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THE EVALUATION OF FOREST DEGRADATION USING REMOTE SENSING TECHNIQUE: A CASE STUDY OF MINNA REGION

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ABSTRACT

Forest and vegetation are important in the urban cycle as a source of fuel wood, building materials, general indicator of ecological condition and for the aesthetics needs of man. Information about the forest cover in any nation is indispensable for the purpose of management, planning, monitoring geographical location according to species and foliage studies can be met with the use of conventional remote sensing technique. The paper described the electromagnetic radiation, interaction with green vegetal bodies and the factors influencing data collection on vegetal cover for forest management and planning. The composite Spot Images of Niger State for the year 1976-1978 and 1993-1995 re-mapped by the Ministry of Agric and Natural Resources, dept. of Forestry which was coordinated by FORMECO, Abuja were used in conjunction with SPOT 98 and the Nigeria Sat-1 images of Minna. Those Images were used to determine the rate of degradation by overlaying the two images to detect changes over time. It becomes obvious that more than 85% of the natural forest habitat has been lost under various human developmental and uncontrolled lumbering activities. This therefore poses a challenge to the environmentalist and policy makers.

KEYWORDS: Forest management, Monitoring, Remote Sensing and Sensors, Environmental refugee .

INTRODUCTION

The environmental impact of human developmental activities on the biologically inhabited part of the biosphere has becoming a global challenge as reveal in the form of global warming, desertification, draught occurrences to mention but a few. The major focus in this paper is on plant life and its degraded state, which have a direct impact on the well -- being of the human population. It is worthy to not that plants comprise the greatest bulk of the total world biomass. There is always the need to carry out an inventory of the forest stand in countries with an abundant forest cover to determine the volume of the timber resources for economic and management purposes. The Forest Management Institute of the Canadian Forest Service has developed techniques to collect tree data with larger–scale aerial photographs. These generally involve two stages of work: (1) Tree species recognition, (2) Volumetric inventory. The method of identification of tree species was developed by Sagn – Wittgenstein (1961, 1978) who advocated the use of morphological characteristics of trees, such as crown shape, branching habit and foliage characteristics for identification dues. The basic model for tree volume estimation "v" is V = bi (H) + b2 (H2) + b3 (eH/100 – 1) where bi, b2 and b3 are regression coefficient – empirically determined, it is photo – measured tree height and 'e' is the exponential functions.

The evaluation, planning and management of a nation's vegetal cover is based on the availability of information concerning the past, present trend, and the future of which according to Adefolalu, D. O (2002) should cover the distribution of species, canopy layering, stress area or forest fire hazard that has happen or about to occur. In the early 70s, Nigeria is one of the leading exporters of hardwood species like the Iroko tree, white Afara, Mahogany, Obeche etc, to the overseas countries for foreign earning. While countries like Canada (North of the great lakes) are known for their soft wood species like the pine species, Balsam fir, and spruce e.t.c. All these are major material for the construction industries and even rail slipper and pit- prop in tunnel mining. The continuous lumbering of those three species without proper control in countries like Nigeria call for up-to-date real-time evaluation of the nation's forest resources.

The study area

Minna, the state capital of Niger State in Nigeria is the study area. It lies on latitude 9° 37^1 North and longitude 6° 33^1 East. It was the arrival of the rail line from Baro northward that started the growth of the settlement in 1905. It became a state headquarters when Niger State was created in 1976. The population estimate of the town as at 1979 was 65,000 while the 1991-1992-population census result gave a total number of 157,159 people including Chanchaga. This is about 6.13% of the state total population of 2,482,367. The creation of the new federal capital territory at Abuja has highly influenced positively the growth of Minna. In fact, many civil servants posted to Abuja built or buy houses in Minna and shuttling between Minna and Abuja on weekly basis for their duties and business activities which aggravated the demand for wooden materials and other related forest resources.

For the forest cover study, a radius of about 25km from Minna urban areas was considered because this enclosed the major villages that commute with Minna on almost daily basis. This include villages like Gurusu, Paiko, Beji, Gwada, etc.

Aim And Objectives Of The Study

The aim of this study is to estimate the total spatial forest area lost to degradation between the year 1978-1998 (20years) using remote air-born sensors derived imageries.

Study limitation

The major limitation of this study is the cost of acquiring current imageries that cover the study area which was however complimented with the Nigeria-Sat 1of 2004.

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The Need For Forest Management

Forest and related land cover types (Woodland, shrub lands, degraded forests and forest fallows) are important terrestrial ecosystems. They account for over 52 x 10^6 km^2 of the earth's land area. The world's forest serves a series of vital environmental services, without which the functioning of the biosphere world is endangered. In Africa, deforestation is most common in the open woodland ecosystems, Aina (1989),. The amount of open woodland lost due to land clearance between 1980 and 1985 was approximately 11.5 x 10^6 ha. The loss of African closed forests has mainly occurred in the West African countries of Ghana, guinea, Ivory Coast, Liberia and Nigeria, due to the steady expansion of hardwood logging. Deforestation has a long history, which is on part related to European Colonization and later phases of forest and woodland destruction in the 20th century, which have been stimulated by the government mechanized agricultural policies. At the local level, forest and woodland canopy protect soil from rain splash and reduce erosional activities. It also creates local microclimate, regulating temperature and humidity in their immediate vi. inity.

Forest has two other major environmental functions at the global scale, both of which are seriously threatened by current pattern of deforestation, Haruna (1991). These are, firstly, their role as carbon sinks in the global carbon cycle (see fig 1.) and, secondly, as pools of biodiversity.

The issue of dry valleys and drought occurrences in the lack of vision about how to develop societies without perturbing African countries is of a major concern. The cases of drought are not unconnected to the environment to the point of self – destruction, Adefolalu, (1989)

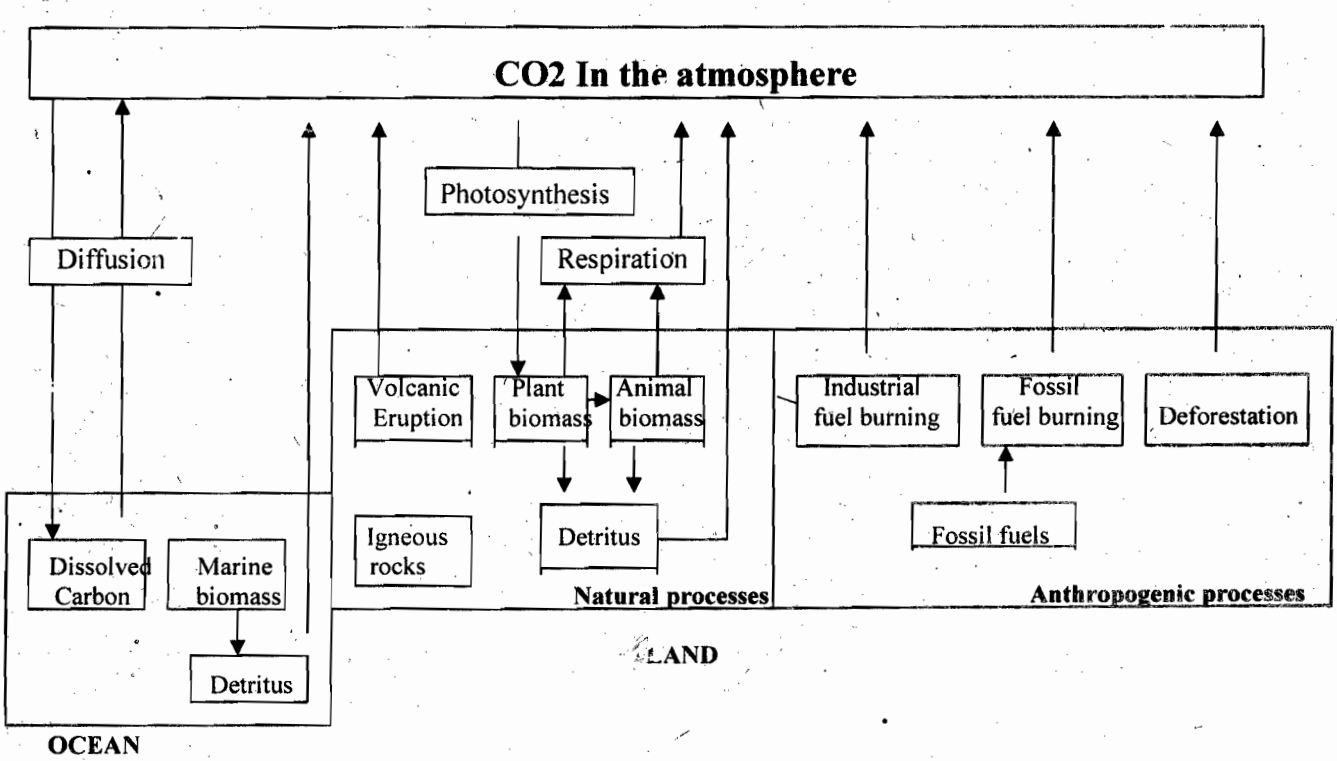


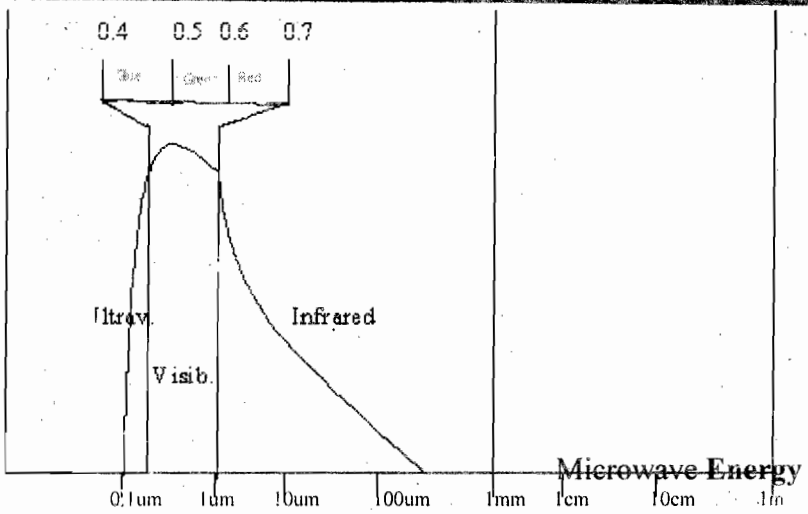
Figure 1. The global biogeochemical cycle of carbon.
Source: Energy for sustainable development, in humanity CD-ROM digital library, UN-Habitat, Nirobi.

Sensors – Radiant Reaction With Green Plant (Forest).

In general, Remote Sensing technology can be defined as "an act of observing and measuring an object or phenomenon by the use of electromagnetic sensors placed on a fixed or moving vehicle without physical contact with the object of interest. Remote sensing systems wholly depend on electromagnetic sensors that operate within the various wave bands which ranges from the gamma ray (0.03 micrometer) through the visible and infra – red band to the micro wave b-nd of 0.3 – 300 centimeter, Rencz, Andrew N., ed. (1999). (See fig. 2). Generally, the electromagnetic radiant energy incident on the earth surface is reflected, absorbed or transmitted. The relationship between them is given by this equation: Ei (/) =ER(/) +EA(/) +ET(/). The degree of reflection, absorption and transmission of this mechanism depend on the structural components of the target. Hence for green plant (forest), the absorption, reflection and transmission takes place at the different wave bands.

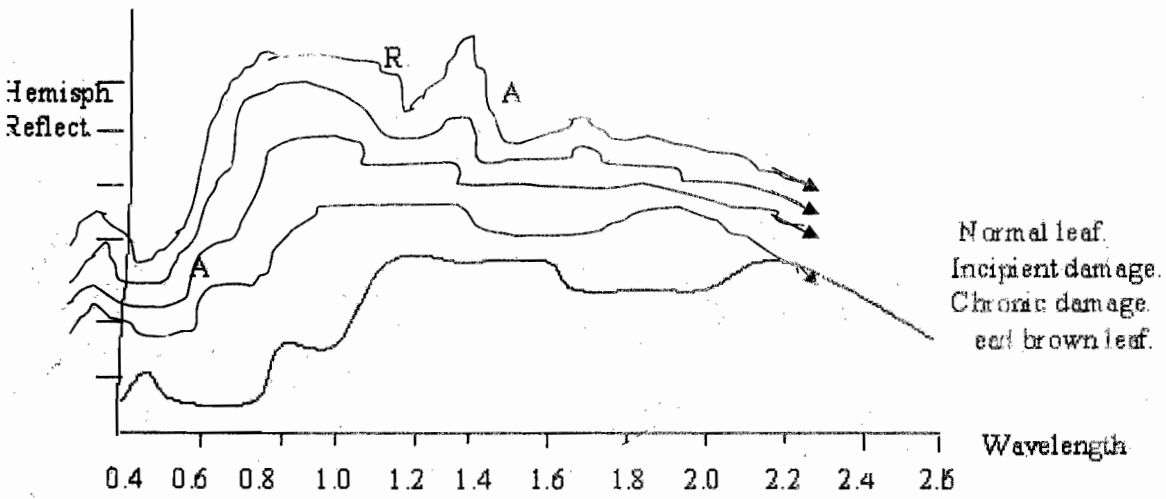
The spectral reflectance of a vegetation canopy varies with wavelength. The tree canopy leaves with its pigmentation physiological structure and water content have an effect on the reflectance, absorbance and transmittance properties, Lillesand, et al (1994). One interesting and important curve is the reflectance of healthy green vegetation. The high absorption by plant in the visible band is typical and conspicuous as shown in figure 3. The plant pigment takes over the incoming solar energy for its growth, production of new tissue during photosynthesis as show with small peak at the wave band 0.5 – 0. 6um. At the near infra – red of the wave band, there is a sharp rise on the level of reflectance cu.ve often called the chlorophyll region curve. The pigment of the leaf chlorophyll is effective in absorption in the visible band but ineffective in the infra – red band.

Vegetation damages are therefore detected from the host healthy vegetation. There are two manifestations of damage; either the tree has suffered from a change in



Wavelength → (Logarithmic scale)

Figure. 2 Electromagnetic wavelengths Bands of sensors' operation.
Source: After Curran, P. J. (1985).



Spectral Reflectance patterns effect of physiological damage.

Figure. 3

Source: Murtha 1978.

(A= Region of Absorption, R= Region of Reflection)

morphology or a change in physiology, or sometimes both, that is defoliation. The visual symptom of physical damage is yellowish of the foliage. The physiological damage therefore will effect normal colour or colour infrared film. The damage may be the result of an environmental stress, such as pollution (sulfur dioxide) or a biotic stress. See figure. 3 for illustration.

Over view of past projects.

A large-scale project of Radar mapping of vegetation in Nigeria was successfully under taken in 1976 by the Federal government of Nigeria through the Federal department of forestry who commissioned the British technical service using the Motorola Real-aperture Radar system with a horizontal plane polarization to survey the whole country. This project actually assisted the Federal Department of Forestry to advice the federal government on the state of the country's forest reserve as at then and the necessary policy formation on reservation and conservation activities. Also the projector Radar grammatical–del–Amazons in Columbia used the synthetic Aperture Radar (SAR) to map the whole Amazon forest area to evaluate the countries forest reserve (Pro–Radam–Columbian Amazon, 1975 – 1979).

In USA, Walsh (1980) demonstrated an analytical identification, mapping and evaluation of coniferous trees species in Crater Lake National Park, Oregon with the aid of

computer satellite image analysis system known as Interactive Digital Image Manipulation System (IDIMS). Landsat–XS was also used to map the forest plantation in yellow stone national part to detect and evaluate wild forest fire disaster term.

Remote sensing assisted forest-vegetal cover mapping and evaluation should be a continuous exercise if the crusade for sustainable eco-development will not be a mirage in the face of what people like Hinnawi (1985) and Baba (2003) call 'environmental refugee problem'. In this context, an environmental refugee is a person who has been forced to move as a result of environmental disruptions which may "encompass all types of ecosystem agitations, anthropogenic extremes, derive from the actions of man on the environment in the pursuit of his economic and societal obligations that render the physical environment useless.....", which necessitate the relocation of people (sometimes on permanent basis) to safer environments irrespective of whether or not an international boundary has been crossed. The issue of desert encroachment and drought is now a major problem in many African countries including Nigeria. Therefore the issue of forest mapping and evaluation cannot be over emphasized.

Methodological Approach and Ground truthing

The composite Spot Images of Niger State for the year 1976-1978 and 1993-1995 re-mapped by the Ministry of Agric and Natural Resources, dept. of Forestry which was coordinated by FORMECO, Abuja were used in conjunction with SPOT 98 and the Nigeria Sat-1 images of Minna. Those images were geo-referenced by the use of the hand-held geographical positioning system (GPS) to obtain the co-ordinate of four notable points on the ground and on the images. After the geo-referencing, the two images were digitized on-screen and then supper-imposed using 'ILWIS 3.0 academy' to derive the rate of changes over the years, that is, the level of deforestation, see fig. 4 for the SPOT image used.

Ground truthing is the practical site visitation and the identification of some objects on the acquired image (Photograph) and the true position on the study site The exercise help to verify correct and enhance the image interpretation. Other secondary materials like, cadastral maps, topographical maps and historical written material can be of importance.

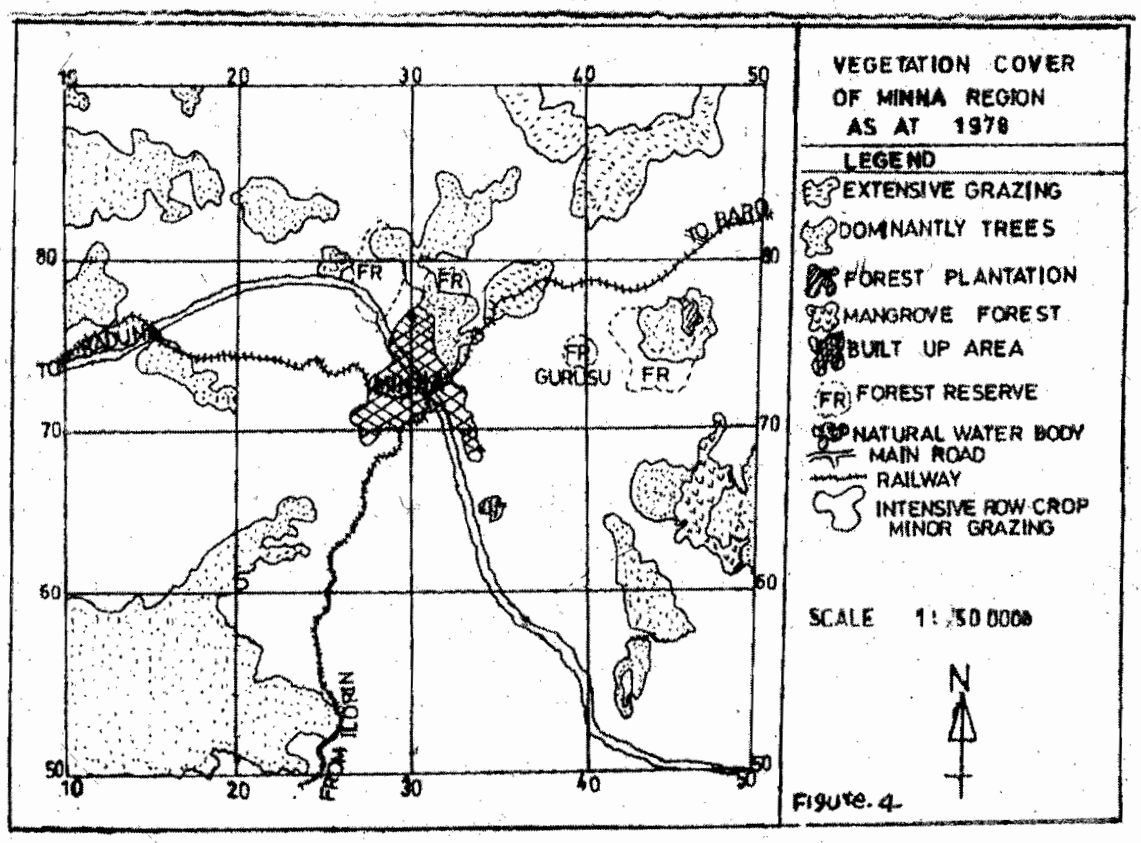


Figure. 4

Data analysis.

From the images used, two maps were generated to show the level of forest lost over the years as a result of human uncontrolled activities. Figure 4, show the percentage Land use/forest cover map of Minna region as at 1978 as analysed in table 1, while figure 5 and table 2 show the same for 1995. From table 2, the percentage of areas subjected to extensive grazing has increased significantly and this could be attributed to the replacement of the natural forest due to shifting cultivation with grassland and fodders. Forest fire has done a great harm to this par of the country due to the activities of the the nomadic herders (the Bororos).

Item no. 2 in table 2 show major increase in the built up area which has direct impact on the forest stand. Forest is cleared for developmental activities while timbers were also harvested for wooden structures and furniture especially from Lapai forest area. As t 1978, in his area, only natural water bodies were noticeable accounted for about 0.63% of the study area, but in 1995, there is the growth in the development of major and minor manmade earth dams like Shiroro and Tunga Kawo irrigation scheme. Reservoir now accounted for about 9.38% of the total land area under review.

Although the forest reserve areas increase from 2.8% to about 3.75%, but the Mangrove forest has given way to secondary forest. The degree of degradation is clearly shown in table 3 where the negative signs indicate reduction in the area coverage of such land use and positive signs mean increase in the area coverage. It is only the built-up areas (urban growth) and the forest reserved areas that actually show

Table 1. LAND USE/FOREST COVER OF MINNA REGION AS AT 1978

S/N	Types of cover	Percent	Area (km^2)
1	Extensive grazing, row crop	6.2	15.87
2	Trees/sparse grass dominant	25	64
3	Forest plantation	1.25	3.2
4	Mangrove forest	1.87	4.79
5	Built-up area	3.13	8.02
6	Forest reserve	2.8	7.17
7	Water bodies (natural)	0.63	1.62
8	Minor grazing, row crop	59.12	151.35
	Total	**100**	**256**

Source: Researchers·Image interpretation 2004.

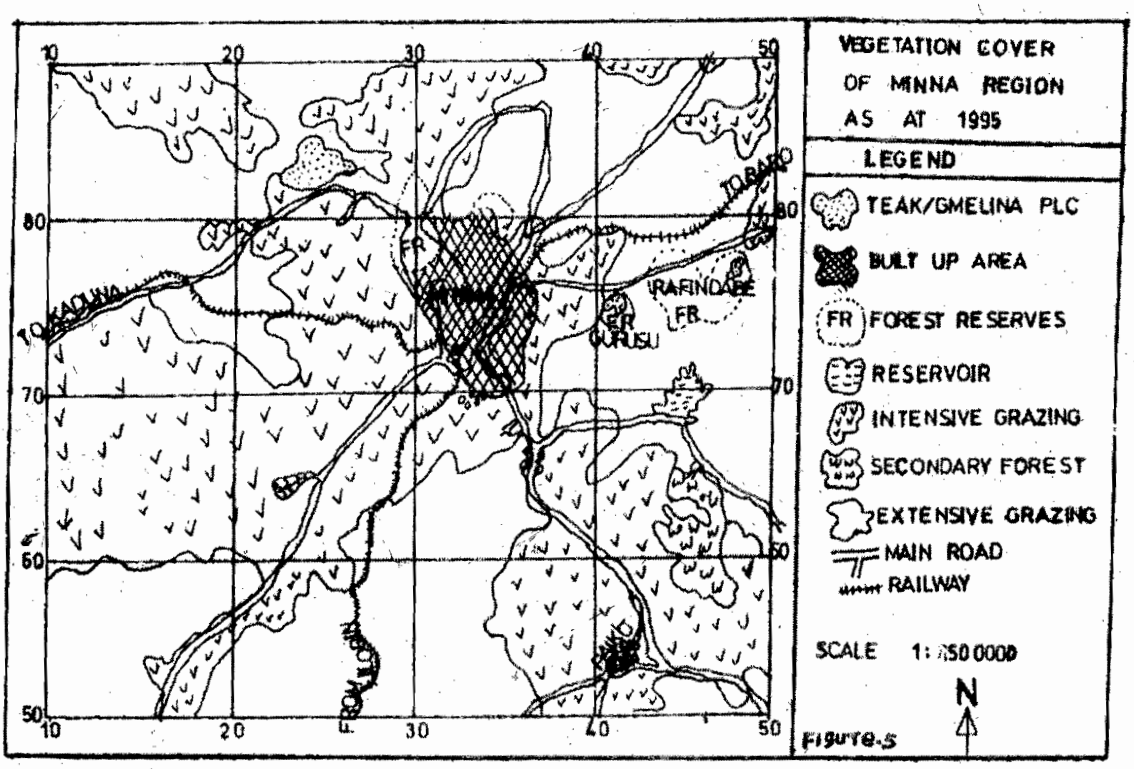


Table 2. LAND USE/FOREST COVER OF MINNA REGION IN 1995

S/N	Types of cover	Percent	Area (km^2)
1	Teak/Gmelina plantation	1.25	3.2
2	Built-up areas	5	12.8
3	Forest reserve	3.75	9.6
4	Reservoir	9.38	24.01
5	Minor grazing, row crop	50	128
6	Secondary Forest	3.13	8.01
7	Extensive grazing	27.5	70.4
	Total	**100**	**256**

Source: Researchers Image interpretation 2004.

Table. 3 THE DEGREE OF DEFERENCES OVER THE YEARS.

S/N	Types of cover	Area (km^2)
1	Extensive grazing, row crop	-21.3
2	Trees/sparse grass dominant	-25
3	Forest plantation	-1.25
4	Mangrove forest	-1.87
5	Built-up area	+1.87
6	Forest reserve	+2.50
7	Water bodies (natural)	-0.63
8	Minor grazing, row crop	-9.12
	Total	-54.8

Source: Researchers data analysis 2004.

positive improvement. Presently in this century, even those forest reserved areas are now been taking over by human developmental activities like housing as noted in places like Bosso, Tudun Fulani, Tunja Awoje, Gurusu Reserves and many others.

The way forward.

The question now is, 'what then is the way forward from here', the following are therefore recommended.

* Intensive agricultural and co-operative system should be encouraged within the state as against extensive shifting cultivation the people are used to.
* The state government should check the activities of the lumbers with fake lumbering certificate with which they deceived the local communities and even the forest warders.
* The government at all level should seize from their lip service to environmental management and ecological research funding where the price of kerosene is even higher than that of petrol and people are being forced back to fuel wood.
* The issue of forest fire resulting from the activities of the Fulani herdsmen and the local youth hunters should be strictly handled with full penalties as stated by the FEPA law.
* There should be more grass root mass literacy education on environmental sustainability.
* All the prospective environmental managers should be knowledgeable in air-photo and satellite image data interpretation for proper forest monitoring and evaluation.

CONCLUSION

That drought, desertification and deforestation has come to stay in African countries like Nigeria is not flogging the fact that forest both in its natural or man made is highly mismanaged. The paper discussed fully the need to carefully manage the forest stand through the use of modern remote sensing technique as a means of data collection on forest morphology and physiological condition. Niger State is seriously loosen her forest stands to lumbers and fuel wood vendors to the extent that even the forest reserves are not spared

Proper inventorying of national forest reserve is very important in geo-physical planning and budgeting. The paper therefore calls for the general awakening of policy make and environmental managers toward proper forest management.

REFERENCES

Adefolalu, D. O., 2002. 'Environmental issues in Nigeria: A challenge to technology education', a keynote address presented at the 15th annual national conference of the Nigerian association of teachers of technology held on the 18th-22nd of November 2002 at FUT, Minna, Niger State Nigeria.

Adefolalu, D. O., 1989. Regional studies with satellite data in Africa on Desertification of the Sudan Sahara both in Nigeria in prot – ISESCP Conference Rome – Ivory.

Aina, E. O., 1989. 'Nigeria needs sustainable environmental protection', in Daily times of 23rd May.

Baba, J. M., 2003. 'Towards a lasting solution to the problem of environmental resugees in africa: an ecosystem and resource management perspective', a paper presentation at the UNESCO – sponsored Multi-Stake holder National Workshop on the Application of Remote Sensing for the Integrated Management of Ecosystems and Water Resources in Nigeria, held in Collaboration with the Department of Geography, Federal University of Technology, Minna, at the Abdulsalam Youth Centre, Minna, Thursday, September 4, 2003.

Curran, P. J., 1985. *Principle of remote sensing*, Longman group ltd. UK, pp. 80 – 199.

Drury S.A., 1993. Image Interpretation in Geology (2nd ed.). London: Chapman and Hall. Pp. 283.

Hinnawi, E.E ., 1985. Environmental Refugees, New York: United Nations Development Program, cited in 'Towards a lasting solution to the problem of environmental refugees in Africa: an ecosystem and resource management perspective', a paper presentation by Baba (2003) at the UNESCO – sponsored Multi-Stake holder National Workshop on the Application of Remote Sensing .

Juris Haruna K., 1991 Afforestation programme and desertification menace in Nigeria, in New Nigerian of 21st Oct, pp7.

Jensen, John R., 1996. Introductory Digital Image Processing: a Remote Sensing Perspective (2nd ed.). Upper Saddle River, NJ: Prentice-Hall. Pp 316 .

Lillesand, et al ., 1994. Remote Sensing and Image Interpretation (3rd ed.). New York: John Wiley and Sons. 750 p.

Rencz, Andrew N., ed., 1999. Remote Sensing for the Earth Sciences. Manual of Remote Sensing, (3rd ed.). Volume 3. New York: John Wiley and Sons. 707 p

Walsh, G. E. 1980. 'Exploitation of mangal. In V. J. Chapman, ea., Ecosystems of the World. Vol. 1, Wet coastal ecosystems, pp. 347-362. Elsevier Scientific Publishing Company, New York.