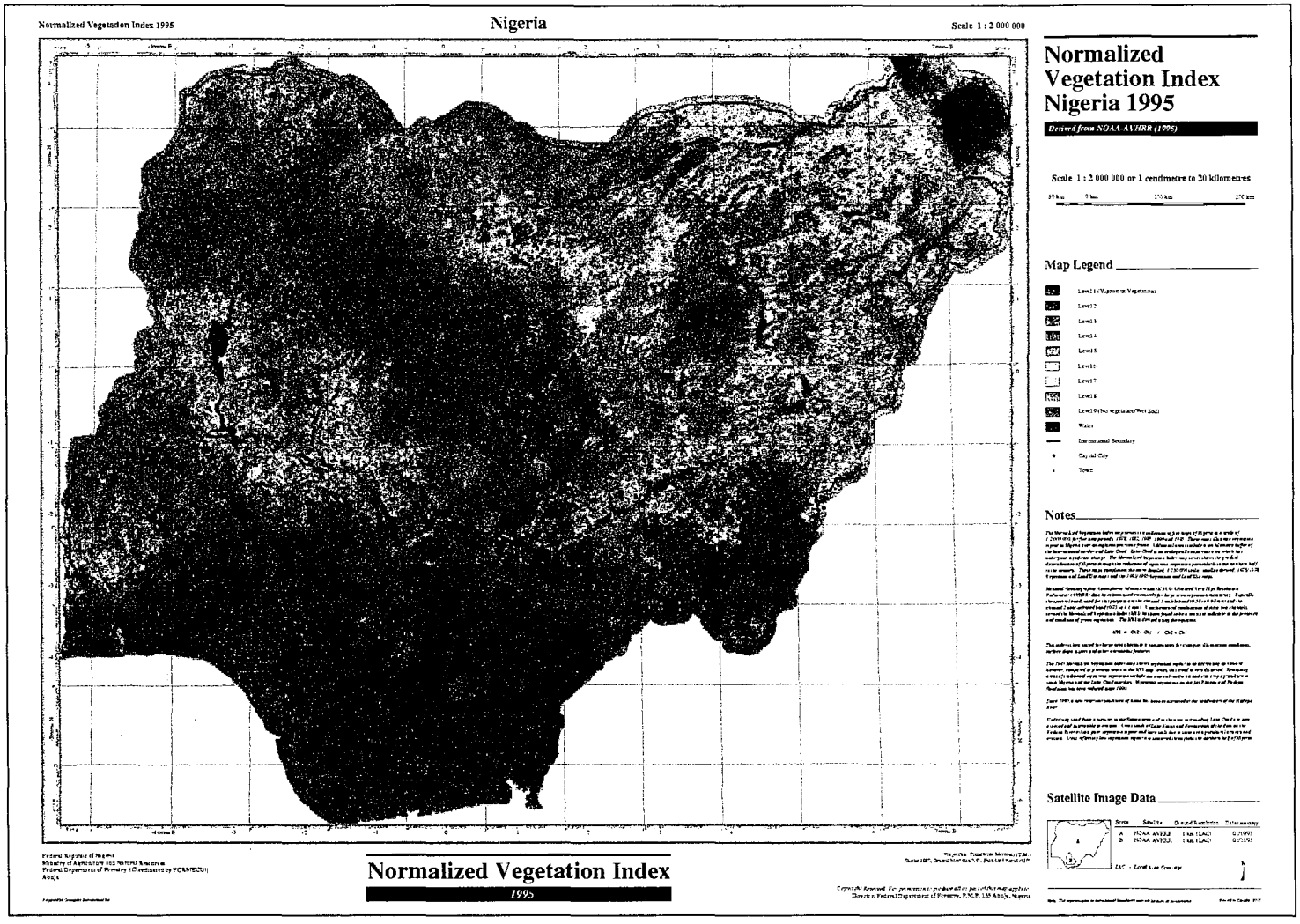


Figure 5.5 1995 Normalized Vegetation Index Map.

Adobe Illustrator 5.5 was used to create all map surround information such as titles, legend, indexes, scale bars and marginal notes. The NVI map, as an EPS file, was placed into the map surround. Adobe Illustrator was used to reformat the final map into postscript format.

In order to do QA/QC for these maps, "Image Alchemy" was used to convert the postscript file to a plot file for the HP Design Jet plotter. Draft maps were printed for QA/QC. Once complete, the postscript file was sent to a printing house for preparation of films and plates for printing. Test plots were produced by the printer for confirmation of colour. One hundred copies of each map were printed, packaged, and shipped to FORMECU.

5.4.4 Legend Development for Interpretation of the AVHRR Imagery

The NOAA AVHRR data was also used to interpret vegetation and land use classes similar to that done using the 1976/78 MSS and 1993/95 SPOT data. AVHRR colour composite images were plotted at scale of 1:1 000 000 using bands NVI, 2, and 1 as red, green, and blue respectively. An examination of the images revealed that the detailed interpretation done on the 1976/78 and 1993/95 images could not be repeated due to the course resolution of the AVHRR data. A new legend, based on what we believed could be visually discriminated, and also usable for trend analysis with the 1976/78 and 1993/95 information was developed (*see* Table 5.2). The legend classes used for the 1976/78 and 1993/95 maps were combined to make generalized classes appropriate for use with the AVHRR imagery.

Table 5.2 Vegetation and Land Use Legend Used for Mapping AVHRR Data.

Urban	
10	Urban (11, 12)
Agriculture	
200	Intensive and extensive agriculture (211, 212, 213)
23	Floodplain agriculture
20	All plantations (agriculture and forest and irrigation projects) (22, 24, 26, 25, 54, 541)
Woodland/Shrub/Grassland	
41	Dominantly trees/woodlands/shrubs with a subdominant grass component
42	Dominantly shrubs and dense grasses with a minor tree component
43	Dominantly grasses with discontinuous shrubs and scattered trees
30	Grassland (31,32)
33	Montane grassland
Forest	
50	Forest (51, 52, 53, 55)
Wetlands	
60	Freshwater marsh/swamp (62, 63)
61	Forested freshwater swamp
65	Mangrove forest (64)
Water	
70	Water (71, 73, 74)
Bare Surfaces	
80	All bare surfaces (81, 82, 83, 84)

5.4.5 Vegetation and Land Use Interpretation using AVHRR Imagery

The interpretation of vegetation and land use classes using AVHRR data at a scale of 1:1 000 000 was very difficult due to the coarseness of the resolution. Interpretation using AVHRR data alone would be subjective and not recommended. In order to provide a reasonable interpretation of vegetation and land use from the AVHRR imagery, Geomatics developed a methodology which made the interpretations from the SPOT-XS and MSS data for the 1993/95 and 1976/78 time periods an integral part of the AVHRR interpretation.

As a first step, national scale maps of Nigeria were printed using the vegetation and land use interpretation from the 1976/78 and 1993/95 time periods created from SPOT-XS and MSS data. The legend classes from the original interpretation were combined so that they reflected the classes used for AVHRR interpretation. These maps, derived from the SPOT-XS (1993/95) and MSS (1976/78) imagery, were used as an integral part of the interpretation process for the NOAA imagery from the same time periods. Once the AVHRR imagery was interpreted for the 1995 and 1978 time periods, these interpretations were used to interpret the AVHRR imagery of the next closest time periods.

To implement this interpretation process, the 1993/95 SPOT-XS derived vegetation and land use classification was printed on translucent paper and placed between the AVHRR image and a new acetate to be used for the AVHRR interpretation. Relationships between the vegetation and land use classes on the SPOT-XS classification and changes in colour, intensity, tones and textures on the AVHRR image were used to delineate the legend classes on the AVHRR image. The same procedure was repeated with the 1976/78 vegetation and land use classification on translucent paper and the 1978 AVHRR data.

Upon completion of the 1995 AVHRR vegetation and land use interpretation, this acetate was placed between the 1990 AVHRR image and the new interpretation acetate. The 1995 interpretation was used to successfully interpret the 1990 AVHRR imagery. Once again the 1990 AVHRR vegetation and land use interpretation was used in the same process to interpret the 1986 AVHRR data. The 1978 AVHRR vegetation and land use acetate was used to assist in the interpretation of the 1983 AVHRR data.

All vegetation and land use acetates were scanned, converted to ARC/INFO vector or line coverages, registered, and each land use polygon was labelled. All maps were printed for QA/QC checking and final results were incorporated as a vegetation and land use coverage in the database.

5.5 FIELD SURVEY

During the interpretation of the 1993/95 satellite imagery, a field survey was conducted to provide

ground truth of vegetation and land use which could be used as a reference tool to ensure and verify the accuracy of the satellite image interpretation.

The main field survey was undertaken during May 9 to 22, 1995. Thirty representative or problematic map sheets were selected in order to include representative areas of the country, and all vegetation and land use categories from each of the ecological zones within Nigeria.

At this point in time not all the 1993/95 SPOT and/or radar images were corrected or interpreted. Maps used for the field survey included a set of 30 image maps plotted at a scale of 1:150 000 with the 1976/78 vegetation and land use polygons and their corresponding labels overlain. These image maps were from the 1976/78 time period however, in the northern half of the country the 1993/95 image maps were used with the 1976/78 vegetation and land use polygons overlain. All maps used for the field survey were laminated in order to withstand the heat and humidity. The lamination also enabled one to easily write on the sheets to mark station locations and make notes.

The final products of the survey included:

1) annotated road maps along travel routes
2) data forms with
   a) natural tree/shrub species
   b) longitude/latitude reading (GPS)
   c) agricultural crops
   d) human activities
   e) map legend class(es)
3) field notebooks with general impressions on degree/nature of change, as well as land use activities between field sites
4) laminated image maps with accurate vegetation and land use identifications written along the route
5) site photographs

5.5.1 Equipment

Equipment used for the field survey included:

- 4 Magellan Global Positioning Units (GPS)
- 2 four-wheel drive Nissan Pathfinder vehicles
- 1 Toyota Corolla wagon
- cameras, field books, film
- 30 laminated image map sheets
- military surveillance aircraft (rented)

5.5.2 Set Up and Organization

Prior to the survey, a 3-day training coarse was held in Ibadan in early May. The instructors included Daryl Cowell (Geomatics Burlington, Canada), Ademola Omojola (University of Lagos, Nigeria), and Dele Olowokudejo (University of Lagos, Nigeria).

The training course comprised the following elements:

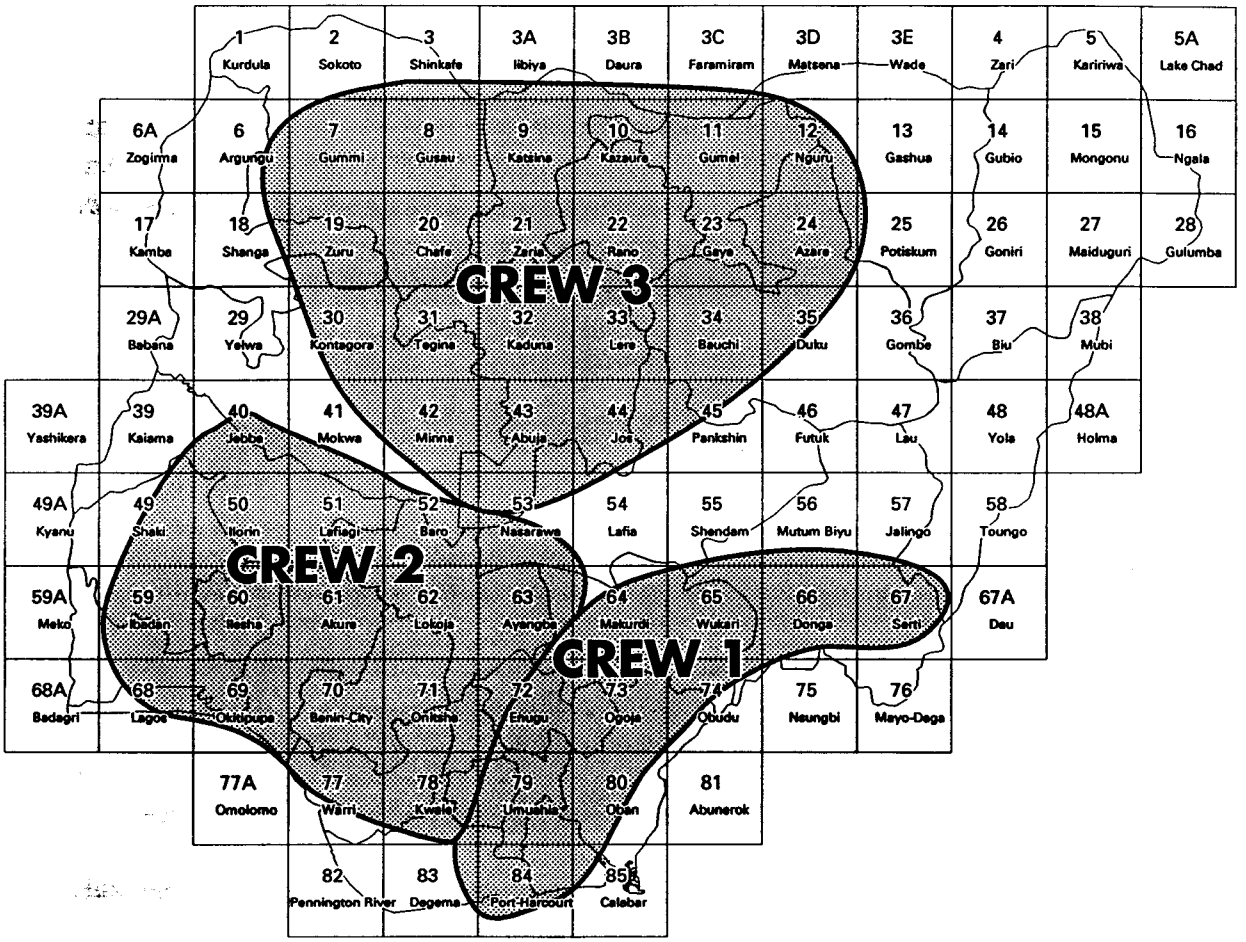
- review of the project background including a description of how the image maps were derived
- detailed description of all land use classes
- use of the GPS equipment
- methodology for collecting the data
  - outline of survey routes and the establishment of field stations for data collection
  - discussion of data forms and field notebooks – practised how to complete all forms and ensured all the required information would be collected
  - demonstration of the way to mark vegetation and land use classes on the image maps
  - discussion of the logistics of the survey routes
- botany and native vegetation descriptions

5.5.3 Description of Work and Areas of Focus

The staff were divided into three crews; one to cover the east, one for the west and one to cover the northern areas of Nigeria. Survey areas are shown in Figure 5.6. Each crew comprised four team members: a leader who was responsible for survey planning and also assisted with data and photo collection; a forester responsible for species identification; a GPS specialist to record station coordinates; and an individual responsible for recording all information. All the crew members worked together to determine the station or data collection points and determine the land use class present at each station.

Crews covering the east and west areas used the Nissan Pathfinders. A minimum of 20 stations were established and photographed for each map sheet. Vegetation and land use types, changes and unique features were recorded between stations.

The crew in the north followed the same procedure while using the Toyota Corolla wagon. In addition, large areas in the north were covered using a Donner-6 military surveillance aircraft. The Kano and Kaduna airports were used as a base for the airborne survey. Before each flight, transects and their coordinates were drawn on the satellite image maps. These transects were used to guide the flight path. During the flight, notes were written on the image map identifying vegetation, land use and obvious change. Photographs were taken of representative classes and special features and their GPS coordinates recorded.


1 Kurdula
2 Sokoto
3 Shinkafe
3A Ilbiya
3B Daura
3C Faramiram
3D Matsena
3E Wade
4 Zari
5 Kaririwa
5A Lake Chad
6A Zogirma
6 Argungu
7 Gummi
8 Gusau
9 Katsina
10 Kazaure
11 Gumel
12 Nguru
13 Gashua
14 Gubio
15 Mongonu
16 Ngala
17 Kamba
18 Shanga
19 Zuru
20 Chafe
21 Zaria
22 Rano
23 Gaya
24 Azare
25 Potiskum
26 Goniri
27 Maiduguri
28 Gulumba
29A Babana
29 Yelwa
30 Kontagora
31 Tegina
32 Kaduna
33 Lere
34 Bauchi
35 Duku
36 Gombe
37 Biu
38 Mubi
39A Yashikera
39 Kaiama
40 Jebba
41 Mokwa
42 Minna
43 Abuja
44 Jos
45 Pankshin
46 Futuk
47 Lau
48 Yola
48A Holma
49A Kyanu
49 Shaki
50 Ilorin
51 Lafiagi
52 Baro
53 Nasarawa
54 Lafia
55 Shendam
56 Mutum Biyu
57 Jalingo
58 Toungo
59A Meko
59 Ibadan
60 Ilesha
61 Akure
62 Lokoja
63 Ayangba
64 Makurdi
65 Wukari
66 Donga
67 Sarti
67A Dau
68A Badagri
68 Lagos
69 Okitipupa
70 Benin City
71 Onitsha
72 Enugu
73 Ogoja
74 Obudu
75 Nsungbi
76 Mayo-Dega
77A Omolomo
77 Warri
78 Kwale
79 Umuahia
80 Oban
81 Abunerok
82 Pennington River
83 Degema
84 Port Harcourt
85 Calabar
CREW 3
CREW 2
CREW 1
Field Survey Area (1995)

At the end of the survey period, a debriefing was held in Ibadan to review the procedure, identify problems, and discuss the nature of the data recorded. Problems identified included weather conditions and lack of access in the south. In the north, the difficulty in booking an aircraft for the flight survey was noted.

5.5.4 Field Notes

Upon return to Canada, the field notes were transposed into electronic format. These notes incorporated the information from the data sheets, field notebooks and images. All photographs were labelled. These notes and photographs were used during the interpretation of the 1993/95 satellite images. All stations were plotted on each map sheet and all survey information relevant to the map sheet reviewed. The survey information provided both ground truth and accuracy checks as well as an improved understanding and appreciation for the ecology and current human activity.

5.6 GIS DATABASE

5.6.1 Projection Parameters

There were two projections used in the process of compiling the data: Universal Transverse Mercator (UTM) and the Transverse Mercator (TM). All the data was originally captured in the UTM projection (either zone 31, 32, 33) with the land use data at a scale of 1:150 000 and the infrastructure data at 1:250 000. The land use data was captured in a one degree by one degree manner, the format of the existing Nigerian Topological Map series.

The individual map sheets were joined by UTM zone and then projected into a TM projection then the three zones were appended together. The data was projected into the TM projection in order to append the entire country coverage together.

The following is a break down of the projection parameters used for the various data layers:

TM (Transverse Mercator)

Units	metres
Spheroid	Clarke 1880
Scale Factor	0.9996
Longitude at Central Meridian	07 30 00
Latitude at Origin	10 00 00
False Easting	0.0
False Northing	0.0

UTM (Universal Transverse Mercator)

Zone	31,32,33
Units	metres
Spheroid	Clarke 1880

5.6.2 File Naming and Attribute Coding

The digital database delivered to the client contains a series of files representing the various layers of information used to create the vegetation and land use maps. All the files are provided in ARC/EXPORT format and are easily imported into GIS software. File names have been limited to eight characters or less for use on PC platforms.

The data has been exported in single precision accuracy and using compression. Note that some GIS software packages cannot import compressed ARC/EXPORT data. As ARC/EXPORT format files are made up of ASCII data, users should ensure that any file transfers (FTP) across drives/servers/PCs are carried out using the ASCII, rather than the binary, option.

The names of the ARC/EXPORT files are listed and described below.

LUSE##.E00 and ZONE##.E00 layers: The legend classes were all captured as polygons and attributed with a centroid. The arcs contain no relevant attributes but the centroid (label) was given a numeric code representing one of the possible legend classes. This attribute is stored as a numeric value in the field named "CODE" and can be related to a specific land use class as shown in Table 4.1.

ECO##.E00 layers: This is a polygon coverage with the ecological zone name stored in the centroid in a field named "ECONAME". The arcs in this field have no attributes.

FOREST##.E00 layers: This is a polygon coverage of the existing forest reserves digitized from the 1976 NIRAD maps. The polygons are attributed by a centroid with the reserve name in the "NAME" field.

PPOINT##.E00 layers: This is a point coverage of national parks/game reserves/strictnature reserves with the designation stated in the field "DESIGNATE" and the name in the "AREANAME" field.

PPOLY##.E00 layers: This is a polygon coverage of national parks/game reserves/strict nature reserves with the designation stated in the field "DESIGNATE" and the name in the "AREANAME" field attributed to the centroid. The arcs have no attribute assigned.

ROADS##.E00 layers: This layer contains the infrastructure such as roads/rail/cities/towns/airports/seaports/oil fields or terminals. This layer was captured as a line and point theme with the attributes stored as follows:

ARCS: attributes stored in the "ROADS##-ID" field

ROADS##-ID	ATTRIBUTE
1	- main roads
3	- railroads

POINTS: attributes stored in the "ROADS##-ID" field and site name in the "NAME" field

ROADS##-ID	ATTRIBUTE
1	- city/towns
3	- airports
4	- oil rigs
5	- sea ports

STATE##.E00 layers: The individual UTM zone coverages were captured as a line coverage and the TM coverage as a line and point coverage. The arcs in the UTM zone coverages area coded in the "STATE##-ID" field as follows:

STATE##-ID	ATTRIBUTE
1	- state boundaries
2	- national boundary

The Transverse Mercator coverage contains the state arcs/ecozone arcs and points to identify state names. The arcs in the Transverse Mercator coverage area coded in the "STATE##-ID" field as follows:

STATE##-ID	ATTRIBUTE
1	- state boundaries
2	- national boundary
3	- ecological zones

The points contain the state name in the "STATES" field.

NOAA##.E00 layers: This is a polygon coverage with the attribute stored on the centroid in the "CODE" field. The code was captured as a numeric number that is related to a specific legend class as shown in Table 5.2.

Table 5.3, 5.4 and 5.5 outline the individual layers found in the GIS database. Only the more up-to-date information was provided for the infrastructure, state boundaries, reserves and ecological zones layers.

Table 5.3 GIS Database – 1976/78 Vegetation and Land Use Map Series.

File Name	Content	Data Source	Projection
Luse76.E00	Land Use	Interpreted from Landsat MSS imagery	Transverse Mercator
Zone31.E00	Land Use	Interpreted from Landsat MSS imagery	UTM Zone 31
Zone32.E00	Land Use	Interpreted from Landsat MSS imagery	UTM Zone 32
Zone33.E00	Land Use	Interpeted from Landsat MSS imagery	UTM Zone 33

Table 5.4 GIS Database – 1993/95 Vegetation and Land Use Map Series.

File Name	Content	Data Source	Projection
Eco31.E00	Ecological Zones	Interpreted from SPOT/Landsat TM/ERS1 imagery	UTM Zone 31
Eco32.E00	Ecological Zones	Interpreted from SPOT/Landsat TM/ERS1/JERS imagery	UTM Zone 32
Eco33.E00	Ecological Zones	Interpreted from SPOT/Landsat TM/ERS1 imagery	UTM Zone 33
Eco93.E00	Ecological Zones	Interpreted from SPOT/Landsat TM/ERS1 imagery	Transverse Mercator
Zone3193.E00	Land Use	Interpreted from SPOT/Landsat TM/ERS1 imagery	UTM Zone 31
Zone3293.E00	Land Use	Interpreted from SPOT/Landsat TM/ERS1/JERS imagery	UTM Zone 32
Zone3393.E00	Land Use	Interpreted from SPOT/Landsat TM/ERS1 imagery	UTM Zone 33
Luse93.E00	Land Use	Interpreted from SPOT/Landsat TM/ERS1 imagery	Transverse Mercator
Forest31.E00	Forest Reserves	Digitized from the NIRAD Maps	UTM Zone 31
Forest32.E00	Forest Reserves	Digitized from the NIRAD Maps	UTM Zone 32
Forest33.E00	Forest Reserves	Digitized from the NIRAD Maps	UTM Zone 33
Forest93.E00	Forest Reserves	Digitized from the NIRAD Maps	Transverse Mercator
Ppoint31.E00	National Parks/Game Reserves - points	Digital data from World Bank database	UTM Zone 31
Ppoint32.E00	National Parks/Game Reserves - points	Digital data from World Bank database	UTM Zone 32
Ppoint33.E00	National Parks/Game Reserves - points	Digital data from World Bank database	UTM Zone 33
Ppoint93.E00	National Parks/Game Reserves - points	Digital data from World Bank database	Transverse Mercator

File Name	Content	Data Source	Projection
Ppoly31.E00	National Parks/Game Reserves - polygons	Digital data from World Bank database	UTM Zone 31
Ppoly32.E00	National Parks/Game Reserves - polygons	Digital data from World Bank database	UTM Zone 32
Ppoly33.E00	National Parks/Game Reserves - polygons	Digital data from World Bank database	UTM Zone 33
Ppoly93.E00	National Parks/Game Reserves - polygons	Digital data from World Bank database	Transverse Mercator
Road31.E00	Infrastructure - line/point	Captured from SPOT/Landsat TM/ERS1 imagery	UTM Zone 31
Road32.E00	Infrastructure - line/point	Captured from SPOT/Landsat TM/ ERS1/JERS imagery	UTM Zone 32
Road33.E00	Infrastructure - line/point	Captured from SPOT/Landsat TM/ERS1 imagery	UTM Zone 33
Roads93.E00	Infrastructure - line/point	Captured from SPOT/Landsat TM/ERS1 imagery	Transverse Mercator
State31.E00	State Boundaries - line/point	Digitized from Satode 1992 map	UTM Zone 31
State32.E00	State Boundaries - line/point	Digitized from Satode 1992 map	UTM Zone 32
State33.E00	State Boundaries - line/point	Digitized from Satode 1992 map	UTM Zone 33
State.E00	State Boundaries - line/point	Digitized from Satode 1992 map	Transverse Mercator

Table 5.5 GIS Database – Normalized Vegetation Index Map Series.

File Name	Content	Data Source	Projection
Noaa78.E00	1978 Land Use	Interpreted from NOAA imagery	Transverse Mercator
Noaa82.E00	1983 Land Use	Interpreted from NOAA imagery	Transverse Mercator
Noaa86.E00	1986 Land Use	Interpreted from NOAA imagery	Transverse Mercator
Noaa90.E00	1990 Land Use	Interpreted from NOAA imagery	Transverse Mercator
Noaa94.E00	1995 Land Use	Interpreted from NOAA imagery	Transverse Mercator

5.6.3 Ancillary Data

In order to augment the vegetation and land use information derived from the satellite data, additional ancillary data was entered into the database. This involved the digitization of several maps and their corresponding legends. Ancillary information incorporated into the GIS database included:

- geology map
- soils map
- mean annual rainfall
- mean annual temperature
- cultural areas
- relief and drainage
- population density
- groundwater provinces (hydrogeology)

All vector coverages plus plot files for printing any of these maps on the HP Design Jet plotter are included as part of the database.

5.7 SATELLITE IMAGE MAPS

Satellite image maps, at scale of 1:250 000 were required as an output product. Producing these maps with the proper grid coordinates, and surrounding titles and indexes was a process that required the use of four different software packages.

First, using EASI/PACE image analysis software, the image file for each map sheet was enhanced. When mosaicked images were vastly different (i.e., SPOT-XS and a radar image) separate enhancements were prepared. Once the image, at full 20 m resolution, was permanently enhanced, a TIFF file was created at 150 dpi. This file also included a surrounding UTM and latitude/longitude border.

This TIFF file was converted to an Encapsulated Postscript File (EPS) using Adobe Photoshop software.

Adobe Illustrator 5.5 was used to create all map surround information such as titles, legend, indexes and scale bars. The enhanced satellite image, as an EPS file, was placed into the map surround. Adobe Illustrator was used to reformat the final map into postscript format.

All final maps were printed on the HP Design Jet plotter. In order to do this the postscript file was converted to a plot file using Image Alchemy software. Plot files for all the satellite imagery were included as part of the database.

Ten copies of each of the 100 map sheets were printed, laminated, packaged and shipped to FORMECU.

5.8 PREPARATION OF DIAPOSITIVE IMAGES

Diapositive films, showing all the 1993/95 imagery at a scale of 1:800 000 was another deliverable product. SPOT, Landsat TM and radar imagery was mosaicked into six files with a pixel resolution of 50 m. It was decided to produce six diapositives at a scale of 1:800 000 because by dividing the country down the middle and each half into three equal parts also roughly reflected the ecological zones which in turn resulted in less enhancement problems.

Mosaics were created, enhanced and written as a TIFF file at 150 dpi. The TIFF file also included geographic coordinates and map title. Diapositives were created directly from the TIFF file.

Five copies of each of the 6 diapositives were produced, and shipped to FORMECU.

5.9 DELIVERABLES

Maps, reports and digital files were all required as deliverables for the Assessment of Vegetation and Land Use Changes in Nigeria Between 1976/78 and 1993/95. A list of all deliverables is provided below.

Maps

- 1976/78 Vegetation and Land Use Map Series, 1:250 000 (100 copies of each map)
- 1993/95 Vegetation and Land Use Map Series, 1:250 000 (1000 copies of each map)
- Normalized Vegetation Index Map Series, 1:2 000 000 (100 copies of each map)
- 1993/95 Satellite Image Map Series, 1:250 000 (10 copies of each map)
- 6 diapositive films of the 1993/95 imagery, 1:800 000 (5 copies of each)

Digital Files

- geographic information system (GIS) database (included all vector files, satellite imagery both raw and geometrically corrected according to map sheet, and plot files for all prepared maps)
- ancillary data

Reports

- technology transfer and training manuals
- report and procedural manual
- slide presentation

6.0 Training And Technology Transfer

On-the-job training was provided to FORMECU counterpart staff throughout the study. This included training in field inventory, legend determination for the maps, both manual and computerized satellite image analysis, map preparation, GIS digitizing and GIS analysis. In addition, FORMECU management was provided with introductory training in remote sensing, GIS and their applications to vegetation and land use analysis, as well as project management training.

The Canadian International Development Agency (CIDA) provided supplemental funding for technology transfer. This allowed for the purchase of GIS and remote sensing hardware and software, as well as for training in both Canada and Nigeria in their use and application. Consequently, the objective of these activities was to make the client self-sufficient upon the completion of the project so that they would be able to effectively use the databases and the technology that were provided by the consultant.

Training and technology transfer took place in five steps as outlined below:

(1) *Equipment Acquisition*: Acquired all hardware and software needed to set up a GIS and remote sensing laboratory in Nigeria. Set up all the equipment and configured the system in Canada.

(2) *Courses in Canada*: Conducted initial comprehensive training courses in Canada using the equipment to be sent to Nigeria. Basic skills were introduced to all trainees.They were then split into two groups depending on their area of expertise or specialization. These groups focused on either GIS or remote sensing.

(3) *FORMECU Laboratory Set Up*: Shipped all hardware and software to Ibadan, Nigeria and set up a GIS and Remote Sensing Laboratory in Nigeria.

(4) *Courses in Nigeria*: Conducted refresher courses for the trainees who participated in the earlier training courses. The focus of this training was on independent work.

5) *On-Site Support*: Provided on-site support on a weekly basis for eight weeks.

6.1 COMPUTER SYSTEM ACQUISITION

A list of all computer hardware and software purchased for FORMECU is provided in Table 6.1.

Table 6.1 List of all Computer Hardware and Software Assembled in Nigeria at FORMECU.

DESCRIPTION	Serial Number
RISC 6000 25T COMPUTER	26-41721
POWERDISPLAY 17	26-21289
EXTERNAL 4mm TAPE	26-01526
KEYBOARD	5080959
MEMORY CARD 8MB	B14X3000316
MEMORY CARD 8MB	B14X3000322
MEMORY CARD 8MB	B14X3000318
MEMORY CARD 8MB	B14X3000312
HARD DISK 2GB	130107726CMS
GRAPHICS CARD 8bit	A16H548504R
PC COMPUTER	91003451
MONITOR 14"	H1BD902198
MOUSE	1312682
KEYBOARD	J5620118
PC COMPUTER	91003436
MONITOR 14"	H1BD901570
MOUSE	996859
KEYBOARD	J8637395
PC COMPUTER	91003441
MONITOR 14"	H1BD901555
MOUSE	1312719
KEYBOARD	J4609736
TRANSFORMER	N/A
TRANSFORMER	N/A
UPS	S94114391003
UPS	S94114391008
DIGITIZING TABLE	22361
DIGITIZER CONTROLLER	2592
TYDIG SOFTWARE	2333
TYDIG SOFTWARE	2334
4 mm TAPES (30)	N/A
POWER CORDS (2)	N/A
POWER BARS (2)	N/A
OS/2 SOFTWARE	N/A
2 LAPTOPS	N/A
GPS UNITS	N/A
DESIGNJET PLOTTER	N/A
EASI/PACE	N/A
MS-PROJECT	N/A
MODEM	N/A

6.2 COURSES IN CANADA

Four FORMECU representatives were designated to study GIS and remote sensing in Canada from December 4, 1994 to January 10, 1995. These FORMECU representatives and their areas of specialization included:

Dr. Sanni D. Usman	Remote Sensing Specialist
Mr. Christopher E. Ameh	Forest Officer (GIS)
Mr. Cyril U. Nwagbara	Forest Officer (Thematic Mapping)
Mr. Rasak K. Adekola	Forest Officer (Digitizing)

These individuals participated in user training courses and were provided with training materials in order to make it possible for them to train their coworkers in Nigeria. All the training manuals used Nigerian data and information from databases created by Geomatics. Basic concepts and skills were taught to the entire group, which was subsequently split into two groups specializing in either GIS or remote sensing. Courses focused on project work — databases were created and manipulated and maps printed.

The six training manuals produced through the CIDA-funded contract included:

(1) Overview of GIS and Remote Sensing
(2) UNIX and System Administration
(3) Introduction to SPANS MAP
(4) TYDIG
(5) Introduction to SPANS GIS
(6) Introduction to EASI/PACE

In addition, two FORMECU management personnel were given introductory training in remote sensing, GIS and their uses. They were also trained in computerized project management methods. The management staff trained in Canada were:

Mr. Peter Papka	Head FORMECU
Dr. Francis Akinsanmi	EMP Project Coordinator

6.3 FORMECU LABORATORY SET UP

Hardware and software for the GIS and remote sensing laboratory were crated and shipped to Ibadan, Nigeria in February, 1995. Peter Ferwerda, from Geomatics International, installed and configured the system during March, 1995, at the FORMECU offices in Ibadan.

6.4 COURSES IN NIGERIA

Mr. Ferwerda provided follow-up training in systems management while in Nigeria. As well, Andrew Dyk visited Nigeria during July, 1995, to fix system configuration problems and provide refresher training courses in GIS and remote sensing to the participants of the earlier courses in Canada. This training session focused on a project that encouraged independent work. The project directly applied to the types of projects they would be conducting in the future. As part of this training, participants digitized a plantation, created a database, added thematic data and created a number of maps.

6.5 ON-SITE SUPPORT

On-site support was supplied by Unilag Consult of Lagos throughout the study. This included provision of professional botanists, geographers, sociologists and environmentalists from the University of Lagos staff. They had extensive responsibilities in the field inventory program. One member of the Geography Department, Ademola Omojola, took part in the Canadian remote sensing/GIS training and was responsible for periodic training updates at the FORMECU site in Ibadan.

7.0 Socio-Economic and Land Use Analysis - National Overview

7.1 SOCIO-ECONOMIC OVERVIEW

7.1.1 Introduction

The history of the Nigerian people extends backward in time for some three millennia. Their history evolved from a variety of traditions, but many of the most outstanding features of modern society reflect the strong influence of the three regionally dominant ethnic groups - the Hausa in the north, the Yoruba in the southwest, and the Igbo in the southeast.

There are several dominant themes in Nigerian history that are essential in understanding contemporary Nigerian politics and society (Metz 1992). Firstly, the spread of Islam through the northern part of the country and much later in southwestern areas. The creation of the Sokoto Caliphate in the Jihad (holy war) of 1804-10 brought most of the northern region and adjacent parts of Niger and Cameroon Republics under a single Islamic government. This history helps to account for the dichotomy between north and south and for the divisions within the north that have been so strong during the colonial and post-colonial eras when Christianity was introduced.

Secondly, the slave trade, within Nigeria and across both the Sahara Desert and the Atlantic Ocean, had a profound influence on Nigerian society, including land use and settlement patterns. Within Nigeria, slavery was widespread, with social implications that are still evident today. Indeed, many ethnic distinctions, especially in the middle belt, were reinforced because of slave raiding and defensive measures that were adopted for protection against enslavement. The subsequent settlement pattern changes and the internal movement of peoples between regions and to the cities have necessitated the reassessment of ethnic loyalties, which in turn has been reflected in both politics and religion.

Thirdly, the colonial era was relatively brief, lasting approximately six decades, depending on the part of Nigeria, but it unleashed such rapid change that the full impact was still felt in the contemporary period. The expansion of agricultural products as the principal export earner and the corresponding development of infrastructure resulted in severely distorted economic growth that has subsequently collapsed.

In the almost four decades since the independence of Nigeria in 1960, Nigeria has experienced unstable governments, the civil war of 1967 to 1970, and continuing economic crisis. Such experiences, combined with rapid population growth, have profoundly influenced settlement patterns, land use and consequent vegetation change.

7.1.2 Population and Human Settlement

The National Census of 1963 estimated the nation's population at 56 million people. By 1980, the population had grown to approximately 71 million, and in 1993, it was estimated at 104 million (World Bank 1995), although the 1991 Nigerian census estimate was only 89 million people. The CIA World Factbook lists the Nigerian population as 104 million people in July 1996, with a 3.1% annual growth rate (CIA 1996). The majority of the urban centres are concentrated in the southwest where the Yoruba peoples live. Other major urban centres are located along the country's two main railway lines. The three main centres of very high population density each coincide with the core areas of the country's three major ethnic groups. Table 7.1 indicates population and density estimates by state.

Table 7.1 Population and Density Estimates by State, 1993 (World Bank 1995).

State	Population	Density (people / km²)
Abia	2 300 000	340
Adamawa	2 100 000	57
Akwa Ibom	2 600 000	375
Anambra	2 800 000	590
Bauchi	4 300 000	65
Benue	2 800 000	91
Borno	2 600 000	35
Cross River	3 800 000	190
Delta	2 600 000	153
Edo	2 100 000	107
Enugu	3 200 000	252
FCT	400 000	58
Imo	2 500 000	492
Jigawa	2 800 000	121
Kaduna	4 000 000	93
Kano	5 600 000	274

State	Population	Density (people / km²)
Katsina	3 900 000	161
Kebbi	2 200 000	59
Kogi	2 100 000	74
Kwara	1 600 000	47
Lagos	5 700 000	1479
Niger	2 500 000	35
Ogun	2 300 000	143
Ondo	4 000 000	196
Osun	2 200 000	232
Oyo	3 500 000	125
Plateau	3 300 000	60
Rivers	4 000 000	206
Sokoto	4 400 000	67
Taraba	1 500 000	26
Yobe	1 400 000	31

The most densely populated areas have a population density of 500 to 1500 persons per km². There are two very densely populated areas in the north and two in the south: the areas surrounding Kano and Sokoto cities in the north and the areas surrounding Lagos and Ibadan cities in the southwest.

The regions around Kano and Sokoto cities have been intensely farmed and are now characterised by a shortage of arable land, extreme fragmentation of farmland and reduced fallows. Hence, there is a growing migration of people from these areas in search of paid labour in the towns, and in the cocoa and rubber growing areas of the southwestern states. In the Lagos and Ibadan areas, individual tenure has replaced traditional systems of communal land tenure, farm sizes are very small and few

farmers produce enough food to feed their families. These areas typically suffer from extensive gully and sheet erosion.

The areas of medium density (i.e., 200 to 500 persons per km^2) are located primarily in the middle belt, around the Jos Plateau and the Mubi district of the Adamawa Highlands. Historically, these two hilly zones provided refuge for people fleeing from Jihad warriors and slave raiders. Also, the discovery of tin before 1920 and the subsequent development of mining industries in the area have attracted many migrant workers to the Jos Plateau.

Large areas of Nigeria are sparsely settled or virtually uninhabited (i.e., less than 200 persons per km^2). These areas include the Niger Delta and the Great Mubi Plain which are flooded for many months of the year, as well as the Cross River district, the Lake Chad Basin and the grasslands of Oyo, Borgu and Kontagora. Only those sections accessible by road have higher population densities. The relative emptiness of these areas has facilitated the establishment of large forest reserves and national parks.

7.1.3 Ethnic and Cultural Diversity

There are an estimated 480 ethnic groups and languages in Nigeria (Grimes 1996). In the days of infrequent contact among the different ethnic groups, each had a distinct territory and a shared background, language, religion, philosophy, political structure and economy. However, with increased contact among groups and the diffusion of ideas, the previously sharp boundaries of these territories are being obscured.

The three major ethnic nations of Nigeria are the Hausa concentrated in the north, the Yoruba of the southwest, and the Igbo in the southeast. The Hausa (and Fulani) are predominantly Muslim and speak the Hausa language. Many Hausa people continue to be subsistence farmers, with a few practising mixed farming (e.g., agropastoralism), while others are skilled craftsmen, such as leather workers. The Fulani are generally agropastoralists. Hausa/Fulani language and culture has influenced many other parts of Nigeria, particularly to the south.

The Yoruba nation is in the southwestern area of Nigeria. Most men are involved in farming activities, as central Yorubaland is the main cocoa growing part of the country. In contrast, Yoruba women are often skilled traders and heavily involved in the markets. Urbanisation has significantly influenced Yoruba culture and political organisation, however, traditional chiefs still maintain political control in many rural areas. In northern areas, Yoruba have been influenced by the Fulani; therefore, approximately 40% of the Yoruba are followers of Islam.

The Igbo cultural area is less homogenous than the Hausa or Yoruba areas. There are few urban settlements but the rural areas are densely populated with villages. Farming is the major economic

activity among the Igbo, with crops such as yams, cassava, oil palm and rice being dominant. Many inhabitants of the area, especially those in the working age group, have migrated to other parts of Nigeria partly because of the high population density in the area and the consequent shortage of arable farm land. Generally, Igbo people who have migrated to other areas are actively involved in trading at various levels.

7.1.4 Economy

The Nigerian economy has been characterised by many abrupt changes due to political instability (e.g., the civil war of 1967-70), political crises, and unstable world oil prices. Major exports include crude petroleum and cocoa, while primary imports include machinery, transportation equipment, chemicals, manufactured goods, food and live animals. Major trade partners are the United States, Britain, other European Economic Community countries, Japan, and Canada.

A major feature of Nigeria's economy in the 1980s, as in the 1970s, was its dependence on petroleum, which accounted for 87% of export receipts and 77% of the federal government's revenue in 1988. Nigeria was the world's sixth largest oil exporter in 1988. Falling oil output and prices contributed to another noteworthy aspect of the economy in the 1980s; a decline in per capita real gross national product (GNP) that persisted until oil prices began to rise in 1990. Indeed, the yearly GNP per capita has decreased 4.8% from 1980 to 1987, a decrease that led to Nigeria's classification by the World Bank as a low-income country in 1989. The World Factbook 1996 (CIA 1996) estimated the GDP per capita as US$1300 in 1995. Table 7.2 summarizes the Nigerian economic indicators.

Table 7.2 Economic Overview of Nigeria (CIA 1996).

Economic Indicator	Nigerian Statistic	Date of Estimate
Total GDP	US$ 135.9 billion	1995
GDP Real Growth/ Annum	2.6%	1995
GDP per Capita	US$ 1 300	1995
GDP by Sector: - Agriculture - Industry - Services	 38% 22% 40%	 1994
Inflation Rate / Annum	57%	1994
Unemployment Rate	28%	1992
Federal Budget - Revenues - Expenditures	 US$ 2.7 billion US$ 6.4 billion	 1994
National Debt	US$ 32.4 billion	1994
Exports	US$ 9.9 billion	1993
Imports	US$ 7.5 billion	1993

Note: The CIA (1996) uses the official Naira Dollar exchange rate of 1 US$ = 22 ₦ for 1996, while the street value at the time of this report was about 1 US$ = 85 ₦.

7.1.5 Land Tenure

Land tenure in Nigeria reflects the superimposition of modern law on traditional (customary) law. Traditionally, land tenure systems in Nigeria were based on customary laws under which land was considered community property. Therefore, while land control resided within the community, an individual had rights to farm the land belonging to his family or the community. Individuals could possess lands as long as they used it to the benefit of society. Moreover, land could be passed on to heirs or pledged to satisfy a debt, but could not be sold or mortgaged. However, while this was generally relevant for many rural areas, it is important to point out that there were numerous local practices and norms associated with land tenure.

Customary tenure remained the principal form of landholding throughout Nigeria until the early 1970s. However, growing population density, increased urbanization, the introduction of cash crops, and a trend towards transactions in landed property led to the establishment of permanent land rights in many areas of Nigeria, particularly in the south (Osemeobo 1989, Renne 1995). During the 1970s, individuals and business began to invest heavily in real estate, especially in newly urbanised areas. This resulted in an escalation in land prices. In the south, customary owners leased their farm land at very high profits.

In response to a potential crisis in land distribution, the Nigerian government established an Anti-Inflation Task Force in 1975 that raised the possibility of formulating a uniform land reform policy. The subsequent report, which recommended nationalization of all lands was accepted in 1978. In accordance with the Act, all rural and urban land is held in trust by the state, with state governors having authority over urban lands and local "Land Allocation Advisory Committees" controlling rural lands (Renne 1995). Rural land, although inherited on the basis of customary rights and held according to customary land tenure practices, is claimed on the basis of occupancy which replaces any previous forms of title (Renne 1995). Therefore, the objectives of the Act were to:

- rationalize customary tenure so as to make land ownership more secure, uniform and available as security for raising capital
- undermine the authority of groups with vested interests in maintaining customary land tenure in favour of more socially just forms of land ownership and distribution

Despite these objectives, the administration of the Act has proven complicated and many transactions are unreported and undocumented. Moreover, people continue to view their security in rural land ownership as based on local customary tenure systems (Renne 1995). This has resulted in an unclear tenure and ownership system which influences how people utilize land and resources.

7.1.6 Cropping Systems

Nigeria's climate permits the cultivation of a variety of crops, many of which are listed in Table 7.3.

In the south, abundant precipitation and relatively short dry seasons enable the growing of root crops such as cassava, yams, cocoyams, and sweet potatoes. Tree crops such as cocoa, oil palm and rubber constitute this zone's main commercial products. Cocoa grows mostly in the southwest, whereas oil palms predominate in the southeast and are numerous in the south-central area. Rubber stands are common in south-central and southeastern Nigeria. These different species are often intercropped with annual or arable crops in agroforestry systems or as part of the *taungya* system in forest reserves.

Crops associated with the middle belt area include such staples such as yams, sorghum, millet, cassava, cowpeas and maize, with rice in some commercial and irrigated areas. The southern edge of the middle belt represents the lower limits of the northern grain-dominated economy.

In the northern third of Nigeria, which experiences a dry season 5 to 7 months long, millet, cowpeas and a drought-resistant variety of sorghum, known as guinea corn, are the primary crops. Maize is also cultivated, as well as rice in suitable lowland areas. The principal commercial crops in the north are cotton and groundnuts (peanuts).

Fallow periods throughout Nigeria have experienced a reduction ranging from 40 to 60%. This is due in part to population pressures on the land, as well as the high cost of clearing bush for agricultural purposes (Eshett 1990).

Table 7.3 Nigeria: Agricultural Yields by Major Crop (thousands of hectograms per hectare)(World Bank 1995).

Crop	1980	1985	1990	1993
Cocoa	3.9	3.1	3.9	3.3
Palm oil	20.9	22.7	21.7	21.7
Cotton	1.8	1.6	6.8	7.9
Groundnuts	8.4	7.7	11.7	12.5
Sorghum	11.2	16.0	10.5	10.7
Millet	8.7	15.7	11.8	10.3
Maize	14.0	11.7	12.2	14.4
Rice	19.8	21.3	19.4	19.4
Yams	106.0	56.4	111.3	105.3
Cassava	95.8	112.5	116.5	105.0

Cocoa and groundnuts were Nigeria's two major exports until petroleum surpassed both in 1965. Although Nigeria was the world's largest exporter of groundnuts in the early 1970s, groundnuts fell from the export list by the end of the 1970s as a result of the severe Sahel drought of 1972 to 1974 and a viral disease epidemic in 1975.

In the late 1980s, Nigeria decontrolled farm prices, maintained subsidies on fertiliser and farm

exports, and maintained import bans on some food items to encourage agricultural activity. Agricultural output rose slowly but not significantly due to inadequate transportation and power networks, lack of appropriate technology, and the ineffective application of rural credit. The increased food production was not substantial enough to keep up with the growth of the population; therefore, the amount of food per capita dropped during this period.

Traditional cultivators throughout Nigeria used elemental irrigation systems long before the colonial period. The first government irrigation project brought 9000 ha under irrigation between 1949 and the end of the 1960s. The severe Sahel drought prompted federal government and some state governments to invest large sums of money into irrigation development. Major irrigation projects after the mid 1970s included the South Chad Project and the Bakolori Project in Borno State, and the Kano River Project.

7.1.7 Livestock

The United Nations Food and Agricultural Organisation estimated that in 1987 there were 12.2 million cattle, 13.2 million sheep, 26.0 million goats, 1.3 million pigs, 700 000 donkeys, 250 000 horses, 18 000 camels, and 175 million poultry in Nigeria. This livestock was owned mostly by villagers rather than by commercial operators. Livestock numbers have fluctuated in the past due to external factors such as droughts or disease. The livestock subsector accounted for about 2 percent of the GDP in the 1980s.

The vast majority of cattle are zebu, although there is a small proportion of savanna muturu and kuri. Most cattle are found north of the Niger and Benue rivers. The lower rainfall in this area results in less tsetse fly infestation. About 96% of the cattle are zebu-type cattle, most of which are tended by Fulani pastoralists. Most of the national cattle herd is pastoral, and less than a fifth of the total population is kept in towns or rural settlements. Due to seasonal migration, cattle concentrations tend to be higher on the Jos and Mambila plateaus and on the river floodplains during the dry season where the moisture levels are higher than the north where they spend the remainder of the year.

The hardiness of the goat makes it an attractive species in all ecological zones. In the north, goats have a similar distribution to that of sheep, but are more abundant further south where sheep are considered more susceptible to humidity-related diseases. Most are village animals, and only 3% were found to be pastoral, predominantly in Borno and Sokoto states.

Village sheep are ubiquitous throughout Nigeria with the highest levels in the north. Approximately 13% of the sheep population are pastoral. They are often herded with cattle into the savanna regions during the dry seasons. Pastoral sheep are found throughout the north-central regions, with concentrations highest during the wet season and around the larger northern towns.

Chickens are the most numerous of all livestock in Nigeria, and are common wherever there is human habitation. Consequently they are most abundant in the south and the Kano city area.

7.1.8 Forestry

Nigeria's forests can be divided into two principal categories:

> *Woodlands and Savanna Forests*: located predominately in the middle and northern latitudes and account for approximately four-fifths of the country's forested area. Woodlands and savanna forests are important sources for fuelwood, poles and some timber.
>
> *Rain Forests*: located in the southern humid zone and provide virtually all domestic timber and lumber requirements, as well as some fuelwood requirements. They are also a source of a significant number of non-timber forest products (e.g., nuts, game, medicines, etc.).

Toward the end of the 1800s, the colonial government began establishing forests reserves in order to maintain forest resources and provide a supply of lumber. By 1900, more than 970 km^2 of forest reserve land had been established. By 1930, reserve lands had increased to almost 30 000 km^2, and by 1970, reserve lands had increased in size to 93 420 km^2 (mostly in the north). However, Nigeria's forests have been diminishing gradually over the centuries, especially in the north, where uncontrolled commercial exploitation of privately owned forests began in the late nineteenth century. This process was greatly exacerbated by the introduction of cash crops in the 1950s which involved large-scale clearing of natural forests

During the last several decades, pressure on forest resources has continued to increase, primarily as a result of rapid population growth, unclear tenure systems, reliance on wild biotic resources (e.g., timber and non-timber forest products) for rural economies and rural livelihoods, and a reliance on subsistence farming practices. Specifically, forest resources in Nigeria continue to shrink due to clearing for extensive agriculture and shifting cultivation, commercial logging and fuelwood collection. Fuelwood collection and charcoal production play an important role in meeting household energy requirements in both rural and urban areas. Moreover, there has been significant and increasing pressure on forestry departments to "de-reserve" forests for agricultural production.

The steady decline in the remaining forest resources is recognized as a significant threat by the Government of Nigeria, as well as bi-lateral, multi-lateral and conservation-oriented organisations. Despite the fact that forested lands now exist in fragmented and discontinuous units, they still provide essential socio-economic and ecological benefits. As a result, numerous initiatives have been undertaken to reduce the rate of forest loss in Nigeria. These initiatives include forest inventories and forest management planning, plantation establishment, community and farm forestry programs (taungya system), restrictions on round log timber exports, as well as efforts to control and manage

ongoing timber harvesting activities. Most of these initiatives have met with limited and/or short-lived success.

7.2 NATIONAL VEGETATION AND LAND USE CHANGE

7.2.1 Vegetation and Land Use Change Analysis

This section discusses the land use and vegetation change across the nation over the time period of the study, 1976/78 to 1993/95 (tables 7.4 and 7.5). The vegetation and land use maps created under this project and statistical data generated from the GIS database were both used to assess the changes.

The vegetation and land use maps and database were created by visual interpretation of satellite images from 1976/78 and 1993/95. The data for the two time periods was very high quality which allowed for an excellent comparison of vegetation change. However, the 1993/95 imagery had a higher resolution which made it possible to accurately delineate a greater number of urban areas and erosional features than was possible in the 1976/78 imagery. It was decided that the interpretation should take advantage of the greater detail of the 1993/95 imagery and create a database that was as detailed and accurate as possible. As a result, some change detected through GIS analysis may be due to variations in detail between time periods, particularly in terms of the change in size of urban areas. Therefore, in the discussion of land use and vegetation change in this section, only significant or actual changes between the time periods will be addressed.

Although field work and verification were done to ensure the accuracy of the interpretation, it is important to note that the vegetation and land use data was visually interpreted using imagery at a scale of 20 m to 50 m resolution. Also, vegetation changes do not occur on a definite boundary, rather they occur gradually over some distance. The interpretation can be confidently used to indicate general trends in vegetation and land use change at a national and state level. Further, more focused research would need to be done using data sources of appropriate detail (satellite, radar, air photo, field work) in order to make measurements about specific types of relatively small-scale change, such as erosion or coastal inundation.

Table 7.4 Vegetation and Land Use Classes for 1976/78 and 1993/95, Nigeria.

Land Use Category	1976/78		1993/95		Change (km²)
	Area (km²)	% of country	Area (km²)	% of country	
Intensive (crop) Agriculture	322 794	35.5	365 491	40.2	42 697
Extensive (grazing) Agriculture	166 326	18.3	187 236	20.6	20 910
Dominantly Shrubs/Grasses	113 880	12.5	81 694	9.0	-32 186
Dominantly Trees/Woodlands/Shrubs	151 293	16.6	81 386	9.0	-69 907
Floodplain Agriculture	9451	1.0	20 918	2.3	11 467
Disturbed Forest	14 573	1.6	18 990	2.1	4417
Gullies	122	<0.1	18 517	2.0	18 395
Forested Freshwater Swamp	18 316	2.0	16 499	1.8	-1817
Undisturbed Forest	25 951	2.9	12 114	1.3	-13 837
Dominantly Grasses	12 549	1.4	11 983	1.3	-566
Discontinuous Grassland	6137	0.7	11 248	1.2	5111
Mangrove Forest	9994	1.1	9977	1.1	-17
Shrub/Sedge/Graminoid Freshwater Marsh/Swamp	16 899	1.9	9248	1.0	-7651
Extensive Agriculture with Denuded Areas	3518	0.4	9206	1.0	5688
Grassland	1034	0.1	7989	0.9	6955
Natural Waterbodies	6591	0.7	7851	0.9	1260
Montane Forest	6762	0.7	6759	0.7	-3
Urban (major+minor)	2083	0.2	5444	0.6	3361
Riparian Forest	7402	0.8	5254	0.6	-2148
Sand Dunes	812	0.1	4829	0.5	4017
Montane Grassland	1739	0.2	3112	0.3	1373
Reservoir	1327	0.2	2888	0.3	1561
Rock Outcrop	1424	0.2	2632	0.3	1208
Agricultural Tree Crop Plantation	830	0.1	1641	0.2	811
Forest Plantation	997	0.1	1573	0.2	576
Teak/Gmelina Plantation	628	0.1	1156	0.1	528
Irrigation Project	147	0.1	988	0.1	841
Graminoid/Sedge Freshwater Marsh	4882	0.5	871	0.1	-4011
Saltmarsh/Tidal Flat	4	<0.1	545	0.1	541
Rainfed Arable Crops	16	<0.1	485	0.1	469
Alluvial	487	0.1	269	<0.1	-218
Livestock Project	52	<0.1	139	<0.1	87
Mining Areas	0	0.0	62	<0.1	62
Canal	2	<0.1	29	<0.1	27

Table 7.5 Dominant Vegetation and Land Use Changes between 1976/78 to 1993/95, Nigeria.

Land Use 1976/78	Land Use 1993/95	Area (km^2)	Percent of Country
Intensive agriculture	Area with no change	248 113	27.30
	to Extensive agriculture	31549	3.47
	to Dominantly trees/woodlands/shrubs	6787	0.75
	to Gullies	6227	0.69
	to Disturbed forest	4886	0.54
	to Extensive agriculture with denuded areas	3273	0.36
	to Dominantly shrubs with grasses	2854	0.31
	to Grassland	2539	0.28
	to Floodplain agriculture	1949	0.21
	to Discontinuous grassland	1821	0.21
	to Forested freshwater swamp	1530	0.17
	to Riparian forest	1093	0.12
	to Sand dunes	863	0.09
	to Shrub/sedge/graminoid freshwater	849	0.09
	to Undisturbed forest	843	0.09
	to Reservoir	734	0.08
	to Rock outcrop	665	0.07
Extensive agriculture	Area with no change	79019	8.69
	to Intensive agriculture	53410	5.88
	to Dominantly trees/woodlands/shrubs	11436	1.26
	to Dominantly shrubs/grasses	8346	0.92
	to Gullies	2710	0.30
	to Extensive agriculture with denuded areas	2535	0.28
	to Discontinuous grassland	1846	0.20
	to Dominantly grasses	1447	0.16
	to Floodplain agriculture	1075	0.12
	to Grassland	913	0.10
	to Disturbed forest	722	0.08
	to Sand dunes	497	0.05
	to Reservoir	357	0.04
Dominantly shrubs/grasses	Area with no change	59271	6.52
	to Extensive agriculture	23049	2.54
	to Intensive agriculture	14354	1.58
	to Gullies	4344	0.48
	to Dominantly grasses	4033	0.44
	to Grassland	2866	0.32
	to Discontinuous grassland	1624	0.18
	to Sand dunes	1070	0.12
	to Disturbed forest	718	0.08
	to Rock outcrop	452	0.05
	to Extensive agriculture with denuded areas	435	0.05
	to Floodplain agriculture	353	0.04
	to Irrigation Project	283	0.03

Land Use 1976/78	Land Use 1993/95	Area (km^2)	Percent of Country
Dominantly trees/woodlands/shrubs	Area with no change	58587	6.45
	to Extensive agriculture	42448	4.67
	to Intensive agriculture	26594	2.93
	to Dominantly shrubs/grasses	9711	1.07
	to Gullies	4796	0.53
	to Disturbed forest	2236	0.25
	to Montane forest	1305	0.14
	to Discontinuous grassland	922	0.10
	to Riparian forest	840	0.09
	to Montane grassland	720	0.08
	to Grassland	598	0.07
	to Floodplain agriculture	483	0.05
	to Rock outcrop	476	0.05
Dominantly grasses	Area with no change	4798	0.53
	to Extensive agriculture	4743	0.52
	to Discontinuous grassland	1149	0.13
	to Sand dunes	572	0.06
	to Extensive agriculture with denuded areas	521	0.06
	to Grassland	495	0.05
Floodplain agriculture	Area with no change	6815	0.75
	to Intensive agriculture	973	0.11
	to Shrub/sedge/graminoid freshwater	455	0.05
	to Extensive agriculture	447	0.05
	to Irrigation project	161	0.02
Disturbed forest	Area with no change	4781	0.53
	to Intensive agriculture	6166	0.68
	to Disturbed forest	2014	0.22
	to Teak/Gmelina plantation	369	0.04
Undisturbed forest	Area with no change	8384	0.92
	to Disturbed forest	5120	0.56
	to Intensive agriculture	3929	0.43
	to Dominantly trees/woodlands/shrubs	2718	0.30
	to Extensive agriculture	1796	0.20
	to Forested freshwater swamp	1152	0.13
	to Dominantly shrubs/grasses	821	0.09
	to Montane forest	817	0.09
Riparian forest	Area with no change	1737	0.19
	to Intensive agriculture	2104	0.23
	to Floodplain agriculture	1427	0.16
	to Extensive agriculture	538	0.06
Montane forest	Area with no change	4395	0.48
	to Montane grassland	1100	0.12
	to Dominantly trees/woodlands/shrubs	515	0.06
Discontinuous grassland	Area with no change	3128	0.34
	to Sand dunes	1090	0.12
	to Extensive agriculture	864	0.10
	to Extensive agriculture with denuded areas	437	0.05

Land Use 1976/78	Land Use 1993/95	Area (km^2)	Percent of Country
Forested freshwater swamp	Area with no change	12229	1.35
	to Intensive agriculture	3414	0.38
	to Mangrove forest	1241	0.14
	to Ocean	508	0.06
	to Saltmarsh/tidal flat	333	0.04
Graminoid/sedge freshwater marsh	Area with no change	602	0.07
	to Shrub/sedge/graminoid freshwater	3240	0.36
	to Dominantly grasses	569	0.06
Shrub/sedge/ graminoid freshwater marsh/swamp	Area with no change	3123	0.34
	to Floodplain agriculture	7583	0.83
	to Intensive agriculture	2388	0.26
	to Extensive agriculture	1177	0.13
	to Riparian forest	584	0.06

7.2.2 Summary of National Vegetation and Land Use Change Statistics

Agriculture

Changes associated with agricultural land designations were:

- Intensive agriculture increased from 35.5% of the total area of Nigeria in 1976/78 to 40.2% in 1993/95 (an increase of 42 697 km^2).
- Extensive agriculture increased from 18.3% of the total area of Nigeria in 1976/78 to 20.6% in 1993/95 (an increase of 20 910 km^2).
- Extensive agriculture with denuded areas increased from 0.4% of the total area of Nigeria in 1976/78 to 1.0% in 1993/95 (an increase of 5688 km^2).
- Floodplain agriculture increased from 1.0% of the total area of Nigeria in 1976/78 to 2.3% in 1993/95 (an increase of 11 467 km^2).
- Plantations/Projects are summarized in Table 7.6

Table 7.6 Area Changes in Plantations and Projects between 1976/78 and 1993/95, Nigeria.

Plantation/Project	Area in 1976/78 (km^2)	Area in 1993/95 (km^2)
Agricultural Tree Crop Plantation	830	1641
Forest Plantation	997	1573
Teak/Gmelina Plantation	628	1156
Irrigation Project	147	988
Rainfed Arable Crops	16	485
Livestock Project	52	139
Total Area	2670	5982

Overall there was a significant increase in the agricultural area in Nigeria. Combined, the agricultural land designations identified above grew by a total area of 84 073 km^2 (approximately 9% of the total area of the country) in the 18 year time period of this study. The majority of agricultural land growth was a result of the need for more agricultural land by a growing population and increasing population densities. Much of the new agricultural land was derived from areas of less intensive use, or from relatively unexploited, natural lands such as savanna, forest or swamp. Over 1000 km^2 of previously designated agricultural land was converted for reservoirs by 1993/95.

Of the land area that changed, approximately three-quarters showed less human disturbance and the natural vegetation was growing back. In some cases, this reversion to natural vegetation was due to areas being designated as grazing reserves. Most of the area changed to extensive agriculture, dominantly trees/woodlands/shrubs,dominantly shrubs and grasses, forested freshwater swamp and riparian and disturbed forests. The other quarter of land mapped as intensive agriculture in 1976/78 showed a higher degree of human impact in 1993/95. The loss of vegetation led to the mapping of these areas as gullies, extensive agriculture with denuded areas, grassland, sand dunes and rock outcrops.

Approximately 48% of the land area mapped as extensive agriculture in 1976/78 remained as extensive agriculture in 1993/95. Of the land area that changed, over 20 000 km^2 was mapped as dominantly trees/woodlands/shrubs (guinea vegetation), dominantly shrubs and grasses (sudan vegetation), dominantly grasses (sahel vegetation), or disturbed forest in 1993/95, all showing a reduced level of human impact. In contrast, more than 60 000 km^2 of the extensive agricultural land became more intensively used by 1993/95 with the majority of this area becoming intensive agriculture, gullies, agriculture with denuded areas, or sand dunes. Often, areas that appeared as grassland or savanna in the imagery were in fact areas of fallow.

Agriculture with denuded areas became a more common classification in the 1993/95 time period. Extensive agricultural activity continued from 1976/78 to 1993/95, particularly in the northern regions, however, many more denuded areas were present. In some areas the absence of vegetation exposed buried sand dunes.

By visual interpretation alone it was often difficult to distinguish between the different types of agricultural projects and plantations; therefore, they have been grouped together for purposes of discussion. The total area of plantations/projectshas doubled in area from 2670 km^2 to 5982 km^2 in 1993/95. Clearly the number and size of all types of plantations grew dramatically in the time period of this study. Generally, forest and teak plantations are located inside forest reserves. Many shelterbelts, mapped as forest plantations, were established in the north to arrest the progress of desertification. Usually, irrigation projects were located near reservoirs in areas that had been used for floodplain agriculture.

Tree/Shrub/Grass

Identified changes associated with the various tree/shrub/grass land designations were:

- Dominantly trees/woodlands/shrubs (guinea vegetation) decreased by almost half from 16.6% of the total area of Nigeria in 1976/78 to 9.0% in 1993/95 (a decrease of 69 907 km^2).
- Dominantly shrubs and grasses (sudan vegetation) decreased from 12.5% of the total area of Nigeria in 1976/78 to 9.0% in 1993/95 (a decrease of 32 186 km^2).
- Dominantly grasses (sahel vegetation) decreased slightly from 1.4% of the total area of Nigeria in 1976/78 to 1.3% in 1993/95 (a decrease of 566 km^2).

Perhaps the most dramatic land use and vegetation change in the country has occurred to areas of dominantly trees/woodlands/shrubs. More than 60% of the land area mapped as dominantly trees/woodlands/shrubs in 1976/78 changed to another land use by 1993/95. Almost 75% of the dominantly trees/woodlands/shrubs was being used for agriculture in 1993/95. Many areas of dominantly trees/woodlands/shrubswere affected by fuelwood collection — the tree component of the vegetation assemblage was thinned or removed. This resulted in many areas of dominantly trees/woodlands/shrubs being mapped as dominantly shrubs and grasses, grasslands or in more severe cases, gullies or rock outcrops in 1993/95.

A similar trend was also evident in areas of dominantly shrubs and grasses which experienced an overall decrease of 48% in area over the time period of the study. The majority of this decrease was due to the expansion of agricultural activities into more than 65% of the dominantly shrubs and grasses area in 1993/95. Erosion was visible along the northern border of the country in Borno, Sokoto and Katsina states where large areas of gullies, sand dunes, continuous and discontinuous grasslands replaced areas mapped as dominantly shrubs and grasses in 1976/78.

Overall statistics showed that there was little change in areas of dominantly grasses. However, many areas of dominantly shrubs and grasses changed to dominantly grasses over the time period of the study. At the same time, areas mapped as dominantly grasses in 1976/78 had degraded to discontinuous grassland and sand dunes in 1993/95.

Forests

Changes in forested areas were:

- Undisturbed forest decreased from 2.9% of the total area of Nigeria in 1976/78 to 1.3% in 1993/95 (a decrease of 13 837 km^2).
- Disturbed forest increased from 1.6% of the total area of Nigeria in 1976/78 to 2.1% in 1993/95 (an increase of 4417 km^2).
- Riparian forest decreased from 0.8% of the total area of Nigeria in 1976/78 to 0.6% in 1993/95 (a decrease of 2148 km^2).

Undisturbed and riparian forests decreased in area, which is consistent with changes in other natural types of land cover. Correspondingly, the extent of disturbed forest increased. More than 65% of the undisturbed forest areas mapped in 1976/78 changed to another land use by 1993/95. Almost two-thirds of the previously undisturbed forest area had experienced some tree cover removal and was mapped as disturbed forest in 1993/95. More than 30% of the forested area that changed in 1993/95 changed to agriculture. Areas where tree cover was removed, and agriculture was not evident, were mapped as a tree/shrub/grass legend class. Many areas of riparian forest along waterways were being used for floodplain agriculture in 1993/95.

Mountainous Vegetation

Changes to the two land classes associated with mountainous vegetation were:

- Montane forest remained unchanged at 0.7% of the total area of Nigeria in 1976/78 and 1993/95.
- Montane grassland increased from 0.2% of the total area of Nigeria in 1976/78 to 0.3% in 1993/95 (an increase of 1373 km^2).

Mountainous vegetation did not show dramatic changes in areal extent, however, there was some encroachment of fuelwood collection/human activity in these areas, particularly along river valleys.

Grasslands

Identified changes to grassland designations were:

- Grassland increased from 0.1% of the total area of Nigeria in 1976/78 to 0.9% in 1993/95 (an increase of 6955 km^2).
- Discontinuous grassland increased from 0.7% of the total area of Nigeria in 1976/78 to 12% in 1993/95 (an increase of 5111 km^2).

There were many areas throughout the country where these classes were identified. Generally, these classes were used to map areas where agricultural yields were too low to justify cultivation and the land had been left fallow, or where there were initial signs of erosion (perhaps due to wind - gully erosion or sand dunes were not evident). The new areas of grassland were found in regions that had been mapped as dominantly trees/woodlands/shrubs, dominantly shrubs and grasses, dominantly grasses and agriculture in 1993/95. Some areas mapped as discontinuous grassland in 1976/78 were designated in 1993/95 as sand dunes or agriculture with denuded areas.

Marsh/Swamp

Changes associated with marsh and swamp land designations were:

- Shrub/sedge/graminoid freshwater marsh/swamp decreased from 1.9% of the total area of Nigeria in 1976/78 to 1.0% in 1993/95 (a decrease of 7651 km^2).
- Graminoid/sedge freshwater marsh decreased from 0.5% of the total area of Nigeria in 1976/78

to 0.1% in 1993/95 (a decrease of 4011 km^2).

Two trends account for the decrease in wetland areas: 1) the reduction of water levels in Lake Chad and surrounding areas - mapped as graminoid/sedge freshwater marsh in 1976/78, appeared as a shrub/sedge/graminoid freshwater marsh/swamp in 1993/95; and 2) the overall loss of shrub/sedge/graminoid freshwater marsh/swamp along major waterways to cultivation.

Coastal Vegetation

Changes associated with coastal vegetation classes were:

- Forested freshwater swamp decreased from 2.0% of the total area of Nigeria in 1976/78 to 1.8% in 1993/95 (a decrease of 1817 km^2).
- Mangrove forest decreased only very slightly from 9994 km^2 in 1976/78 to 9977 km^2 in 1993/95.
- Saltmarsh/tidal flats increased from <0.1% of the total area of Nigeria in 1976/78 to 0.1% in 1993/95 (an increase of 541 km^2).

Agriculture encroached into areas originally mapped as forested freshwater swamp in 1976/78. This process was particularly evident east of Lagos and north of Calabar. Increased areas of saltmarsh/tidal flats is of concern since they are the result of salt water inundation; the cause of this was not evident. There has been some suggestion (RIM 1992; Eedy et al. 1994) that this change may have been the result of pollution from large cities or oil exploration activities such as canal development.

Exposed Areas

Changes associated with exposed area designations were:

- Gullies increased from <0.1% of the total area of Nigeria in 1976/78 to 2.0% in 1993/95 (an increase of 18 395 km^2).
- Sand dunes increased from 0.1% of the total area of Nigeria in 1976/78 to 0.5% in 1993/95 (an increase of 4017 km^2).
- Rock outcrops increased from 0.2% of the total area of Nigeria in 1976/78 to 0.3% in 1993/95 (an increase of 1208 km^2).

Determination of the extent of these changes was somewhat difficult because the imagery for 1976/78 was not quite as detailed as 1993/95 imagery. However, the trend towards more areas of erosion was clearly evident and the accurate mapping of the 1993/95 time period pointed out many regions of concern. Generally, the clearing of natural vegetation for fuelwood or agricultural land use exposed areas that were susceptible to erosion.

Reservoirs

Land designated as reservoirs increased from 0.2% of the total area of Nigeria in 1976/78 to 0.3% in 1993/95 (an increase of 1561 km^2). While the number of reservoirs increased significantly and improved the water supply for villages and irrigation projects, the long-term environmental effects are of some concern given the resulting changes in surrounding and downstream land uses and the growing areas of erosion.

7.2.3 Further Details

Further details of the trends outlined above are discussed at the state level (*see* Section 8.0). Certain land use and vegetation categories were not included in this summary for the following reasons:

- they occupied such a small area of the country
- identification of these land uses was difficult since their visual characteristics on the satellite imagery were not sufficiently unique to differentiate it from other classes
- the resolution of the imagery in the two time periods was different enough that these small areas could not be compared

These land classes include alluvial deposits, mining areas, canals, urban areas and ocean.

7.3 LAND USE AND VEGETATION CHANGE - NOAA TREND ANALYSIS

7.3.1 Introduction

National Oceanographic Atmospheric Administration (NOAA) Advanced Very High Resolution Radiometer (AVHRR) imagery was acquired for five time periods to provide for a general trend analysis of vegetation and land use change between the periods of 1976/78 and 1993/95. The years for analysis included 1978, 1983, 1986, 1990 and 1995.

The resolution of the data determined the scale of land cover change that could be detected. The data collected for 1978 and 1983 was collected by Global Areas Coverage (GAC) and has a resolution of 4 km by 4 km. The data collected for 1986, 1990 and 1995 was collected by Local Area Coverage (LAC) with a ground resolution of 1 km by 1 km. This relatively coarse resolution meant that the detailed legend classes used for the Landsat MSS and SPOT-XS interpretations were generalized for interpretation of the NOAA imagery. Therefore land cover classes that cover relatively small areas such as plantations and urban areas will not be included in the trend analysis. The primary interest in the trend analysis is the relationship between natural vegetation and agriculture over time.

7.3.2 Trend Analysis

Changes in the area of vegetation and land use classes over time are summarized in Table 7.7.

Table 7.7 NOAA Data for all Study Years.

Class	Area in hectares				
	Global Area Coverage		Local Area Coverage		
	1978	1983	1986	1990	1995
Agriculture (Intensive/Extensive)	51 000 000	53 200 000	50 900 000	55 000 000	61 900 000
Floodplain agriculture	1 150 000	1 560 000	1 880 000	1 980 000	2 400 000
Grassland	700 000	1 330 000	1 860 000	1 980 000	3 150 000
Dominantly trees/woodland/shrubs	17 800 000	16 600 000	15 400 000	12 300 000	9 000 000
Dominantly shrubs and grasses	12 000 000	11 700 000	13 200 000	11 200 000	7 100 000
Dominantly grasses	1 220 000	1 280 000	1 790 000	1 620 000	1 100 000
Forest	4 850 000	3 450 000	2 900 000	3 200 000	2 650 000
Freshwater marsh/swamp	1 670 000	1 370 000	1 430 000	730 000	620 000
Forested freshwater swamp	2 080 000	1 890 000	2 200 000	2 290 000	1 800 000
Mangrove forest	1 240 000	1 510 000	1 170 000	1 140 000	1 190 000
Water	148 000	81 000	520 000	710 000	680 000
Bare surfaces	99 000	26 000	394 000	1 433 000	1 892 000

Agriculture (Intensive and Extensive) and Floodplain Agriculture

Agricultural areas increased significantly during the study, primarily at the expense of areas of natural savanna vegetation. The greatest increase associated with this process occurred between 1990 and 1995, with an increase of approximately 6 900 000 ha.

There was a steady increase in the extent of floodplain agriculture (fadama) from 1978 through 1995, with the amount of floodplain agriculture more than doubling. This took place mostly as a result of the transition of wetlands to agriculture use. Considerable World Bank funding went into development of fadama projects over this period.

Continuous and Discontinuous Grasslands

Continuous and discontinuous grasslands are the transition between natural savanna vegetation and bare ground, or between natural savanna vegetation and agricultural land use. The largest increase in this class occurred between 1990 and 1995 where the area of grassland increased over one and a half times from 1 980 000 ha to 3 150 000 ha.

Dominantly Trees/Woodlands/Shrubs

Areas dominated by trees/woodlands/shrubs(guinea vegetation) decreased by 50% during the study period, with the majority of the area converting to agricultural use in the 1990s. Between 1986 and 1990, this area declined significantly, by 3 100 000 ha and between 1990 and 1995, the amount of area declined by a further 3 300 000 ha. Not only is the decrease significant but there was an increase in fragmentation too.

Dominantly Shrubs and Grasses

The areal extent of areas dominated by shrubs and grasses (sudan vegetation) remained stable until 1986, however by 1995 it had decreased approximately 40%. Specifically, between 1986 and 1995, the extent decreased by approximately 6 100 000 ha, with a decrease of 4 100 000 ha between 1990 and 1995. This was largely due to impacts associated with grazing, fuelwood collection and the establishment of smallholder agriculture. As a result, there were very few areas of dominantly shrubs and grasses remaining and what was left was highly dissected and fragmented.

Dominantly Grasses

The amount of land mapped as dominantly grasses (sahel vegetation) remained relatively constant from 1978 through 1995. However, of significance are the changes in its distribution. For example, large areas of dominantly grasses were found to have migrated up to three-quarters of a degree (latitude) southward. In addition, from 1990 onwards, areas were more dissected and commonly associated with disturbed grasslands, bare soil and/or areas of sand dune features.

Forest

Lands designated as forest have experienced a significant decline between 1978 and 1995. Specifically, 2 200 000 ha of forest were converted, primarily to agriculture, during that time frame. Of significance was the fragmentation and decline of forest in western parts of the country in Taraba, Cross River and Benue states. As well, there appears to be a transition of lands designated as forest in the southern areas of Ondo and Edo states to forested freshwater swamp, mangrove forest and agricultural designations. However, this designation may be related to classification problems due to the coarse resolution and subtle differences between these classes.

Freshwater Marsh/Swamp, Forested Freshwater Swamp and Mangrove Forest

Areas of land designated as mangrove have remained relatively constant, with increases and decreases in area more a function of the difficulty in interpreting these lands. Likewise, areas of forested freshwater swamp remained relatively constant until 1990 (the 1983 decrease is a function of the coarser resolution of the 1983 imagery when compared to the 1986 to 1995 imagery).

However, since 1990, significant areas of forested freshwater swamp have been drained for agricultural purposes. As a result, areas of forested freshwater swamp have decreased from 2 080 000 ha in 1990 to 1 800 000 ha in 1994.

By 1990, the majority of freshwater marsh and swamps along the Niger, Benue and Hadejia rivers had all but disappeared. These lands were being utilized for floodplain agriculture. The areal extent of Lake Chad also remained constant until 1990. However, by 1994, its shoreline had receded and the extent of floodplain agriculture along the Hadejia River had decreased. Since this time period, a new dam and reservoir have been constructed southwest of Kano on one of the tributaries that drain into the Hadejia River, and therefore, into Lake Chad.

Water

Although most water bodies were too small to be accurately measured at the coarse resolution of the NOAA imagery (especially the GAC data of 1978 and 1983), large reservoirs were observed. There was a dramatic increase in the area of water from 148 000 ha in 1978 to 680 000 ha in 1995. The largest increase in area appears to have occurred between the 1983 and 1986 time periods.

Bare Surfaces

Areas of erosion/bare soil started to become more prevalent in 1986 (which may have also been a function of improved resolution in the NOAA data). From 1986 to 1995, there was a noticeable progression from areas dominated by trees and shrubs to bare soil. In the areas dominated by trees and shrubs, the trees and shrubs were removed, probably for fuelwood, leaving behind the grasses. The remaining grasses were not able to stabilize the soils (given the adverse anthropogenic and biophysical conditions), which resulted in erosion. Consequently, grassland areas converted to areas of bare soil.

Mappable bare surfaces increased nearly twenty times between 1978 and 1995. The largest increase in bare surfaces occurred from 1986 to 1990, an increase from 394 000 ha to 1 433 000 ha.

7.3.3 Conclusions

Based on this analysis, significant changes appear to have occurred after 1986. For example, from 1978 through 1986, there were constant but relatively insignificant decreases in the quantity of naturally vegetated areas. Even with the change in the spatial resolution of data between 1983 and 1986 (from 4 km resolution to 2 km resolution), changes are still modest.

8.0 Land Use And Socio-economic Analysis – State Overview

8.1 INTRODUCTION

The purpose of this chapter is to discuss land use and vegetation change, by state, over the time period of the study, 1976/78 to 1993/95. The vegetation and land use maps created under this project as well as statistical data generated from the GIS database were both used to perform this analysis. For each state the dominant vegetation and land use changes are discussed, where possible these changes are quantified and probable causes identified.

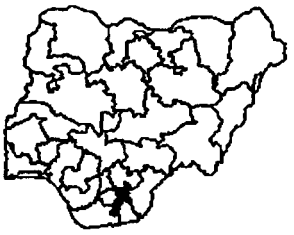
The descriptions of land use change are described using the 30 states and Federal Capital Territory as defined by the boundaries of 1991. Social and economic data was readily available for this time period, to compliment the land use change statistics derived from the GIS database. Therefore, although state boundaries are frequently modified, the 1991 state boundaries will be utilized in the land use and socio-economic analysis at the state level.

The land use maps provided by Geomatics for this project include the state boundaries from 1992 (Satode 1992). These 1992 boundary lines were used in both the 1976 and 1994 land use maps in order to provide a consistent database for analysis. Summarized below are the August 1991 state boundary changes.

The analysis of land use change presented below is based on the visual interpretation of land use from satellite images of the entire country from roughly 1976 to 1995 as described in Section 7.2.1. The social and economic information presented in the description of land use change was derived from existing reports as outlined in the bibliography. A primary source utilized was the 1992 Nigerian Livestock Resources Survey (RIM 1992). This report provided information on state histories, infrastructure, ethnic characteristics and ecological variables, as well as detailed information on livestock populations, rearing methods and infrastructure.

Table 8.1. State Boundary Changes, 1991.

State Name	Boundary Change
Abia	created from the eastern part of Imo State
Adamawa	created from the northern part of Gongola State
Akwa Ibom	remained unchanged
Anambra	was split into two - the eastern part became Enugu State and the western part retained the name of Anambra State
Bauchi	remained unchanged
Bendel	was split into two - the northern part became Edo State and the southern part became Delta State
Benue	was split into two - the western part became Kogi State and the eastern part retained the name Benue State
Borno	was split into two - the western part became Yobe State and the eastern part retained the name Borno State
Cross River	remained unchanged
Delta	created from the southern part of Bendel State
Edo	created from the northern part of Bendel State
Enugu	created from the eastern part of Anambra State
Federal Capital Territory	remained unchanged
Gongola	was split into two - the northern part became Adamawa State and the southern part became Taraba State
Imo	was split into two - the eastern part became Abia State and the western part retained the name Imo State
Jigawa	created from the northeastern part of Kano State
Kaduna	remained unchanged
Kano	was split into two - the northeastern part became Jigawa State and the southwestern part retained the name of Kano State
Katsina	remained unchanged
Kebbi	created from the southwestern part of Sokoto State
Kogi	created from the western part of Benue State and the southern part of Kwara State
Kwara	was split into three - the northern portion became part of the expanded Niger State, the southern portion became part of Kogi State and the central portion retained the name of Kwara State
Lagos	remained unchanged
Niger	the boundary of Niger State was extended to the northwest to incorporate the northern part of the former Kwara State
Ogun	remained unchanged
Ondo	remained unchanged
Osun	created from the eastern part of Oyo State
Oyo	was split into two - the eastern part became Osun State and the western part retained the name of Oyo State
Plateau	remained unchanged
Rivers	remained unchanged
Sokoto	was split into two - the southwestern part became Kebbi State and the northeastern part retained the name of Sokoto State
Taraba	created from the southern part of Gongola State
Yobe	created from western part of Borno State



8.2 ABIA STATE

Introduction

Abia State, with an area of 6771 km^2 and population of approximately 2.3 million, is located is south-central Nigeria and is bounded to the east by the Cross River. The state was created from the eastern part of the former Imo State and is characterized by a ridge structure that is a continuation of the structure associated with Enugu and Anambra states. The state capital of Umuahia is an important cattle trading and distribution centre. The railway passes along the western boundary of the state and continues to Port Harcourt, which plays an important role in commerce. An expressway built in the 1970s linking the cities of Enugu and Port Harcourt in the neighboring state of Imo provides an important transportation link for this state.

Human Population

Abia State is closely associated with the Igbo. The Igbo are an agricultural people, whose traditional land ownership belongs to the community, or to aggregates of smaller localised lineages. The male heads of families may personally own land through inheritance or purchase. Where there is not enough community land, it is farmed in sequence. In these cases land is allocated according to whether individuals are living on the land and depending on payment of community dues. Until recently, it was typical to find Igbo villages without men for much of the year since they left to find work elsewhere. However, the downturn in the national economy has brought many men back to the villages.

Minorities in Abia State include the pastoral Fulani and the Hausa. There is a larger community of Hausa and Fulani cattle farmers in Umuahia who are well integrated into the local community. Generally these pastoralist groups tend to be smaller and are based in the larger towns, and they concentrate on cattle rearing as well as trading. Overall Abia State is fairly densely populated although most of the population remains rural.

Farming and Agropastoral Systems

Two primary farming systems are dominant in the state. Specifically, areas of derived savanna are dominated by row crop agriculture where maize, grains and livestock are important. The lowland rain forest areas are dominated by tree-crop agriculture, including oil palms, along with plantains, cassava and yams. In the uplands, farmers depend on forest or bush fallow and the cropping system is based around tree-crops and tubers. The ferralitic soil is low in fertility except for the thin top layer on which cassava, yam, maize, cocoyam, plantain, banana and oil-palm can be grown. Roughly half of the tree crops are in plantations, such as the oil-palm estates. The main crops grown in the swampy areas are rice, cocoyams and a variety of vegetables.

Livestock herding is a peripheral activity in the state. Traditionally, livestock rearing was based on a free-range system. However, increases in the population have intensified pressures on the land and labour is no longer available to manage livestock on a cut-and-carry basis (hand-cutting of fodder for the livestock). Owning livestock is associated more with prestige than with economic advantages. Indeed, most of the meat and fish eaten in the state is imported from the outside. Larger livestock markets mainly deal with cattle while smaller livestock of importance includes goats, sheep, chickens and other waterfowl. Livestock arrives directly or indirectly from northern Nigeria and the trade is largely in the hands of northern suppliers, including the Fulani and the Hausa.

Vegetation and Land Use Change

Table 8.2 Dominant Vegetation and Land Use Classes for 1976/78 and 1993/95, Abia State, Nigeria.

Land Use Category	1976/78		1993/95	
	Area (km^2)	Percent of state	Area (km^2)	Percent of state
Intensive (crop) Agriculture	5867	86.7	6035	89.1
Discontinuous Grassland	0	0	272	4.0
Urban (major+minor)	47	0.7	150	2.2
Undisturbed Forest	113	1.7	127	1.9
Disturbed Forest	111	1.6	90	1.3
Forested Freshwater Swamp	276	4.1	36	0.5
Trees/Woodlands/Shrubs	246	3.6	0	0

Table 8.3 Dominant Vegetation and Land Use Changes between 1976/78 to 1993/95, Abia State, Nigeria.

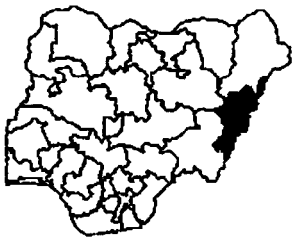
Land Use 1976/78	Land Use 1993/95	Area affected (km^2)	Percent of state
Trees/Woodlands/Shrubs	to Discontinuous Grassland	201	3.0
	to Intensive (crop) Agriculture	35	0.5
Disturbed Forest	no change	15	0.2
	to Intensive (crop) Agriculture	89	1.3
Forested Freshwater Swamp	no change	28	0.4
	to Intensive (crop) Agriculture	248	3.7
Intensive (crop) Agriculture	no change	5571	82.3
	to Urban (major+minor)	106	1.6
	to Discontinuous Grassland	69	1.0
	to Disturbed Forest	52	0.8

During the study period, land use in Abia State was dominated by intensive agricultural practices, which resulted in degradation of the land cover. As a result, the ecological boundary between the Derived Savanna and Lowland Rain Forest ecological zones, which passed through the top quarter of Abia State in 1976/78, moved southward. In 1993/1995 the north half of the state was in the Derived Savanna Ecological Zone. The south half of the state remained in the Lowland Rain Forest

Ecological Zone. However there was very little natural vegetation remaining in the state and the zone delineation was based on the type of agriculture practiced. Specifically, the Derived Savanna Ecological Zone was dominated by row crop agriculture, whereas the Lowland Rain Forest Ecological Zone was dominated by tree crop agriculture, in particular oil palms.

In the northern half of the state there is a continuation of the Udi Ridge from the north (Enugu State area). The ridge was mapped as dominantly trees/woodlands/shrubs (246 km^2) and disturbed forest (111 km^2) in 1976/78. In 1993/95, the same area was mapped as discontinuous grassland, intensive agriculture and disturbed forest with adjacent areas of gully erosion. No areas of dominantly trees/woodlands/shrubs remained in the state. Both the loss of tree cover and the presence of gully erosion indicated an increasing pressure on the land which resulted in degradation of the land and declining agricultural yields.

In 1976/78, 4.1% (276 km^2) of the state was designated as forested freshwater swamp, almost entirely along the Cross River. Almost all of this area was cleared for intensive agriculture with only 28 km^2 remaining along the river. In addition to the 8 km^2 of forested freshwater swamp mapped in the rest of Abia, the state is left with only 0.5 % (36 km^2) in total of forested freshwater swamp in 1993/95.



8.3 ADAMAWA STATE

Introduction

Adamawa State, with an area of 36 647 km^2 and a population of approximately 2.1 million people, is located in east-central Nigeria along the Cameroon border. The state was created following the split of Gongola State into Adamawa State in the north and Taraba State in the south. Generally, roads and cross-border traffic are poorly developed. One of the largest but least known game reserves in Nigeria, the Gashaka-Gumpti Reserve, extends along the international border with the Republic of Cameroon.

Human Population

Adamawa State is notable for the diversity of ethnic groups that inhabit it with up to 80 languages being spoken in the state. The population falls into a number of major groups which include the Fulani, peoples of the Muri Mountains, the Chadic and Adamawa speaking people north of the Benue River, the Adamawa speaking people of the centre of the state, the Jukun, the Mambila and, the Tiv. Other than the Junkun peoples, none of these groups have large-scale social organisations and they live in dispersed communities without any central authority.

Fulani pastoralists migrated into the state in the mid nineteenth century, opened the pastures of the Benue River valley and moved into the savannas and lightly forested lowlands in the north of the state. The process of gradually shifting the frontiers of the pastoral zone further south has continued up to the present day.

The Muri Mountains appear to be a refuge area, as they contain numerous small populations who speak languages from a variety of different linguistic stocks. Many of the montane settlements are being deserted as new villages are established on the plain.

Adamawa speakers in the centre of the state include in the Mumuye, Vere and Chamba peoples. Originally all of these groups lived in the hills that extend across the centre of the state, but they moved down to the plains in the colonial era.

The Mambila Plateau is an isolated region with linguistic and cultural affiliations with the Republic of Cameroon. The main populations of the plateau are the Mambila people and the Yamba. Friction between Mambila and the Fulani pastoralists over land rights, and a series of outbreaks of violence, have led to a wave of emigration away from the plateau.

Population densities in the state are relatively low when compared to such states as Imo or Benue. The estimated population density is approximately 50 people per km^2 , although the population is not evenly distributed throughout the state (Geomatics Nigeria Ltd. 1997a).

Farming and Agropastoral Systems

Although much of Adamawa state is not densely populated, the state contains large areas of fertile soil which have attracted large-scale intensive farmers and ranchers. There is an unusually high concentration of commercial farms in the state. Cotton and maize are the main agricultural crops although rice farms are also under development. Bush or forest-fallow cultivation is still predominant in most parts of the state. Some flood-retreat cultivation is practiced, both to supply the towns with vegetables and to grow *masakwa* dwarf sorghum.

In the mountainous plateau areas, the river valleys are intensively cropped while the upland regions are typically planted only with cereals, and the location of cropped fields is changed regularly. The Mambila Plateau has been subjected to intense settlement and increasing livestock densities. Much of the original grass cover has disappeared which has led to extensive loss of topsoil. Although the plateau has some original tree cover in the river valleys, numerous tree plantations established in the colonial era continue to provide fuelwood and building materials. Several species of eucalyptus were planted and today these extensive plantations are an important source of fuelwood resource on the Plateau.

In the central part of the state the Vere and Chamba have mixed cultivation systems which use animals to cultivate maize and a variety of other crops. In contrast, the cropping system of the Mumuye is centred on mounded yam production and so ploughing has not generally been adopted. The Chadic and Adamawa speakers north of the Benue River are subsistence farmers who largely depend on shifting cultivation.

Overall, fallow periods in the state have declined from 5.8 years to 2.7 years over the past ten years and in many cases fallowing is no longer practiced (Geomatics Nigeria Ltd. 1997a).

With its diverse ecology and extensive pastoral region, parts of the state export a wide variety of animals to southern areas. Small ruminants, pigs, dogs and donkeys are traded in significant numbers. Pig production for market is greatest in this state and has potential to increase given improvements in veterinary services and management practices. Previously the Mambila Plateau had one of the most productive pastoral zones in Nigeria, for many years being a major exporter of cattle to the lowland areas. Cattle production is mainly handle by various groups of pastoralists, especially the Fulani. However, uncontrolled grazing has now caused gully and sheet erosion, and the original grasses have been replaced by less nutritious grasses which has led to decreases in cattle production. A series of warnings about overgrazing have had no discernible impact to date.

Vegetation and Land Use Change

Table 8.4 Dominant Vegetation and Land Use Classes for 1976/78 and 1993/95, Adamawa State, Nigeria.

Land Use Category	1976/78		1993/95	
	Area (km^2)	Percent of state	Area (km^2)	Percent of state
Extensive (grazing) Agriculture	9291	25.4	10 928	29.8
Shrubs/Grasses	11 723	32.0	10 062	27.5
Intensive (crop) Agriculture	8487	23.2	8082	22.1
Trees/Woodlands/Shrubs	4361	11.9	2319	6.3
Disturbed Forest	0	0	1543	4.0
Floodplain Agriculture	348	1.0	1120	3.1
Montane Grassland	0	0	614	1.7
Montane Forest	281	0.8	573	1.6
Rock Outcrop	5	<0.1	169	0.5
Shrub/Sedge/Graminoid Freshwater Marsh/Swamp	679	1.9	129	0.4
Undisturbed Forest	1022	2.8	119	0.3

Table 8.5 Dominant Vegetation and Land Use Changes between 1976/78 and 1993/95, Adamawa State, Nigeria.

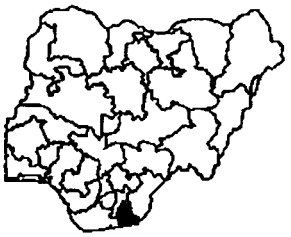
Land Use 1976/78	Land Use 1993/95	Area affected (km^2)	Percent of state
Floodplain Agriculture	no change	282	0.8
	to Water	19	< 0.1
	to Irrigation Project	12	< 0.1
	to Extensive (grazing) Agriculture	10	< 0.1
	to Intensive (crop) Agriculture	7	< 0.1
Trees/Woodlands/Shrubs	no change	1964	5.4
	to Extensive (grazing) Agriculture	730	2.0
	to Montane Grassland	463	1.3
	to Disturbed Forest	446	1.2
	to Shrubs/Grasses	372	1.0
	to Montane Forest	319	0.9
Shrubs/Grasses	no change	7404	20.2
	to Extensive (grazing) Agriculture	2535	6.9
	to Intensive (crop) Agriculture	1124	3.1
	to Disturbed Forest	258	0.7
	to Rock Outcrop	149	0.4
Undisturbed Forest	no change	93	0.3
	to Disturbed Forest	450	1.2
	to Trees/Woodlands/Shrubs	281	0.8
Intensive (crop) Agriculture	no change	4864	13.3
	to Extensive (grazing) Agriculture	2664	7.3
	to Shrubs/Grasses	366	1.0
	to Floodplain Agriculture	166	0.5
Extensive (grazing) Agriculture	no change	4866	13.3
	to Intensive (crop) Agriculture	1977	5.4
	to Shrubs/Grasses	1889	5.2
	to Disturbed Forest	363	1.0

Over the study period, there was only a minor intensification of land use in Adamawa state in the agricultural area north of the Benue River. However, there were marked changes in land use in the Benue River floodplain, in the agricultural plains to the south, as well as in the Shebshi Mountains and Mambila Plateau.

In 1976/78, the Benue River floodplain in Adamawa State was predominantly a shrub-dominated swamp with an area of 679 km^2. In addition, there was some floodplain (fadama) agriculture at the confluence of the Hawal and Benue rivers surrounding the town of Numan and eastward to the town of Yola. However, in the Numan area in particular, there was a dramatic change in land use. Specifically, the floodplain expanded in several places and the area of floodplain agriculture almost tripled from 348 km^2 in 1976/78 to 1120 km^2 in 1993/95. Most of the floodplain was being used for agriculture. The World Bank has supported fadama development through its financing. Intensification of land use is also indicated by construction of a new dam and subsequent reservoir, with an area of 77 km^2, north of the Benue River along the Hawal River. Additionally irrigation canals linking the new reservoir with various irrigation projects (covering 109 km^2) north of the Benue River were visible. There was also a number of agricultural tree crop plantations, agricultural projects and livestock projects established in the Numan area. This time period saw an increase in the number of commercial farmers in the state (RIM 1992).

In 1976/78, 4361 km^2 (11.9% of the state) was mapped as dominantly trees/woodlands/shrubs; by 1993/95, only 2319 km^2 (6.3% of the state) remained. This loss of 2042 km^2 was likely due to the collection of fuelwood and the growing need for grazing lands. In 1993/95, the dominantly trees/woodlands/shrubs changed to areas of extensive (grazing) agriculture, montane grassland, disturbed forest, dominantly shrubs/grasses and montane forest. This loss was particularly evident in the highland areas south of the Benue River, which includes the Shebshi Mountains and the edge of the Mambila Plateau. In 1976/78, this large area was all dominantly trees/woodlands/shrubs, with undisturbed forest in the Shebshi Mountains, some undisturbed forest on the Mambila Plateau, and montane forest in the highlands. By 1993/95 this area had deteriorated showing a marked increase in the area of extensive agriculture and disturbed forest.

In several areas, south of the Benue River, there was more grazing activity in 1993/95 as opposed to the intensive crop agriculture identified in 1976/78. During the study period, 7.3% of the state changed from intensive agriculture to extensive agriculture.



8.4 AKWA IBOM

Introduction

Akwa Ibom State, with an area of 6927 km^2 and population of approximately 2.6 million, is located in the southeastern portion of Nigeria along the Bight of Benin. Although predominately rural, it is one of the most densely populated states in the country. The state has a poor road system with tenuous air linkage to other states.

Human Population

This state has experienced a high population growth which has substantially increased the demand on agricultural land. This increased use of agricultural land has led to erosion and decreased crop yields that in turn has reduced the number of people necessary to farm. The unemployed agricultural workers have had to look for non-agricultural jobs either in the towns or out of the state.

Farming and Agropastoral Systems

Farming activities in the state are characterized by a nearly continuous cropping system. This is a change from the traditional practice of leaving the land fallow for at least five years. The continuous cycle is causing erosion and decreased crop yields.

Typically, home compounds are surrounded by forest-fallow which is used for fruit trees and palms, with permanent groves of palms intercropped with yam, cassava, okra and pepper. Other key crops include cocoyams, plantains, bananas and swamp rice. Oil palm is a crop which plays an important role in the economic, social and ceremonial life of the Ibibio peoples.

Livestock production remains small scale in the state, with the only intensive enterprises being poultry and pig production. Potential livestock production is limited by unreliable sources of feed and veterinary medical services. Most livestock is reared and consumed by local rural producers while sale of out-of-state livestock is limited due to few markets and high prices. The cattle market at the Iba Oku near Uyo is a focal point for trade in the northern states.

Historically, much of the state was covered by lowland rain forest species but now only remnants are found along the coast and major waterways. This is in part due to the replacement of forested lands with oil-palm plantation. Oil palm plays an important role in the economic, social and ceremonial life of the Ibibio peoples.

Vegetation and Land Use Change

Table 8.6 Dominant Vegetation and Land Use Classes for 1976/78 and 1993/95, Akwa Ibom State, Nigeria.

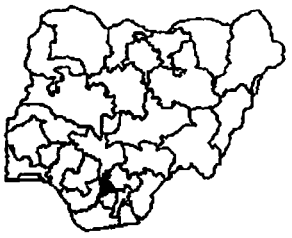
Land Use Category	1976/78		1993/95	
	Area (km^2)	Percent of state	Area (km^2)	Percent of state
Intensive (crop) Agriculture	5438	78.5	5228	75.5
Forested Freshwater Swamp	864	12.5	890	12.9
Mangrove Forest	226	3.3	358	5.2
Undisturbed Forest	59	0.9	107	1.5
Shrub/Sedge/Graminoid Freshwater Marsh/Swamp	103	1.5	0	0

Table 8.7 Dominant Vegetation and Land Use Changes between 1976/78 and 1993/95, Akwa Ibom State, Nigeria.

Land Use 1976/78	Land Use 1993/95	Area affected (km^2)	Percent of state
Forested Freshwater Swamp	no change	529	7.6
	to Mangrove Forest	157	2.3
	to Intensive (crop) Agriculture	141	2.0
Shrub/Sedge/Graminoid Freshwater Marsh/Swamp	to Forested Freshwater Swamp	86	1.2
Intensive (crop) Agriculture	no change	5005	72.3
	to Forested Freshwater Swamp	204	2.9
	to Undisturbed Forest	73	1.1

In 1993/95, approximately 75.5% of land cover in Akwa Ibom State was mapped as intensive agriculture. Areas of freshwater swamp and mangrove predominate along the coast and along the Cross River. While the area of land used for intensive agriculture remained fairly constant, some coastal vegetation adjacent to the Cross River was cleared for agricultural use.

Along the ocean coastline and upstream along the Kwa Iba River there was an increase in the area of forested freshwater swamp. In addition, some areas mapped as forested freshwater swamp in 1996/78 were mapped as mangrove forest in the 1993/95 time period. This change could be due to higher water levels and/or improved imagery available in the later time period of the study.



8.5 ANAMBRA STATE

Introduction

Anambra State, with an area of 4745 km^2 and population of approximately 2.8 million people, is located in south-central Nigeria, and is bounded by the Niger River to the west and Enugu State to the east. The former Anambra State was split into two, the western part remaining as Anambra state while the eastern part became Enugu State. A sandstone ridge along the Udi Plateau divides Anambra and Enugu states. Onitsha is the state's centre of trade and industry. A number of major highways link this state to the international airport in Enugu and to the rest of Nigeria.

Human Population

The state is characterized by a dense rural population. The population is almost exclusively composed of Igbo people. There is great diversity within the Igbo cultural group although these people are primarily farmers and traders. Land ownership among the Igbo belongs to the village community or clan unit.

The pastoral Fulani have migrated to the state in increasing numbers after the end of the civil war of 1967 to 1970.

Farming and Agropastoral Systems

The two main farming systems utilized in the state are rainfed cropping in the upland areas and floodplain farming in the riverine areas. Upland crops include yam, cassava, sweet potato, cocoyam, vegetables, egusi (melon), tomatoes, pepper, legumes and grains. For land under intensive cultivation, complex systems of mulching and composting are used to maintain soil fertility.

The pastoral Fulani are the main cattle rearers in the state. They remain in the swampy grasslands of the Niger and Anambra rivers in the dry season, migrating upland as the rains start. The dense rural population effectively precludes large-scale livestock production and as a result, small-scale production predominates. Yet even this is in decline as primary educational opportunities result in children being less available to manage the animals. In particular, muturu cattle, once kept throughout the Igbo area, are gradually disappearing.

Vegetation and Land Use Change

Table 8.8 Dominant Vegetation and Land Use Classes for 1976/78 and 1993/95, Anambra State, Nigeria.

Land Use Category	1976/78		1993/95	
	Area (km^2)	Percent of state	Area (km^2)	Percent of state
Intensive (crop) Agriculture	3677	77.5	3466	73.0
Forested Freshwater Swamp	504	10.6	516	10.9
Floodplain Agriculture	0	0	201	4.2
Discontinuous Grassland	0	0	119	2.5
Riparian Forest	166	3.5	110	2.3
Gullies	0	0	95	2.0
Plantation (agricultural tree crop, teak)	13	0.3	62	1.3
Disturbed Forest	102	2.2	36	0.8
Trees/Woodlands/Shrubs	131	2.8	0	0

Table 8.9 Dominant Vegetation and Land Use Changes between 1976/78 and 1993/95, Anambra State, Nigeria.

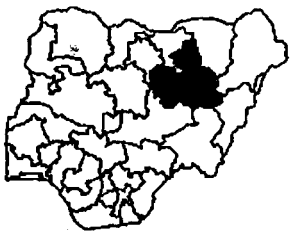
Land Use 1976/78	Land Use 1993/95	Area affected (km^2)	Percent of state
Trees/Woodlands/Shrubs	to Intensive (crop) Agriculture	70	1.5
Disturbed Forest	to Intensive (crop) Agriculture	92	1.9
Riparian Forest	no change	25	0.5
	to Intensive (crop) Agriculture	110	2.3
Forested Freshwater Swamp	no change	304	6.4
	to Intensive (crop) Agriculture	136	2.9
	to Floodplain Agriculture	63	1.3
Intensive (crop) Agriculture	no change	3027	63.8
	to Forested Freshwater Swamp	151	3.2
	to Discontinuous Grassland	110	2.3
	to Floodplain Agriculture	108	2.3
	to Riparian Forest	79	1.7
	to Gullies	69	1.5

The vegetation cover of the state changed significantly over the time period of this study. Due to the high population density and related pressures on land use and vegetation, the majority of the state has changed from the Lowland Rain Forest Ecological Zone to Derived Savanna Ecological Zone. This discrimination was based primarily on the difference in rural agricultural practices. For example, in the Lowland Rain Forest Ecological Zone, oil palm plantations are dominant, whereas in the Derived Savanna Ecological Zone more row crops and generally a degraded environment are present.

In 1993/95, there were new areas of gully erosion (95 km^2) and discontinuous grassland (119 km^2). The small area mapped as dominantly trees/woodlands/shrubs in 1976/78 was mapped as intensive agriculture in 1993/95. In 1993/95 none of the original 102 km^2 area mapped as disturbed forest in 1976/78 remained in 1993/95, almost all of it changed to intensive agriculture. Additionally, small areas mapped as intensive agriculture in 1976/78 became disturbed forest in the 1993/95 time period leaving only 36 km^2 of disturbed forest in the state.

Another indication of increasing intensity of land use was the increase in the extent of plantations. In 1976/78, a total of 0.3% (13 km^2) of the state was covered by teak and agricultural tree crop plantations. In 1993/95, the area of teak and agricultural tree crop plantations had increased to 1.3% (62 km^2) of the state.

While the area of forested freshwater swamp did not change dramatically, the extent of floodplain agriculture along the Niger River did increase. For example, in 1976/78, there was no visible floodplain agriculture in this area; however by 1993/95, the area of floodplain agriculture had grown to 4.2% (201 km^2).



8.6 BAUCHI STATE

Introduction

Bauchi State, with an area of 66 034 km^2 and a population of approximately 4.3 million, is located in the northeast of the country. It is bordered by two mountainous areas; in the southwest by the foothills of the Jos Plateau and in the southeast by the Tula uplands and Filiya hills. The state's transportation network is characterized by an old road that joins the cities of Yola and Maiduguri, and an extensive network of rural roads dating from the early 1980s. A railway passes through Bauchi from Jos, en route to Maiduguri.

Bauchi State is the site of Yankari National Park, Nigeria's premier wildlife sanctuary and one of the largest forest reserves in Nigeria, as well as the Lame-Burra Reserve which occupies a major area in the northwest of the state. The recent damming of the Gongola River along the eastern border of the state has created Dadin Kowa Reservoir.

Human Population

Bauchi State represents an interface between several cultures: the Hausa/Fulani in the north, the pastoral peoples of Borno State to the northeast, and the diverse cultures characteristic of Nigeria's Middle Belt. As many as a hundred ethnic minorities may be present in the state, evenly divided between Islam, Christianity and traditional religions.

Virtually the whole of the northern portion of the state is populated by Hausa and settled Fulani. In the south, the diverse groups of people are characterized by individualistic social organisation based on small villages. Historically slave-raiding in this region forced most of these communities to settle in inaccessible mountainous sites, and it is only recently that they began to farm the plains areas.

Population densities in the northeast of the state are variable, while population densities in the north (between Azare and Misau) and the southeast (around Gombe and the state border) are relatively high. Overall, population densities in the state are approximately 65 people per km^2 (Geomatics Nigeria Ltd. 1997b).

Farming and Agropastoral Systems

Much of Bauchi State is flat and characterized primarily by a semi-arid savanna regime. Consequently, cultivation is largely rainfed, although the damming of the Gongola River has created a potential for expanded irrigation. There are two cultivation systems: one in the semi-arid regions based on sorghum and millet intercropped with pulses, and one in the southeast based on intensive hill-agriculture. The Tula uplands in the southeast support an extremely elaborate terracing system,

featuring wide shallow stone terraces planted with complexes of mixed crops. Dry season cultivation of fadama areas expanded during the 1980s. Over the past ten years, the fallow period has declined from 5.3 years to 2.5 years (Geomatics Nigeria Ltd. 1997b).

Although Bauchi State is predominantly an agricultural state, livestock production has an integral role in most farming systems. The plains-based farmers have developed effective systems of raising and fattening their livestock while also using them to cultivate large areas of land. The Fulani pastoralists play an integral part in cattle production in Bauchi State.

Vegetation and Land Use Change

Bauchi State is relatively large and diverse and has seen dramatic changes in ecological zone boundaries. In 1976/78, approximately 60% of the state was designated as Sudan Savanna Ecological Zone. By 1993/95, the Sudan Savanna Ecological Zone covered most of the state (approximately 80%), with only a small area of the Guinea Savanna Ecological Zone remaining in the southwest, bordering the Jos Plateau. By 1993/95, the Sahel Savanna Ecological Zone was present in the northern part of the state. Overall, the Sahel Savanna Ecological Zone migrated one degree of latitude south in this area.

Table 8.10 Dominant Vegetation and Land Use Classes for 1976/78 and 1993/95, Bauchi State, Nigeria.

Land Use Category	1976/78		1993/95	
	Area (km^2)	Percent of state	Area (km^2)	Percent of state
Intensive (crop) Agriculture	20 026	30.3	27 338	41.4
Shrubs/Grasses	14 833	22.5	15 593	23.6
Extensive (grazing) Agriculture	11 049	16.7	12 050	18.3
Trees/Woodlands/Shrubs	14 754	22.3	3571	5.4
Gullies	0	0	1403	2.1
Disturbed Forest	0	0	1322	2.0
Floodplain Agriculture	882	1.3	1163	1.8
Discontinuous Grassland	683	1.0	956	1.5
Shrub/Sedge/Graminoid Freshwater Marsh/Swamp	770	1.2	622	0.9
Grassland	0	0	470	0.7
Reservoir	0	0	175	0.3
Extensive Agriculture with Denuded	26	<0.1	137	0.2
Undisturbed Forest	2367	3.6	125	0.2

Table 8.11 Dominant Vegetation and Land Use Changes between 1976/78 and 1993/95, Bauchi State, Nigeria.

Land Use 1976/78	Land Use 1993/95	Area affected (km^2)	Percent of state
Trees/Woodlands/Shrubs	no change	3140	4.8
	to Shrubs/Grasses	5395	8.2
	to Extensive (grazing) Agriculture	4277	6.5
	to Intensive (crop) Agriculture	1325	2.0
Shrubs/Grasses	no change	7888	12.0
	to Intensive (crop) Agriculture	4183	6.3
	to Extensive (grazing) Agriculture	1248	1.9
Undisturbed Forest	no change	124	0.2
	to Disturbed Forest	907	1.4
	to Intensive (crop) Agriculture	732	1.1
Intensive (crop) Agriculture	no change	15437	23.4
	to Extensive (grazing) Agriculture	1972	3.0
	to Shrubs/Grasses	639	1.0
Extensive (grazing) Agriculture	no change	4837	7.3
	to Intensive (crop) Agriculture	4422	6.7
	to Shrubs/Grasses	1217	1.8

The Jama'are River and its cultivated wetlands in the northern part of the state have undergone little land use change. However, outside of the floodplain area there was an increase in extensive agriculture, and a general degradation of the savanna and forest areas. Erosional processes resulting in denuded patches became more prevalent in this area. In 1976/78, only <0.1% of the state (26 km^2) was mapped as extensive agriculture with denuded areas, however, by 1993/95, this number had increased to approximately 0.2% (137 km^2) of the state. Many patches of dominantly shrubs/grasses had the shrub component removed and were mapped as dominantly grasses in 1993/95. In fact this area became a transition zone between the Sahel Savanna and Sudan Savanna ecological zones.

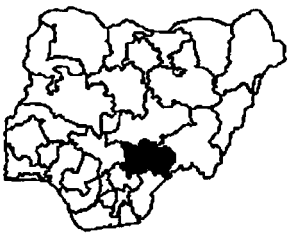
In the western part of the state there are a number of large forest reserves. In 1976/78, there were large expanses of dominantly trees/woodlands/shrubscovering 22.3% (14 754 km^2) of the state, by 1993/95, this number had dropped to 5.4%. In fact, only 4.8% of the dominantly trees/woodlands/shrubs area remained - 6.5% of the state had changed to extensive agriculture, 2.0% had changed to intensive agriculture and a further 8.2% (5395 km^2) had the tree cover removed, likely for use as fuelwood, and was mapped as dominantly grasses.

In the Lame-Burra Forest and Game Reserve, and a number of other forest reserves in the area, the tree cover remained largely intact. However, there was some encroachment of agriculture and the associated removal of trees for fuelwood and building materials. As a result, there were many areas

where the vegetation had been removed. In 1976/78, there were no visible areas of erosion, but by 1993/95, gullies were clearly visible in 2.1% (1403 km^2) of the state. Yankari National Park is located in the southern part of the state where the natural vegetation of the Guinea Savanna Ecological Zone has remained largely intact. However, it was affected by the encroachment of agriculture, fuelwood collection and the formation of gullies. A patch of continuous grassland appeared where the tree cover had been removed.

In 1976/78, there was a large expanse of dominantly shrubs/grasses with areas of undisturbed forest located in the south-central part of the state, east of Bauchi. Most of the state's 14 833 km^2 of dominantly shrubs/grasses and 2367 km^2 of undisturbed forest lands were located here in 1976/78. However, by 1993/95, only 7888 km^2 of the dominantly shrubs/grasses remained (a loss of 6945 km^2), while only 124 km^2 of the original undisturbed forest remained. These areas changed to disturbed forest or extensive or intensive agriculture.

In 1993/95, a new reservoir encompassing 175 km^2 was visible east of Gombe on the Gongola River. The reservoir appears to have had a negative environmental impact. For example, there are some newly flooded swampy areas and many new areas of discontinuous grassland and gully erosion where dominantly shrubs/grasses had previously existed, both east and west of the reservoir. There was also a new 129 km^2 agricultural plantation evident west of Gombe, another indicator of the growing intensity of land use.



8.7 BENUE STATE

Introduction

Benue State, with an area of 30 911 km^2 and population of approximately 2.8 million people, is bounded by the Niger River along its western border and the Benue River along its northern border. The former state of Benue was split into Kogi State in the western region while the eastern region remained as Benue State. The town of Makurdi has expanded considerably since becoming the state capital. A reasonably good internal transportation network exists, with water, road, rail and air networks.

Human Population

Three primary cultural groups are associated with Benue State: the Tiv, the Idoma and the Igala. The Tiv have a distinctive form of village architecture - circle of houses around a central meeting place. The Igala are organised into a series of territorial clans. The Idoma have a kingdom structure as well, but significant power is also held at the clan level.

Farming and Agropastoral Systems

The complex of streams, rivers, ponds and lakes and the fertile soil along the Benue River have considerable potential for swamp rice production, fishing and fish farming. Swamp cultivation usually depends on the specialised building of fields which are subject to natural flooding, and is often combined with fishing. Primary crops are rice, cocoyams, and some types of vegetables.

Agricultural activities on uplands beyond the floodplain were originally based on bush-fallow, with crops of yams, casavas, cereals and fruit. More recently, however, the intensity of cultivation has necessitated the introduction of a system of crop rotation involving tubers, cereals and legumes. Soils in the rest of the state have a high iron content, and have undergone considerable weathering. These soils are relatively low yielding as intensive farming has interrupted the deposition of leaf litter on which the soils' fertility depends.

The Tiv have a very characteristic pattern of agricultural expansion; pioneer settlements are established in virgin land outside the heartland region and cultivated using slash-and-burn systems. This practice seems to have increased as the availability of productive land in the core areas has decreased.

Benue State is an important transit point in the north-south movement of livestock. The Makurdi Cattle Control Post, as well as the sheep and goat market, are on the north bank of the Benue River and are major market locations for stock brought by Hausa, Fulani, Igala, Idoma and Tiv traders en route to Anambra and Imo states. After Makurdi, the second most important livestock market in the

state is Katsina-Ala. However, livestock production is in decline in Benue State due to disease, conflicts between pastoralists and farmers, and large scale changes in the agricultural economy of Nigeria.

Vegetation and Land Use Change

Table 8.12 Dominant Vegetation and Land Use Classes for 1976/78 and 1993/95, Benue State, Nigeria.

Land Use Category	1976/78		1993/95	
	Area (km^2)	Percent of state	Area (km^2)	Percent of state
Intensive (crop) Agriculture	17 903	57.9	22 660	73.3
Extensive (grazing) Agriculture	7785	25.2	3879	12.6
Trees/Woodlands/Shrubs	3111	10.1	2475	8.0
Disturbed Forest	149	0.5	475	1.5
Floodplain Agriculture	28	0.1	437	1.4
Riparian Forest	551	1.8	314	1.0
Shrub/Sedge Graminoid Freshwater Marsh/Swamp	614	2.0	123	0.4
Undisturbed Forest	354	1.1	11	< 0.1

Table 8.13 Dominant Vegetation and Land Use Changes between 1976/78 and 1993/95, Benue State, Nigeria.

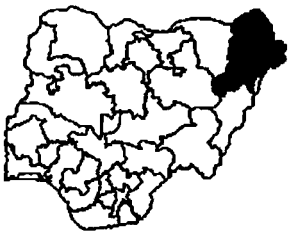
Land Use 1976/78	Land Use 1993/95	Area affected (km^2)	Percent of state
Trees/Woodlands/Shrubs	no change	544	1.8
	to Intensive (crop) Agriculture	1187	3.8
	to Extensive (grazing) Agriculture	1210	3.9
Undisturbed Forest	no change	2	< 0.1
	to Disturbed Forest	295	1.0
Riparian Forest	no change	172	0.6
	to Intensive (crop) Agriculture	236	0.8
Intensive (crop) Agriculture	no change	16 249	52.6
	to Trees/Woodlands/Shrubs	1145	3.7
Extensive (grazing) Agriculture	no change	2329	7.5
	to Intensive (crop) Agriculture	4677	15.1
	to Trees/Woodlands/Shrubs	640	2.1
Shrub/Sedge/Graminoid Freshwater Marsh/Swamp	no change	41	0.1
	to Floodplain Agriculture	254	0.8
	to Intensive (crop) Agriculture	189	0.6
	to Extensive (grazing) Agriculture	79	0.3

The majority of Benue State lies within the Derived Savanna Ecological Zone. Approximately one quarter of the state, primarily in the northeast, is designated as Guinea Savanna Ecological Zone.

Dominantly trees/woodlands/shrubs was identified in the small area north of the Benue River and along the eastern border of the state in 1993/95. In 1976/78, 10.1% (3111 km^2) of the state was covered with dominantly trees/woodlands/shrubs. By 1993/95 only 1.8% remained, while all other areas (2397 km^2 in total) were cleared for intensive and extensive agriculture. Interestingly, approximately 1785 km^2 of dominantly trees/woodlands/shrubs in the centre of the state reestablished itself in former agricultural areas. This may have been due to the introduction of grazing reserves (RIM 1992).

This state has experienced an intensification of land use with an increase in the area of intensive agriculture and floodplain agriculture. Over the time period of this study, the area of intensive agriculture increased from 57.9% of the state in 1976/78, to 73.3% in 1993/95. A total of 4677 km^2 (15.1%) of the state changed from extensive agriculture to intensive agriculture.

In 1976/78, the Benue River valley was covered by 614 km^2 of shrub/sedge/graminoid freshwater marsh/swamp and small areas of riparian forest and only 28 km^2 of floodplain agriculture. By 1993/95, the area of shrub/sedge/graminoid freshwater marsh/swamp had decreased to 123 km^2, while the extent of floodplain agriculture had increased to 437 km^2.



8.8 BORNO STATE

Introduction

Prior to 1989, Borno State was the largest state in Nigeria. However, in 1991 it was divided into the current Yobe (western part) and Borno (eastern part) states. This has resulted in Borno State having an area of 74 363 km^2 and a population of approximately 2.6 million. Maiduguri, the capital of Borno state, was settled in colonial times. Generally, the state is characterized by poor road infrastructure despite extensive road construction during the 1980s. Maiduguri has an international airport and is connected to Bauchi State by rail.

Human Population

Borno State is characterized by a low population density and sparse settlement pattern. The population is generally divisible into two groups: the diverse agricultural people of the south, and the peoples of the north-central region. The north-central region corresponds roughly to the domain of the Kanuri people. In general, the Kanuri are cultivators but they also have substantial holdings of cattle and other livestock. The agricultural people of the south have practiced cultivation since pre-colonial times, and have had limited contact in the past with pastoral people. However, as pastoral herds of the north have pushed further south, agricultural people have gradually acquired cattle for use in farming.

Farming and Agropastoral Systems

Lake Chad in the northwestern part of the state no longer exists as a body of open water in Nigeria, but it has been replaced by open plains of swampy grassland or even dry savanna. One feature of the lake is that the water is at its highest level during the dry season (January) and falls as the wet season progresses. Water levels are partly a function of subterranean flows which feed the lake, as well as inflow from the Logone-Chari (in the Cameroon). The lake can be cultivated three times a year; twice in the dry season, when use can be made of the residue moisture, and once during the rains, when upland crops can be sown. The current availability of land that used to flood seasonally has stimulated a surge of migrants from other parts of Nigeria, who have come to exploit the dry season farming and fishing. There are settlements of people from Sokoto State, far into the lake area, who fish and produce vegetables and other fadama crops for subsistence and sale. Similarly, fishermen from the Benue River have also come into these areas. Fish resources are already under significant pressure and catches are at record low levels.

Borno State is a major source of Nigeria's meat and supplies the needs of major cities. There are numerous livestock markets throughout the state, of which the most important are Maiduguri, Dikwa, Monguno and Malum Fatori. Although there is some local sale, the main business of the markets is to sell to large-scale entrepreneurs who in turn sell to the large markets of the south.

Except in the extreme south, livestock production in Borno is dominated by cattle pastoralism. With the opportunities for dry season cultivation of staples in the Chad region, and in the valley of the Komadugu Yobe, many pastoralists harvest two crops a year. In the Lake Chad area, cattle that are tolerant of insect bites are one element of a tripartite production system that integrates flood-retreat farming and fishing. The cattle are pastured on the land along the shore of the lake, which retains moisture and keeps grass-cover longer than the surrounding rangelands, although there is an increase in the incidence of biting flies, especially in the wet season. Because of the abundant pasture in Lake Chad, little use is made of the crop residues, although the lake is extensively farmed.

In the central rangelands, between Lake Chad and the western border of the state, cropping is based on the cultivation of rainfed sorghum and millet but yields are low and most people concentrate on managing large herds of Wadara cattle. In addition, the Fulani cross the region in large-scale, north-south migrations.

A major constraint in this state has been the availability of water. As reported in the Nigerian Livestock Resouces Survey (RIM 1992), studies by James in 1973 and 1977 have shown that borehole programs were not particularly successful in Borno State. By 1977, many of the boreholes drilled were no longer functioning. This, however, may have saved the existing pasture land as working boreholes would have attracted more cattle to the area. The long term effect of an inundation of cattle would probably have been overgrazing and pasture degradation, as seen on the Mambila Plateau. Water availability has also been affected by the decrease in rainfall levels. However, this factor has also had a positive effect on the amount of pasture land available for use. Low water levels have made the success of crop agriculture uncertain and opened the way for grazing cattle and small ruminants.

Finally, the valley of the Komadugu Yobe was green throughout the year until the Tiga Dam was constructed. Prior to dam construction, the valley was a major focus of transhumant herds, but now it is only a seasonal grazing resource. It is settled by agropastoralists (of the Kanuri) who combine fishing and flood retreat cultivation, and often entrust their own herds to the Fulani and Badawai during the dry season.

Vegetation and Land Use Change

Table 8.14 Dominant Vegetation and Land Use Classes for 1976/78 and 1993/95, Borno State, Nigeria.

Land Use Category	1976/78		1993/95	
	Area (km²)	Percent of state	Area (km²)	Percent of state
Extensive (grazing) Agriculture	19 392	26.1	25 885	34.8
Shrubs/Grasses	27 981	37.6	17 477	23.5
Intensive (crop) Agriculture	9 606	12.9	10 681	14.4
Grasses	8 742	11.8	6466	8.7
Shrub/Sedge/Graminoid Freshwater Marsh/Swamp	4 200	5.6	4029	5.4
Discontinuous Grassland	1 830	2.5	3641	4.8
Grassland	127	0.2	2082	2.8
Gullies	0	0	1023	1.4
Sand Dunes	429	0.6	892	1.2
Extensive Agriculture with Denuded	242	0.3	871	1.2
Graminoid/Sedge Freshwater Marsh	4200	5.6	482	0.6
Irrigation Project	27	< 0.1	411	0.6
Urban	57	0.1	140	0.2

Table 8.15 Dominant Vegetation and Land Use Changes between 1976/78 and 1993/95, Borno State, Nigeria.

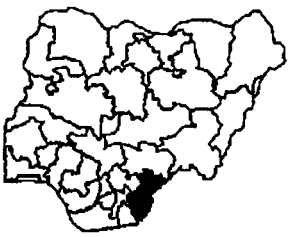
Land Use 1976/78	Land Use 1993/95	Area affected (km²)	Percent of state
Shrubs/Grasses	no change	14 888	20.0
	to Extensive (grazing) Agriculture	6917	9.3
	to Intensive (crop) Agriculture	2179	2.9
	to Grassland	1414	1.9
	to Discontinuous Grassland	737	1.0
	to Grasses	578	0.8
	to Gullies	574	0.8
Grasses	no change	3955	5.3
	to Extensive (grazing) Agriculture	3490	4.7
	to Discontinuous Grassland	662	0.9
Graminoid/Sedge Freshwater Marsh	no change	452	0.6
	to Shrub/Sedge/Graminoid Freshwater Marsh/Swamp	3098	4.2
	to Grasses	572	0.8
Intensive (crop) Agriculture	no change	6011	8.1
	to Extensive (grazing) Agriculture	1716	2.3
	to Extensive Agriculture with Denuded	491	0.7
Extensive (grazing) Agriculture	no change	12 705	17.1
	to Intensive (crop) Agriculture	2090	2.8
	to Shrubs and Grasses	1852	2.5
	to Discontinuous Grassland	1078	1.5

By 1976/78, open water was no longer visible in Lake Chad within the boundary of Nigeria. However, there were some wet areas visible, but most of the former lake area was covered by a lush grassy marshland. By 1993/95, the marsh had changed to a much drier shrub swamp and there was grassland where the former shore area receded. In fact, the area covered by graminoid/sedge freshwater marsh decreased from 4200 km^2 to only 452 km^2 in 1993/95 . Also over this time period, 572 km^2 of the graminoid/sedge freshwater marsh changed to dominantly grasses while 3098 km^2 changed to shrub/sedge/graminoid freshwater marsh/swamp.

Inland from Lake Chad, more dramatic changes are evident. Large areas in the earlier time period were stable, vegetated sand dunes were mapped as dominantly shrubs/grasses. Much of this area changed to grassland, exposed sand dunes or agriculture. In 1976/78, 36 723 km^2 of the state was once covered with dominantly grasses or dominantly shrub/grasses; however, by 1993/95 only 23 943 km^2 of this type of vegetation remained.

The cause of land use and vegetation change in this area is not clear and may be due in part to cyclical climatic change. However, during this time period, this area experienced the creation of three large irrigation projects south of Lake Chad (with irrigation canals draining the lake) and the construction of many new reservoirs. In addition, as the lake receded and grassland vegetation expanded, increasing numbers of cattle were brought into these new areas. Improvements in road infrastructure through the 1980s also allowed for the intensification of land use and access to the irrigation projects. For example, on the Komadugu Yobe floodplain more fadama agriculture and increased grazing activity throughout the area represents more intensive land use, and much of the former dominantly grass area is now grazing land.

The town of Maiduguri also grew and the sandy soils in this area appeared to be very sensitive to increased activity. Large areas around the town were being farmed so intensely that denuded areas were evident in 1993/95. The dominantly shrubs/grasses areas south of Maiduguri changed significantly; the agricultural area increased and became associated with many denuded and eroded areas. Finally, there were agricultural areas present along the river valleys and the removal of trees and shrubs for fuelwood was common.



8.9 CROSS RIVER STATE

Introduction

Cross River State, with an area of 20 041 km^2 and an estimated population of 3.8 million people, is located in southeastern Nigeria. It has an Atlantic Ocean coastline of 129 km and shares an international border with the Republic of Cameroon. Calabar, the state capital, developed originally in the seventeenth century as a commercial trading port. Calabar's connections with the rest of the country have improved in recent years since the building of a bridge over the Cross River. Cross River State is characterized primarily by lowland areas, although the Oban Hills along the Cameroon border represent one of the last regions of almost untouched primary rain forest in Nigeria. An area of the Oban Hills that abuts Korup National Park in Cameroon was designated as Cross River National Park in 1991.

Human Population

The main concentrations of populations in Cross River State are in the south on the mainland plains between Calabar and Ugep. In the inaccessible Oban hills, and on the sea-coast, villages are both small and uncommon. Accordingly, human settlement and livestock populations are very low in these areas. The derived savanna in the north of the state has become a focus of both seasonal and permanent migration from other areas. There is no one dominant ethnic group in Cross River State.

Farming and Agropastoral Systems

On the coast and in the riverine areas, fishing dominates the economy. Farmers also cultivate tree crops, including oil-palm, coconut, cocoa, raffia and rubber. In lowland rain forest area additional income opportunities are available through the gathering of forest products, hunting and trapping. Further north, farmers concentrate on the production of staples, particularly yam, cassava, cocoyam, maize and plantains. The harvesting and marketing of rattan is also a major source of employment and income for individuals in the state (Morakinyo 1994).

Cross River State is a net importer of some livestock species as local production meets only part of its needs. Generally, there are two cattle types in Cross River: the zebu and the muturu. The zebu are almost exclusively utilized by the Fulani pastoralists, who migrate between Cross River and Benue states. In the south, Kanuri or Fulani grazers are paid to find patches of grass in the forest close to the main markets, on which they manage herds of zebu cattle to marketable size. There are also some private fattening ranches on the outskirts of Calabar town. In contrast, muturu cattle have been kept in most villages essentially for prestige, and are sacrificed on important ceremonial occasions in many communities. The number of muturu in villages has decreased since the 1960s largely due to their lack of availability.

Vegetation and Land Use Change

Table 8.16 Dominant Vegetation and Land Use Classes for 1976/78 and 1993/95, Cross River State, Nigeria.

Land Use Category	1976/78		1993/95	
	Area (km^2)	Percent of state	Area (km^2)	Percent of state
Intensive (crop) Agriculture	8087	40.4	8626	43.0
Undisturbed Forest	6928	34.6	6149	30.7
Disturbed Forest	2531	12.6	2158	10.8
Extensive (grazing) Agriculture	249	1.2	1068	5.3
Forested Freshwater Swamp	807	4.0	438	2.2
Mangrove Forest	461	2.3	383	1.9
Plantation (forest, teak, agricultural tree crop)	328	1.6	366	1.8
Trees/Woodlands/Shrubs	77	0.4	123	0.6
Montane Forest	223	1.1	113	0.6
Shrub/Sedge/Graminoid Freshwater Marsh/Swamp	19	0.1	44	0.2
Montane Grassland	20	0.1	16	0.1

Table 8.17 Dominant Vegetation and Land Use Changes between 1976/78 and 1993/95, Cross River State, Nigeria.

Land Use 1976/78	Land Use 1993/95	Area affected (km^2)	Percent of state
Disturbed Forest	no change	1152	5.8
	to Intensive (crop) Agriculture	1130	5.6
Undisturbed Forest	no change	5471	27.3
	to Disturbed Forest	734	3.7
	to Intensive (crop) Agriculture	372	1.9
	to Extensive (grazing) Agriculture	323	1.6
Forested Freshwater Swamp	no change	280	1.4
	to Intensive (crop) Agriculture	444	2.2
Intensive (crop) Agriculture	no change	6565	32.8
	to Extensive (grazing) Agriculture	530	2.6
	to Undisturbed Forest	475	2.4

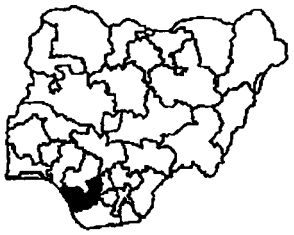
Most of the state is in the Lowland Rain Forest Ecological Zone with large areas of undisturbed vegetation in Cross River National Park. The northwest portion of the state is in the Derived Savanna Ecological Zone. In the south, the Forested Freshwater Swamp and Mangrove Forest and Coastal Vegetation ecological zones are situated along the coast.

Undisturbed forest occupied 34.6% of the state in 1976/78, but by 1993/95, this map class had decreased to 30.7%. Much of this area was protected to a degree in 1991 when Cross River National Park was established. There were also many forest reserves established in these areas including the

Afi and Ekinta River forest reserves. However, there was some encroachment of agriculture and removal of trees for fuelwood, and some of the original undisturbed forest areas were changed to disturbed forest (734 km^2), intensive agriculture (372 km^2) and extensive agriculture (323 km^2).

The western portion of the state is densely populated and characterized by intense land pressure and numerous plantations. Forest, teak and agricultural tree crop plantation areas remained significant, covering an area of 328 km^2 in 1976/78 and 366 km^2 in 1993/95. The plantations probably supply wood products to the local population, the local urban markets such as Calabar, and perhaps for export goods.

Coastal vegetation experienced the greatest impacts as a result of population growth. For example, upstream from Calabar, there was a loss of coastal forested freshwater swamp along the Cross River. In 1976/78, forested freshwater swamp was found in 4% (807 km^2) of the state. However, by 1993/95, approximately half of this area was lost to intensive agriculture with only 2.2% (438 km^2) of the state remaining as forested freshwater swamp.



8.10 DELTA STATE

Introduction

Delta State, with an area of 16 945 km^2 and a population of approximately 2.6 million people, is located in south-central Nigeria, with the southern border extending along the Gulf of Guinea. Delta State was created when Bendel State was split in two. The state has good transportation access to oil-bearing areas and ports, the major six ports being Warri, Burutu, Escravos, Forcados, Koko and Sapele. Warri is an important centre for oil refining, as well as for forestry products, particularly timber, rubber and oil-palm. The oil industry and rubber plantations have attracted wage labourers from all over the country, particularly the Igbo from the east.

Human Population

This state is populated mainly by the Edo peoples who belong to two major groups: the Edo of the central plains, and the Edo of the delta. In the southern delta, there are four main groups of peoples. The Itsekiri and Ijaw live between Warri and Burutu in small, mobile communities in the mangrove and freshwater swamp forests, while the Urhobo and Isoko live in the regions of lowland forest north of the creeks.

Farming and Agropastoral Systems

Delta State is characterised by a network of creeks and estuaries dominated by mangroves and swamp forest. These areas, especially those around the ports of Warri and Ughelli, have been affected by pollution from oil spills in recent years. This is of note given the importance of fishing and water-based resource exploitation typical of the state. Plantains and cocoyams are the main crops. Among the southern populations of the Edo peoples, the Itsekiri and Ijaw depend on fishing, the collection of crustaceans and some oil-palm processing, while the Urhobo and Isoko practise dry-land farming as well as rubber tapping, oil-palm processing and trading. In rural areas the Edo are smallholder subsistence farmers.

Livestock production is of little importance in this state. Some cattle are left to graze in the swamps and on beaches, but typically most people keep only a few chickens.

Vegetation and Land Use Change

Table 8.18 Dominant Vegetation and Land Use Classes for 1976/78 and 1993/95, Delta State, Nigeria.

Land Use Category	1976/78		1993/95	
	Area (km^2)	Percent of state	Area (km^2)	Percent of state
Intensive (crop) Agriculture	7585	44.8	7949	46.9
Forested Freshwater Swamp	4649	27.4	3518	20.8
Mangrove Forest	3077	18.2	3306	19.5
Urban (minor+major)	77	0.4	502	3.0
Undisturbed Forest	158	0.9	274	1.6
Floodplain Agriculture	0	0	206	1.2
Saltmarsh/Tidal Flat	0	0	203	1.2
Plantations (forest, agricultural tree crop)	99	0.6	150	0.9
Disturbed Forest	163	1.0	72	0.4
Riparian Forest	337	2.0	34	0.2

Table 8.19 Dominant Vegetation and Land Use Changes between 1976/78 and 1993/95, Delta State, Nigeria.

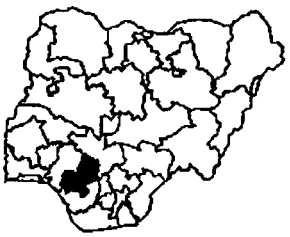
Land Use 1976/78	Land Use 1993/95	Area affected (km^2)	Percent of state
Disturbed Forest	no change	39	0.2
	to Intensive (crop) Agriculture	109	0.6
Riparian Forest	no change	1	< 0.1
	to Undisturbed Forest	174	1.0
	to Intensive (crop) Agriculture	135	0.8
Forested Freshwater Swamp	no change	2823	16.7
	to Intensive (crop) Agriculture	799	4.7
	to Mangrove Forest	586	3.5
	to Saltmarsh/Tidal Flat	156	0.9
	to Floodplain Agriculture	104	0.6
Mangrove Forest	no change	2421	14.3
	to Forested Freshwater Swamp	354	2.1
	to Water	186	1.1
Intensive (crop) Agriculture	no change	6730	39.7
	to Urban (minor+major)	502	3.0
	to Forested Freshwater Swamp	229	1.4

In Delta State, the Mangrove Forest and Coastal Vegetation and Forested Freshwater Swamp ecological zones occupy coastal areas and along the Niger River. Inland areas in the northeast portion of the state are situated in the Lowland Rain Forest Ecological Zone. These inland areas are characterized by intensive agriculture with remnants of riparian and old growth forest along the waterways.

As in other states in this area, intensive land use was associated with an increase in areas designated as plantations. In 1976/78, agricultural tree crop and forest plantations occupied 0.6% (99 km^2) of the state. By 1993/95, the area covered by plantations increased 50% and covered 0.9% (150 km^2) of the state.

There was some loss of forested freshwater swamp areas along the Niger River floodplain. It was cleared for intensive agriculture or cultivated for floodplain agriculture. Over the study period, 799 km^2 of forested freshwater swamp vegetation was cleared for intensive agriculture, and 104 km^2 of forested freshwater swamp was changed to floodplain agriculture.

Along the Gulf of Guinea coastline, there were changes in vegetation that are of concern. Specifically, there has been some recession of the coastline which requires a more detailed approach to measure accurately. There were three areas, totaling 156 km^2, of forested freshwater swamp in 1976/78 that appeared as saltmarsh or tidal flats in 1993/95. This change was probably a result of saltwater inundation.



8.11 EDO STATE

Introduction

Edo State, with an area of 19 606 km^2 and a population of approximately 2.1 million people, is located in south-central Nigeria, north of Delta State. Its eastern border runs along the Niger River and its northern border extends almost as far north as the confluence of the Niger-Benue rivers. Edo State was created in 1991 following the split of Bendel State and occupies the northern part of this former state. The capital, Benin City, is an ancient town with a history extending back nearly a thousand years, and is the traditional centre of the Edo peoples.

Human Population

The Edo people are the dominant cultural group populating this state. They are comprised of two major groups: the Edo of the central plains, and hill peoples of the north. The hill regions in the north are inhabited by a mosaic of small ethnic groups related to the Edo as well as recent migrants including the Fulani pastoralists.

Farming and Agropastoral Systems

In the southern part of the state, oil palm plays an important role in the agricultural system. Within this area patches of open grassland have become important as areas for fattening cattle in recent years. Agriculture in these areas is rainfed, and tubers, especially yams, cocoyams and cassava, are the subsistence staples, complimented by maize, potherbs and egusi melons. The harvesting and marketing of rattan is also an important employment and income-generating activity in the state (Morakinyo 1994). However, much of the benefit is derived by the rattan cane cutters, and few benefits are derived by forest communities.

In central areas of the state, a range of fruits is produced in large quantities, including pineapple, plantain, bananas, avocados and pears.

In the northern part of the state, cereals are cultivated, notably maize and sorghum in the hill areas and rice in the swampy zones along the valley of the Niger River.

Livestock production becomes increasing important northward in the northern part of state although it is still of minor importance compared to agriculture. In the northwest, grassy uplands allow permanent grazing sites for the cattle of the Fulani pastoralists. Livestock production is mainly village-based, where goats, sheep and pigs are the main species raised.

Vegetation and Land Use Change

Table 8.20 Dominant Vegetation and Land Use Classes for 1976/78 and 1993/95, Edo State, Nigeria.

Land Use Category	1976/78		1993/95	
	Area (km^2)	Percent of state	Area (km^2)	Percent of state
Intensive (crop) Agriculture	12 385	63.2	13 047	66.6
Disturbed Forest	2395	12.2	3294	16.8
Forested Freshwater Swamp	490	2.5	852	4.4
Agricultural Tree Crop Plantation	175	0.9	470	2.4
Forest Plantation	344	1.8	414	2.1
Teak/Gmelina Plantation	186	1.0	369	1.9
Floodplain Agriculture	0	0	252	1.3
Undisturbed Forest	3108	15.9	219	1.1
Grassland	0	0	169	0.9
Riparian Forest	146	0.7	34	0.2

Table 8.21 Dominant Vegetation and Land Use Changes between 1976/78 and 1993/95, Edo State, Nigeria.

Land Use 1976/78	Land Use 1993/95	Area affected (km^2)	Percent of state
Disturbed Forest	no change	997	5.1
	to Intensive (crop) Agriculture	1217	6.2
Undisturbed Forest	no change	110	0.6
	to Disturbed Forest	1390	7.1
	to Intensive (crop) Agriculture	810	4.1
	to Forested Freshwater Swamp	356	1.8
	to Forest Plantation	170	0.9
	to Agricultural Tree Crop Plantation	169	0.9
Forested Freshwater Swamp	no change	300	1.5
	to Intensive (crop) Agriculture	132	0.7
Intensive (crop) Agriculture	no change	10 628	54.2
	to Disturbed Forest	817	4.2
	to Floodplain Agriculture	176	0.9

The centre of Edo State is situated in the Lowland Rain Forest Ecological Zone, while the northern third of the state is located in the Derived Savanna Ecological Zone. A small band in the southern part of the state is located in the Freshwater Swamp and Mangrove Forest and Coastal Vegetation ecological zones.

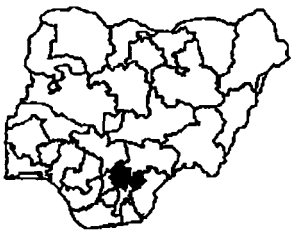
The most significant change occurred in an area of 3108 km^2 previously designated as undisturbed forest. By 1993/95, only 110 km^2 of this area remained unchanged. A large part of this area (1390 km^2) underwent some removal of trees and shrubs for fuelwood, and was mapped as disturbed forest in 1993/95. Another 810 km^2 was cleared for intensive agriculture. The remaining 339 km^2 changed

to agricultural tree crop plantation and forest plantations. Also in the south, approximately 132 km^2 of forested freshwater swamp was cleared for agriculture. However, this loss of forested freshwater swamp was balanced by 356 km^2 of undisturbed forest (in 1976/78) that changed to forested freshwater swamp.

In the north, the Derived Savanna Ecological Zone has shifted southward as an area of disturbed forest was cleared and is now used for intensive agriculture. Overall in Edo State, 1217 km^2 of the previously disturbed forest was changed to intensive agriculture.

In 1976, there were only small areas of floodplain agriculture within the Niger River floodplain. However, by 1993/95, 252 km^2 of this area was devoted to floodplain agriculture. In addition, the size of the floodplain seems to have been extended, possibly due to irrigation works. This is particularly evident south of Agenebode both the east and west side of the Niger River.

As seen in other areas of the Derived Savanna Ecological Zone, there were regions of discontinuous grassland emerging where agriculture was previously identified. These may be areas of fallow or areas of very low productivity which were abandoned. In the Livestock Survey (RIM 1992) there is some mention that such areas were being used as pasture.



8.12 ENUGU STATE

Introduction

Enugu State, with an area of 12 710 km^2 and a population of approximately 3.2 million people, is located in south-central Nigeria, and is bounded by Anambra State to the west and the Cross River to the east. This state was formed from the eastern part of the former Anambra State, and is divided from Anambra State by a sandstone ridge along the Udi Plateau. Enugu, the state capital, is a major commercial centre for livestock brought by road from northern and central Nigeria and it is also a coal mining centre. There is an international airport in Enugu and a number of major highways linking this state to the rest of Nigeria.

Human Population

The state is characterised by a dense rural population. The population of Enugu State is almost exclusively comprised of Igbo peoples, although there is great diversity within this cultural group. Primary occupations of the Igbo, and other people inhabiting this state, are farming and trade. Their culture is characterized by community/clan unit ownership of land. Additionally, groups of pastoral Fulani have migrated to the northern part of the state since the civil war in the mid 1970s.

Farming and Agropastoral Systems

There are two main farming systems in Enugu State: rainfed cropping in upland areas and row cropping in the north. Crops commonly planted in the uplands include yam, cassava, sweet potato, cocoyam, vegetables, egusi (melon), tomatoes, pepper, legumes and grains. Further south, there is a transition to more tropical types of oil palm-based agriculture. Since the land is under intensive cultivation, complex systems of mulching and composting are used to maintain soil fertility.

The pastoral Fulani are the main cattle rearers, although overall a dense rural population effectively precludes large-scale livestock production. As a result, small-scale production predominates. However this production continues to decline as primary educational opportunities result in fewer children being less available to manage the animals. In particular, the muturu breed of cattle, once kept throughout the Igbo area, are gradually disappearing.

Vegetation and Land Use Change

Table 8.22 Dominant Vegetation and Land Use Classes for 1976/78 and 1993/95, Enugu State, Nigeria.

Land Use Category	1976/78		1993/95	
	Area (km^2)	Percent of state	Area (km^2)	Percent of state
Intensive (crop) Agriculture	10 487	82.5	10 947	86.1
Discontinuous Grassland	0	0	635	5.0
Gullies	0	0	371	2.9
Riparian Forest	398	3.1	293	2.3
Disturbed Forest	886	7.0	155	1.2
Trees/Woodlands/Shrubs	873	6.9	82	0.6
Floodplain Agriculture	0	0	75	0.6

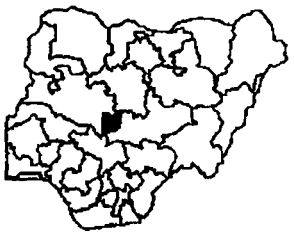
Table 8.23 Dominant Vegetation and Land Use Changes between 1976/78 and 1993/95, Enugu State, Nigeria.

Land Use 1976/78	Land Use 1993/95	Area affected (km^2)	Percent of state
Trees/Woodlands/Shrubs	to Discontinuous Grassland	459	3.6
	to Intensive (crop) Agriculture	242	1.9
	to Gullies	166	1.3
Disturbed Forest	no change	109	0.9
	to Intensive (crop) Agriculture	718	5.7
Riparian Forest	no change	84	0.7
	to Intensive (crop) Agriculture	307	2.4
Intensive (crop) Agriculture	no change	9656	76.0
	to Gullies	191	1.5
	to Riparian Forest	187	1.5
	to Discontinuous Grassland	146	1.2
	to Trees/Woodlands/Shrubs	74	0.6

Enugu State is entirely in the Derived Savanna Ecological Zone. Growing pressures on land resources in the state from increasing population density is resulting in general degradation of land cover with widespread erosion.

In 1976/78, dominantly trees/woodlands/shrubs on the plateau covered 873 km^2, while in 1993/95, none remained. This area changed predominantly to discontinuous grassland (459 km^2), gully erosion (166 km^2) and intensive agriculture (242 km^2). In 1976/78, the disturbed forest areas that were mainly on the ridge of the plateau covered an area of 886 km^2. In 1993/95, only 109 km^2 remained as disturbed forest, while 718 km^2 had been cleared for intensive agriculture.

The most striking change was the dramatic increase in gully erosion along this ridge and on the Udi Plateau. In 1976/78, there where no visible areas of erosion. However, by 1993/95, 371 km^2 of gully erosion were clearly identifiable. The new areas of discontinuous grassland were indicative of some degree of erosional activity.



8.13 FEDERAL CAPITAL TERRITORY

Introduction

The Federal Capital Territory (FCT) was established in central Nigeria in 1976. It has an area of 6947 km^2 and population of approximately 0.4 million with a population density of 58 people per km^2. Major construction work in Abuja, the national capital city, occurred in the early 1980s and is still continuing. A network of access roads was developed and housing construction continues. Large, low-cost estates were established west of the main town, with the expectation that expanded commerce and increased governmental activity would initiate rapid population growth. The airport in Abuja has regular connecting flights to Lagos, as well as international flights.

Human Population

The rural areas of the Federal Capital Territory (FCT) are dominated by two ethnic groups, the Gwari and the Gade. The Gwari, whose territory includes the west of the FCT, are one of the most numerous peoples of west-central Africa. They are extremely decentralized and characterized by self-governing individual village communities. This individualism is reflected throughout their society, but is most visible in their methods of agricultural expansion. Gwari villages are constantly fragmenting, with compounds moving into regions of uncultivated bush to begin new farms. The Gade and other groups in the area have a similar social structure to the Gwari, in that they are decentralized and do not have a strong clan structure. The Koro, who have inhabited the region for a long time, are also present in the state.

In addition, the new territory is attracting migrants from all parts of Nigeria, although most are in the service sector and do not compete for farm land. In general, the population of the plains areas in the middle belt of Nigeria have been growing since the civil war as people are resettling in these areas.

Farming and Agropastoral Systems

Farming systems in the FCT are dominated by rain-fed cultivation, although along the Gurara River and its associated tributaries, there is swamp-farming of rice, cocoyams and plantains, and dry-season farming of vegetables. In the upland areas, the main crops include sorghum, millet, maize, fonio, yams, sweet potatoes, Irish potatoes and a variety of vegetables.

Livestock production is limited within the FCT. However, Fulani herds arrive just after the harvest to graze the crop residues, and then continue southwards towards the riverine pastures along the Niger and Benue rivers. Generally, goats and sheep are left to graze largely unsupervised and confined only in the wet season to prevent them from interfering with agricultural crops. Pigs are

also commonly kept by the Gwari and Koro peoples, especially around Kwali. Pigs are confined to pens in the growing season.

Vegetation and Land Use Change

Table 8.24 Dominant Vegetation and Land Use Classes for 1976/78 and 1993/95, Federal Capital Territory, Nigeria.

Land Use Category	1976/78		1993/95	
	Area (km^2)	Percent of state	Area (km^2)	Percent of state
Extensive (grazing) Agriculture	3399	48.9	2986	43.0
Intensive (crop) Agriculture	766	11.0	2314	33.3
Trees/Woodlands/Shrubs	2123	30.6	1375	19.8
Urban (major+minor)	0	0	92	1.3
Riparian Forest	114	1.6	81	1.2
Undisturbed Forest	500	7.2	1	<0.1

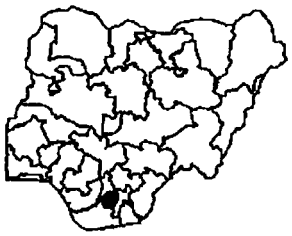
Table 8.25 Dominant Vegetation and Land Use Changes between 1976/78 and 1993/95, Federal Capital Territory, Nigeria.

Land Use 1976/78	Land Use 1993/95	Area affected (km^2)	Percent of state
Trees/Woodlands/Shrubs	no change	703	10.1
	to Extensive (grazing) Agriculture	890	12.8
	to Intensive (crop) Agriculture	505	7.3
Undisturbed Forest	no change	0	0
	to Trees/Woodland/Shrubs	279	4.0
	to Extensive (grazing) Agriculture	178	2.6
Intensive (crop) Agriculture	no change	544	7.8
	to Extensive (grazing) Agriculture	161	2.3
Extensive (grazing) Agriculture	no change	1704	24.5
	to Intensive (crop) Agriculture	1212	17.4
	to Trees/Woodlands/Shrubs	338	4.9
	to Urban	69	1.0

The Federal Capital Territory is located in the centre of the savanna region of central Nigeria. However, the Federal Capital Territory has seen a general degradation of the environment as the population of the area has grown.

Cattle grazing (extensive agriculture) is a major agricultural activity in the state, covering approximately 2986 km^2 in 1993/95. Intensive or row crop agriculture increased from 766 km^2 in 1976/78, to 2314 km^2 in 1993/95, or almost as much land area as extensive (grazing) agriculture.

Over the time period of this study there was a dramatic loss of the dominantly trees/woodlands/shrubs area and undisturbed forest, and a tripling in the land area devoted to intensive agriculture. In 1976/78, there was 500 km^2 of undisturbed forest. In 1993/95, only 1 km^2 of this forested area remained. Tree cover was removed for fuelwood or cleared for agriculture. Dominantly trees/woodlands/shrubs covered an area of 2123 km^2 in 1976/78, while only 703 km^2 of this area remained in 1993/95.



8.14 IMO STATE

Introduction

Imo State, with an area of 5081 km^2 and population of approximately 2.5 million, is located in south-central Nigeria, north of Rivers State. This state was formed from the western part of the former Imo State. The largest town is Aba, a busy commercial and industrial town, while the state capital, Owerri, is a large cattle trading and distribution centre. Aba owes its importance to the railway which passes south to Port Harcourt. An expressway built in the 1970s through Imo State, links Port Harcourt in the south to Enugu in the north.

The state is partly defined by the valleys of the Imo River and its tributaries, the Otamiri and Azumini, as well as the Cross River that forms its eastern border. A local salt industry has developed around Abadaba Lake in Etiti Local Government Area and the Uburu Salt Lakes in Ohaozara Local Government Area.

Human Population

Imo State is in the Igbo heartland and, apart from Hausa traders in the towns, in-migration has been limited. Although Imo State is one of the more densely populated states in Nigeria, the majority of the population has remained rural. An estimated 10% of the population lives in the larger towns and cities (Imo State Government 1984).

Land traditionally belongs to the community or to aggregates of smaller localized lineages among the Igbo people. Land may be privately owned by the male heads of families through inheritance or purchase. Where there is not enough community land for everyone, it is farmed in sequence by individuals. Until recently, it was typical to find Igbo villages with few men for much of the year since they left to search for employment elsewhere. However, the downturn in the national economy has brought many back to the villages.

Farming and Agropastoral Systems

Farming systems in the state can be broadly divided into upland and riverine systems, corresponding to rainfed and naturally flooded land. In the uplands, farmers depend on forest or bush fallow and the cropping system is based around tree-crops and tubers. The soil is low in fertility except for the thin top layer on which cassava, yam, maize, cocoyam plantains, bananas and oil-palms are grown. Approximately half of the tree-crops are in plantations (such as oil-palm estates). The main crops in the swampy areas are rice, cocoyams and a variety of vegetables.

Livestock herding is a peripheral activity in the state. Traditionally, livestock rearing was based on a free-range system. However, increases in the population have intensified land use pressures and labour is no longer available to manage livestock on a cut-and-carry basis. Consequently, owning livestock is associated with prestige in the community rather than related to economic incentives. As a result, most of the meat and fish eaten in the state is imported. Livestock comes directly or indirectly from northern Nigeria, and the trade is largely in the hands of northerners. The main livestock markets are at Owerri, Umuahia, Aba and Okigwe.

Vegetation and Land Use Change

Table 8.26 Dominant Vegetation and Land Use Classes for 1976/78 and 1993/95, Imo State, Nigeria.

Land Use Category	1976/78		1993/95	
	Area (km^2)	Percent of state	Area (km^2)	Percent of state
Intensive (crop) Agriculture	4411	86.8	4287	84.4
Forested Freshwater Swamp	241	4.7	303	6.0
Discontinuous Grassland	0	0	184	3.6
Plantation (agricultural tree crop and teak)	78	1.5	89	1.7
Disturbed Forest	0	0	58	1.1
Gullies	0	0	22	0.4
Riparian Forest	117	2.3	14	0.3
Reservoir	2	< 0.1	5	0.1
Trees/Woodlands/Shrubs	167	3.3	0	0
Shrub/Sedge/Graminoid Freshwater Marsh/Swamp	45	0.9	0	0

Table 8.27 Dominant Vegetation and Land Use Changes between 1976/78 and 1993/95, Imo State, Nigeria.

Land Use 1976/78	Land Use 1993/95	Area affected (km^2)	Percent of state
Trees/Woodlands/Shrubs	no change	0	0
	to Discontinuous Grassland	120	2.4
	to Shrubs/Grasses	46	0.9
Riparian Forest	no change	1	< 0.1
	to Intensive (crop) Agriculture	71	1.4
Intensive (crop) Agriculture	no change	4097	80.6
	to Forested Freshwater Swamp	76	1.5
	to Discontinuous Grassland	64	1.3

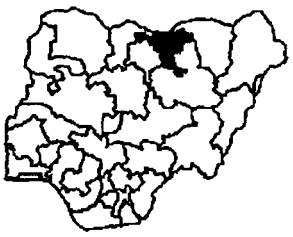
Indeed, over the time period of this study, there was a definite degradation of the environment in Imo State due to a growing population and the increase in land use pressures. In 1976/78, all of this state was in the Lowland Rain Forest Ecological Zone. By 1993/95, the Derived Savanna Ecological Zone had shifted southwards to include the northern half of the state. The delineation of the zones is based on the type of natural vegetation present, however, in the areas cleared of natural vegetation, the

agricultural practices are an indicator of the ecological zone. In the Derived Savanna Ecological Zone there is a predominance of row crops whereas in the Lowland Rain Forest Ecological Zone agriculture is characterized by oil palm and economic tree agriculture.

Along the northern border of the state is the eroded ridge of the Udi Plateau, which continues into Enugu State. Along this ridge, the tree cover was removed from the areas of dominantly trees/woodlands/shrubsand in 1993/95 they appeared as discontinuous grassland, with some areas resembling the dominantly shrubs/grasses map unit. In 1976/78, 167 km^2 of the state (3.3%) was dominantly trees/woodlands/shrubs, by 1993/95, none remained.

The acidic and sandy soils throughout the state do not withstand erosion processes very well. As a result, there is severe sheet and gully erosion in many areas. While gully erosion was not identifiable on the radar imagery of this state, erosional processes were evident on the SPOT imagery north of Owerri where large areas were bare and could support only grasses.

There was some increase in the area of plantations. Agricultural tree crop and teak plantations encompassed 78 km^2 in 1976/78, and increased in area to 88 km^2 in 1993/95.



8.15 JIGAWA STATE

Introduction

Jigawa State, with an area of 23 089 km^2 and population of approximately 2.8 million people, is located along the northern border of Nigeria, and was created after the original Kano State was split in two. In general, Jigawa State is fairly isolated, although it remains connected to the more commercially and industrially-oriented Kano State to the southwest.

Human Population

The Hausa form the majority of the population of Jigawa State. Hausa society is based around a fundamental division between the urban areas and the rural village. The towns specialize in trade and crafts. These urban areas are encircled by high-density cultivation areas which supply the town with staples, fuelwood, meat and livestock in exchange for trade goods, manure, potsherds and ash to keep the farms fertile.

Additionally, other ethnic groups in Jigawa State include Ngizim, Bade and Karekare peoples who inhabit the eastern regions of the state.

Farming and Agropastoral Systems

The main river system is the Hadejia-Jama'are, which crosses the state. The swampy grasslands between Hadejia and Gashua (in Borno State) have traditionally been a significant resource for fadama cropping, fishing and livestock feed.

Systems of virtually continuous cultivation exist in many areas, although some farmers still have access to sufficient land to practice bush-fallowing. Jigawa State, like Kano State to the southwest, is intensively farmed and very little natural vegetation remains. The fertility of this zone is maintained through the application of animal manure and waste from the urban areas. Rainfed dry-grain farming systems which are based on the cultivation of millet and sorghum with an interplanting of cowpeas, are important in this state.

In Jigawa State, livestock production plays an integral role in farming systems. Farmers have developed effective systems that use animal power to cultivate under difficult climatic conditions. Both ploughs and carting allow farmers to exploit a larger area of land, which compensates for low yields. However, the overall intensity of agriculture in the state is gradually eliminating pastoralism. Greater numbers of local farmers keeping cattle need crop residues to feed their own animals, thus are increasingly less likely to make these available to Fulani pastoralists. The fadama regions are

likely to retain pastoralists longest, but the existence of these wetlands is threatened by upstream irrigation projects.

Water shortages are a perennial problem for livestock production since rivers are often dry for much of the year. Communal grazing has deteriorated some areas to the extent that the surface has become bare and gully erosion has set in along cattle tracks.

Vegetation and Land Use Change

Table 8.28 Dominant Vegetation and Land Use Classes for 1976/78 and 1993/95, Jigawa State, Nigeria.

Land Use Category	1976/78		1993/95	
	Area (km^2)	Percent of state	Area (km^2)	Percent of state
Intensive (crop) Agriculture	8496	36.8	15 940	69.0
Floodplain Agriculture	1795	7.8	2341	10.1
Discontinuous Grassland	692	3.0	1122	4.9
Extensive Agriculture with Denuded	1265	5.5	832	3.6
Shrub/Sedge/Graminoid Freshwater Marsh/Swamp	1075	4.7	701	3.0
Extensive (grazing) Agriculture	7746	33.6	561	2.4
Grasses	48	0.2	556	2.4
Shrubs/Grasses	1201	5.2	473	2.1
Gullies	0	0	101	0.4
Graminoid/Sedge Freshwater Marsh	251	1.1	45	0.2
Reservoir	0	0	45	0.2
Undisturbed Forest	260	1.1	3	< 0.1

Table 8.29 Dominant Vegetation and Land Use Changes between 1976/78 and 1993/95, Jigawa State, Nigeria.

Land Use 1976/78	Land Use 1993/95	Area affected (km^2)	Percent of state
Shrubs/Grasses	no change	146	0.6
	to Intensive (crop) Agriculture	473	2.1
	to Grasses	437	1.9
Shrub/Sedge/Graminoid Freshwater Marsh/Swamp	no change	468	2.0
	to Floodplain Agriculture	480	2.1
Intensive (crop) Agriculture	no change	7858	34.0
	to Extensive Agriculture with Denuded	165	0.7
Extensive (grazing) Agriculture	no change	453	2.0
	to Intensive (crop) Agriculture	6501	28.2
	to Floodplain Agriculture	160	0.7
	to Extensive Agriculture with Denuded	158	0.7
Extensive Agriculture with Denuded	no change	451	2.0
	to Intensive (crop) Agriculture	757	3.3

Jigawa State has experienced significant vegetation change which may indicate the effects of desertification. The Sahel Savanna Ecological Zone appears to have shifted southwards during the study period. For example, in 1976/78, most of the state was in the Sudan Savanna Ecological Zone, with a small portion of the northern border showing sahel vegetation. By 1993/95, most of the northern parts of the state appeared to be within the Sahel Savanna Ecological Zone, with just the southern tip showing sudan vegetation. Much of the state is now a transition zone between the Sahel Savanna and Sudan Savanna ecological zones.

The entire state has experienced an intensification in agricultural land use. In 1976/78, 7746 km^2 (33.6%) of the state was used for extensive agriculture, by 1993/95, this area was reduced to only 561 km^2 of the state (2.4%). Ninety percent of the extensive (grazing) agricultural land was converted to intensive agriculture, with the remaining land area going to agriculture with denuded areas and floodplain agriculture.

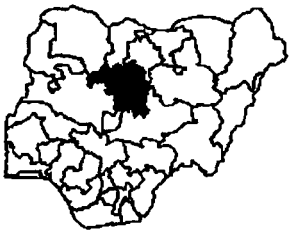
The effects of the Kano River Project and the Tiga Dam south of Rano have been of great concern because they seem to have reduced the flooding regime of the northern rivers flowing to Lake Chad. The Hadejia and Jamaare rivers run through the centre of Jigawa State. The natural vegetation surrounding these floodplains was dominantly shrubs/grasses. However, the intensity of land use in many parts of the state reduced it to dominantly grasses. The area devoted to floodplain agriculture increased as swamp areas were cultivated. These floodplains have traditionally been a very significant resource for fadama cropping, fishing and livestock feed. The area of the floodplain used for agriculture increased from 1795 km^2 in 1976/78 to 2341 km^2 in 1993/95. In the area of the floodplain, a new reservoir, approximately 45 km^2 in size was established.

Over the time period of the study land use in the area north of the Hadejia floodplain appears to have intensified. In 1976/78, the area north of the Hadejia floodplain was grass covered and used for grazing, with patches of relatively undisturbed shrubs/grasses. An area of 1265 km^2 along the northern border had denuded patches in the grazing areas. In 1993/95 imagery, the extensive agriculture with denuded areas had reduced to an area of 832 km^2; however, agricultural practices seemed to have intensified from grazing to predominantly row crop agriculture. The areas of dominantly shrubs/grasses experienced the removal of their shrub component and appeared as dominantly grasses. Many rows of tree plantations were established to provide shelterbelts.

South of the Hadejia floodplain are large areas of discontinuous grassland that appear to be increasing in size. In 1976/78, discontinuous grassland covered 692 km^2 (3.0%) of the state, whereas by 1993/95, it had increased to 1122 km^2 (4.9%). These areas showing growth may indicate a reduction in the area of floodplain, erosion and/or desertification. A multitemporal study of these areas could be more conclusive.

In the far south end of the state, south of Birnin Kudu, the trend of overall intensification of land use seemed to continue. Areas of extensive (grazing) agriculture in 1976/78 appear as intensive

agriculture. A 260 km^2 forest in 1976/78 has had the tree cover removed and 202 km^2 of the previously forested area now appears as dominantly shrubs/grasses. Some of these areas were in forest reserves, such as Farin Ruwa and Rabadi. It was this southern area of the state where 101 km^2 of gully erosion was visible in the 1993/95 imagery.



8.16 KADUNA STATE

Introduction

Kaduna State has an area of 43 233 km^2 and a population of approximately 4.0 million people. Kaduna city is a major industrial centre in northern Nigeria, as well as being a terminus for the railway lines from the south, and a major road junction. The airport has been upgraded to international standards.

Human Population

Rural populations in Kaduna State are generally concentrated around two main areas. In the north one group is centered around the ancient kingdom of Zaria, and in the south a large population of dispersed and heterogeneous ethnic groups who are most closely linked to the peoples of nearby Plateau State. Additionally there is a large population centred around Kaduna city made up of the large numbers of immigrants from groups all over Nigeria. The people of the Zaria region specialize in trade and crafts. The towns in the region are encircled by high-density agricultural areas which supply the towns with staples, fuelwood, meat and livestock, in exchange for traded goods, manure and ash to keep the farms fertile. Key cultural groups in this region include the Hausa, the Gwari and the Fulani. Fulani in the Zaria region generally fall into four classes; the true nomads without any permanent base, the transhumant agropastoralists with home farms and large mobile herds, the settled Fulani who keep small herds and practice subsistence agriculture, and the wealthy urban Fulani who live in the towns and hire herders to manage their cattle.

Farming and Agropastoral Systems

The major river system in the state is the Kaduna River and its tributaries, most of which flow throughout the year. The northern part of the state is semi-arid, but further south, as the rainfall levels increase, the climate becomes sub-humid. The extreme southern part of the state is marked by a series of rocky hills which are responsible for an area of high rainfall. Farming strategies are dominated by the presence of a layer of hard clay pan and shallow topsoil, which creates runoff and mineral leaching. This is responsible for the most characteristic feature of the farming systems of southern Kaduna State - high ridges with complex systems of multiple cropping.

Cultivation in the semi-arid parts of Kaduna State is based on rainfed upland cropping of cereals and pulses. The density of settlement makes the maintenance of soil fertility a priority of the farmers, and manure from both domestic animals and Fulani herds is carefully collected and spread on fields. The use of animals for farming is widespread in the north of the state, allowing farmers to cultivate large areas rapidly. In the region of Kaduna town, lower human densities have allowed bush fallow

systems to remain. The Hausa villagers of this region practice bush-fallowing rather than continuou cultivation. A characteristic of the Gwari settlements is the interplanting of yams with sorghum o ridges. The use of animals is less highly valued in these systems.

Until recently, cultivation of the flooded pastures along the Kaduna River was uncommon, and t grasses were available for grazing. However, in many places, mechanical pumps have been used draw water from the pastures during the dry season to allow cultivation. The cultivation of rice i spreading in naturally flooded valley bottoms throughout southern Kaduna.

Kaduna State has an extremely diverse ecology and a good transportation network, with the resul that it exports a wide variety of animals to southern areas. Along with the stock belonging pastoralists, small ruminants, pigs, rabbits and guinea pigs are also produced in significant numbers The cattle in Kaduna State are almost exclusively of the zebu type and are kept by the Fulani an subsistence farmers for fattening for security and wealth. The use of animals for farming is genera practiced only in the northern part of the state within the Hausa settlements. Southern Kaduna Stat is well know for the abundance of pigs in its villages. Pigs are quite popular as food but th economic basis of pig production is sales to traders from the south.

Vegetation and Land Use Change

Table 8.30 Dominant Vegetation and Land Use Classes for 1976/78 and 1993/95, Kaduna State, Nigeria.

Land Use Category	1976/78		1993/95	
	Area (km^2)	Percent of state	Area (km^2)	Percent of state
Intensive (crop) Agriculture	12 610	29.2	16 306	37.7
Extensive (grazing) Agriculture	10 434	24.1	11 841	27.4
Trees/Woodlands/Shrubs	18 855	43.6	10 217	23.6
Gullies	0	0	2567	5.9
Floodplain Agriculture	8	< 0.1	445	1.0
Shrubs/Grasses	60	0.1	403	0.9
Rock Outcrop	285	0.7	292	0.7
Shrub/Sedge/Graminoid Freshwater Marsh/Swamp	340	0.8	126	0.3
Forest Plantation	58	0.1	124	0.3
Reservoir	11	< 0.1	57	0.1
Grasses	163	0.4	0	0

Table 8.31 Dominant Vegetation and Land Use Changes between 1976/78 and 1993/95, Kaduna State, Nigeria.

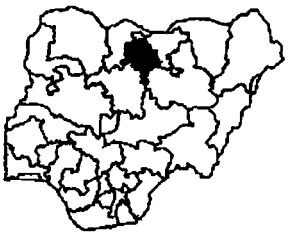
Land Use 1976/78	Land Use 1993/95	Area affected (km^2)	Percent of state
Trees/Woodlands/Shrubs	no change	8911	20.6
	to Extensive (grazing) Agriculture	4978	11.5
	to Intensive (crop) Agriculture	2390	5.5
	to Gullies	1727	4.0
Intensive (crop) Agriculture	no change	9892	22.9
	to Extensive (grazing) Agriculture	1575	3.6
Extensive (grazing) Agriculture	no change	5153	11.9
	to Gullies	488	1.1
	to Intensive (crop) Agriculture	3731	8.6
	to Trees/Woodlands/Shrubs	932	2.2

Kaduna State is located almost entirely in the Guinea Savanna Ecological Zone along the northern border of the state. There was some shift southward of the Sudan Savanna Ecological Zone. The Jos Plateau Ecological Zone along the eastern border of the state remained static. In general there was an intensification of land use in this state over the time period of the study.

There are a number of factors influencing this change. The growing population has been putting increasing pressures on land resources which has resulted in tree and shrub removal for fuelwood, clearing of land for agriculture, as well as more intensive use of agricultural areas and more plantations (Adegbehin and Omijeh 1994). The area classified as intensive agriculture increased from 12 610 km^2 (29.2%) of the state in 1976/78 to 16 306 km^2 (37.7%) of the state in 1993/95. Also, over the time period of this study, there have been a number of new reservoirs constructed which may impact watersheds in the long term.

The most dramatic vegetation and land use change in the state has been experienced in areas of dominantly trees/woodlands/shrubs, particularly in the west side of the state, north and south of Kaduna town. Dominantly trees/woodlands/shrubs covered 43.6% (18 855 km^2) of the state in 1976/78. By 1993/95 there was a 45.8% loss, with an area of only 10 217 km^2 remaining. A number of cohesive areas of dominantly trees/woodlands/shrubs were still evident but usually in areas of park/reserves such as Kuyambana and Kamuku national parks, Kamaku, Alawa and Birnin Gwari forest reserves. The former areas of dominantly trees/woodlands/shrubs were replaced with agriculture and gullies. The area of gully erosion increased from no identifiable areas in 1976/78 to 2567 km^2 in 1993/95. These gullies have generally appeared in areas of dominantly trees/woodlands/shrubs and intensive agriculture where the tree cover had been removed for fuelwood.

Two other indicators of the intensification of land use were the increase in plantations and reservoirs. In 1976/78, reservoirs totaled 11 km^2 in size, however, by 1993/95 this increased to 57 km^2. A forest plantation near Kaduna town increased in size from 58 km^2 in 1976/78, to 124 km^2 in 1993/95.



8.17 KANO STATE

Introduction

Kano State, with an area of 20 430 km^2 and a population of approximately 5.6 million, is located in north-central Nigeria, near the border of Niger Republic. Kano city is the commercial and industrial centre of northern Nigeria, and is both the site of Nigeria's second international airport with flights to countries outside of Africa. It is also the economic terminus of the railway from Lagos and Port Harcourt. An area referred to as 'The Close Settled Zone' (Mortimer and Wilson 1965) is a high density farming area that occupies an irregular ring approximately 45 to 50 km wide around the city.

Human Population

The Hausa form the majority of the population in the state. Hausa society is based on the fundamental division between the urban areas and the rural village. Towns, which specialize in trade and crafts, are surrounded by high-density cultivation areas which supply staples, fuelwood, meat and livestock in exchange for traded goods, manure, and ash to keep the farms fertile.

Several other ethnic groups live in the eastern part of the state, especially in the upper reaches of the Hadejia-Jama'are River. These people belong to the Ngizim, Bade and Karekare groups. The Manga Kanuri form a major agricultural group. Additionally, during the dry season, landless farmers from other parts of Nigeria come and work as casual laborers on farms or in building construction. Fulani and Buzaye (the former Tuareg slave class) pastoralists and their herds of cattle pass through the state in the dry season but typically continue to pastures further south. Some Fulani have settled and began to cultivate and integrate into Hausa society.

Farming and Agropastoral Systems

Systems of virtually continuous cultivation exist in many areas, but some farmers have access to sufficient land to practice bush-fallowing. Kano State is the most intensively farmed state in the north and very little natural vegetation remains. The Close Settled Zone, which extends for a radius of some 45 to 50 km around Kano city is a region where almost 100% of the land cover is under cultivation. Some trees that have economic value have been left in the fields. The fertility of this zone is maintained through the application of animal manure and waste from the urban areas. Kano State is well known for its rainfed dry-grain farming system which is based on the cultivation of millet and sorghum with an interplanting of cowpeas.

Kano State is predominantly an agricultural state, although livestock production has an integral role to play in the farming system. Farmers have developed effective systems that use animal power to

cultivate under difficult climatic conditions. Both ploughs and carting allow farmers to exploit a larger area of land, which compensates for low yields.

However, the intensity of agriculture is gradually eliminating pastoralism. As greater numbers of local farmers keep cattle and need to feed their own animals, smaller amounts of crop residues are made available to Fulani pastoralists.

Water shortages are a perennial problem for livestock production since rivers are dry for most of the year. Only during the wet season is the natural grass adequate to feed stock in non-swampy areas; yet the problems of controlling herds around farms restrict cattle to uncultivated areas. Communal grazing lands have in some areas deteriorated, the land surface has become bare and gully erosion has set in along cattle tracks. Still, the livestock markets of Kano State are the largest in the north, supplying both the town and its surroundings, and acting as a loading point for long-distance trade.

Vegetation and Land Use Change

Kano State is almost entirely in the Sudan Savanna Ecological Zone with the southern tip in the Jos Plateau Ecological Zone. In 1976/78, the Sahel Savanna Ecological Zone met the northern border of Kano State. By 1993/95, the Sahel Savanna Ecological Zone shifted to run along the north-western border of the state.

Table 8.32 Dominant Vegetation and Land Use Classes for 1976/78 and 1993/95, Kano State, Nigeria.

Land Use Category	1976/78		1993/95	
	Area (km^2)	Percent of state	Area (km^2)	Percent of state
Intensive (crop) Agriculture	17 470	85.5	15 691	76.8
Shrubs/Grasses	460	2.3	909	4.5
Gullies	0	0	803	3.9
Extensive Agriculture with Denuded	0	0	772	3.8
Extensive (grazing) Agriculture	574	2.8	538	2.6
Shrub/Sedge/Graminoid Freshwater Marsh/Swamp	176	0.9	347	1.7
Reservoir	250	1.2	335	1.6
Floodplain Agriculture	274	1.3	258	1.3
Trees/Woodlands/Shrubs	817	4.0	171	0.8
Irrigation Project	46	0.2	109	0.5

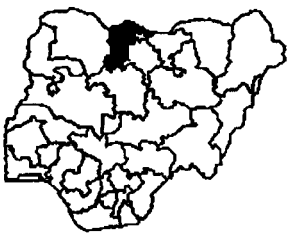
Table 8.33 Dominant Vegetation and Land Use Changes between 1976/78 and 1993/95, Kano State, Nigeria.

Land Use 1976/78	Land Use 1993/95	Area affected (km^2)	Percent of state
Trees/Woodlands/Shrubs	no change	148	0.7
	to Shrubs/Grasses	422	2.1
	to Intensive (crop) Agriculture	143	0.7
Shrubs/Grasses	no change	131	0.6
	to Intensive (crop) Agriculture	179	0.9
Intensive (crop) Agriculture	no change	14 854	72.7
	to Extensive Agriculture with Denuded	757	3.7
	to Gullies	646	3.2
	to Shrubs/Grasses	334	1.6
	to Extensive(grazing)Agriculture	286	1.4
Extensive (grazing) Agriculture	no change	230	1.1
	to Intensive (crop) Agriculture	296	1.5

Kano State is the most intensely farmed state in the north and very little natural vegetation remains. In 1976/78, 85.5% of the land area in the state was designated as intensive agriculture. In the 1993/95 imagery there were identifiable areas of agriculture with denuded areas and gully erosion. In 1993/95, a 772 km^2 area was classified as agriculture with denuded areas, whereas none were identifiable in 1976/78. In 1976/78 no areas of gully erosion were significant enough to map, however, by 1993/95, a 803 km^2 area of gully erosion was mapped in Kano State.

Another indication of the intensification of land use in the state is the increase in the number and size of reservoirs and irrigation projects. In the 1993/95 imagery, Lake Tiga water levels were low compared to the 1976/78 image. In 1976/78, 250 km^2 of the state was classified as reservoir; by 1993/95, this had grown to 335 km^2. There was a large new reservoir southwest of Kano city. South of Kano city, an irrigation canal can be seen leading northward to an irrigation project which grew from 46 km^2 in 1976/78 to 109 km^2 in 1993/95.

In the south of the state, agriculture has encroached into the area around the Kogin Kano Game Reserve, leading to environmental degradation. In 1976/78, all of the state's 817 km^2 of dominantly trees/woodlands/shrubs were in this area. By 1993/95, the tree cover was largely removed and the area was mapped almost entirely as dominantly shrubs/grasses. This area became a transition zone between the Sudan and Guinea ecological zones. There were visible areas of gully erosion throughout these previously forested areas.



8.18 KATSINA STATE

Introduction

Katsina State, with an area of 24 176 km^2 and a population of approximately 3.9 million, is located in northern Nigeria along the border with Niger Republic. Katsina town, the state capital, has an important position on the main watershed between rivers draining to the west and the east. This watershed provides a north-south access route during the rainy season. The growth of Katsina town has been limited due to its lack of road and rail connections.

A railway line crosses the southwest corner of the state between the towns of Zaria (in Kaduna State) and Kaura Namoda and has led to the expansion of the town of Funtua, a centre of cotton production. Two of the major border crossings on the trade routes to Niger Republic, Jibiya and Daura, are within the state boundaries.

Human Population

The population of Katsina State is ethnically homogenous. Most farming villages and towns are populated by the Hausa. Hausa society is structured around a division between urban and rural villages. The towns are encircled by high density cultivated areas, which provide the townspeople with staples, fuelwood, meat and livestock in exchange for goods, manure and ash which farmers use to fertilize fields.

Additionally, Fulani and Buzaye pastoralists are present only in smaller numbers since they typically pass through the state on their way further south. Overall, population in the state is growing and population densities are increasing.

Farming and Agropastoral Systems

Farming systems in Katsina State are based on rainfed cropping of cereals and pulses. Near Funtua, the ridge-based cultivation of sorghum is common, but in the drier areas, millet predominates and ridge systems are replaced by dune agriculture. Cultivation and fuelwood collection is intense, particularly along the central ridge of the state, and little of the original vegetation remains. Some regions in the northwest have virtually lost all the topsoil and are without grass cover even in the wet season. It is common around Katsina to preserve trees of economic value on farms that are continuously cultivated. Fertilizer and all types of household wastes are conserved and spread on the fields in an effort to maintain crop yields. The use of draught animals allows farmers to cultivate larger areas which compensates for low crop yields.

Katsina State is predominantly an agricultural state; livestock production plays a secondary role in a system of mixed farming. Traditionally cattle are tended and owned by the Fulani, although recently village farmers are acquiring their own cattle. However, as the area of land under cultivation is increasing traditional forms of pastoralism are gradually being eliminated.

Vegetation and Land Use Change

Table 8.34 Dominant Vegetation and Land Use Classes for 1976/78 and 1993/95, Katsina State, Nigeria.

Land Use Category	1976/78		1993/95	
	Area (km^2)	Percent of state	Area (km^2)	Percent of state
Intensive (crop) Agriculture	18 567	76.8	16 546	68.4
Gullies	0	0	2857	11.8
Shrubs/Grasses	3035	12.6	1554	6.4
Extensive Agriculture with Denuded	214	0.9	1318	5.5
Discontinuous Grassland	0	0	582	2.4
Floodplain Agriculture	171	0.7	290	1.2
Shrub/Sedge/Graminoid Freshwater Marsh/Swamp	417	1.7	266	1.1
Extensive (grazing) Agriculture	994	4.1	225	0.9
Grasses	22	0.1	81	0.3
Reservoir	12	0.1	79	0.3
Trees/Woodlands/Shrubs	563	2.3	8	< 0.1

Table 8.35 Dominant Vegetation and Land Use Changes between 1976/78 and 1993/95, Katsina State, Nigeria.

Land Use 1976/78	Land Use 1993/95	Area affected (km^2)	Percent of state
Trees/Woodlands/Shrubs	no change	2	< 0.1
	to Shrubs/Grasses	269	1.1
	to Gullies	243	1.0
Shrubs/Grasses	no change	1174	4.9
	to Gullies	787	3.3
	to Intensive (crop) Agriculture	691	2.9
Intensive (crop) Agriculture	no change	14 675	60.7
	to Gullies	1664	6.9
	to Extensive Agriculture with Denuded	1156	4.8
	to Discontinuous Grassland	413	1.7
	to Extensive (grazing) Agriculture	214	0.9
Extensive (grazing) Agriculture	to Intensive (crop) Agriculture	791	3.3

Katsina State is situated primarily in the Sudan Savanna Ecological Zone. The area of sahel vegetation increased in the north of the state, while the Sudan Savanna Ecological Zone boundary moved further south within the state. The primary concern in Katsina State is erosion. Cultivation

and fuelwood collection is intense, particularly along the central ridge of the state where little original vegetation remains.

In 1976/78, almost all of the state's 3035 km^2 of dominantly shrub/grasses was in an area along the northwest border, with some shrub swamp areas along the major river banks. This area includes a number of forest reserves, such as Ruma and Kukar Jangara. By 1993/95, only 1554 km^2 of the dominantly shrubs/grasses remained, with 691 km^2 changing to intensive agriculture. Perhaps more significantly, 787 km^2 changed to gully erosion.

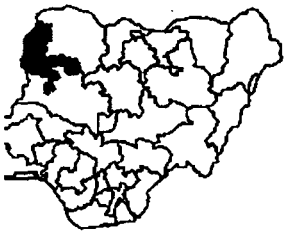
Gully erosion is severe in this state. Although visible, gully erosion was not mappable in 1976/78. However, by 1993/95, 11.8% (2857 km^2) of the state was readily mapped as gully erosion.

Katsina town in the northwest of the state is very intensively farmed and was mapped as intensive agriculture in 1976/78. By 1993/95, an area 5 to 20 km surrounding the town was classified as agriculture with denuded areas and areas of gully erosion. In 1976/78, 214 km^2 in the state were mapped as agriculture with denuded areas, increasing to 1318 km^2 in 1993/95. Narrow shelter belts, established to ward off erosion, are visible in the 1993/95 imagery.

The northeast portion of the state had many patches of dominantly shrubs/grasses in 1976/78 but by 1993/95 only patches of discontinuous grassland appeared throughout this agricultural area.

The increasing number of reservoirs and areas of floodplain devoted to floodplain agriculture also indicated an intensification in land use. There were new reservoirs near Jibiya and Dutsin Ma, which increased the state's area of reservoirs from 12 km^2 in 1976/78 to 79 km^2 in 1993/95. The area devoted to floodplain agriculture also increased from 171 km^2 in 1976/78 to 290 km^2 in 1993/95.

In the southwestern area of the state is Kogo National Park. This area was dominantly trees/ woodlands/shrubs; however, by 1993/95 much of the tree cover had been removed. The area was mapped as dominantly shrubs/grasses with approximately half the area covered by gully erosion. In 1976/78, 563 km^2 of the state were mapped as dominantly trees/woodlands/shrubs, whereas only 8 km^2 remained in 1993/95. Of the area that had been dominantly trees/woodlands/shrubs in 1976/78, 269 km^2 changed to dominantly shrubs/grasses and 243 km^2 changed to gully erosion.



8.19 KEBBI STATE

Introduction

Kebbi State, with an area of 37 182 km^2 and population of approximately 2.2 million people, is located in the northwestern corner of Nigeria and is bounded by Sokoto State to the northeast. Kebbi State was created from a division of Sokoto State in 1991. Kebbi State remains associated with Sokoto State and is nominally linked via road networks.

Human Population

Kebbi State has a very unevenly distributed population. Population densities are very high around key towns and along the major rivers but compounds are very sparse and scattered in the rangelands. Kebbi State is ethnically diverse: major cultural groups include the Hausa, Fulani and Buzaye pastoralists. Parts of the state are the domain of Kainji speaking people.

Hausa towns are often surrounded by intensive agricultural areas which supply the towns with staples, fuelwood, meat and livestock. Apart from the Hausa, areas of the state have a number of other Islamic populations including the Zarma, with a substantially different cultural heritage. These groups are subsistence cultivators, some with large livestock holdings.

Pastoralists constitute a major segment of the population of Kebbi State and they are divided into two main groups, the Fulani and their subgroups, and the Buzaye. Fulani and Buzaye pastoralists come through the state in the early dry season, but as there is limited grazing, usually continue further southwards. In the 1950s, some Buzaye (former slaves) moved southwards away from their masters and began farm and livestock enterprises. Starting with small ruminant husbandry, some Buzaye quickly became successful and now have large herds of cattle and camels, as well as sheep and goats. Additionally, small groups of Hausa speaking pastoralists who are resident in the Republic of Niger, sometimes bring herds of small ruminants into Kebbi State in the dry season.

Farming and Agropastoral Systems

The farming systems used in Kebbi State combine rainfed cropping of cereals and pulses with intensive river-basin cultivation. Ridge-based cultivation of sorghum is common, but in the drier areas, cultivation of millet predominates. In parts of the state, yields are so poor that application of manure to the land is essential for productivity, and the farmers compete to attract Fulani herds on to their land in the dry season.

Intensive river basin cultivation in the state is divided into three basic types: swamp cultivation, based on naturally flooded fields, flood-retreat farming using residual moisture after the fall of the

flood, and dry season market gardening, using water lifted by mechanical pumps. The cultivation of swamp rice is still practiced but dry season farming in the riverine areas is dominated by the production of cash crops, especially of onions and tomatoes.

The intensive system of cultivation around major towns has been described as 'farmed parkland' since economic trees are preserved among continuously cultivated crop farms. In these areas manure, potsherds and all types of household wastes are conserved and spread on the fields in an effort to maintain crop yields.

Kebbi State is an important state for livestock production and use. However, relatively little is known about the pastoralists who manage the majority of the livestock, either in terms of their ethnic affiliations or their systems of production. Camels are increasingly popular as work animals in Kebbi State. In contrast to cattle, camels remain healthy without significant veterinary care and can exploit vegetation unused by other stock.

There are a number of Fulani pastoralists that stay in the state all year round. The settled Fulani have developed a pattern of moving to riverine pastures during the dry season, and returning to their home villages during the rains. As in Sokoto State, entrustment is a major component of the pastoral system in Kebbi State. Most farmers, both settled Fulani and Hausa, have both 'investment' cattle and traction oxen. Pastures are not adequate to keep these around the village and so they are entrusted to Fulani, who take them to riverine pastures in the dry season. Relationships between farmers and Fulani are usually non-monetary, where cattle owners often pay the herders with food and/or clothes, or by preparing a farm for them when they return with the cattle at the beginning of the wet season.

Vegetation and Land Use Change

Table 8.36 Dominant Vegetation and Land Use Classes for 1976/78 and 1993/95, Kebbi State, Nigeria.

Land Use Category	1976/78		1993/95	
	Area (km^2)	Percent of state	Area (km^2)	Percent of state
Extensive (grazing) Agriculture	10 145	27.3	14 986	40.3
Intensive (crop) Agriculture	10 102	27.2	9162	24.6
Shrubs/Grasses	10 086	27.1	6116	16.5
Floodplain Agriculture	2312	6.2	2670	7.2
Trees/Woodlands/Shrubs	1855	5.0	992	2.7
Gullies	0	0	878	2.4
Reservoir	512	1.4	558	1.5
Shrub/Sedge/Graminoid Freshwater Marsh/Swamp	1209	3.3	434	1.2
Extensive Agriculture with Denuded	147	0.4	357	1.0
Sand Dunes	0	0	277	0.8
Rock Outcrop	231	0.6	127	0.3

Table 8.37 Dominant Vegetation and Land Use Changes between 1976/78 and 19935/96, Kebbi State, Nigeria.

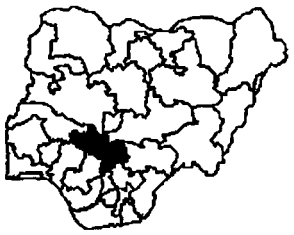
Land Use 1976/78	Land Use 1993/95	Area affected (km^2)	Percent of state
Trees/Woodlands/Shrubs	no change	603	1.6
	to Extensive (grazing) Agriculture	958	2.6
Shrubs/Grasses	no change	4980	13.4
	to Extensive (grazing) Agriculture	3063	8.2
	to Intensive (crop) Agriculture	1375	3.7
	to Gullies	271	0.7
Shrub/Sedge/Graminoid Freshwater Marsh/Swamp	no change	267	0.7
	to Floodplain Agriculture	706	1.9
Intensive (crop) Agriculture	no change	5338	14.4
	to Extensive (grazing) Agriculture	3747	10.1
	to Gullies	279	0.8
	to Extensive Agriculture with Denuded	218	0.6
Extensive (grazing) Agriculture	no change	6712	18.1
	to Intensive (crop) Agriculture	1952	5.3
	to Shrubs/Grasses	652	1.8
	to Trees/Woodlands/Shrubs	266	0.7
	to Gullies	234	0.6

Kebbi State is almost entirely in the Sudan Savanna Ecological Zone although the southernmost area of the state lies in the Guinea Savanna Ecological Zone. The border along the southernmost area of the state runs through Lake Kainji, a very large reservoir, which was completed in 1974. Many of the areas that were shrub/sedge/graminoid freshwater marsh/swamp in 1976/78 were used for floodplain agriculture in 1993/95. The area of floodplain agriculture grew from 2312 km^2 in 1976/78, to 2670 km^2 in 1993/95.

The area of extensive (grazing) agriculture increased by 4841 km^2 in the time period of the study, to occupy 40.3% of the state in 1993/95. The growth of grazing agriculture occurred in areas that had been dominantly shrubs/grasses or intensive agriculture. Specifically the imagery showed a 3747 km^2 area where land use changed from intensive agriculture to extensive agriculture.

In many parts of the state, areas of dominantly shrubs/grasses disappeared. In 1976/78, 27.1% (10 086 km^2) of the state was mapped as dominantly shrubs/grasses. This area was reduced to 16.5% (6116 km^2) of the state in 1993/95. Areas of dominantly trees/woodlands/shrubs also disappeared but predominantly in the southeast portion of the state. In 1976/78 they covered 5.0% (1855 km^2) of the state, this decreased to 2.7% (992 km^2) in 1993/95.

With many trees and shrubs removed for fuelwood in these savanna areas, susceptibility to erosion increased. In fact, the areas of erosion (gullies, extensive agriculture with denuded areas, sand dunes) in Kebbi State increased from 147 km^2 in 1976/78 to 1512 km^2 in 1993/95.



8.20 KOGI STATE

Introduction

Kogi State, with an area of 28 482 km^2 and population of approximately 2.1 million people, is located in central Nigeria, east of Kwara State and west of Benue State. The state was formed following the division of Kwara State in 1991. Kogi State includes the confluence of the Niger and Benue rivers. The Niger River, once a major axis of trade and transport, is now a barrier to the movement of goods and vehicles between the north and south. However, the construction of bridges, access roads and an interstate railway will greatly improve transportation and communication links.

Human Population

Kogi State is largely inhabited by people of the northern Muslim Fulani culture who populate the larger towns, and dispersed traditionalists or Christian populations who predominate the rural areas.

In several parts of the state, the Yoruba people form the main population. They are highly urbanized and often maintain town and country residences that allow them to farm and to participate in the complex political and social life of towns. Other groups in Kogi State include the Nupe, who are based along the Niger River. Traditionally their culture has been based on trade, fish production and the intensive cultivation of swamp rice. The Ebira people are a patrilineal society and are divided into clans that inhabit separate territories in a ring around the rocky range near Okene. The Ebira depend on rainfed crops and do very little fishing or hunting.

Farming and Agropastoral Systems

The valley of the Niger River is an important geographical feature in Kogi State. The valley consists of alluvial soils and extensive floodplains, which are partly used for agriculture. Along the Niger River, irrigation and swamp cultivation is combined with fishing. Cereal-based savanna agriculture predominates, while near the Niger-Benue confluence, oil-palms are grown in combination with tubers.

As crop farming dominates in the state, pastoral activities are limited. In rice growing areas along the Niger River, the cattle feed on rice residues, although the use of animals for farming is rare. Generally cattle production is not well organized and remains minor. However, Kogi is a transit state for livestock passing through from the north to southern markets.

Vegetation and Land Use Change

Table 8.38 Dominant Vegetation and Land Use Classes for 1976/78 and 1993/95, Kogi State, Nigeria.

Land Use Category	1976/78		1993/95	
	Area (km^2)	Percent of state	Area (km^2)	Percent of state
Intensive (crop) Agriculture	18 337	64.4	19 318	67.8
Trees/Woodlands/Shrubs	1968	6.9	3421	12.0
Extensive (grazing) Agriculture	3098	10.9	1957	6.9
Floodplain Agriculture	113	0.4	1104	3.9
Riparian Forest	1456	5.1	1025	3.6
Grassland	0	0	391	1.4
Disturbed Forest	506	1.8	283	1.0
Shrub/Sedge/Graminoid Freshwater Marsh/Swamp	1185	4.2	251	0.9
Forested Freshwater Swamp	237	0.8	75	0.3
Undisturbed Forest	1153	4.1	0	0

Table 8.39 Dominant Vegetation and Land Use Changes between 1976/78 and 1993/95, Kogi State, Nigeria.

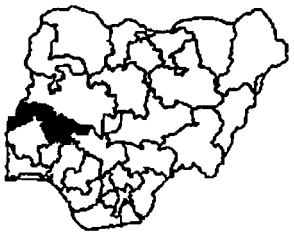
Land Use 1976/78	Land Use 1993/95	Area affected (km^2)	Percent of state
Trees/Woodlands/Shrubs	no change	515	1.8
	to Intensive (crop) Agriculture	727	2.5
	to Extensive (grazing) Agriculture	662	2.3
Disturbed Forest	no change	14	0.1
	to Intensive (crop) Agriculture	270	1.0
Undisturbed Forest	no change	0	0
	to Intensive (crop) Agriculture	529	1.9
	to Disturbed Forest	185	0.6
	to Trees/Woodlands/Shrubs	129	0.4
	to Riparian Forest	121	0.4
Riparian Forest	no change	471	1.7
	to Floodplain Agriculture	323	1.1
	to Intensive (crop) Agriculture	360	1.3
	to Grassland	137	0.5
Shrub/Sedge/Graminoid Freshwater Marsh/Swamp	no change	30	0.1
	to Floodplain Agriculture	419	1.5
	to Intensive (crop) Agriculture	381	1.3
Intensive (crop) Agriculture	no change	15 319	53.8
	to Trees/Woodlands/Shrubs	1369	4.8
	to Extensive (grazing) Agriculture	742	2.6
Extensive (grazing) Agriculture	no change	336	1.2
	to Trees/Woodlands/Shrubs	1157	4.1
	to Intensive (crop) Agriculture	1550	5.4

The northern third of Kogi State is within the Guinea Ecological Zone and the southern two-thirds is within the Derived Savanna Ecological Zone. In Kogi State, the area of floodplain agriculture increased from 113 km^2 in 1976/78 to 1104 km^2 in 1993/95. Along the waterways, areas that were covered with riparian forest and shrub/sedge/graminoid freshwater marsh/swamp were used for floodplain cultivation in 1993/95.

While this state experienced an increased intensity of land use, particularly in the floodplain areas, there were also large areas that returned to a less intensive land use. These areas changed from intensive (crop) agricultural use in 1976/78 to extensive (grazing) agriculture or dominantly trees/woodlands/shrubs in 1993/95. The Nigerian Livestock Resources Survey of 1992 (RIM 1992) refers to many of these areas being set aside for use as grazing reserves - at least eleven sites in Nigeria have been set aside for this purpose. There are four small reserves in Kogi State, including Kpata in Bassa Local Government Area. Kpata Reserve is likely located in the extensive agriculture area identified on the imagery, east of the Niger River. There are many livestock markets in this area (e.g., Dekina, Ayangba, Ejule and Ajaka) and this grazing reserve could be used to fatten stock prior to market. A large 7000 ha reserve was planned in the early 1990s near Abejukolo, south of Bugana. In the 1993/95 imagery, there are large expanses of dominantly trees/woodlands/shrubs in this area.

Kogi State lost forest cover over the time period of the study. In 1976/78, 1153 km^2 was classified as undisturbed forest and 506 km^2 was classified as disturbed forest. By 1993/95, all of the undisturbed forest was eliminated and only 283 km^2 of the disturbed forest remained. The majority of the lost forest area was a result of land clearing for agriculture. In the northwest area of the state, many areas of dominantly trees/woodlands/shrubs also changed to agriculture. In 1976/78, 6.9% (1968 km^2) of the state was dominantly trees/woodlands/shrubs of which only 1.8% (515 km^2) remained unchanged in 1993/95.

In 1976/78, the southeast area of the state appeared to be flooded. This flooded area was vegetated with riparian and undisturbed forest as well as shrub/sedge/graminoid freshwater marsh/swamp. By 1993/95, this area appeared dried up and was vegetated with trees/woodlands/shrubs along the stream and continuous grassland and limited swamp vegetation to the south. The reason for this change was not evident, but it may have been a seasonal variation captured on the imagery.



8.21 KWARA STATE

Introduction

Kwara State, with an area of 33 740 km^2 and a population of approximately 1.6 million people, is located in west-central Nigeria, south of Niger State. The state capital, Ilorin located in the west of the state, is the main urban centre. Ilorin has an airport of international standard. Since Kwara is a long, narrow state, communications between Ilorin and outlying regions of the state are slow and often difficult. The construction of bridges over the Niger River, access roads and an interstate railway will greatly improve transportation and communication links. The Borgu Game Reserve is one of the most important national parks, and is the focus of numerous recent studies.

Human Population

The larger towns in Kwara State are dominated by the northern Muslim Fulani culture, while traditionalists or Christians form populations dispersed throughout the rural areas. As well as the long established resident Fulani, there is a large population of Fulani pastoralists who have recently migrated into the state, especially at Borgu. The presence of four crossings over the Niger River has increased the numbers of herds that travel from the northern states to the bank of the Niger River in the dry season. In some cases the pastoralists enter farms without permission and disrupt the relations between the resident Fulani and the farmers.

The Yoruba, Nupe and Ebira and other smaller groups are cultivators, possess few livestock, and have relatively large settlements in the east part of Kwara State. The Yoruba, who predominate in the centre of the state, are highly urbanized and often maintain town and country residences that allow them to farm and to participate in the complex political and social life of towns. The Nupe are located along the Niger River. Nupe culture has traditionally been based on trade, fish production and the intensive cultivation of swamp rice. The Ebira are patrilineal and are divided into clans that inhabit separate territories in a ring around the rocky hills near Okene. Ebira peoples depend on rainfed crops and do very little fishing or hunting.

Minorities within the state include the Baatonun or Bariba. In the rural areas their villages are very dispersed. They depend on subsistence farming based on rainfed cultivation and cattle herding. Peoples in the west, such as the Kambari and Busa, are also cultivators but they may have substantial livestock holdings. West of Lake Kainji is a sparsely populated pastoral zone, quite different from the crop farming areas along the south bank of the Niger River.

Farming and Agropastoral Systems

Kwara State is dominated by its principal geographical feature, the valley of the Niger River. The

valley consists of alluvial soils and extensive floodplains which are partly used for agriculture. Along the Niger River, irrigation and swamp cultivation is combined with fishing. In Borgu, cereal-based savanna agriculture is typical. The intense hill-agriculture of the Okene area was replaced by slash-and-burn when the populations moved down the plain. The Niger River floodplain includes a major sugar cane estate at Bacita.

The specialized Lake Kainji fishing populations have extremely dispersed settlements and often move onto temporary islands in the lake to gain access to fish. Their economy was disturbed by the damming of Lake Kainji in the early 1970s but they have adapted both fishing and farming strategies to the new ecological realities.

The pastoral Borgu zone is the only region in which livestock plays a central role in the local economy, as crop farming dominates elsewhere in the state. The Borgu area in the northwest is notable for its populations of the tripano-tolerant, Keteku cattle, the use of animals for farming and cheese production. In rice growing areas along the Niger River, the cattle feed on rice residues but the use of animals for farming is rare.

Pastoral production in the Borgu zone is based around a tripartite seasonal movement. The herds remain close to the farm areas in the wet season, graze crop residues in the early dry season, and graze in riverine pastures in the late dry season.

In the villages, sheep and goats are usually seasonally confined and fed on leaves and grasses. In the dry season, large herds of Uda sheep from Sokoto State sometimes cross into Kwara State and then move further south into northern Oyo State. These are herded by the young men of the Uda people, a specialist Fulani group.

Vegetation and Land Use Change

Kwara State is located almost entirely in the Guinea Savanna Ecological Zone, while the Derived Savanna Ecological Zone traverses the southern border of the state. Generally, there was an intensification of land use as indicated by more of the floodplain devoted to agriculture, the encroachment of agriculture into savanna areas, and agricultural areas shifting from extensive (grazing) agriculture to a more intensive (crop) agriculture. Other indications of an intensification of land use include the increase in the number and extent of reservoirs and plantations.

Table 8.40 Dominant Vegetation and Land Use Classes for 1976/78 and 1993/95, Kwara State, Nigeria.

Land Use Category	1976/78		1993/95	
	Area (km^2)	Percent of state	Area (km^2)	Percent of state
Trees/Woodlands/Shrubs	16 718	49.6	12 713	37.7
Intensive (crop) Agriculture	8970	26.6	9701	28.8
Extensive (grazing) Agriculture	6406	19.0	7803	23.1
Gullies	0	0	937	2.8
Floodplain Agriculture	50	0.2	579	1.7
Grassland	0	0	414	1.2
Riparian Forest	253	0.8	400	1.2
Disturbed Forest	5	< 0.1	230	0.7
Plantations (agricultural tree crop, forest, teak), Rainfed Arable Crops and Irrigation Project	83	0.2	184	0.5
Reservoir	0	0	114	0.3
Irrigation Project	57	0.2	98	0.3
Shrub/Sedge/Graminoid Freshwater Marsh/Swamp	819	2.4	60	0.2
Undisturbed Forest	247	0.7	0	0

Table 8.41 Dominant Vegetation and Land Use Changes between 1976/78 and 1993/95, Kwara State, Nigeria.

Land Use 1976/78	Land Use 1993/95	Area affected (km^2)	Percent of state
Trees/Woodlands/Shrubs	no change	9796	29.0
	to Extensive (grazing) Agriculture	3706	11.0
	to Intensive (crop) Agriculture	1932	5.7
	to Gullies	785	2.3
Shrub/Sedge/Graminoid Freshwater Marsh/Swamp	no change	0	0
	to Floodplain Agriculture	391	1.2
Intensive (crop) Agriculture	no change	4896	14.5
	to Extensive (grazing) Agriculture	2581	7.7
	to Trees/Woodlands/Shrubs	913	2.7
Extensive (grazing) Agriculture	no change	1409	4.2
	to Intensive (crop) Agriculture	2503	7.4
	to Trees/Woodlands/Shrubs	1859	5.5

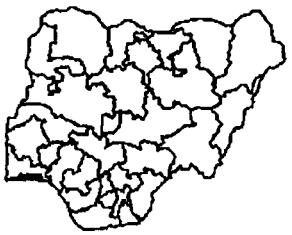
Upstream from Jebba along the Niger River, there are two large reservoirs which have affected the watershed over the time period of the study. In 1976/78, the predominant vegetation of the floodplain was shrub/sedge/graminoid freshwater marsh/swamp covering an area of 819 km^2, and floodplain agriculture occupying 50 km^2. By 1993/95, this balance reversed with marsh/swamp occupying only 60 km^2, and areas of floodplain agriculture increasing to 579 km^2. The floodplain irrigation projects near Pategi and Jebba increased in area from 57 km^2 in 1976/78 to 98 km^2 in 1993/95.

South of the floodplain, the town of Ilorin has more than doubled in size over the time period of the study. This area south of the floodplain remained predominantly an agricultural area. Much of the land changed from predominantly extensive agriculture in 1976/78 to predominantly intensive agriculture in 1993/95 with large patches of continuous grassland. The areas of continuous grassland may have been agricultural areas left to fallow.

The agricultural area south of the Niger River also showed many new and expanded plantations (forest, teak/Gmelina, rainfed arable crops and irrigation projects). The total area of all of the plantations increased from 83 km^2 in 1976/78 to 184 km^2 in 1993/95.

The western and eastern areas of the state have large expanses of dominantly trees/woodlands/shrubs. In 1976/78, 49.6% (16 718 km^2) of the state was mapped as dominantly trees/woodlands/shrubs, however, this area had declined to 37.7% (12 713 km^2) of the state by 1993/95, with only 9796 km^2 remaining unchanged. The majority was cleared for agriculture, with 3706 km^2 used for extensive agriculture and 1932 km^2 for intensive agriculture. Also, another, 785 km^2 of the dominantly trees/woodlands/shrubs changed to gullies.

In the western area of the state, dominantly trees/woodlands/shrubs covered the Borgu and Kaiama local government areas and includes Kainji National Park as well as the Borgu, Dagida, and Gidan Magajiya grazing reserves. East of Ilorin is the Laba Grazing Reserve. Encroachment of agriculture and fuelwood collection activities into these reserved areas was evident. The increase in the size of reservoirs in this watershed, such as the Jebba and Kainji Reservoirs, may be affecting trends identified in this state.



8.22 LAGOS STATE

Introduction

With an area of 3853 km^2, Lagos State is the smallest of the Nigeria's states, but also the most densely populated with approximately 5.7 million people. It is located along the coast in the southwest. Ikeja was made the state capital in 1967. Ikeja has since been incorporated into Lagos City. Badagry is the second largest town in the state and is an old coastal trading port. Epe is a fishing and boat-building town 90 km east of Lagos City.

Lagos became a British Protectorate in 1851 and gradually developed into the capital of colonial Nigeria. The shortage of land available for building in Lagos has stimulated major land reclamation exercises during the twentieth century. Lagos City remains the economic capital of Nigeria and the seat of many overseas missions, although these were all scheduled to move to Abuja in 1992. The exact population of Lagos City is uncertain, but it is the largest city in Nigeria.

Lagos City is connected by expressways to the north and east of Nigeria and to the Republic of Benin. The city is the southern terminus of the main railway line to the north, but expansion of the road system in the 1980s has precipitated a decline in the use of rail travel. The main international airport is in Ikeja. There is also a domestic terminal at Ikeja.

Human Population

The city of Lagos has been growing throughout the twentieth century, but in the period since the 1970s, it has expanded dramatically and now extends into Ogun State. Practically all of Nigeria's peoples are represented in the area called Greater Lagos, although the core population is still Yoruba. Most Yoruba are highly urbanized and often maintain town and country residences, allowing them both to farm and to participate in the complex political and social life of their town. The peoples of the rural areas of Lagos State are predominantly Yoruba and Egun. The Egun people live in settlements along the coast. A few Fulani camps can be found in the state near Badagry. They are integrated with the local community and grow maize, rice and coconuts as well as rear livestock. The rural population of Lagos State is dominated by the influence of Lagos town, which provides a market for their crops and a source of livestock for ceremonies

Farming and Agropastoral Systems

Although Lagos State is often thought of as the most urban of the Nigerian states, it contains a sizeable agricultural area. Farming activities are based on a forest-fallow system with a dependence on cash income from tree-crops to supplement production staples. In some of the creeks, swamp cultivation of rice and cocoyams is practiced, and vegetables are grown on the moist soil of the

floodplains. The cultivation of cassava and maize dominates the dryland farming, and is integrated with small coconut and oil-palm plots. The use of manure from domestic livestock is central to keeping this integrated system productive. In the Epe area, villages are less accessible. Tree crops are correspondingly less important and the range of crops is wider. Major crops include yams, okra, beans, plantains, oranges, and kola-nut. Cassava production to make gari for sale to urban consumers is also an important industry, particularly in the Ikorodu area.

Chickens are the most common form of livestock and are found in all villages. Cattle keeping is confined to the west, and no cattle are found in the Epe or Ikorodu areas. Since the 1960s, the whole system of cattle production in the west of the state has been radically transformed. The two elements of this change are the arrival of Fulani and Hausa cattle-owners, and the introduction of new breeds. The main consequences of this have been that most of the cattle in the state are now crossbreeds and the majority are looked after by caretakers rather than by their owners.

Among the rural Yoruba, livestock production seems never to have been important and the basis of subsistence has always been tree-crop production and fishing. Among the Egun of Badagary, livestock have traditionally been more important, and muturu cattle and pigs are still reared throughout their area. Since the increase in the area under cultivation, the expansion of the road system and the subsequent increase in traffic have required livestock to be confined, the extra investment needed in both labour and fencing materials has made the keeping of livestock less attractive and livestock numbers are in decline.

Vegetation and Land Use Change

Table 8.42 Dominant Vegetation and Land Use Classes for 1976/78 and 1993/95, Lagos State, Nigeria.

Land Use Category	1976/78		1993/95	
	Area (km^2)	Percent of state	Area (km^2)	Percent of state
Intensive (crop) Agriculture	1268	32.9	1565	40.6
Forested Freshwater Swamp	1235	32.1	629	16.3
Urban	233	6.1	608	15.8
Saltmarsh/Tidal Flat	0	0	147	3.8
Mangrove Forest	51	1.3	45	1.2
Riparian Forest	39	1.0	6	0.2
Undisturbed Forest	220	5.7	0	0
Graminoid/Sedge Freshwater Marsh	42	1.1	0	0

Table 8.43 Dominant Vegetation and Land Use Changes between 1976/78 and 1993/95, Lagos State, Nigeria.

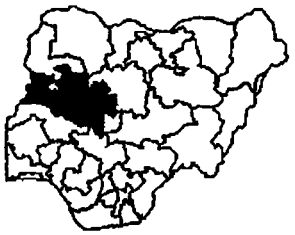
Land Use 1976/78	Land Use 1993/95	Area affected (km^2)	Percent of state
Undisturbed Forest	to Forested Freshwater Swamp	112	2.9
	to Intensive (crop) Agriculture	90	2.3
Forested Freshwater Swamp	no change	333	8.6
	to Intensive (crop) Agriculture	666	17.3
	to Urban	79	2.1
	to Saltmarsh/Tidal Flat	52	1.3
Intensive (crop) Agriculture	no change	730	18.9
	to Urban	259	6.7
	to Forested Freshwater Swamp	141	3.7
	to Saltmarsh/Tidal Flat	61	1.6

Lagos State encompasses three ecological zones, including the Lowland Rain Forest Ecological Zone along the northern border of the state, the Freshwater Swamp Forest through the middle and Mangrove Forest and Coastal Ecological Zone along the Atlantic coast. The coastal strip is a network of islands, sandbanks, creeks and lagoons which are replaced by swamp and mangroves immediately inland.

Very little of the vegetation remains in its natural state, due to the pressure on arable land and to the pervasive influence of the city. In 1976/78, the total urban area in the state was 233 km^2. However, by 1993/95, this area almost tripled to 608 km^2. Some of this growth may be due to the improved detail of the imagery in 1993/95. The new areas of urban settlement had been used for intensive agriculture and some areas were forested freshwater swamp in 1976/78.

There was evidence of salt water inundation affecting some areas of coastal vegetation. These areas appeared uncharacteristically dark in the imagery and were mapped as saltmarsh/tidal flats. In 1976/78, this type of vegetation did not exist. By 1993/95, 147 km^2 of saltmarsh/tidal flats were identifiable in Lagos State. Geomatics International's research further south along the Nigerian coast identified petroleum activities and canal building as likely causes of increased saltwater intrusion (Eedy et al. 1994).

Freshwater swamp vegetation was identified along the coast and in lagoons in 1976/78, and covered an area of 32.1% (1235 km^2). In 1993/95 imagery, only 16.3% (629 km^2) of the state remained as forested freshwater swamp. Some of the forested freshwater swamp area changed to urban or saltmarsh, but the majority changed to intensive agriculture. This change was most evident in the area between Lagos and Lekki Lagoon.



8.23 NIGER STATE

Introduction

Niger State, with an area of 71 676 km^2, is the second largest state in Nigeria. It has an estimated population of 2.5 million people and is located in west-central Nigeria and is bounded to the west by the Republic of Benin. In 1991 the state's northwestern boundary was extended to incorporate the northern part of the former Kwara State. Minna, the state capital, has a poorly developed infrastructure although in the 1980s major investments were made in the development of roads, hospitals, drainage and water-supply systems. All-weather roads now connect the major population centres in Niger State.

The main railway line from Kaduna to Lagos crosses Niger State although the branch to Baro, a terminus for goods brought along the Niger River, has been all but abandoned. The cities of Minna, Bida and Kontagora have recently refurbished airports with connections to the north and south. Niger State is the location of three major hydro-electric schemes: the Kainji Dam, completed in 1974, and the Jebba Dam, both of which span the Niger River; and the Shiroro Dam, on the Kaduna River northeast of Minna, completed in 1988.

Human Population

Niger State is dominated by two peoples, the Nupe (based in Bida) and the Gwari (based in Minna). The Nupe were originally based along the Niger River, but after being conquered by the Fulani in the early nineteenth century moved into the surrounding savannas. As a result, populations of Nupe-speakers expanded further north and scattered the indigenous populations. The Gwari are one of the most numerous peoples of central Nigeria. They are a very individualistic people which is reflected in their land use patterns. Gwari villages are constantly fragmenting as some people move into regions of uncultivated bush to begin new farms. Settlements form rapidly when new roads through the bush are established. For example, the road from Bokani to Tegina was only completed in 1987, but by 1990 there were already Gwari villages along it.

A variety of other ethnic groups live near the southern and northern edges of the state. There has been an interface between the Muslims of the north and the middle belt peoples within Niger State. This has created a complex mosaic of cultures and corresponding crop and livestock production systems. Recently, the Hausa and Zarma farmers (from Sokoto and Katsina states to the north) have been migrating into Niger State, prompted by the exhaustion of the agricultural lands in their home states. They have settled along the roads in the sparsely populated region between Tegina, Kontagora and Mokwa.

The other indigenous populations of the state can be divided into the Kainji-speakers such as the Gambari, Hunne, Basa and Kamuku peoples, who live in the region of Lake Kainji and whose

populations extend into Sokoto State, and the southern Nupe groups, such as the Kede, Gupa and Kakanda, who live along the floodplain of the Niger River. In addition, Niger State has populations of two types of Fulani: the settled, urbanized Fulani who came with the Jihad at the beginning of the nineteenth century, and the pastoral Fulani who followed in their wake. Since 1970, Niger State has experienced seasonal Fulani migrations from much further north, particularly from the Sokoto area.

Farming and Agropastoral Systems

Niger State has a wide range of vegetation types from semi-arid savanna to dense woodland. The range of environmental conditions found in the state is mirrored by a diversity of agricultural production systems. In the north, agriculture is based on crops of rainfed cereals and pulses, often cultivated using animal power. By contrast, agricultural activities adjacent to the Niger River are based on the cultivation of oil palms and tubers with few cereals except maize, and virtually no livestock. Farming in the central region of the state combines tubers, cereals and a wide variety of vegetables cultivated on high ridges.

Along the Niger River and parts of the Kaduna River, rice is the predominant crop. The fields flood naturally, but are dyked to retain water. A range of traps designed to catch the different species of fish are also set in these flooded fields. The building of Shiroro Dam on the Kaduna River has submerged a substantial region of formerly arable land, but it has also reduced flooding downstream. This has caused a significant decline in fish populations. Many riverside villages that depended on fishing have been forced to revert to rainfed agriculture.

Niger State produces significant amounts of livestock and is an important staging post in the north-south trade. The cattle presently in the state were brought in by Fulani pastoralists, and are thus all of the zebu type. Zebu production is handled by three main groups: Fulani pastoralists, indigenous village pastoralists and wealthy individuals. As soon as the harvest is over, the migrant Fulanis move south allowing their cattle to graze on cereal residues as they travel to the pastures of the Niger and Kaduna rivers.

In the southeast portion of the state, there are semi-settled Fulani who cultivate sufficient areas to feed their families. They have adopted existing agricultural practices in the area and grow yams and cassava, in addition to staple cereals such as sorghum, millet and maize. Although cattle are still valued, the semi-settled Fulani have smaller herds due to limited grazing areas near their settlements and the growing reliance on their food crops.

A large number of cattle have been transferred from the pastoralists into the hands of the settled farmers. These cattle are being raised for meat and dairy products and for use as draught animals. Generally, the village cattle are owned by wealthy urban businessmen, wealthy Fulani and government officials who keep the cattle as a source of milk or for ceremonial purposes. In addition, Niger State has experienced a major influx of camels since 1980. These camels are used for farm

work and in many cases farmers are exchanging their cattle for camels. Camels are less destructive to the environment and can work throughout the year.

Vegetation and Land Use Change

Table 8.44 Dominant Vegetation and Land Use Classes for 1976/78 and 1993/95, Niger State, Nigeria.

Land Use Category	1976/78		1993/95	
	Area (km^2)	Percent of state	Area (km^2)	Percent of state
Extensive (grazing) Agriculture	21 316	29.7	29 651	41.4
Trees/Woodlands/Shrubs	28 206	39.4	17 601	24.6
Intensive (crop) Agriculture	15 427	21.5	17 244	24.1
Floodplain Agriculture	146	0.2	1634	2.3
Riparian Forest	1325	1.9	1259	1.8
Gullies	0	0	995	1.4
Reservoir	483	0.7	948	1.3
Shrubs/Grasses	1553	2.2	362	0.5
Shrub/Sedge/Graminoid Freshwater Marsh/Swamp	1869	2.6	304	0.4
Plantations (agricultural tree crop, forest, teak), Rainfed Arable Crops, Irrigation and Livestock Projects	75	0.1	241	0.3
Rock Outcrop	103	0.1	207	0.3
Undisturbed Forest	681	1.0	11	< 0.1

Table 8.45 Dominant Vegetation and Land Use Changes between 1976/78 and 1993/95, Niger State, Nigeria.

Land Use 1976/78	Land Use 1993/95	Area affected (km^2)	Percent of state
Trees/Woodlands/Shrubs	no change	12 669	17.7
	to Extensive (grazing) Agriculture	10 931	15.3
	to Intensive (crop) Agriculture	3079	4.3
	to Gullies	537	0.8
Shrubs/Grasses	no change	107	0.2
	to Extensive (grazing) Agriculture	1136	1.6
Shrub/Sedge/Graminoid Freshwater Marsh/Swamp	no change	145	0.2
	to Floodplain Agriculture	1105	1.5
	to Intensive (crop) Agriculture	101	0.1
Intensive (crop) Agriculture	no change	8201	11.4
	to Extensive (grazing) Agriculture	5392	7.5
	to Trees/Woodlands/Shrubs	949	1.3
Extensive (grazing) Agriculture	no change	11 440	16.0
	to Extensive (grazing) Agriculture	5163	7.2
	to Trees/Woodlands/Shrubs	3473	4.8

Niger State is almost entirely within the Guinea Savanna Ecological Zone, with the northernmost areas of the state in the Sudan Savanna Ecological Zone. Dramatic vegetation and land use changes that have occurred in this state during the study period were likely due to changes in the watershed, as well as in part due to the damming of the Niger and Kaduna rivers. The total area of reservoirs in the state increased from 483 km^2 in 1976/78 to 948 km^2 in 1993/95.

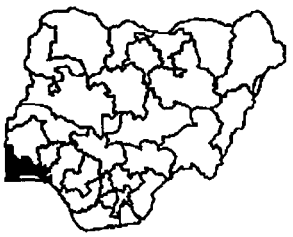
In 1976/78, shrub/sedge/graminoid freshwater marsh/swamp covered 1869 km^2 (2.6%) in the state, although by 1993/95 only very small patches remained with a total area of 304 km^2 (0.4%). Most of the previous shrub/sedge/graminoid freshwater marsh/swamp areas changed to floodplain agriculture, with some areas used for intensive agriculture. The total area of floodplain agriculture increased from 146 km^2 in 1976/78 to 1634 km^2 in 1993/95.

There are many plantations in the Niger River floodplain area, including rainfed arable crops, agricultural tree crops, forest, teak and livestock and irrigation projects, particularly around Mokwa. The total area of plantations has increased from 75 km^2 in 1976/78 to 241 km^2 in 1993/95. Often, plantations indicate an increase in land use intensity, as larger areas of land need to be farmed in low yielding areas.

The larger areas of the state that maintained their trees/woodlands/shrubs are the large reserved areas, including Lake Kainji National Park as well as many other game reserves, forest reserves and grazing reserves. However, agriculture encroached into many of these areas and in the 1993/95 imagery, there was evidence of erosional processes. Gully erosion was not significant enough to be mapped in 1976/78, but in 1993/95, 995 km^2 of gully erosion was mapped.

In 1976/78, dominantly trees/woodlands/shrubs occupied 39.4% (28 206 km^2) of the state. However, by 1993/95, the area decreased to 24.6% (17 601 km^2) of the state. Most of the dominantly trees/woodlands/shrubs changed to extensive agriculture (10 931 km^2), with a large area changing to intensive agriculture (3079 km^2) and gully erosion (537 km^2).

North of Lake Kainji, a 1553 km^2 area of dominantly shrubs/grasses was identified in 1976/78. Only 107 km^2 of this vegetation remained in 1993/95 as most of the area was being used for grazing land (extensive agriculture).



8.24 OGUN STATE

Introduction

Ogun State, with an area of 16 085 km^2 and a population of approximately 2.3 million people, is located in southwest Nigeria. Abeokuta, the capital of Ogun State, has expanded rapidly since 1976, and is now one of the major Yoruba urban settlements in the country. Ijebu-Ode, the other primary urban centre in Ogun State, is an important commercial and trading centre between Yorubaland and the Republic of Benin. After Lagos State, Ogun State is the most important commercial and industrial area in Nigeria, and many companies have their headquarters located in the south of the state.

The central part of the state benefits from a good system of access roads that have been developed for Ibadan and Lagos. For example, the state is traversed by the Lagos-Ibadan and Benin-Shagmu expressways. In addition, Ogun State is crossed by the railway line extending from Lagos to northern Nigeria.

Human Population

The great majority of population in Ogun State is Yoruba. Most of the Yoruba are highly urbanized and often maintain town and country residences. This allows them to both practice farming as well as to participate in the complex political and social life of their town.

Additionally there are people of the Ijaw group in the coastal region in the southeast, and Egun in the southwest. Ijaw fisherman are now well established in the coastal and lagoon region of Ogun State, although they originally migrated from Rivers State. Their main enterprise is fishing, but they also trade along the coast via the lagoon system. The Egun people are centered on Badagry, but their settlements have also spread inland to southern Ogun State.

There appear to be two influxes of Fulani pastoralists in Ogun State. In the derived savanna areas Fulani pastoralists have begun to settle and to establish farms, having arrived in the early 1960s. The more recent Fulani are migrants, having arrived in small numbers since the early 1980s from further north, pressured by a major drought in the semi-arid zone. Other migrants such as Hausa and Nupe from the north, and Tiv and Igbo from the east, have settled in Ogun state to work as farm labourers on plantations, and as palm-wine tappers.

Farming and Agropastoral Systems

The natural vegetation of Ogun State is climax rainforest in the south, and heavily wooded savanna in the north and west. However, intense cultivation over a long period has eliminated the primary forest and has promoted secondary growth, dominated by oil palms.

The farming systems employed in Ogun State are essentially those traditionally associated with the Humid Zone (i.e., slash-and-burn followed by forest and bush fallow). Traditionally, yams were the main crop, but they have now been replaced by cassava and maize. Tree-crops, especially kola-nut, cocoa, oil palm, rubber and citrus fruits, have been integrated with the forest farms and are often the primary source of income for farmers. In the derived savanna regions, cropping systems combine tubers, cereals and vegetables which are grown on ridges. There are few tree-crops. Surplus staples are grown for selling. In addition, part of the flat coastal plain, which is liable to become swampy in the rainy season, is a rich agricultural area famous for cocoa and palm production.

Originally, a few Fulani were brought to the state to herd cattle owned by Yoruba businessmen. Since settling, they no longer have their traditional large herds of cattle, and have now established permanent farms on which they grow subsistence crops. They take on herding contracts with local Yoruba, in which they work in exchange for milk and a share of the offspring. In contrast, the more recent migrant Fulani are not cultivators and they maintain large herds, from which they sell stock and dairy products for subsistence.

Generally, livestock production in Ogun State is at relatively low levels. The state imports much of its meat from outside, especially from northern Nigeria and the Republic of Benin. In the northern part of the state there is a greater emphasis placed on livestock production. In the mangrove swamps and the swamp forest of the south, many fishing camps and villages have no livestock other than chickens. In the central area, local breeds are kept in small numbers, mostly for sacrifice. Most Yoruba farmers put their major investment of labour into the cultivation of tree-crops, especially of cocoa and oil palm. A trend established in Ogun State that appears to be successful is the spread and development of fish farming.

In more densely populated areas, the number of domestic animals is in decline and, a trend unlikely to reverse as long as competition for land accelerates. Most of the cattle in Ogun State are of the zebu type, and are owned by the Fulani in the derived savanna areas. The herds stay close to the farm areas in the wet season, and move to riverine pastures in the dry season. Crop residues play only a minor role in the nutrition of livestock, as tubers are predominate in the densely cultivated areas and farms are scarce in the northwestern savanna zone. Egun and Yoruba people keep muturu and Keteku cattle in small numbers in other parts of the state.

Vegetation and Land Use Change

Ogun State covers a wide range of ecological zones. The northwestern tip of the state is located in the Guinea Savanna Ecological Zone, while south of this area is situated in the Derived Savanna Ecological Zone. The Lowland Rain Forest Ecological Zone has the largest presence in the state, running east to west through the centre of the state. The small coastal area in the southeastern tip of the state supports the Freshwater Swamp Forest and Mangrove Forest and Coastal Vegetation ecological zones.

Table 8.46 Dominant Vegetation and Land Use Classes for 1976/78 and 1993/95, Ogun State, Nigeria.

Land Use Category	1976/78		1993/95	
	Area (km^2)	Percent of state	Area (km^2)	Percent of state
Intensive (crop) Agriculture	11 981	74.5	11 139	69.3
Trees/Woodlands/Shrubs	1147	7.1	906	5.6
Forested Freshwater Swamp	476	3.0	817	5.1
Grassland	0	0	741	4.6
Plantations (agricultural tree crop, teak, forest) and Rainfed Arable Crops	318	2.0	666	4.1
Undisturbed Forest	262	1.6	641	4.0
Disturbed Forest	1421	8.8	629	3.9
Riparian Forest	372	2.3	139	0.9
Reservoir	0	0	37	0.2

Table 8.47 Dominant Vegetation and Land Use Changes between 1976/78 and 1993/95, Ogun State, Nigeria.

Land Use 1976/78	Land Use 1993/95	Area affected (km^2)	Percent of state
Disturbed Forest	no change	193	1.2
	to Undisturbed Forest	610	3.8
	to Teak Plantation	254	1.6
	to Intensive (crop) Agriculture	270	1.7
Trees/Woodlands/Shrubs	no change	874	5.4
	to Extensive (grazing) Agriculture	254	1.6
Undisturbed Forest	to Forested Freshwater Swamp	117	0.7
	to Shrubs/Grasses	134	0.8
Riparian Forest	no change	16	0.1
	to Intensive (crop) Agriculture	279	1.7
Intensive (crop) Agriculture	no change	10 069	62.6
	to Grassland	736	4.6
	to Disturbed Forest	399	2.5
	to Forested Freshwater Swamp	236	1.5

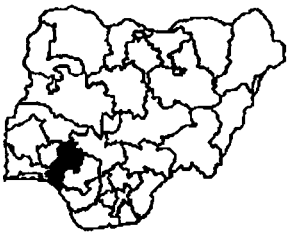
Areas of forested freshwater swamp are increasing north of Lekki Lagoon and along the waterways north of Badagry. The area of forested freshwater swamp in Ogun State increased from 476 km^2 in 1976/78 to 817 km^2 in 1993/95. Some areas that had been undisturbed forest or intensive agriculture in 1976/78 appeared as forested freshwater swamp in 1993/95.

The area of plantations in the southern and central areas of the state increased over the time period of the study. This includes agricultural tree crop, forest, teak and rainfed arable crops. The area under plantation in 1976/78 was 318 km^2, this number more than doubled to 667 km^2 in 1993/95. The increase in plantations may be indicative of increasing pressure on the land as the populations have grown. It may also indicate a change in land production systems and ownership.

In the eastern portion of the state, east of Ijebu Igbo, large forested areas straddle the border of Ogun, Osun and Ondo states. In Ogun State, most of this area was incorporated into the Omo Forest Reserve. This area was mapped primarily as disturbed forest with a large teak plantation in the south in 1976/78, although 1993/95, this area had grown slightly and more differentiation was visible in the forest. It was possible to distinguish between undisturbed areas and disturbed areas of forest, as well as teak, forestry, agricultural plantations. In particular, the teak plantation in the south end of the Omo Forest Reserve.

The central area of the state is an area of intensive agriculture with large patches of grasslands. In 1976/78, no grasslands were identified; however, by 1993/95, a total of 741 km^2 of grasslands were mapped. The majority of these new grassland areas were found on the plains north of Abeokuta along the Oyo border. They were also found in patches roughly following the highway from Abeokuta to Lagos and a number of similar areas were visible throughout the Derived Savanna Ecological Zone. The reasons for their development are not clear but there are several possibilities. These areas could have been left to fallow because they were low yielding, although some forest growth would be expected if these areas were left to naturally regenerate. Therefore, it is possible that these grasslands may have formed from erosional processes or due to annual fires.

8.25 ONDO STATE



Introduction

Ondo State, with an area of 20 449 km^2 and population of approximately 4 million people, is located in southwest Nigeria and is accessible via the main Lagos-Benin expressway, which passes through the southern half of the state, and a new road that has allowed direct access to northern Nigeria. However, many regions, especially in the riverine south, are poorly served by feeder roads.

Human Population

Ondo State is ethnically quite homogeneous. Yoruba people form the largest part of the population. Most of the Yoruba are highly urbanised, and often maintain town and country residences. This allows them to both farm and participate in the complex political and social life of their town. Although many Yoruba in the northern part of state are Muslims, most Yoruba have a strong Christian tradition and have developed a multiplicity of different sects and groups. One of the best known of these is the Aladura church. A group of Aladura, fleeing persecution in 1947, founded a utopian community at Aiyetoro, in the Ilaje area of the mangrove swamp. They were extremely innovative and introduced commercial fish production and processing into what was otherwise an economically depressed area.

Apart from the Yoruba there are several small, coastal communities of Ijaw fishermen, Fulani and Akoko speaking people inhabiting Ondo State. The cocoa farms in the area have attracted a regular influx of migrant labour, especially from the Igbo and Ebira regions.The Fulani peoples in Ondo state belong to two distinct groups: the Fulani who settled in the state in the 1960s, many establishing permanent farms, or the recent migrants from further north who have arrived in smaller numbers and concentrate on cattle rearing. Overall, population densities are relatively low in Ondo State.

Farming and Agropastoral Systems

Farming systems in the state correspond to the different ecological zones. In the coastal swamps, cultivation is sparse and is confined to land exposed by receding waters; plantains and cocoyams are the main crops. Further inland, the naturally flooded swamps are suitable for growing rice (Ademola 1994), and paddy cultivation is becoming more common in the Owena basin. Farmers in the central plains practice rainfed slash-and-burn cultivation followed by forest or bush fallow. The subsistence staples are tubers, especially yams, cocoyams and cassava, complemented by maize, peppers, tomatoes and egusi (melon).

The low population density in Ondo State has made it a prime area for the cultivation of cash crops. Cocoa is the major cash crop of the state, but oil-palm, rubber, cashew, kola-nuts and coffee are also grown. Apart from individual small holdings, there are extensive oil-palm plantations in the south of the state.

Livestock production in Ondo State is insufficient to meet local demand. Therefore, it has been necessary to import from other states, mainly cattle, sheep and goats. The state encompasses a wide range of ecological zones, thus livestock varies in importance from one region to the next. Generally, the farther north, the greater the emphasis placed on livestock production. In the mangrove swamps and the swamp forest of the south, many fishing camps and villages have no livestock other than chickens. In the central plains, local breeds are kept in small numbers, mainly for sacrifices. In this predominantly crop-farming region, livestock rearing is of secondary importance, as most of the Yoruba farmers place greater emphasis on the cultivation of tree-crops, especially cocoa.

In the northern part of the state, herds of zebu cattle are either managed or owned by Fulani pastoralists. Most of the Fulani are still cattle producers, but some have become involved in large cropping enterprises. Pastoral production is based around a tripartite seasonal movement; the herds stay close to the farm areas in the wet season, graze crop residues in the early dry season and move to riverine pastures in the late dry season. In the mangrove swamp areas, as in Rivers and Akwa Ibom states, fish farming is an established trend.

Vegetation and Land Use Change

Table 8.48 Dominant Vegetation and Land Use Classes for 1976/78 and 1993/95, Ondo State, Nigeria.

Land Use Category	1976/78		1993/95	
	Area (km^2)	Percent of state	Area (km^2)	Percent of state
Intensive (crop) Agriculture	13 651	66.8	13 128	64.2
Disturbed Forest	3849	18.8	3119	15.3
Forested Freshwater Swamp	1373	6.7	1842	9.0
Trees/Woodland/Shrubs	184	0.9	601	2.9
Undisturbed Forest	935	4.6	512	2.5
Rock Outcrop	27	0.1	317	1.6
Plantations (agricultural tree crop, teak, forest) and Rainfed Arable Crops	189	0.9	266	1.3
Saltmarsh/Tidal Flats	0	0	159	0.8
Mangrove Forest	108	0.5	31	0.2

Table 8.49 Dominant Vegetation and Land Use Changes between 1976/78 and 1993/95, Ondo State, Nigeria.

Land Use 1976/78	Land Use 1993/95	Area affected (km^2)	Percent of state
Disturbed Forest	no change	1751	8.6
	to Undisturbed Forest	431	2.1
	to Rock Outcrop	111	0.5
	to Intensive (crop) Agriculture	1421	7.0
Undisturbed Forest	no change	47	0.2
	to Forested Freshwater Swamp	477	2.3
	to Intensive (crop) Agriculture	252	1.2
	to Rock Outcrop	14	0.1
Intensive (crop) Agriculture	no change	11 160	54.6
	to Trees/Woodlands/Shrubs	475	2.3
	to Disturbed Forest	1291	6.3
	to Rock Outcrop	169	0.8
Mangrove Forest	no change	3	< 0.1
	to Forested Freshwater Swamp	60	0.3
	to Saltmarsh/Tidal Flats	33	0.2
	to Water/Ocean	13	0.1

Ondo State straddles four ecological zones, including: Derived Savanna across the north, Lowland Rain Forest occupying the central areas of the state, and Freshwater Swamp Forest and Mangrove Forest and Coastal Vegetation along the coastline. The far southern part of Ondo State, which borders the Atlantic Ocean, is a network of creeks and estuaries dominated by mangroves. The mangroves give way to lowland forest in the centre of the state around Ore, most of which is secondary forest with extensive areas of oil-palm, although patches of the high forest remain. The north of the state is undulating derived savanna with some rugged hills.

The area of mangrove forest along the coastline decreased greatly over the time period of this study. In 1976/78, mangrove forest covered an area of 108 km^2. However, by 1993/95, it had been reduced to 31 km^2. Only 3 km^2 of the area of mangrove identified in 1976/78 remained unchanged, 60 km^2 converted to forested freshwater swamp, 33 km^2 to saltmarsh, and 13 km^2 to ocean. The accuracy of the satellite data is not sufficient enough to identify or measure coastal subsidence in this area; however, it would seem that some amount of saltwater inundation was taking place. Geomatics International and Beak studied coastal loss in the Awoye area of the Ondo coast (Eedy et al. 1994) and concluded the most likely causes are petroleum development and canal building. More detailed analysis of this area using accurately georeferenced data and ground truthing is necessary to draw accurate conclusions about the environmental processes occurring along the coast.

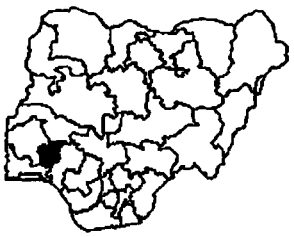
The central portion of the state has experienced an increase in the number and area of plantations, (agricultural tree crop, forest, teak and rainfed arable crops). The total area of plantations in 1976/78 was 189 km^2, which increased to 266 km^2 in 1993/95.

West of the town of Ore is a very large area of forest, a portion of which extends into Ondo State. This area is part of the Oluwa Forest Reserve which was mapped as disturbed forest in 1976/78. In the 1993/95 imagery, there was some encroachment of agriculture into the forested area. However, the remaining portion seemed more densely vegetated than in the earlier time period, and was consequently mapped as undisturbed forest with some new areas of forest plantations. It would seem that these forested areas have had a chance to regenerate.

The Ifon Game Reserve and National Park in the centre of the state was mapped as disturbed forest and remained largely unchanged over the time period of the study. However, in the centre of the state there are large areas of disturbed forest which generally lie within forest reserves such as Onishere, Idanre, Akure-Ofosu, Ala, Owo and the Ifon Forest and Game Reserve. Although there have been some areas of encroachment from agriculture, generally these areas remain intact.

A total of 317 km^2 were mapped as rock outcrop in 1993/95. A large part of this area changed from intensive agriculture (169 km^2), disturbed and undisturbed forest (125 km^2). It is, however, possible that some of the areas mapped as rock outcrop could be bare areas exposed during the slash-and-burn process of clearing land.

The central and northern portions of the state are dominated by intensive farming with patches of disturbed forest and some dominantly trees/woodlands/shrubs. Overall, the area of intensive agriculture did not change very much from 1976/78 to 1993/95 (a decrease of 528 km^2) and neither did the area of disturbed forest (a decrease of 730 km^2). However, many of the areas of disturbed forest had changed to intensive agriculture and vice versa. This suggests that in this area of forest fallow farming, the patches mapped as forest and dominantly trees/woodlands/shrubs were likely areas left to fallow.



8.26 OSUN STATE

Introduction

Osun State, with an area of 9491 km^2 and a population of approximately 2.2 million people, is located in southwestern Nigeria, adjacent to Oyo, Ogun and Ondo states. Osun State was created from the eastern part of the former Oyo State following its division in 1991. The state is well connected via road and rail networks to the Lagos, Ibadan and Benin City areas.

Human Population

Osun State is ethnically very homogeneous and most inhabitants are Yoruba whose kingdoms densely populate the south-central regions of the state. Generally, Yoruba are highly urbanized, and often maintain town and country residences. This allows them to both farm and participate in the complex political and social life of their towns. In Osun State many Yoruba are Muslims despite having a strong Christian tradition.

There are limited numbers of Fulani pastoralists inhabiting the state as well small groups of Ijaw fishermen. The Fulani either belong to the groups who settled in Osun State in the 1960s and have begun to establish permanent farms, or to more recent groups of migrants from further north (Sokoto State) who have a pastoralist lifestyle and largely concentrate on cattle rearing.

Farming and Agropastoral Systems

Vegetation in Osun State is classifiable into two very different areas. The degraded oil-palm forest covers much of the state. In the oil-palm forest, intense cultivation over a long period has eliminated the primary forest and has promoted secondary growth, dominated by the oil-palms. The derived savanna is present in limited areas in the northern part of the State.

Farming systems used in this state are those traditionally associated with the humid zone, i.e. slash-and-burn followed by forest and bush fallow. Traditionally, yams were the main crop but they have now been replaced by cassava and maize. Tree-crops, especially cocoa, oil-palm and fruits, have been integrated with the crops, and are the farmers' main source of cash income.

Towards the derived savanna regions, cropping systems more closely resemble those of the middle belt, and include a mixture of tubers, cereals and vegetables which are grown on ridges. There are fewer tree crops, and surplus staples are sold. The use of Fulani cattle manure to fertilize fields is common, although where tubers are intercropped with cereals, cattle cannot be allowed onto the fields since they may eat the tubers.

Osun State is densely populated and predominantly a crop-farming region. Consequently, livestock production is given low priority in rural areas. As a result, Osun State is a major consumer of livestock from outside the state. There are several varieties of cattle that are reared in the state. Generally the Yoruba do not rear zebu cattle themselves, although some own cattle. In some savanna villages, cattle are bought by Yoruba farmers and handed over to the Fulani to manage. The herder is commonly given access to the milk and given every second calf as payment for their services.

Vegetation and Land Use Change

Table 8.50 Dominant Vegetation and Land Use Classes for 1976/78 and 1993/95, Osun State, Nigeria.

Land Use Category	1976/78		1993/95	
	Area (km^2)	Percent of state	Area (km^2)	Percent of state
Intensive (crop) Agriculture	8194	86.3	7000	73.8
Disturbed Forest	1032	10.9	931	9.8
Undisturbed Forest	101	1.1	796	8.4
Rock Outcrop	10	0.1	147	1.6
Grassland	0	0	134	1.4
Teak Plantation	51	0.5	86	0.9
Forest Plantation	0	0	28	0.3
Reservoir	13	0.1	27	0.3
Agricultural Tree Crop Plantation	5	0.1	2	< 0.1
Rainfed Arable Crops	0	0	10	0.1

Table 8.51 Dominant Vegetation and Land Use Changes between 1976/78 and 1993/95, Osun State, Nigeria.

Land Use 1976/78	Land Use 1993/95	Area affected (km^2)	Percent of state
Disturbed Forest	no change	0.5	48
	to Undisturbed Forest	7.3	692
	to Intensive (crop) Agriculture	2.3	220
Intensive (crop) Agriculture	no change	70.8	6723
	to Disturbed Forest	9.3	881
	to Grassland	1.4	132
	to Rock Outcrop	1.4	130

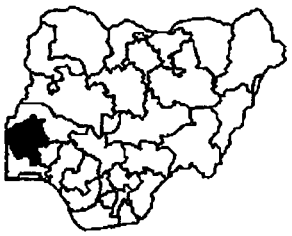
Osun State is situated within the Derived Savanna Ecological Zone in the north and the Lowland Rain Forest Ecological Zone in the south.

Overall, there was a decrease in disturbed forest and an increase in undisturbed forest in the state. The gain in undisturbed forest occurred in the forest reserves in the south of the state where forests seemed to have regenerated. A shift in patches of disturbed forest is a result of fallow patterns. There were a few new areas of disturbed forest that were of significant size, west of Iwo and north of

Ilesha. The reason for these new forest areas was not evident since the areas seemed too large to be fallow. These areas could be areas cleared for agricultural purposes by the Department of Food, Rural Roads and Infrastructure.

Intensive agriculture occupied 8194 km^2 (86.3%) of the state area in 1976/78. By 1993/95, the area had decreased to 7000 km^2. Some of the area had changed to disturbed forest as mentioned above. However, east of Iwo there was evidence of erosion, suggested by areas of continuous and discontinuous grassland as well as larger areas of bare rock outcrops. The area of continuous grassland grew from none mappable in 1976/78 to 134 km^2 in 1993/95. The area of rock outcrops increased from 10 km^2 in 1976/78 to 147 km^2 in 1993/95.

The change in area of reservoirs and plantations indicates an increase in land use intensity. The total area of reservoirs in the state has increased from 13 km^2 in 1976/78 to 27 km^2 in 1993/95. The total area of plantations (agricultural tree crop, forest and teak) and rainfed arable crops was 56 km^2 in 1976/78, and increased to 126 km^2 in 1993/95.



8.27 OYO STATE

Introduction

Oyo State, with an area of 27 899 km^2 and a population of approximately 3.5 million people, is located in southwestern Nigeria, along the border with the Republic of Benin. This state was formed from the western part of the former Oyo State in 1991. The state is characterized by two very different habitats; the sparsely inhabited derived savanna of the northwest, and the densely settled south-central regions.

Ibadan, the state capital, has a population of several million. It is characterized by areas of extremely high density with scattered settlements and farmland at its periphery. The main railway line linking northern to the southern Nigeria passes through Ibadan, and a series of expressways link the capital to Lagos and Benin cities.

Human Population

Oyo State is ethnically very homogeneous, most inhabitants belonging to the Yoruba group. Generally, Yoruba are highly urbanized, and often maintain town and country residences. This allows them to both farm and participate in the complex political and social life of their towns. Many Yoruba in the state are Muslims in spite of the strong Christian tradition of these people.

Small communities of Busa and Baatonun have settled the extreme north. The Baatonum are Muslims and have their most important towns in the Republic of Benin. Busa villages are very dispersed in rural areas where a pattern of subsistence based on rainfed cultivation and cattle-herding is practiced. Also in northern Oyo State are the city dwelling Hausa and Fulani, who act as middlemen in trade between the north and south. The derived savanna in northern Oyo State has attracted a substantial population of Fulani pastoralists, comprised of three main groups. The Borgu people are agropastoralists who moved in from Kwara State in the 1960s and are now more or less settled in the Shaki area. The Hausa people, who are originally from Sokoto State, began to arrive in 1974, when they were driven south by drought. The recent wave of Fulani migrants, who began to arrive from Sokoto State in the 1980s, because of drought conditions, focus on cattle rearing but are often in conflict with local farmers.

Farming and Agropastoral Systems

Oyo State is divided between two very different vegetation types; derived savanna and degraded oil-palm forest. The natural vegetation is climax rainforest in the south and heavily wooded savanna in the north and west. However, intense cultivation over a long period has eliminated the primary forest and has promoted secondary growth, dominated by the oil-palms.

Farming systems employed are essentially those traditionally associated with the humid zone (i.e., slash-and-burn followed by forest and bush fallow). Traditionally, yams were the main crop but they have now been replaced by cassava and maize. Tree-crops, especially cocoa, oil-palm and fruits, have been integrated with the crops, and are often the primary source of income for farmers.

In the derived savanna regions, cropping systems more closely resemble those practices of the middle belt, and include a mixture of tubers, cereals and vegetables which are grown on ridges. There are fewer tree crops, and surplus staples are sold. The use of Fulani cattle manure to fertilize fields is typical, but where tubers are intercropped with cereals, cattle cannot be allowed onto the fields for fear they will eat the tubers.

Oyo State is densely populated and predominantly a crop-farming region. As a result, livestock production is given a lower priority in rural areas. Consequently, Oyo State is a major consumer of livestock from outside the state. Ibadan is a major commercial trading centre for livestock in southwestern Nigeria. In the past, livestock arrived in Ibadan by rail or on the hoof, but during the 1970s dealers gradually began to switch to the use of trailers, with the advantage that losses from disease were greatly reduced.

There are three varieties of cattle in Oyo State, the zebu, keteku and the muturu. The zebu, which are the most common, are either herded or owned by Fulani pastoralists. Most Fulani are still cattle producers, although some have large cropping enterprises. Pastoral production is based on a tripartite seasonal movement: the herds stay close to the farm areas in the wet season, graze crop residues in the early dry season and move to riverine pastures in the late dry season.

The Yoruba do not rear zebu cattle themselves, although some own cattle. In some savanna villages, cattle are bought by Yoruba farmers and handed over to the Fulani to manage. The Borgu people who used to herd cattle now concentrate on crop farming, so much so that they now grow cash crops as well as staples. They still have some cattle, and generate additional income by selling *wara* (cheese) to the Yoruba. The Hausa people originally herded cattle, and like the Borgu people, they are beginning to farm.

Vegetation and Land Use Change

Oyo State is situated within three ecological zones: Guinea Savanna in the north, Derived Savanna in the centre, and Lowland Rain Forest in the south.

Table 8.52 Dominant Vegetation and Land Use Classes for 1976/78 and 1993/95, Oyo State, Nigeria.

Land Use Category	1976/78		1993/95	
	Area (km²)	Percent of state	Area (km²)	Percent of state
Intensive (crop) Agriculture	47.0	13 101	55.7	15 526
Trees/Woodlands/Shrubs	35.7	9966	21.3	5955
Extensive (grazing) Agriculture	10.7	2996	9.9	2749
Disturbed Forest	2.9	796	5.9	1638
Grassland	0	0	3.9	1095
Undisturbed Forest	2.6	735	0.4	120
Rock Outcrop	< 0.1	11	0.4	107
Reservoir	< 0.1	2	0.2	64

Table 8.53 Dominant Vegetation and Land Use Changes between 1976/78 and 1993/95, Oyo State, Nigeria.

Land Use 1976/78	Land Use 1993/95	Area affected (km²)	Percent of state
Trees/Woodlands/Shrubs	no change	4243	15.2
	to Intensive (crop) Agriculture	3786	13.6
	to Disturbed Forest	1210	4.3
	to Grassland	325	1.2
Disturbed Forest	no change	308	1.1
	to Intensive (crop) Agriculture	338	1.2
Undisturbed Forest	no change	1	< 0.1
	to Trees/Woodlands/Shrubs	409	1.5
	to Intensive (crop) Agriculture	172	0.6
Intensive (crop) Agriculture	no change	9851	35.3
	to Disturbed Forest	932	3.3
	to Trees/Woodlands/Shrubs	681	2.4
	to Extensive (grazing) Agriculture	608	2.2
	to Grassland	599	2.2
Extensive (grazing) Agriculture	no change	925	3.3
	to Intensive (crop) Agriculture	1305	4.7
	to Trees/Woodlands/Shrubs	613	2.2

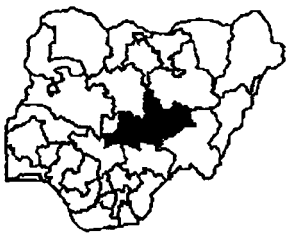
Across the state there was a drastic decrease in undisturbed forest, from 735 km² in 1976/78 to 120 km² in 1993/95. There were also large tracts of disturbed forest that changed to intensive agriculture (308 km²); however, two new areas of disturbed forest that appeared in the southeast part of the state greatly influenced the final area of disturbed forest. These two areas may represent areas of forest fallow where agricultural tree crops were growing, but the intensity of cropping under the trees had decreased.

The increase in continuous grassland areas is very significant in showing a degradation in vegetation. There was no continuous grassland mapped in 1976/78, but 599 km² of intensive agriculture and 325 km² of dominantly trees/woodlands/shrubs had changed to continuous grassland by 1993/95.

The south-central areas of the state, along the Oyo and Ogun rivers, were characterized by extensive areas of discontinuous grassland that traversed the Oyo and Ogun state boundary. There were many other areas of discontinuous grassland, particularly through the centre of the state, south of Shaki. In 1976/78, no discontinuous grassland was mapped. In 1993/95, the area of discontinuous grasslands totalled 1095 km^2. Most of this area had been intensive agriculture or dominantly trees/woodlands/shrubs in 1976/78.

In 1976/78, the majority of the north and western state was vegetated with dense areas of dominantly trees/woodlands/shrubs and undisturbed forest and minor areas of agriculture. By 1993/95, most of this area appeared as intensive agriculture with areas of continuous grassland. In 1976/78, the area of dominantly trees/woodlands/shrubs was 9966 km^2; however, by 1993/95, this area had decreased to 5955 km^2. The remaining areas of dominantly trees/woodlands/shrubs were within Old Oyo National Park, east of Shaki, and the Opara Game Reserve, west of Shaki. The eliminated dominantly trees/woodlands/shrubs changed to intensive agriculture (3786 km^2), disturbed forest (1210 km^2) or grassland (325 km^2).

Another indication of more intensive land use in Oyo State was the establishment of a reservoir on the Ogun River situated on the southern boundary of the Ogun Forest Reserve.



8.28 PLATEAU STATE

Introduction

Plateau State, with an area of 55 382 km^2 and a population of approximately 3.3 million people, is located in central Nigeria. With the exception of the capital, Jos, there are no large traditional urban centres in Plateau State. Jos was founded during the colonial times by tin miners who came to Plateau State soon after the imposition of indirect rule. In the post-independence period there has been substantial industrial development and Jos has attracted migrant workers from all over Nigeria. The population of Plateau State was estimated to be over half a million in 1978.

Plateau State is well served by access roads. The main road passes through Jos which connects the state to southern Nigeria. Railways no longer play a major role in the economy of the state, although Jos is served by a spur from the main line that reaches Maiduguri in Borno State. Jos has an airport of international standard.

Human Population

Plateau State contains a great diversity of ethnic groups, without any of the large-scale political units such as those which characterize Hausaland and Yorubaland. Thus no one language or people has become dominant, although the largest ethnic groups are probably the Berom, Angas and Tarok. Migrants from all over Nigeria have come to Jos town to work in the tin mines and related service industries.

In the early nineteenth century, the Jos Plateau was one of the most attractive environments for cattle in the whole region. Low population levels, an absence of tsetse flies, and unlimited grassland drew Fulani pastoralists from all over the semi-arid regions, mainly from Bauchi and Borno states. Fulani established themselves in all areas of the plateau, originally living alongside cultivators with minimal friction.

Fulani movement into the lowland regions of the state is generally more recent than the movement onto the Plateau. During this century, the development of trade routes and communications in central Nigeria has attracted people to the state.

Farming and Agropastoral Systems

Plateau State is sharply divided by the Jos Plateau. The plateau was formerly open savanna woodland but is presently almost entirely grassland. Most of the trees present are exotics, such as eucalyptus, or imports from the lowland. Traditional farming systems have not encouraged soil conservation, and as a result much of the plateau is heavily eroded. Tin mining has damaged

substantial areas of the plateau, although farmers are developing new soil reclamation methods.

The farming systems of Plateau State are dominated by rain-fed cultivation. However, along the Benue River, swamp farming of rice is practiced, and in the volcanic crater lakes of the plateau, vegetables are grown on the damp soils exposed in the dry season. The Plateau used to have very distinct agriculture practices based on the production of two cereals, *fonio* and *iburu*, which were uncommon elsewhere in Africa. Fonio gives good yields on eroded soils and is recognized as important feed for stock. Other crops grown include sorghum, millet, maize, yams, cocoyams, sweet potatoes, Irish potatoes and a variety of vegetables, including a number of exotic fruits and vegetables normally associated with a temperate climate.

On the southern edges of the Jos Plateau, especially in the Dimmuk area, are elaborate escarpment farms. These farming systems are unique in Nigeria and terracing and intensive composting are used to keep the hillside farms fertile. When colonial policy compelled the Dimmuk people to move down to the plains they adopted much more destructive slash-and-burn cultivation.

In the lowlands, the basis of subsistence agriculture is rainfed cereal cropping, especially sorghum and maize. Towards Lafia and southwards, yams are a major cash crop, especially associated with the expansion of Tiv farms. Along the Benue River, rice gradually takes on more importance, and in some regions in the southwest of the state, dry season irrigated farming of rice is the dominant subsistence activity.

Plateau State is notable for an extremely diverse ecology suitable for livestock production and a good transportation network. As a result, the state exports a wide variety of animals to southern areas of Nigeria. Cattle in Plateau State are of the zebu and muturu types. The muturu is the indigenous breed and is still widely kept, although numbers are low. Zebu are kept either by the pastoral Fulani or by subsistence farmers who have purchased them from the pastoralists or received them as wages for working as herders. Most farmers keep cattle for fattening or as a store of wealth, except in the northern parts of Plateau State, where zebu are also used for farming. Small ruminant production, including sheep, goats as well as pigs and chickens, is of importance in Plateau State.

Vegetation and Land Use Change

Plateau State is situated almost entirely in the Guinea Savanna Ecological Zone. The Jos Plateau Ecological Zone covers the north-central area of the state and the Sudan Savanna Ecological Zone covers the northeastern area. Within Plateau State, the Jos Plateau and Guinea Savanna ecological zones had only minor changes over the study period. However, the boundary of the Sudan Ecological Zone expanded to include a larger area of eastern Plateau State.

Table 8.54 Dominant Vegetation and Land Use Classes for 1976/78 and 1993/95, Plateau State, Nigeria.

Land Use Category	1976/78		1993/95	
	Area (km^2)	Percent of state	Area (km^2)	Percent of state
Intensive (crop) Agriculture	16 052	29.0	22 258	40.2
Extensive (grazing) Agriculture	17 420	31.5	18 952	34.2
Trees/Woodlands/Shrubs	15 946	28.8	7349	13.3
Shrubs/Grasses	2652	4.8	3180	5.7
Floodplain Agriculture	1	< 0.1	1248	2.3
Riparian Forest	728	1.3	474	0.9
Undisturbed Forest	1250	2.3	215	0.4
Rock Outcrop	77	0.1	150	0.3
Shrub/Sedge/Graminoid Freshwater Marsh/Swamp	874	1.6	82	0.2
Plantations (agricultural tree crop, forest, teak) and Rainfed Arable Crops	26	< 0.1	69	0.1
Extensive Agriculture with Denuded	86	0.2	0	0

Table 8.55 Dominant Vegetation and Land Use Changes between 1976/78 and 1993/95, Plateau State, Nigeria.

Land Use 1976/78	Land Use 1993/95	Area affected (km^2)	Percent of state
Trees/Woodlands/Shrubs	no change	4578	8.3
	to Extensive (grazing) Agriculture	4998	9.0
	to Intensive (crop) Agriculture	4848	8.8
	to Shrubs/Grasses	855	1.5
Shrubs/Grasses	no change	1538	2.8
	to Extensive (grazing) Agriculture	634	1.1
	to Intensive (crop) Agriculture	305	0.6
Undisturbed Forest	no change	202	0.4
	to Trees/Woodlands/Shrubs	592	1.1
Riparian Forest	no change	148	0.3
	to Floodplain Agriculture	333	0.6
Shrub/Sedge/Graminoid Freshwater Marsh/Swamp	no change	48	0.1
	to Floodplain Agriculture	411	0.7
Intensive (crop) Agriculture	no change	10 410	18.8
	to Extensive (grazing) Agriculture	4424	8.0
	to Trees/Woodlands/Shrubs	463	0.8
Extensive (grazing) Agriculture	no change	8630	15.6
	to Intensive (crop) Agriculture	6093	11.0
	to Trees/Woodlands/Shrubs	1600	2.9
	to Shrubs/Grasses	675	1.2

The natural vegetation of the Jos Plateau was open savanna woodland. However, development of tin mines during the colonial era has attracted a large population, and much of this area is now

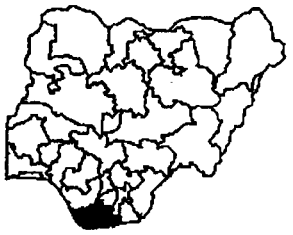
agricultural with patches of dominantly trees/woodlands/shrubs.Over the study period there was not a dramatic change in this area although overall in the state, land use intensity seems to be increasing.

Over the whole state, intensive agriculture increased from 29% (16 052 km^2) of the state in 1976/78, to 40.2% (22 258 km^2) of the state in 1993/95. The data shows that 4848 km^2 of land mapped as dominantly trees/woodlands/shrubs in 1976/78 became intensive agriculture in 1993/95. Additionally, an area of 6093 km^2 that had been mapped as extensive agriculture in 1976/78 changed to intensive agriculture in 1993/95.

In the study period, the most significant vegetation and land use change in Plateau State was the loss of dominantly trees/woodlands/shrubs. More than half of the area mapped as dominantly trees/woodlands/shrubs in 1976/78 changed to extensive (4998 km^2) and intensive (4848 km^2) agriculture. Another 855 km^2 of dominantly trees/woodlands/shrubs changed to dominantly shrubs/grasses in 1993/95.

The area of rock outcrops significant enough to map doubled from 77 km^2 in 1976/78 to 150 km^2 in 1993/95. The area of plantations, including plantations growing rainfed arable crops, agricultural tree crops, forest and teak, increased from 26 km^2 in 1976/78 to 69 km^2 in 1993/95.

The southern border of the state encompasses a portion of the Benue River floodplain near the confluence of the Benue and Niger rivers. As with the rest of the state, this area saw an intensification of land use. In 1976/78, the floodplain was mapped as shrub/sedge/graminoid freshwater marsh/swamp and riparian forest. There were some very small areas of floodplain agriculture. By 1993/95, almost the entire floodplain, including the floodplains of larger rivers from the north, were clearly cultivated for agriculture with only small areas of riparian forest and shrub/sedge/graminoid freshwater marsh/swamp remaining. The area of floodplain agriculture increased from 1 km^2 in 1976/78 to 1248 km^2 in 1993/95. This dramatic change could be due in part to the high resolution of the 1993/95 imagery which makes agricultural patterns more visible. However, this trend of shrub/sedge/graminoid freshwater marsh/swamp being cleared for agricultural use was evident throughout Nigeria.



8.29 RIVERS STATE

Introduction

Rivers State, with an area of 19 416 km^2 and a population of approximately 4.0 million people, is located in south-central Nigeria. The Niger Delta occupies some two-thirds of the state and an extensive, deeply indented coastline borders the Atlantic Ocean. Canoe, ferry and barge are the most common forms of transport. Historically, much of the area was known as Oil Rivers, since it was a source of palm oil, one of the first items of colonial exploitation and trade. Today, the wealth of the state comes from petroleum: 60% of Nigeria's crude oil is produced in Rivers State. Port Harcourt was established in colonial times, but its recent expansion came with the development of the oil industry in the 1970s. It has become a focal point for services in the oil industry and related facilities, such as refineries.

Interstate and international communications are better developed than those within the state. Port Harcourt has an international airport, and is the southeastern terminal of the railway line to Kano, with connections to Jos and Maiduguri. The Port Harcourt expressway provides a direct route to Enugu, and another major highway, known as the East-West Road, crosses the state linking Warri and Sapele to the expressway.

Human Population

The population of Rivers State is dominated by a complex of people known as the Ijo (Ijaw). They are divided into four major groups: the Izon in the west, the people of Nembe/Brass, the eastern Ijaw and the inland Ijaw. In the northern part of the state are other peoples including outlying groups related to the Igbo, such as the Ikwew and Ekpeye, and populations related to the Edo of the former Bendel State. Finally, there are also widely scattered populations of speakers of Cross River languages, which include the Central Delta group and the 'Ogoni'. The pastoral Fulani have no permanent presence in the state. However, the Fulani do bring their herds into Rivers State to graze on grassy patches among the oil-palm. Some travel as far south as Kaiama in the dry season.

Important to the traditional political history of Rivers State was the evolution of "city states", including Brass, Bonny, Kalabari and Okrika. These grew out of fishing villages along the coastline but later became important in trade between coastal communities and inland markets. These cities became less important when deepwater ports were developed further along the coast and modern ships were able to dock at major centres such as Lagos City. Trade declined along the delta sea coast as a result, and the fishing villages are now perceived as being isolated and remote. The decline in commerce has been accompanied by falling fish stocks, due to overfishing and pollution, and the consequences of a significant departure of working age men to find employment elsewhere. The resident populations of the fishing villages now consist only of the elderly, women and children.

Farming and Agropastoral Systems

In the drier northern areas, farming systems are similar to those in other southern states; bush clearing and cultivation, alternating with periods of fallow. Common crops are cassava, yam, cocoyam, sugarcane, vegetables, bananas and plantain. In the riverine areas, farming is practical only on the alluvial soil of the river floodplains. Where there are permanent settlements along the coast, village rubbish heaps are cultivated.

Agricultural development in Rivers State has always concentrated on crops rather than on livestock, although recent initiatives have begun to target fish and crustacean farming to make up for depleted wild stocks. Low human populations and abundance of marine resources have allowed these to be efficiently harvested from the wild until recently. However, pollution and overfishing, as well as increased demand for seafood within Nigeria and as a foreign exchange-earning export, have resulted in depletion of wild stocks.

Fish and fish farming are central to the way of life of the riverine and coastal peoples. Subsistence fishing (harvesting from the wild) predominates in the rivers, creeks and lakes, although ponds are often dammed to trap fish after the retreat of the floodwaters. Wells used for drinking water may also be seeded with young fish. As fish migrate within the delta, some men leave their villages to follow them. Most creeks are owned by the communities that allow free fishing when flood waters are high, but ask for payment during the rest of the year. It is quite usual for families to own individual fish ponds. Many villages have lakes or ponds which are harvested by everyone on a prearranged date, or else leased out for a period and the money used for community purposes.

Chickens and ducks are often the only form of livestock kept in villages. Chickens are plentiful and are kept nearly everywhere, except in very small fishing camps built on sand banks or on stilts out over the water. Larger livestock markets only serve urban areas, such as the cattle, sheep and goat markets in Port Harcourt.

Vegetation and Land Use Change

Table 8.56 Dominant Vegetation and Land Use Classes for 1976/78 and 1993/95, Rivers State, Nigeria.

Land Use Category	1976/78		1993/95	
	Area (km^2)	Percent of state	Area (km^2)	Percent of state
Forested Freshwater Swamp	37.1	7201	34.0	6605
Mangrove Forest	31.0	6025	29.7	5770
Intensive (crop) Agriculture	23.4	4546	23.7	4592
Agricultural Tree Crop Plantation	0.5	94	1.3	250
Saltmarsh/Tidal Flats	< 0.1	5	0.2	34

Table 8.57 Dominant Vegetation and Land Use Changes between 1976/78 and 1993/95, Rivers State, Nigeria.

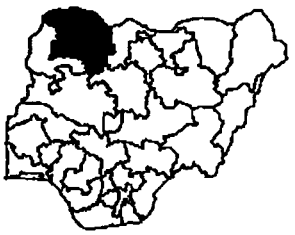
Land Use 1976/78	Land Use 1993/95	Area affected (km^2)	Percent of state
Forested Freshwater Swamp	no change	5847	30.1
	to Intensive (crop) Agriculture	600	3.1
	to Mangrove Forest	423	2.2
	to Floodplain Agriculture	158	0.8
Mangrove Forest	no change	5149	26.5
	to Forested Freshwater Swamp	398	2.1
	to Ocean/Water	287	1.5
Intensive (crop) Agriculture	no change	3779	19.5
	to Forested Freshwater Swamp	248	1.3

Rivers State is dominated by the Niger River Delta. There are three major vegetation types in Rivers State: mangrove forest, freshwater swamp forest and tropical rainforest. The Mangrove Forest and Coastal Vegetation Ecological Zone is found all along the coast and along brackish estuaries up to 100 km inland. The Freshwater Swamp Forest Ecological Zone is a forested area composed of trees that can withstand periodic flooding, particularly raffia palms, the umbrella tree and the screw-pine. These areas are found inland from the coast along the Niger River with Lowland Rainforest through the northeastern part of the state. The northeast region is defined as tropical rainforest, although in reality is one of the most intensively cultivated zones in Rivers State. The area is mainly a mosaic of secondary vegetation, oil-palm forest and cropland. Primary forest survives only in the southwestern part of the state, whose isolation has made timber cutting economically unviable and farming impractical.

Vegetation and land use patterns have remained largely unchanged in Rivers State, with little indication of intensification in land use. The total area of forested freshwater swamp, mangrove forest and agriculture has only changed slightly. The cities of Port Harcourt and Bonny have both grown. In 1993/95, there were some intensive agriculture land areas identified in the Bonny area for the first time. In 1993/95, there were new areas of floodplain agriculture along the Niger River where forested freshwater swamp had previously existed.

At the mouth of the Bonny River along the coast, there were some areas of saltwater inundation that were mapped as saltmarsh/tidal flats in 1993/95. The area of saltmarsh in the state increased from 5 km^2 in 1976/78 to 34 km^2 in 1993/95, the new areas changing from mangrove forest. Some studies (Eedy et al. 1994) have indicated that this change may be the result of canal dredging or petroleum development.

The size of agricultural tree crop plantations increased noticeably during the study period. A total of 94 km^2 was mapped in 1976/78 and this increased to 250 km^2 in 1993/95.



8.30 SOKOTO STATE

Introduction

Sokoto State, with an area of 65 584 km^2 and a population of approximately 4.4 million people, is located in the northwest corner of Nigeria. Previously, Sokoto State included the area which is now Kebbi State. However, the original state was split in 1991 and the northeast part retained the name of Sokoto State. The state capital, the town of Sokoto, expanded during the 1970s when an elaborate network of ring roads was constructed around the old town.

The 1980s witnessed major investments in all-weather roads connecting the state's main urban centres, as well as forming links with the Republic of Niger through Kamba (in Kebbi State) and Illela. However, due to the large size of the state many rural communities remain isolated. The only railway line is a spur line running from Zaria to Kaura Namoda, via Funtua and Gusua. This line services the export of livestock and agricultural produce rather than passenger movement. The town of Sokoto has an airport with links to Kano, Kaduna and Lagos. Extensive water works projects in Sokoto State have cost millions of Naira, and have resulted in displaced populations and flooded farmland (Cridland et al. 1995).

Human Population

Sokoto State has a very unevenly distributed population. Population densities are very high around the town of Sokoto (135 people per km^2), and along the major rivers, but settlements are very sparse and scattered in the rangelands (Cridland et al. 1995).

Sokoto State is ethnically diverse, although the Hausa people are the primary cultural group. Hausa towns are often surrounded by intensive agricultural areas supplying the towns with staples, fuelwood, meat and livestock, in exchange for traded goods. Originally, links between the towns and rural areas may have been more tenuous in Sokoto State, but the rise of the major fortified towns in the nineteenth century appears to have generated a set of relations analogous to those in Kano and Katsina states.

The western part of the state has a number of Islamic populations other than Hausa, with a substantially different cultural heritage. These groups are subsistence cultivators, some with large livestock holdings. The southern edge of the state, from Lake Kainji to Kwiambana, is populated by Kainji-speaking people and several specialist fishing populations.

Pastoralists constitute a major segment of the population of Sokoto State They are divided into two main groups, the Fulani and their subgroups, and the Tuareg. Sokoto State is also populated by Fulani pastoralists who migrate through the state in the early dry season. However, due to limited

grazing these people usually continue further southwards towards Kebbi State. Urban Fulani who migrated to the state in the early 19th century have settled and adopted Hausa lifestyles. The Tuareg are composed of two groups, the Buzaye and Asbenawa. Most Buzaye are agropastoralists who spend their rainy season at their farms in the Republic of Niger and migrate into Nigeria between December and May. The Asbenawa also come to Nigeria in the dry season, but they appear more rarely than the Buzaye. Most live further north in the desert and bring their camels south as far as Nigeria only when conditions are extreme.

In the western part of the state, the Zarma people, whose main centres are in Burkina Faso and the Republic of Niger, have settled in a number of villages.

Farming and Agropastoral Systems

The state is traversed by both the Niger and the Sokoto-Rima rivers, which have created flooded grassland and regions suitable for irrigated farming. The completion of the dam at Lake Kainji in 1974 replaced a meandering network of channels and islands. This generated a major fisheries resource in the lake which compensated for the decline in fish populations downstream.

The farming systems of Sokoto State combine rainfed cropping of cereals and pulses with intensive river-basin cultivation along the Sokoto and Rima rivers. In the south, the ridge-based cultivation of sorghum is common, but in the drier areas, the cultivation of millet predominates. In the northwest poor yields require intensive fertilization of the land for productivity and farmers compete to attract Fulani herds on to their land in the dry season. In general, food production has not kept pace with population growth, and food security is of primary concern (Cridland et al. 1995).

The intensely cultivated land around the major towns, especially Sokoto and Gusau, is sometimes described as 'farmed parkland' because economic trees are preserved among continuously cultivated crop farms. Manure, potsherds and all types of household wastes are conserved and spread on the fields in an effort to maintain crop yields.

Three basic types of river basin cultivation are practiced: swamp cultivation, based on naturally flooded fields, flood-retreat farming using residual moisture after the fall of the flood, and dry season market gardening, using water lifted by mechanical pumps. The cultivation of swamp rice is still practiced, but dry season farming in the riverine areas is dominated by the production of cash crops, especially onions and tomatoes.

Most of the peoples along the Niger River fish at some point in the year although there are two main groups of specialized fishermen. These are the Sarkawa and the Reshe. The Sarkawa migrate between the Republic of Niger and the dam at Lake Kainji, selling their catch to professional fish-smokers situated around the lake. The Reshe are more integrated into the farming economy and combine upland cereal cultivation with intensive fishing.

Sokoto State is the second most important pastoral zone after Borno State, and is a major source of meat for Nigeria. Unlike Borno State, it has an extensive network of river drainage that is far from being fully exploited in terms of integrated systems of livestock production.

Camels are increasingly popular in Sokoto State, and in contrast to cattle, are not limited by constraints of disease and nutrition. Camels remain healthy without significant veterinary care and can exploit vegetation unused by other stock.

There are a number of Fulani pastoralists who remain in the state year-round, while other Fulani groups migrate from northern and northeastern Niger Republic only during the dry season. The settled Fulani have developed a pattern of moving to riverine pastures during the dry season, and returning to their home villages during the rainy season.

Entrustment is a major component of the pastoral system in Sokoto State. Most farmers, both settled Fulani and Hausa, have both 'investment' cattle and traction oxen. Pastures are not adequate to keep these around the village and so cattle are entrusted to Fulani pastoralists, who take them to riverine pastures in the dry season. Relationships between farmers and Fulani are usually non-monetary, where cattle owners often pay the herders with food and/or clothes, or by preparing a farm for them when they return with the cattle at the beginning of the wet season.

Vegetation and Land Use Change

Table 8.58 Dominant Vegetation and Land Use Classes for 1976/78 and 1993/95, Sokoto State, Nigeria.

Land Use Category	1976/78		1993/95	
	Area (km^2)	Percent of state	Area (km^2)	Percent of state
Intensive (crop) Agriculture	19 474	29.7	18 715	28.5
Shrubs/Grasses	25 601	39.0	16 119	24.6
Extensive (grazing) Agriculture	12 232	18.7	15 904	24.3
Gullies	0	0	5014	7.7
Floodplain Agriculture	2015	3.1	2135	3.3
Sand Dunes	8	< 0.1	1708	2.6
Trees/Woodlands/Shrubs	4445	6.8	1510	2.3
Grassland	0	0	927	1.4
Rock Outcrop	463	0.7	775	1.2
Discontinuous Grassland	0	0	595	0.9
Extensive Agriculture with Denuded	200	0.3	582	0.9
Shrub/Sedge/Graminoid Freshwater Marsh/Swamp	376	0.6	345	0.5
Reservoir	27	< 0.1	208	0.3
Irrigation Project	8	< 0.1	182	0.3

Table 8.59 Dominant Vegetation and Land Use Changes between 1976/78 and 1993/95, Sokoto State, Nigeria.

Land Use 1976/78	Land Use 1993/95	Area affected (km^2)	Percent of state
Trees/Woodlands/Shrubs	no change	1428	2.2
	to Shrubs/Grasses	1250	1.9
	to Extensive (grazing) Agriculture	930	1.4
	to Gullies	396	0.6
Shrubs/Grasses	no change	13391	20.4
	to Extensive (grazing) Agriculture	5033	7.7
	to Intensive (crop) Agriculture	2409	3.7
	to Gullies	2115	3.2
	to Grassland	837	1.3
	to Sand Dunes	737	1.1
	to Discontinuous Grassland	397	0.6
	to Rock Outcrop	270	0.4
Intensive (crop) Agriculture	no change	12 731	19.4
	to Extensive (grazing) Agriculture	2733	4.2
	to Gullies	1861	2.8
	to Sand Dunes	758	1.2
	to Extensive Agriculture with Denuded	339	0.5
Extensive (grazing) Agriculture	no change	6962	10.6
	to Shrubs/Grasses	981	1.5
	to Floodplain Agriculture	405	0.6
	to Gullies	559	0.9
	to Intensive (crop) Agriculture	2801	4.3

Sokoto State was almost entirely in the Sudan Savanna Ecological Zone with the southern tip of the state in the Guinea Savanna Ecological Zone. The ecological zone boundaries changed very little in this state, the Sudan Savanna Ecological Zone moved slightly southward further into the Guinea Savanna Ecological Zone. There were a number of indications of environmental degradation in this area. Whether these changes were a result of pressures of a growing population or climatic change was not evident from this study.

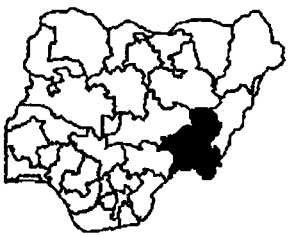
There are three large, intensively cultivated floodplains in Sokoto State, associated with the Sokoto, Rima and Zamfara rivers. These areas have several reservoirs and irrigation projects. In 1976/78, floodplain agriculture occupied 3.1% of the state, growing slightly to an area of 3.3% (2135 km^2) in 1993/95. The area of irrigation projects expanded from 8 km^2 in 1976/78 to 182 km^2 in 1993/95. The total area of reservoirs was 27 km^2 in 1976/78, growing to 208 km^2 in 1993/95. This growth was largely due to the creation of two reservoirs, one on the Sokoto River north of Gusau and the other being the Goronyo Reservoir.

Overall, there was a significant loss of dominantly trees/woodlands/shrubs in the time period of this

study. In 1976/78, dominantly trees/woodlands/shrubs covered 6.8% (4445 km^2) of the state. This area decreased to 2.3% (1510 km^2) of the state by 1993/95, representing a loss of almost 3000 km^2. Most of this loss occurred in the southeast corner of the state within the Kuyambana Forest Reserve. The areas of dominantly trees/woodlands/shrubs changed primarily to dominantly shrubs/grasses (1250 km^2), extensive agriculture (930 km^2), and gullies (396 km^2) in 1993/95. The areas that remained as dominantly trees/woodlands/shrubs were extensively covered with gullies.

There was also a significant loss of dominantly shrubs/grasses. In 1976/78, dominantly shrubs/grasses covered an area of 25 601 km^2 (39% of the state). Only 13 391 km^2 of the dominantly shrubs/grasses remained unchanged, with 7442 km^2 becoming extensive and intensive agriculture. The rest of the dominantly shrubs/grasses areas were affected by erosional processes and changed to continuous and discontinuous grassland, gully erosion, sand dunes and rock outcrops. This erosion was particularly evident east and west of Wurno where the underlying sand dune structures were exposed. The areas of severe gully erosion seemed to be within forest reserves such as Marbe, Zamfara and Illella forest reserves.

Overall, the amount of agricultural land increased over the time period of the study; however, due to the degradation of the land, agriculture did not expand as much as would be expected in an area of growing population pressure. The area devoted to intensive agriculture decreased slightly from 19 474 km^2 in 1976/78 to 18 715 km^2 in 1993/95. The area of extensive agriculture increased from 12 232 km^2 in 1976/78 to 15 904 km^2 in 1993/95. Some areas have changed from intensive agriculture to extensive agriculture. This may be due to a change in agricultural practices due to low crop yields.



8.31 TARABA STATE

Introduction

Taraba State, with an area of 58 309 km^2 and a population of approximately 1.5 million people, is located in east-central Nigeria, southwest of Adamawa State and adjacent to the Cameroon border. This state was created in 1991 from the southern part of the former Gongola State. Generally, roads and cross-border traffic are poorly developed. Topographically, the state is characterized by the Benue basin, hilly uplands and the highlands. The state capital is Jalingo.

Human Population

Taraba State is characterised by a diversity of ethnic groups. The population falls into a number of major groups, including the Chadic and Adamawa speakers north of the Benue River and beyond, the Jukun, the Mambila, the Tiv and the Fulani. Other than the Junkun, none of these groups have large-scale social organizations, and they live in dispersed communities with no central authority. Population densities are variable, although the population appears to be growing considerably. Estimated population density in the state is now approximately 32 people per km^2 (Geomatics Nigeria Ltd. 1997c).

The Chadic and Adamawa speakers north of the Benue River are subsistence farmers that depend on shifting cultivation. The Adamawa speakers are generally Mumuye, Vere and Chamba peoples. Originally all of these groups lived in upland areas, but they moved down to the plains in the colonial era. The Vere and Chamba have mixed cultivation systems which use animals to cultivate maize and a variety of other crops. In contrast, the cropping system of the Mumuye is centered on yam production.

The Junkun kingdom in the south of the state once controlled a network of trade throughout the Benue valley. Junkun fishing groups still travel up and down the Benue River, transporting goods and selling fish.

The Mambila Plateau is an isolated region with linguistic and cultural affiliations with the Republic of Cameroon. The main populations of the plateau are the Mambila people and the Yamba. Friction between Mambila and the Fulani pastoralists over land rights, and a series of outbreaks of violence, have led to a wave of emigration away from the plateau.

The Tiv people now inhabit a wide swathe of southeastern Nigeria, centered in Benue State but with a significant extension into present day Taraba State. Their settlements tend to be spread along roads, and there are Tiv settlements as far as Serti in the east and Mutum Biyu in the north. The Tiv also

have a characteristic pattern of agricultural expansion in which pioneer settlements are established in virgin land outside the heartland region, and are cultivated using slash-and-burn systems.

Fulani pastoralists migrated into Taraba State in the mid-nineteenth century and opened the pastures of the Benue valley and moved into the savannas and lightly forested lowlands in the north part of the state. The process of gradually shifting the frontiers of the pastoral zone further south has continued up to the present day, and Fulani now occupy all but the densest forest areas in southern Taraba State. Only the degradation of the pastures has brought about an effective halt to this process.

Farming and Agropastoral Systems

The vegetation in Taraba State varies from undisturbed tropical rain forest in the extreme south to semi-arid savanna at its border with Borno State in the north. The Benue, Taraba and Donga rivers create extensive networks of seasonally flooded grasslands but in contrast to those in northwestern Nigeria, the riverine areas are not heavily settled, possibly as a result of the incidence of river-blindness. The Mambila and Shebshi plateaus are grassy uplands surrounded by extensive dissected foothills.

Taraba State is not densely populated, although there are large areas of fertile soil within the state. This situation has attracted large-scale intensive farming and ranching and resulted in a marked concentration of commercial farms, especially in the Benue valley. Cotton and maize are the main agricultural crops, although rice farms are also under development. Bush or forest-fallow cultivation is still common in most parts of the state, except for the Mambila Plateau. Rice is cultivated along the seasonally flooded swamps. Along the Benue River, some flood-retreat cultivation is practiced, both to supply Yola with vegetables and to grow *masakwa* dwarf sorghum.

River valleys in the mountainous plateau areas are intensively cropped, while upland regions are usually only planted with cereals and the site of fields are changed regularly. The Mambila Plateau has been subjected to intense settlement and high densities of livestock. A number of more temporate crops such as tea and Arabian coffee are also grown on this plateau. Much of the original grass cover has disappeared which has led to extensive loss of topsoil. Overall, fallow periods in the state have declined from 6.7 years to 2.6 years in the past ten years (Geomatics Nigeria Ltd. 1997c).

Although some original tree cover in the river valleys of the plateau remains, the majority of native tree cover has been replaced by plantations (particularly eucalyptus) developed in the colonial era. These plantations provide fuelwood and building materials.

Due to its diverse ecology and extensive pastoral areas, Taraba State has an active livestock production system. The state exports a wide variety of animals to southern Nigeria; small ruminants, pigs, dogs and donkeys are traded in significant numbers. The Mambila Plateau had one of the most productive pastoral zones in Nigeria, and for many years large numbers of cattle were exported to

the lowland areas. However, uncontrolled grazing has now caused gully and sheet erosion. As well, the original grasses have been replaced by substantially less nutritious grasses which has led to a decline in cattle productivity. A series of warnings about overgrazing have had no discernible impact to date, and it is unlikely that an effective management policy can be instituted.

Vegetation and Land Use Change

Taraba State is located in the Guinea Savanna Ecological Zone, with Montane Region Ecological Zone in the mountainous areas of the south. This state encompasses a portion of the Benue River, upland areas south of the floodplain, and mountainous areas including the Mambila, Fali and Gotel mountains. Although Taraba has not been a highly populated state, over the study period there were dramatic land use changes that indicate a growing population.

In 1976/78, most of the Benue River floodplain was mapped as shrub/sedge/graminoid freshwater marsh/swamp with some areas of riparian forest. By 1993/95, the majority of the Benue, Donga and Taraba rivers floodplains were cultivated although the area west of Mutum Biyu still appeared to have large areas of uncultivated swamp. In 1976/78, the area of floodplain agriculture was 42 km^2, by 1993/95 the area increased to 2727 km^2.

Table 8.60 Dominant Vegetation and Land Use Classes for 1976/78 and 1993/95, Taraba State, Nigeria.

Land Use Category	1976/78		1993/95	
	Area (km^2)	Percent of state	Area (km^2)	Percent of state
Extensive (grazing) Agriculture	11 867	20.4	14 825	25.4
Intensive (crop) Agriculture	2290	3.9	13 718	23.5
Trees/Woodlands/Shrubs	24 836	42.6	10 163	17.4
Montane Forest	6283	10.8	6173	10.6
Floodplain Agriculture	42	0.1	2727	4.7
Undisturbed Forest	5009	8.6	2681	4.6
Montane Grassland	1840	3.2	2645	4.5
Disturbed Forest	595	1.0	1899	3.3
Shrubs/Grasses	727	1.3	936	1.6
Shrub/Sedge/Graminoid Freshwater Marsh/Swamp	3596	6.2	655	1.1
Gullies	0	0	503	0.9
Riparian Forest	613	1.0	461	0.8

Table 8.61 Dominant Vegetation and Land Use Changes between 1976/78 and 1993/95, Taraba State, Nigeria.

Land Use 1976/78	Land Use 1993/95	Area affected (km^2)	Percent of state
Trees/Woodlands/Shrubs	no change	8526	14.6
	to Extensive (grazing) Agriculture	6959	11.9
	to Intensive (crop) Agriculture	5594	9.6
	to Disturbed Forest	1016	1.7
	to Montane Forest	996	1.7
	to Shrubs/Grasses	577	1.0
	to Gullies	336	0.6
Undisturbed Forest	no change	2169	3.7
	to Montane Forest	766	1.3
	to Disturbed Forest	691	1.2
	to Trees/Woodlands/Shrubs	570	1.0
	to Extensive (grazing) Agriculture	517	0.9
	to Intensive (crop) Agriculture	227	0.4
Montane Forest	no change	4168	7.2
	to Montane Grassland	1073	1.8
Shrub/Sedge/Graminoid Freshwater Marsh/Swamp	no change	499	0.9
	to Floodplain Agriculture	2075	3.6
Intensive (crop) Agriculture	no change	1229	2.1
	to Extensive (grazing) Agriculture	733	1.3
Extensive (grazing) Agriculture	no change	5234	9.0
	to Intensive (crop) Agriculture	5871	10.1

South of the Benue River, dominantly trees/woodlands/shrubs with extensive agriculture to the west and some intensive agriculture on the northeastern border of the state, was common in 1976/78. By 1993/95, this area was almost entirely mapped as agriculture up to, and encroaching into, the mountainous areas. There were also new areas of gully erosion east of Jalingo, south of Mutum Biyu. In 1976/78, dominantly trees/woodlands/shrubs covered an area of 24 836 km^2; however, by 1993/95, 16 310 km^2 had been eliminated. Some of the area became disturbed forest, montane forest, dominantly shrubs/grasses and/or gully erosion, but the majority of the area changed to agriculture. In 1993/95, intensive agriculture was identified in 5594 km^2 and extensive agriculture was identified in 6959 km^2 of the land area that had previously been designated as dominantly trees/woodlands/shrubs in 1976/78.

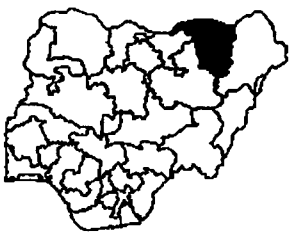
The mountainous areas were more difficult to accurately map in 1993/95 since the radar imagery tends to cast shadows in these areas. Using information from the Nigerian Livestock Resources Survey (RIM 1992) as well as recent imagery, some conclusions can be drawn. In the mid 1990s, on the Shebshi, Fali and Mambila Plateau, there are no terraces built for farming to retain soil. The river valleys are intensely cropped and the upland regions are planted with cereals. On the Mambila Plateau there is intensive settlement as well as high livestock densities. Much of the original grass cover has virtually disappeared and has been replaced by bracken, resulting in extensive soil loss.

In the Fali, Gotel and Mambila mountains, the imagery indicates areas of degradation of the vegetation. Areas of montane forest have expanded somewhat westward into areas of undisturbed forest. An area of 459 km^2 has had the tree cover thinned to the point that the vegetation now appears as dominantly trees/woodlands/shrubs, in addition to another area of 1073 km^2 with tree cover completely removed presently mapped as montane grassland.

Undisturbed forest occupied 5009 km^2 in 1976/78, but decreased to 2681 km^2 by 1993/95. As the tree cover was thinned or removed, areas of previously undisturbed forest changed to montane forest (766 km^2), disturbed forest (691 km^2), dominantly trees/woodlands/shrubs (570 km^2), extensive agriculture (517 km^2), and intensive agriculture (227 km^2).

In the mountainous areas, more dramatic changes occurred in areas mapped as undisturbed forest in 1976/78. The areas of montane grassland appear to have increased from 1840 km^2 in 1976/78 to 2645 km^2 in 1993/95 as land was cleared. In 1976/78, there were no areas of agriculture on the Mambila Plateau. In 1993/95, agriculture had encroached along the periphery of the mountainous areas as well as 540 km^2 of extensive agriculture was present on the plateau itself.

The area of the Shebshi mountains along the eastern border of the state was mapped in 1976/78 as dominantly trees/woodlands/shrubs with areas of undisturbed forest. In 1993/95, the area was mapped as having very little remaining dominantly trees/woodlands/shrubs and most mountainous areas featured disturbed forest and montane grassland. Much of the area previously designated as dominantly trees/woodlands/shrubs is now extensive agriculture which has encroached well into the mountainous areas along the river valleys.



8.32 YOBE STATE

Introduction

Yobe State has an area of 44 716 km^2 and population of approximately 1.4 million people. It is located in northeastern Nigeria, adjacent to Borno State and on the border with the Republic of Niger. Yobe was created following the division of Borno State in 1991 from the western part of the former state. The low population density and sparse settlement pattern has resulted in a poor infrastructure despite extensive road construction during the 1980s.

Human Population

The populations of Yobe State can be divided into two parts: the diverse agricultural people of the south; and the peoples of the north. The northern region corresponds roughly to the domain of the Kanuri people. In general, Kanuri are cultivators but they also have substantial holdings of both cattle and small ruminants. The agricultural people of the south were cultivators in precolonial times, having limited contact with the pastoralists until recent times. As pastoral herds from the north have pushed further south, these agricultural people have gradually acquired cattle for use in farming.

Farming and Agropastoral Systems

Most of the state consists of semi-arid savanna or sub-desert. The basic agriculture of the savanna is upland rainfed cultivation, based on millet, sorghum and pulses. Dry season farming is also practiced in the valley of the Komadugu Yobe, along the Republic of Niger border, due to irrigation practices. The swampy grasslands between the towns of Hadejia and Gashua have traditionally been a significant resource for fadama cropping, fishing and livestock feed. However, the construction of the Tiga Dam in the mid 1980s has reduced the flooded area west of Gashua, leaving the Komadugu Yobe virtually dry in its upper reaches for most of the year.

The natural vegetation of the valley is palm-scrub, dominated by the dum-palm and various acacias. There has been considerable discussion about desertification along the Republic of Niger border.

Livestock in Yobe State supply the meat needs of Nigeria's major cities. Except in the extreme south, livestock production in Yobe State is dominated by cattle pastoralism. With the opportunities for dry season cultivation of staples in the valley of the Komadugu Yobe, many 'pastoralists ' harvest two crops a year. Yields are low and most peoples concentrate on managing large herds of Wadara cattle. In addition, the Fulani and their cattle cross the region in large-scale, north-south migrations.

A major constraint in this state has been the availability of water. As reported in the Nigerian Livestock Resources Study (RIM 1992), studies by James in 1973 and 1977 showed that borehole

programs were not particularly successful in Yobe State. By 1977, many of the boreholes drilled were no longer functioning. This, however, may have saved the existing pasture land as working boreholes would have attracted more cattle to the area. The long term effect of an inundation of cattle would probably have been overgrazing and pasture degradation, as seen on the Mambila Plateau. Water availability has also been affected by the decrease in rainfall levels. However, this factor has also had a positive effect on the amount of pasture land available for use. Low water levels have made the success of crop agriculture uncertain and opened the way for grazing cattle and small ruminants.

The valley of the Komadugu Yobe was green throughout the year until the Tiga Dam was constructed. Before the dam, the valley was a major focus of transhumant herds, but now it is only a seasonal grazing resource. It is settled by Mober agropastoralists of the Kanuri who combine fishing and flood retreat cultivation, and often entrust their own herds to Fulani and Badawai during the dry season.

Vegetation and Land Use Change

The Sahel Savanna Ecological Zone covered the northern part of Yobe State while the Sudan Savanna Ecological Zone was situated in the southern part. The boundary of the Sahel Savanna Ecological Zone appeared to have moved south by about half a degree of latitude over the study period.

Table 8.62 Dominant Vegetation and Land Use Classes for 1976/78 and 1993/95, Yobe State, Nigeria.

Land Use Category	1976/78		1993/95	
	Area (km²)	Percent of state	Area (km²)	Percent of state
Extensive (grazing) Agriculture	10 334	23.1	10 583	23.7
Shrubs/Grasses	14 240	31.8	8674	19.4
Intensive (crop) Agriculture	7826	17.5	7879	17.6
Grasses	3735	8.4	4578	10.2
Extensive Agriculture with Denuded	1433	3.2	4379	9.8
Discontinuous Grassland	3024	6.8	2841	6.4
Sand Dunes	416	0.9	1835	4.1
Floodplain Agriculture	1272	2.8	1824	4.1
Shrub/Sedge/Graminoid Freshwater Marsh/Swamp	1344	3.0	782	1.8
Gullies	123	0.3	609	1.4
Grassland	744	1.7	415	0.9

Table 8.63 Dominant Vegetation and Land Use Changes between 1976/78 and 1993/95, Yobe State, Nigeria.

Land Use 1976/78	Land Use 1993/95	Area affected (km^2)	Percent of state
Shrubs/Grasses	no change	7538	16.9
	to Grasses	2639	5.9
	to Extensive (grazing) Agriculture	2012	4.5
	to Intensive (crop) Agriculture	1233	2.8
	to Gullies	189	0.4
Grasses	no change	839	1.9
	to Extensive (grazing) Agriculture	1237	2.8
	to Extensive Agriculture with Denuded	495	1.1
	to Discontinuous Grassland	486	1.1
	to Sand Dunes	397	0.9
	to Continuous Grassland	256	0.6
Shrub/Sedge/Graminoid Freshwater Marsh/Swamp	no change	501	1.1
	to Floodplain Agriculture	600	1.3
Intensive (crop) Agriculture	no change	5468	12.2
	to Extensive (grazing) Agriculture	1172	2.6
	to Shrubs/Grasses	408	0.9
	to Gullies	269	0.6
Extensive (grazing) Agriculture	no change	5519	12.3
	to Extensive Agriculture with Denuded	2093	4.7
	to Shrubs/Grasses	697	1.6
	to Grasses	673	1.5
	to Intensive (crop) Agriculture	612	1.4
	to Discontinuous Grassland	458	1.0
	to Sand Dunes	156	0.4

North of the floodplain, there was a dramatic increase in the area of bare ground and exposed sand dunes which appeared to be the result of desertification. These changes could have been caused in part by the damming of rivers upstream, an increasing population and the associated pressure on the land base, and perhaps climatic changes. In 1976/78, the area north of the floodplain included extensive agriculture with large areas of discontinuous grassland and patches of dominantly grasses and sand dunes and areas in the west extensive agriculture with denuded areas. By 1993/95, this area was predominantly covered with agriculture with denuded areas, and sand dunes. The area of agriculture with denuded areas increased from 1433 km^2 in 1976/78 to 4379 km^2 in 1993/95. The total area of sand dunes increased from 416 km^2 in 1976/78 to 1835 km^2 in 1993/95. There were small areas of discontinuous grassland, while all of the areas of dominantly grasses were eliminated except for an area east of Matsena on the Niger border.

More intensive land use is evident on the floodplain as more swamp areas appeared to be converted to agriculture. This trend was reflected on the Gongola River in the southern state. The area mapped as floodplain agriculture totalled 1272 km^2 in 1976/78, this increased to 1824 km^2 in 1993/95. The areas of dominantly shrubs/grasses that were mapped south of the Hadejia floodplain as well as in another area south of the Komadugu Gana, were both denuded of their bush vegetation and appeared as dominantly grasses in 1993/95.

In 1976/78, the zones south of the floodplains had large areas of dominantly shrubs/grasses intermixed with areas of intensive and extensive agriculture. Some gully erosion was evident west of Damaturu. In 1993/95, much of the previous dominantly shrubs/grasses area was used for agriculture, and there were much larger areas of gully erosion. Overall, the area of dominantly shrubs/grasses declined from 14 240 km^2 in 1976/78 to 8674 km^2 in 1993/95. The area of gully erosion increased from 123 km^2 in 1976/78 to 609 km^2 in 1993/95.

While agriculture increased in areas that were previously savanna, some of the agricultural land in the state had been degraded and was mapped as gully erosion, discontinuous grassland, sand dunes and agriculture with denuded areas.

9.0 Discussion/Conclusions

9.1 VEGETATION AND LAND USE CHANGE SUMMARY

In the southern areas of the country, in the Lowland Rain Forest, Derived Savanna and Guinea Savanna ecological zones, severe population pressures have resulted in degradation of the environment, especially in the Enugu area. The degradation is primarily due to the removal of trees and shrubs for fuelwood and the clearing of land for agriculture. Many of these areas have erosion-prone, shallow or sandy soils.

Along the coastline, issues of saltwater inundation are evident. Specifically, new areas of saltmarshes/tidal flats were identified over the time period of the study. The coastal area has also witnessed a reduction in the area of freshwater swamp. These areas are being converted to intensive agriculture.

Geomatics International Inc. (Eedy et al. 1994) conducted a study of the Ondo State coast, west of the Niger Delta. An area of significant saltwater intrusion, killing large forested regions, and a loss of approximately 1.6 km of coast over a 20-year period from 1971 to 1991 was identified using satellite imagery. Field studies and historical maps indicated this area had stable shorelines up until more recent petroleum developments and canal dredging operations. More recent studies have shown that the saline intrusion and coastal loss were even greater by 1996 (Geomatics International Inc. 1997).

In the north, a process of desertification is evident as sand dunes that were stable in the past are now exposed. Large areas of gully erosion are clearly visible, and denuded areas can be identified in many agricultural regions. The increasing intensity of agricultural activity due to population growth may be the most important factor influencing this process. Other influential factors may be the change to a drier climate or the establishment of major water works projects (i.e., construction of dams).

In the past, the less densely populated middle belt presented opportunities for conservation such as the creation of the Cross River National Park in 1991. However, as population pressures increase to the north and south, many people are migrating to the middle belt region. As a result, settlements are being established, agriculture is expanding along the floodplains, and tree and shrub cover is being removed for fuelwood, building purposes and agriculture. Furthermore, there has been a significant increase in the number and size of reservoirs in this area over the time period of the study. While the water sources have been beneficial to local populations, their long-term effects on environment conditions are of concern.

9.2 OTHER RECENT STUDIES

Since completion of this vegetation and land use change analysis, a number of studies have been started and completed that are relevant to the conclusions in this report. Other programs under the World Bank Environmental Management Program (EMP) have included a study of soils degradation for the country, and development of a standard, digital, base map series for the country. Also, under EMP, an agricultural resource monitoring (crop assessment) program is just under way. In addition, the World Bank has provided funding for development of State Environmental Action Plans for all of the states.

In a study funded by several industrial and government sources, an attempt is being made to determine the environmental impacts of development in the Niger Delta. A forest resources study, including preparation of a forest management plan for Nigeria and sponsored by the African Development Bank, is nearing completion.

9.3 RECOMMENDATIONS FOR FURTHER STUDY

There are a number of areas recommended for further study, arising out of the conclusions of this project:

1) *Continued Monitoring and Analysis* - Significant changes have occurred in the land use and vegetation of Nigeria. The interactions between these two parameters and the causes of the observed changes as well as continuation into the future require further study to develop management plans. Nigeria has a dense population and significant population growth. These will continue to change the land use and vegetation of the country, and likely in a manner that will make it more difficult for this population to survive and experience quality lifestyles.

   FORMECU has been provided with the technology to continue monitoring and analysing these changes. However, operational costs, especially obtaining and processing satellite imagery, are expensive. A source of financing is needed to maintain the ability to monitor changes in the country. A method of sharing the imagery so that other departments and agencies can benefit is also needed. This had occurred to a certain degree, with the images from this study being used for a soils degradation study. However, significant changes occur in periods of less than 5 years thus the images from this study may already be out of date.

   Recent studies conducted by Geomatics International for RADARSAT and the UN FAO's AFRICOVER program (Geomatics International 1997) have indicated significant seasonal changes in hydrology, agriculture, land use and vegetation cover. Budget limitations did not allow the extensive use of seasonal satellite imagery in this study, but some assessment of the effects of seasonal changes should be conducted for at least several pilot study areas.

2) *Management Planning* - Unless some action is taken to manage some of the changes that have been identified in this study, significant detrimental effects will be incurred within the next 20 years. The movement of the borders of drier ecological regions towards the south will result in further desertification and loss of agricultural productivity. Unmanaged forest harvesting will result in the loss of forest resources. Significant ecosystems will be lost, including coastal freshwater wetlands, high forest areas and some special habitats such as Lake Chad. Further study is needed to develop and implement management plans to avoid long-term adverse changes in land use and vegetation.

3) *Education* - Education at the grass-roots level is essential to long-term management of environmental change. Development of an environmental change awareness curriculum at the primary and secondary level as well as environmental education workshops at the rural community level are recommended. Further training of government and institutional personnel is needed to continue and expand the ability to use advancing technology in environmental management.

4) *Global Environmental Change* - There has been speculation that some of the significant changes, such as coastal loss, saline intrusion, desertification, and drying up of areas like Lake Chad, could be a result of global warming. Many countries have been studying the long-term implications of this phenomenon on the local environment, land use, vegetation change and the resultant impact on human population. Such studies are necessary to minimize the impacts of these changes. Such studies need to be conducted for Nigeria.

5) *Alternative Energy* - A significant portion of the impact on the Nigerian ecosystem results from fuelwood collecting and use at the local level. In many areas, use of alternatives might help manage the loss of forest areas.

6) *Landscape Restoration* - Opportunities for landscape restoration must be identified and implemented. The natural ecosystems are severely degraded and thus, to forestall ecological disaster, some immediate actions must be taken. For example, improve food delivery by maximizing production on the most capable lands, removing marginal land from agriculture (steep slopes, stony soils, etc.), increasing number and size of natural areas, undertaking natural corridor planning, and adding vegetation structure (e.g., restore the shrub layer to savanna areas under agricultural uses). A formal study of restoration opportunities (where and how) must be undertaken.

7) *Funding* - A source of funding is needed to implement many of these recommendations.

8) *Population Management* - Population growth is the most significant cause of environmental change in Nigeria. Management mechanisms that are needed include education, advancement of women's status in the family and community, and financial incentives.

10.0 Bibliography

Adegbehin, J.O. and Omijeh, J.E. 1994. A survey of fuelwood consumption and alternative sources of domestic energy in Kaduna State of Nigeria; Discovery and Innovation, v.6(2), p.166-175.

Ademola, A. 1994. Women farmers in Ondo State; Journal of Anthropological Research, v.50, p.311-326.

Central Intelligence Agency (CIA) 1996. The World factbook 1996; Central Intelligence Agency, Arlington, Virginia.

Cridland, W., Adeniyi, P., Bullock, R. and Mitchell, B. 1995. Sustainable rural development in Sokoto State, Nigeria; Natural Resources Forum, v.19(3), p.203-214.

Economist Intelligence Unit 1990. Country report:Nigeria; London, No. 1, 10.

Eedy, W. 1997. Overview of the vegetation and land use change analysis study for Nigeria between 1976 and 1995; presentation at workshop, Abuja, May, 1997.

Eedy, W., Rodgers, B., Saunders, K. and Akindunni, F. 1994. Application of satellite remote sensing to coastal recession analysis in Nigeria; proceedings of the Coastal Zone Management Conference, Halifax, September 22, 1994.

Eshett, E.T. 1990. Traditional agriculture in southeastern Nigeria: demographic, land tenure, and other socio-economic factors; Beitr. Trop. Landwirtsch. Vet. Med., v.28(1), p.5-17.

Geomatics International Inc. 1997. RADARSAT-1 assessment for the UN-FAO AFRICOVER program; prepared for the Canadian Space Agency and Canada Centre for Remote Sensing, 211p.

Geomatics Nigeria Ltd. 1997a. Adamawa State environmental action plan - second progress report; prepared for the FEPA, Abuja, Nigeria, 55p.

Geomatics Nigeria Ltd. 1997b. Bauchi State environmental action plan - second progress report; prepared for the FEPA, Abuja, Nigeria, 44p.

Geomatics Nigeria Ltd. 1997c. Taraba State environmental action plan - second progress report; prepared for the FEPA, Abuja, Nigeria, 49p.

Grimes, B.F. (editor) 1996. Ethnologue, 13th edition; Summer Institute of Linguistics, Dallas, Texas.

Hunting Technical Services Limited 1978. Vegetation and land use; Government of Nigeria, map series, scale 1:250 000.

Imo State Government 1984. Atlas of Imo State of Nigeria; Planital, Rome.

Keay, R.W.J. 1949. An outline of Nigerian vegetation; Nigerian Forestry Department, Government Printer, Lagos, 52p.

Metz, H.C.,ed.,1992. Nigeria: a country study; Federal Research Division, Library of Congress, U.S. Government Printing Office, Washington, D.C.

Ministry of Works 1976. Catalogue of maps; Survey Division, Ministry of Works, Lagos, Nigeria.

Morakinyo, A. 1994. The commercial rattan trade in Nigeria; Forest, Trees and People, newsletter no.25, p.22-30.

Mortimer, M. and Wilson, J. 1965. Land and people in the Kano Close Settled Zone; Geography Occasional Paper, No 1. ABU, Zaria

Osemeobo, G.J. 1989. Socio-economic effects of forestry on traditional farming systems in Nigeria; Nigerian Journal of Forestry, v.19(1,2), p.9-13.

Pullan, R.A. 1974. Farmed parkland in West Africa; Savanna v.3,2, p.119-151.

Renne, E.P. 1995. Houses, fertility, and the Nigerian Land Use Act; Population and Development Review, v.21(1), p.113-126.

Resource Inventory and Management Limited (RIM) 1992. Nigerian livestock resources survey, volume III: state reports; Federal Department of Livestock and Pest Control Services, Nigeria, 496p.

Satode Cartographic Consultants 1992. Road and administrative map; Satode Cartographic Consultants, scale 1:2 000 000.

Spectrum Books Limited 1994. Spectrum road map, Nigeria; Bartholomew, The Edinburgh Press Limited, scale 1:1 500 000.

World Bank 1993. Ecologically sensitive sites in Africa, volume II, eastern Africa; compiled by the World Conservational Monitoring Centre for The World Bank, Washington, D.C., U.S.A., 64p.

World Bank 1995. African development indicators 1994-95; The World Bank, Washington, D.C.

World Bank 1996. Social indicators of development 1996; The World Bank, Washington, D.C., 395p.

World Conservation Monitoring Centre 1995. Digital map databases; digital files provided by World Conservation Monitoring Centre, Cambridge, United Kingdom.

Unilag Consult 1995. Assessment of land use and vegetation changes in Nigeria 1978 -1994; report of the socio-economic study, internal document, 120p.

United States Library of Congress 1991. Nigeria; Federal Research Division, Country Studies, Area Handbook Series.