REMOTE SENSING AND GIS APPLICATION FOR FOREST RESERVE DEGRADATION PREDICTION AND MONITORING

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Key words: Eleyele, TM
(Eleyele –Forest Plantation, TM-Thematic Mapper)

SUMMARY

Remote Sensing Technology in combination with Geographic Information System can render reliable information on land use dynamics. This study therefore examined the integration of Remote Sensing and Geographic Information System (RS/GIS) for application in urban growth effects on the Eleyele Forest Reserve in Ibadan, Oyo State. The 1972, 1984 and 2000 Landsat TM satellite Remote Sensing data was used to identify and classify Eleyele Forest Reserve. A GIS database of land use categories and their location within 28 years (1972-2000) was generated and analyzed with the aid of GIS analytical functions. These include Area calculation, overlay, image differencing, Markov operation, and cross tabulation. The result showed that population growth (anthropogenic factors) among communities around the forest imposes a lot of pressure on the forest plantation. Forest reserve has suffered seriously and if the present trend of deforestation continues; it is just a matter of time when the whole reserve would have been converted to a bare ground.

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1.0 BACKGROUND INFORMATION

Pressures on forest especially in the tropical world to provide economic resources have been increasing rapidly as a consequence of burgeoning population in the region. This has led to unabated deforestation, which has been recognized as one of the major drivers of biodiversity loss as well as a threat to the existence of the global ecological lung. In Nigeria, the eco-climatic zones range from the very humid fresh water mangrove swamps, in the south to the semi arid Sahelian zone in the north (Salami and Balogun 2004). These varied zones support a variety of vegetation, among which the most extensive vegetation zones are Savannas in the north and forest in the south.

Available records in the department of forestry show that Nigeria has a total of 1160 constituted forest reserves covering a total land area of 10,752,702 hectares and this represents about 10% of the total land area. This excludes from the Games Reserves and National Parks. However, most of these reserves only exist on paper and the federal Department of forestry argues that deforestation in Nigeria is now progressing at the rate of 3.5% per annum. Forest and forest plantation are very important natural resources relied upon by man for food, furniture, fuel wood, timbers, animal and plants to mention a few. In both developed and developing countries, exploitation of these forest resources take place consistently for various purposes which varies from commercial to non commercial, need for space in road construction shifting agriculture, firewood harvesting, construction of residential building, sand excavation etc.

Most of these practices however have had a dangerous impact on the forest plantation and the purpose for which the forest plantation was established is almost been defeated.

1.1 STATEMENT OF PROBLEM

Usually, tree grown surrounding watershed (Forest plantation/ forest reserve) is usually for a purpose or purposes. They usually experience luxuriant growth, close canopy and the resultant effect is that such trees intercept direct rain drops and prevent it from having direct impact on the soil surface, a situation which apart from preventing erosion and stream flood, reducing evaporation.

Forest when located in catchments area regulates stream flow. This regulation ensures that lands on lower slopes are protected from erosion and flooding and the silting of canals and rivers is minimized. Unfortunately, forest reserved constituted for such purpose are being removed indiscriminately in order to satisfy the guest for urbanization and income acquisition.

Ibadan, the Oyo state capital has witnessed remarkable expansion growth and development activities such as building and road construction. Fig.1 shows the gradual spatial growth of Ibadan from 1963-1981 (Ayeni Bola). He identified several factors responsible for such growth as:

i. Headquarters of western province
ii. Construction of Lagos-Ibadan Express way that generated the greatest urban sprawl (East and West).
iii. Construction of Eleyele Express way (West)
iv. Increased in agricultural activities
v. Trading and craft

Fig. 1: *Spatial growth of Ibadan city (1963 - 1981)*

These have led to a tremendous increase in the population of the city. There is an increase demand for land and this has led to gradual deforestation of the watershed. The forest reserve is now a place of spiritual activities such as construction of churches, many unauthorized residential building have been erected, and various types of agricultural activities are now taking place. There is illegal cutting of timbers, illegal harvesting of wood for firewood, sand excavation and block making industries. Something has to be done, we must understand the magnitude of the exploitation and estimate the trend, what are the agent of deforestation and begin to project occurrences in the nearest future if nothing is done. The project therefore, examines forest plantation degradation .land use and land cover changes in Eleyele catchments area of Ibadan using GIS as a tool to assess changes over a 28 years period (1972 – 2000) of time in the study area.

1.2 OBJECTIVES OF THE RESEARCH

The object of this study is to examine the integration of GIS and remote sensing for application in urban growth effects on the Eleyele forest reserve in Ibadan South West Local Government of Oyo State.

The following objectives were pursued to achieve the aim defined above

i. To map out the different land use / land cover and their spatial distribution
ii. To identity, quantify and map out the forest plantation changes in Eleyele forest reserve from 1972 to 2000 using LANDSAT images.
iii. Examine the specific human activity types responsible for the changes.
iv. To demonstrate the capabilities of GIS in the area of classification and overlay in the study of deforestation.
v. To perform NDVI calculation, showing vegetation reflectance
vi. To model / predict possible future changes.

1.3 JUSTIFICATION FOR THE RESEARCH

In general, the aim of managing any resources is to find a way to ensure its sustainability. To understand why deforestation is such a dangerous practice and should be discontinued forth with, forest plantation must first be given credit for the role they play or their impact on the local ecosystem.

The forest plantation in Eleyele catchments area was established to be preserved:

(i). as a protection forest to prevent erosion i.e. to protect the catchments area of the lake.
(ii). to supply building poles, telegraph poles and fuel wood on a maximum sustained annual yield basis for the benefit of the communities of Ibadan.
(iii). to gain experience on the qualities and silviculture of teak as a timber species.

Unfortunately, the increase demand for land in Ibadan has led to gradual deforestation of the watershed. This has resulted in increased land consumption for other purposes, modification and alteration in the status of her land use and land cover over time without any detailed and comprehensive attempt to evaluating these changes.

Deforestation as being practiced in this area present multiple societal and environmental problems. The long term effect and consequence of this local deforestation are almost certain to jeopardize life. Some of the consequences may include exposure of the catchments area that can lead to dryness. Siltation can occur.

Through this research attempt was made to predict same and possible future changes that may occur and planners can have a basic tool for future planning. Recommendation will also be made to the authority concerned.

1.4 THE STUDY AREA

Eleyele Lake Forest is located in Ibadan North West Local Government area of Oyo state. The forest reserve covers the water storage area itself plus a strip of dry land surrounding the reservoir and varying in width from 30.48m – 365.76m. The strip of dry land surrounding the water storage area was planted with teak plantation in 1941 and was constituted a forest reserve in 1956.

It lies within latitude 7^0.41 – 7^0.45N and longitude 3.83^0 – 3.88^0E. The total Area of the reserve is 526.0921 hectares. The area was originally acquired by government under the public lands acquisition ordinance (1941). The plantations on the area have been established at the expense of the native authority (now Ibadan District Council) that also runs the waterworks. Since Government originally acquired the area after the payment of compensation to right holders, no right to individual are admitted.

The Ibadan District Council has the fishing right and have the right of entry for the preservation and maintenance of the reserve. The reservoir was made by damming River Ona.

The study area is situated within the lower boundary of Guinea Savanna vegetation belt having the combination of equatorial and tropical hinterland climate.

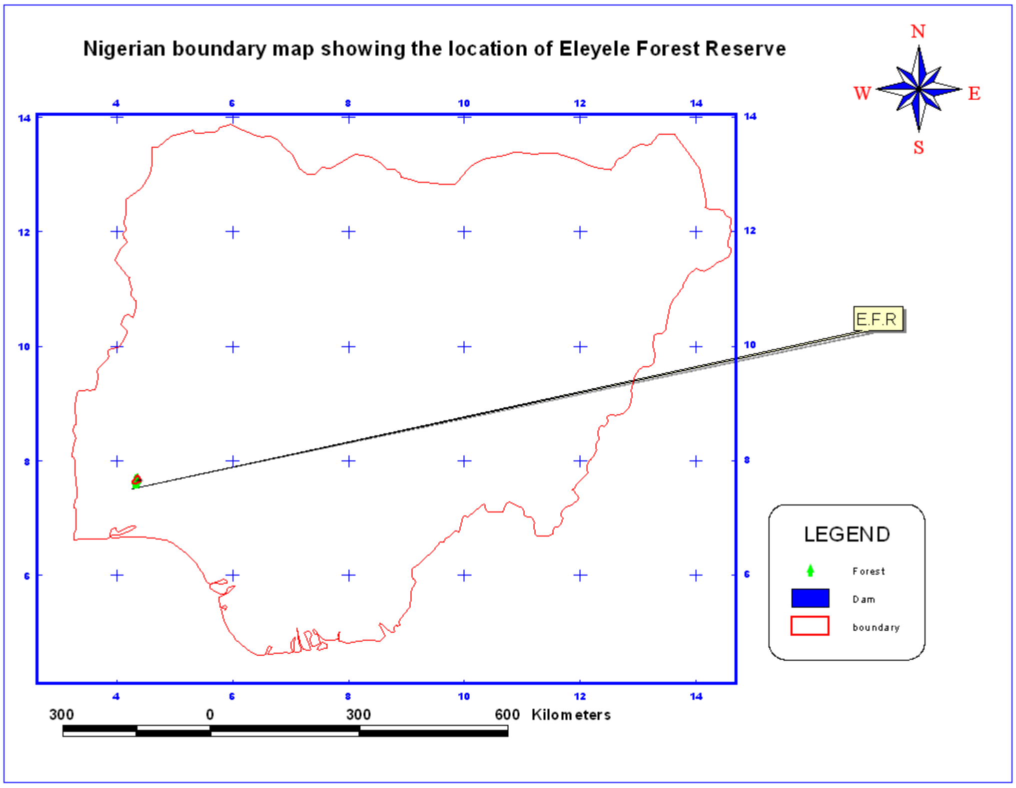


Figure 2: *Map of Nigeria showing the study area Eleyele Forest Reserve*

2.0 LITERATURE REVIEW

All tropical forest (forest plantation, rainforest tropical, subtropical and even temperate) are under threat from human activities at the present time. They are being destroyed at an alarming rate that could potentially lead to many different types of environmental catastrophe, not only in the local forest zones but globally. The greatest threat comes from deforestation. (The gradual reduction of the stocking of the vegetation covers resulting from human activities).

Deforestation is a continuous process, and efforts have to be geared towards proper inventory and changes monitoring. At the 1992 United Nations Conference on Environment and Development, deforestation was identified as a policy issue of global importance. Recent pilot projects carried out by the consortium from International Earth Science Information Network (CIENSIN) showed that to effectively comprehend, manage and predict deforestation at the global scale, we need to integrate and generalize from the results of local and regional studies.

To determine the causes and potential effects of deforestation, study of deforestation must also include an integration of disparate data from both human and natural science discipline, using a Geographic Information System to provide spatial Analysis capabilities.

Venema et al (2005) noted that proper forest monitoring and management can only be achieved by using remote sensing techniques and creating spatial representations such as maps to know the exact locations and extent of deforestation.

The Center of Biodiversity and Conservation (CBC) had in 1998 established the Remote Sensing and Geographic Information System (RS/GIS) facilities. Its technologies have helped identify potential survey sites, analyze deforestation rates in focal study areas, incorporate spatial and non-spatial databases and create persuasive visual aids to enhance reports and proposals.

A remote sensing device records response, which is based on many characteristics of the land surface, including natural and artificial cover. An interpreter uses the element of tone, texture, pattern, shape, size, shadow, site and association to derive information about land cover.

The generation of remotely sensed data/images by various types of sensor flown abroad different platforms at varying heights above the terrain and at different times of the day and the year does not lead to a simple classification system. It is often believed that no single classification could be used with all types of imagery and at all scales. To date, the most successful attempt in developing a general-purpose classification scheme compatible with remote sensing data has been by Anderson et al, which are also referred to as USGS classification scheme. Other classification schemes available for use with remotely sensed data are basically modification of the above classification scheme. Ever since the launch of the first remote sensing (Land sat-1) 1972, land use and cover studies were carried out on different scale for different users. For instance, waste and mapping for India was carried out on 1:1 million scales by NRSA using 1980–82 LANDSAT multi spectral scanner data. About 16.2% of wastelands were using 1980 – 1982 LANDSAT multi spectral scanner data. About 16.2% of wastelands were estimated based on the study.

Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times (Singh, 1989). Change detection is an important process in monitoring and managing natural resources and urban development because it provides quantitative analysis of the spatial distribution of the population of interest.

Macleod and Congation (1998) list four aspects of change detection which are important when monitoring natural resources:

i. Detecting the changes that have occurred
ii. Identifying the nature of the change
iii. Measuring the area extent of the change
iv. Assessing the spatial pattern of the change

The basis of using remote sensing data for change detection is that changes in land cover result in changes in radiance value, which can be remotely sensed. Techniques to perform change detection with satellite imagery have become numerous as a result of increasing versatility in manipulating digital data and increasing computer power. A wide variety of digital change detection techniques have been developed over the last two decades. Singh (1989) and Copping & Bauer (1996) summarize eleven different change detection algorithms that were found to be documented in the literature by 1995. These include:

1. Mono-temporal change delineation
2. Delta or post classification comparisons
3. Multi dimensional temporal feature space analysis
4. Composite analysis
5. Image differencing
6. Multi-temporal linear data transformation
7. Change vector analysis
8. Image regression
9. Multi-temporal biomass index NDVI
10. Background subtraction
11. Image rationing

In some instances, land use land cover change may result in environmental, social and economic impacts of greater damage than benefit to the area (Moshen, 1999). Therefore data on land use change are of great importance to planners in monitoring the consequences of land use change on the area. Such data are of value to resources management and agencies that plan and assess land use patterns and in modeling and predicting future changes.

Shosheng and Kutiel (1994) investigated the advantages of remote sensing techniques in relation to field surveys in providing a regional description of vegetation cover. The results of their research were used to produce four vegetation cover maps that provided new information on spatial and temporal distributions of vegetation in this area and allowed regional quantitative assessment of the vegetation cover.

Arvind Pandy and Nathawat (2005) carried out a study on land use land cover mapping of Panchkula, Ambala and Yamunanger districts, Hangana state in India. They observed that the heterogeneous climate and physiographic conditions in these districts has resulted in the development of different land use land cover in these districts, an evaluation by digital analysis of satellite data indicates that majority of areas in these districts are used for agricultural purposes. The hilly regions exhibit fair development of reserved forests. It is inferred that land use land cover pattern in the area are generally controlled by agro-climatic conditions, ground water potential and a host of other factors.

Adeniyi and Omojola, (1999) in their land use land cover change evaluation in Sokoto – Rima Basin of North – western Nigeria based on Archival Remote Sensing and GIS techniques, used aerial photographs, LANDSAT MSS, SPOT XS/Panchromatic image Transparency and Topographic map sheets to study changes in the two dams (Sokoto and Guronyo) between 1962 and 1986. The work revealed that land use / land cover of both areas was unchanged before the construction while settlement alone covered most part of the area. However, during the post dam era, land use/land cover classes changed but with settlement on earth, affecting the ability of the biosphere to sustain life. Human have become ever more adapt at appropriating and altering the earth's resources for their needs. Intensification and diversification of land use and advances in technology have led to rapid changes in biogeochemical cycles, hydrological processes and landscape cycles, hydrological processes and landscape dynamics.

3.0 FLOW CHART OF THE RESEARCH METHODOLOGY

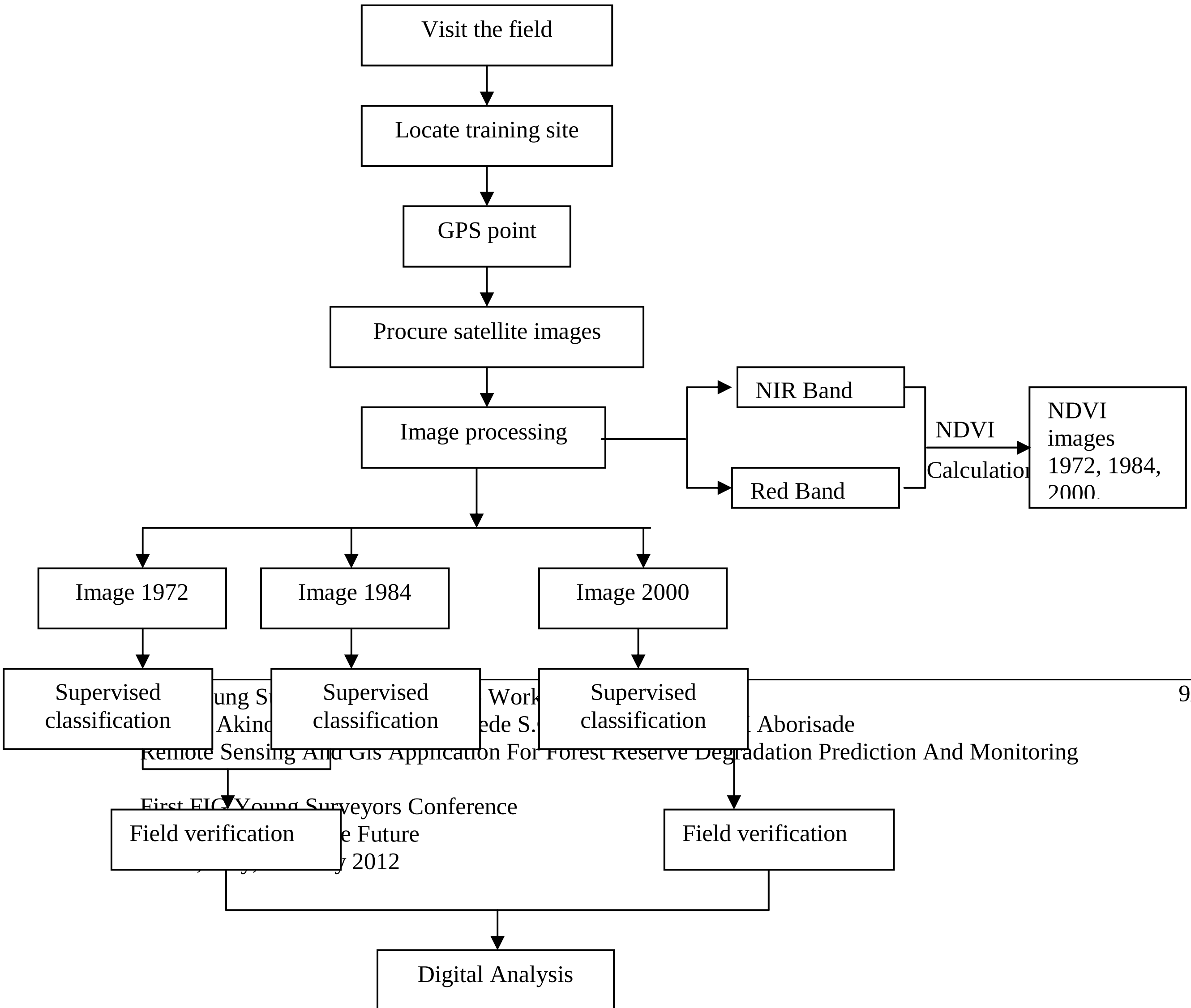


Fig. 3: *Flowchart of the Research Methodology*

3.1 DATA ACQUISITION

Data are observation we make from monitoring the real world, collected as facts or evidence that may be processed to give them meaning and turn them into information Heywood (1988).

Data can therefore be said to be the live wire of any study most especially remote sensing and geographic information system. For this study, data were acquired from a number of sources. Since the nature of land cover monitoring requires images of different time period, and that change detection analysis is carried out most effectively with not less than 3 images of the study area, three LANDSAT ETM Satellite images of Oyo state were acquired. - 1972, 1984 and 2000 with spatial resolution of 30m. Other ancillary data like topographic map were also used. All the imageries were obtained from NASRDA.

3.2 IMAGE REGISTRATION

The images were scanned and imported into Arc View 3.2a for registration .The image reader extension (Tiff images) was activated to allow the software to read Tiff image files. The images were then geo referenced in Arc View due to its flexibility. Subsequently the study area was cut from the whole image for the four-time period. The images were broken into subsets in Arc View and saved as Tiff images.

The geo referencing properties of 1972, 1984, 2000 and 2004 are the same.

Data Type - rgb 8

File type – binary

Column – 535, Rows – 552

Reference system – UTM 31

Referencing units - meters, Unit distance – 1

Minimum X – 582562.654651, Maximum X – 619124.711419

Minimum Y – 798087.407848, Maximum Y – 834940.216559

Image thinning was carried out through contract. Contract generalized an image by reducing the number of rows and columns while simultaneously decreasing the cell resolution. Contradiction takes place by Pixel thinning or pixel aggregation with the contracting factors in X and Y being independently defined with pixel thinning, every n^{th} pixel is kept while the remaining is thrown away.

3.2.1 IMAGE CLASSIFICATION

The images were imported into Idrisi 32 for classification i.e. the process of extraction of differentiated classes or theme from raw remotely sensed digital satellite data (Meyer, 1994). Each cluster of observations is a class. A class occupies its own area in the feature space i.e. a specific part of the feature space corresponds to a specific class. Once the classes have been defined in the feature space, each image pixel observation can be compared to these classes and assigned to the corresponding class. Classes to be distinguished in an image classification need to have different spectral characteristics, which can be analyzed by comparing spectra reflectance curve. The only limitation of image classification is that if classes do not have distinct clusters in the feature space. Such image classification does not give reliable results.

Training sites were generated on the images by on-screen digitizing for each land cover classes derived from image of different band combination. A supervised (full Gaussian) maximum likelihood classification was implemented for the four images. This was due to the fact that the operator has familiarized himself with the study area through dedicated field observation, whereby the spectra characteristics of the classes in the sampled area has been identified. Ground truth information was used to assess the accuracy of the classification. Table 1.shows the selected training site:

Table 1: The selected training sites

S/N	Training Sample	Description
1.	Built up area	Area occupied by people for habitation
2.	Forest plantation	Section of the reserve occupied by Gmelina Arborea
3.	Farmland	Area occupied by farming activities
4.	Vegetation	Area of open forest devoid of forest plantation
5.	Water body	Soil surface area occupied by stream, pond or river, dam

3.3 DATABASE DESIGN

A database system is essentially a computerized record-keeping system. It is an electric filing cabinet, that is, a repository for collection of computerized data files. In any GIS application, there must be a well structured spatial database. The process of designing database is referred to as data modeling.

Kufoniyi (1998) defined data modeling as the process by which real world entities and their relationship are analyzed and modeled in a way that maximum benefits are derived while utilizing a minimum amount of data. It should be noted that an improper database design often leads to implementation problems.

There are two main phases in obtaining a GIS database; these are the design phase and construction or implementation phase. The design phase, otherwise known as data modeling consists of three stages; while the construction phase is made up of the spatial database proper. The three main phases of database design are: Conceptual, Logical and Physical design phases

3.3.1 VIEW OF REALITY

Reality refers to the phenomenon as it actually exists, including all aspects which may or may not be perceived by individuals. The view of reality is the mental abstraction of the reality for a particular application or group of application. In this project, this refers to the deforestation of forest reserve in the study area.

3.3.2 CONCEPTUAL DESIGN

Conceptual design is a conceptual data modeling and it is a human conceptualization of reality. In this phase, we decide how the view of reality will be represented in a simplified manner but still satisfy the information requirement of the project at hand. This phase also deals with the identification of the basic features and the spatial relationship that exist between them. The vector data model was widely used here.

3.3.3 LOGICAL DESIGN

This phase deals with the logical representation of data model with regards to the way they are actually stored in a computer environment. Relational data structure is adopted for this project. The following datasets as well as their attributes were identified.

SOFTWARE USED IN THE RESEARCH

Table 2:

S/N	Software	Used for
1.	Arc view 3.2a	Image registration and enhancement. Carving out of the study area

2.	**Arc GIS 9.2**	**Querying and hot linking**
3.	**Idrisi 32 release 2**	**Image classification and training site selection**
4.	**ERDAS Imagine 9.1**	**Change detection and image differencing**
5.	**MS Excel**	**Pie graphical presentation**

3.3.4 PHYSICAL DESIGN

This is a tabular representation of the entities and their attributes onto the implementation software. It is the first stage of database creation when the attribute data are mapped onto the implementation software. The software used is the ArcGIS which uses number, string, Boolean and date for declaration of data types.

Table 3: Attribute table for the Land cover classes

Attributes of Study Locations

FID	Shape *	ID	LOCATION	X_COORD	Y_COORD	IMAGE
2	Point	1	WATER_BODY	3.86	7.42	C:\IMAGES\WATER_BODY.tif
3	Point	2	BUILT-UP_AREA	3.87	7.44	C:\IMAGES\BUILT-UP_AREA.tif
4	Point	3	VEGETATION	3.87	7.43	C:\IMAGES\VEGETATION.tif
5	Point	4	PLANTATION	3.85	7.43	C:\IMAGES\PLANTATION.tif
6	Point	5	FARMLAND	3.86	7.4	C:\IMAGES\FARMLAND.tif

3.4 DATABASE CREATION

Digital data are used in GIS analysis. But most often, the available data is usually in analog format. The preprocessing involves converting the analog map into digital format through scanning, geo-referencing and digitizing.

The data processing in this study involves conversion of analog maps of the project area into digital. This was done by scanning the maps and vectorizing the maps through on-screen digitizing and this was done using Arcview 3.2a.

ArcGis was used in creating the database. The relations/tables in the database are: Forest Plantation, Built-up-Areas, Farmland, Vegetation, and Water body within the study area. The semantic data of each entity was entered into the tables for spatial query and other spatial analyses that will be carried out in the next section.

3.4.1 DATABASE MANAGEMENT

This involves the use of implementation software to organize information in a database. This is the collection of software for creating, storing, updating, manipulating, retrieving, analyzing and organizing information in the database. The database must be properly managed to ensure that the data stored in the database are correct, consistent and secured.

4.0 METHOD OF DATA ANALYSIS

Seven main methods of data analysis were adopted in this study.

i. Calculation of the area in hectares of the resulting land use/land cover types for each study year and subsequently comparing the result.

ii. Overlay operations. – i.e. mathematical and logical operation between two raster layers on a pixel to pixel basis.

iii. Image differencing – to provide for change analysis through differencing of images pairs.

iv. Cross tab. – to determine all unique combinations of value in two qualitative images and calculate similarity statistics

v. Database query and hot linking

vi. Markovian transition estimator for predicting future change.

vii. Normalized difference vegetation index.

The first three methods will be used to identify changes in the land use types. The comparison of the land use/land cover statistics will assist in identifying the percentage change, trend and rate of change between 1972 and 2004. In achieving this, the first task was to develop a table showing the area in hectares and the percentage change for each year 1972, 1984, 2000 and 2004 measured against each land use/land cover type. Percentage change to determine the trend of change can then be calculated by dividing observed change by sum of changes multiplied by 100.

$$\text{(Trend) percentage change} = \frac{\text{observed change}}{\text{Sum of change}} \times 100$$

A Markovian process is one in which the future state of a system can be modeled purely on the basis of immediately preceding state. The Markov module analyzes a pair of land cover images and outputs a transition probability matrix, a transition area matrix, and a set of conditional probability images. The transition probability matrix is a text file that records the probability that each land cover category will change to every other category. The transition areas matrix is a text file that records the number of pixels that are expected to change from each land cover type to each other land cover type over the specified number of time unit. In both of these files, the rows represent the older land cover categories and the columns represent the newer categories.

The conditional probability images report the probability that each land cover type would be found at each pixel after the specified number of time unit.

In addition, the use of spectra vegetation index, namely the Normalized Difference Vegetation Index (NDVI) was also applied to detect areas of vegetation cover decrease. This method has proved reliable in monitoring vegetation change. Vegetation differential absorbs visible incident solar radiant and reflects much of the infrared (NIR), data on vegetation biophysical characteristic can be derived from visible and NIR and MIR portions of the Electro Magnetic Spectrum (EMS). The NDVI approach is based on the fact that healthy vegetation has low reflectance in the visible portion of the EMS due to chlorophyll and other pigment absorption and has high reflectance by the mesophyll spongy tissue of green leaf (Compbell, 1981). NDVI can be calculated as a sensor system; its values range from -1 to +1. Healthy vegetation is represented by NDVI values between 0.1 and 1. Non vegetated surfaces such as water bodies yield negative values because of the electromagnetic absorption quality of water. Bare soil areas represent NDVI values which are closest to 0.

4.1 DATA ANALYSIS AND DISCUSSION OF RESULT

A supervised (full Gaussian) maximum likelihood classification was implemented for the four images and the final classification products provide an overview of the major land use / land cover features of Eleyele forest reserve for the year 1972, 1984, 2000 .

Five categories of land use / land cover were identified; these are: built up area, farmland, forest plantation, vegetation and water body. Figure 3, 4, 5 and 6 illustrate the land use / land cover map of Eleyele forest reserve for the year 1972, 1984, and 2000.

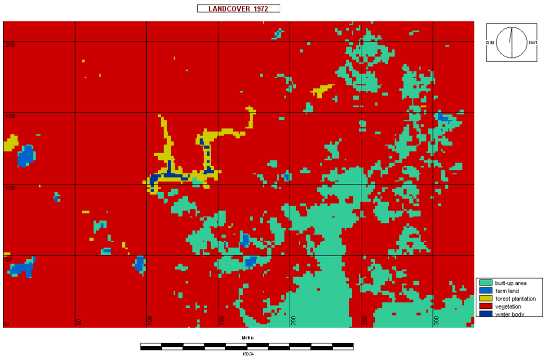


Fig. 4: *Land cover Changes (1972)*

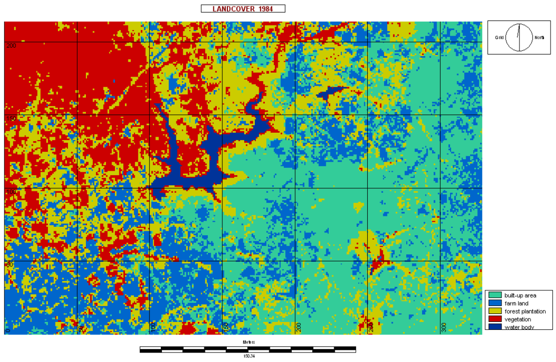


Fig. 5: *Land cover Changes (1984)*

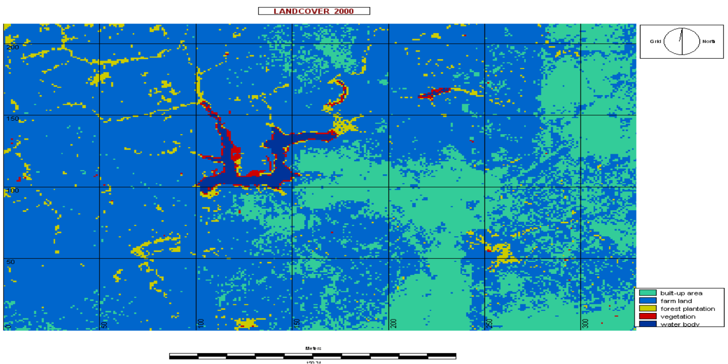


Fig. 6: *Land cover Changes (2000)*

In order to obtain the area extent (in hectares) of the resulting land use / land cover type for each study year and for subsequent comparison, the GIS analysis in database query (AREA) of Idrisi software was carried out.

Tabulation and area calculations provided a comprehensive dataset in term of the overall land scope and the type and the amount of changes that have occurred. Table 4 shows the spatial extent of land cover in hectares and in percentages. Table 5 shows the annual rate of increase/decrease of activity type. Table 6 shows the percentage range of Land cover, 1972-1984, 1984-2000.

Table 4: Land use / Land cover Distribution 1972, 1984, 2000

	1972	1984	2000

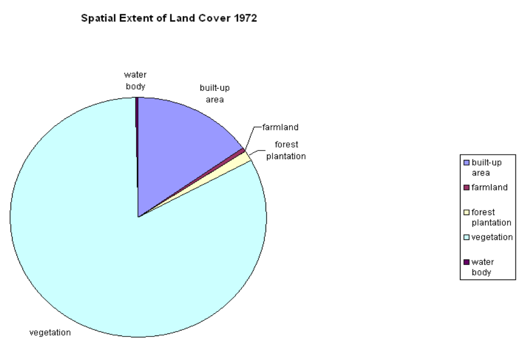
Land cover type	Area (HA)	Area (%)	Area (HA)	Area (%)	Area (HA)	Area (%)
Built up area	**1.0687**	**15.18**	**0.7762**	**11.02**	**1.7706**	**25.14**
Farmland	**0.0447**	**0.63**	**3.7080**	**52.66**	**4.9127**	**69.77**
Forest plantation	**0.1034**	**1.47**	**0.8808**	**12.51**	**0.2280**	**3.24**
Vegetation	**5.8072**	**82.48**	**1.5357**	**21.81**	**0.0414**	**0.59**
Water body	**0.0167**	**0.23**	**0.1399**	**1.98**	**0.0879**	**1.25**

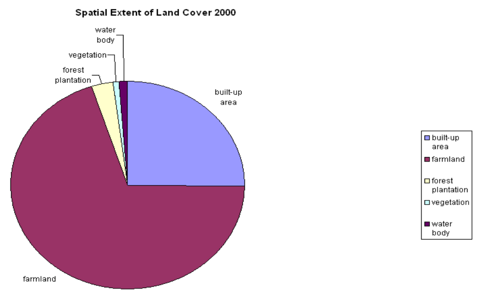
Table 5: Area / Percentage and Annual Rate of Decrease / Increase of Land Use / Land Cover Changes (1972-2000)

Activity Types	Area covered (Ha)		Difference (Ha)	Increase / Decrease %	Annual Rate of increase/decrease %
	1972	**2000**	**1972-2000**	**1972-2000**	**1972-2000**
Built up area	**1.0686**	**1.7706**	**0.7020**	**9.9707**	**0.2244**
Farmland	**0.0447**	**4.9127**	**4.8680**	**28.318**	**0.8833**
Forest plantation	**0.1034**	**0.2280**	**0.1246**	**-1.33**	**0.040**
Vegetation	**5.8072**	**0.0414**	**-5.7658**	**34.27**	**1.070**
Water body	**0.0167**	**0.0879**	**0.0712**	**1.088**	**0.034**

Table 6: Land use / land cover statistics in %

Land use / land cover	% change 1972-1984	% change 1984-2000	% change 1972-2000
Built Up Area	**-4.16**	**14.12**	**-3.47**
Farmland	**52.03**	**17.11**	**-39.98**
Forest plantation	**11.04**	**-9.27**	**-3.11**
Vegetation	**-60.67**	**-21.22**	**46.48**
Water body	**1.75**	**-0.73**	**1.32**





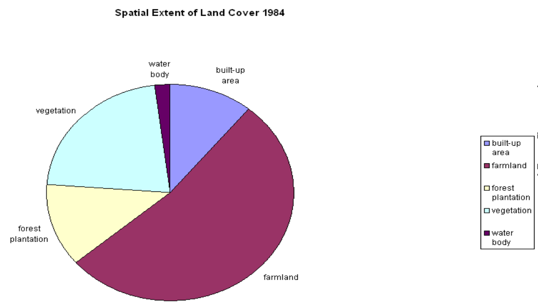


Fig. 7: *Pie charts showing spatial extent of land cover and land changes for three periods (1972, 1984 & 2000)*

4.2 OVERLAY OPERATION

The images generated from this analysis were then overlaid, so as to obtain a visual representation of the area/extent of changes that occurred in the period for each of the land cover classes. In overlay operations, the exact location the amount of changes was determined.

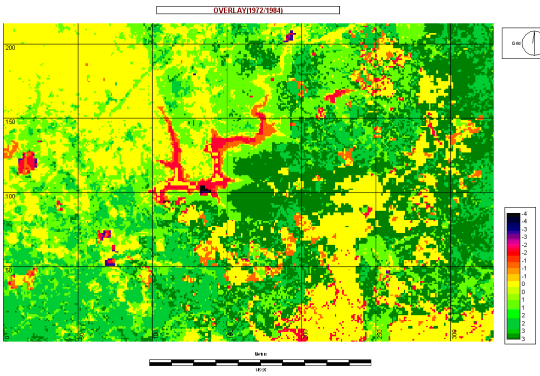


Fig. 8: *Overlay of Land covers Changes (1972 &1984)*

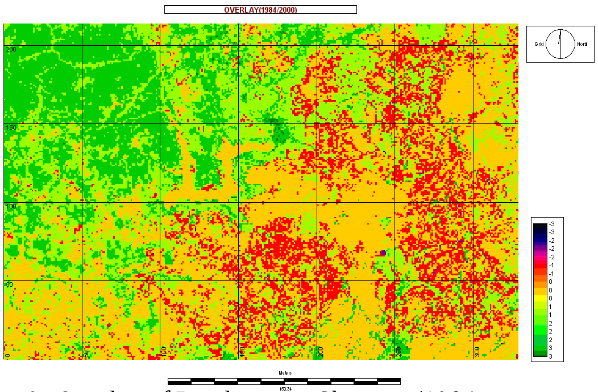


Fig. 9: *Overlay of Land covers Changes (1984 &2000)*

4.3 IMAGE DIFFERENCING – CHANGE DETECTION ANALYSIS

Two classified images (1984/2000) and (1972/1984) were compared i.e. a pair of images compared to identify areas that have distinctly different brightness values. New images representing change were created by taking the difference between images. The basic premise of change detection is that spectra signature change is commensurate with changes in land cover. Change detection analysis was better done in ERDAS IMAGINE.

The new images that represent changes were listed in fig.10. Brightness values are represented as a digital number DN 0-255 in a color image separate red, green and blue values are measured.

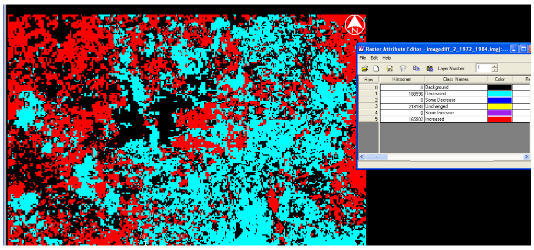


Fig. 10*: Image differencing (1972 & 1984*)

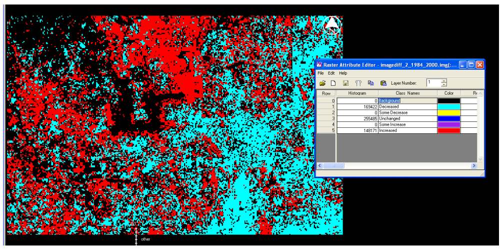


Fig. 11: *Image differencing (1984 & 2000*)

4.4 CROSS TABULATION OPERATION

Cross tab performs two operations:

i. Image cross tabulation and Cross classification

Categories of image 1972 were compared with those of 2000 and image of year 2000 was also compared with image of 1984 and tabulation is kept of the number of cells in each combinations. The result of this operation is a table as shown in table 8 listing the tabulation total as well as several measures of association between the images. The first of these measures is CRAMER'S V, a correlation co-efficient that ranges from 0.0 indicating no correlation to 1.0 indicating perfect correlation.

A chi-square statistics is output along with the appropriate degree of freedom (df 16) and the significance of the Cramer's V was tested. If the chi-square is significant so it is Cramer's V.

Since the 2 images have exactly the same number of categories, another measure of association called Kappa was output.

Table 7: Cross Tabulation: 1972/1984

Cross-tabulation of classification_1972 (columns) against classification_1984 (rows)

	1	2	3	4	5	Total
1	8405	103	9	15587	0	24104
2	1203	138	14	13109	0	14464
3	957	114	128	16022	1	17222
4	96	92	213	12915	0	13316
5	25	0	670	439	166	1300
Total	10686	447	1034	58072	167	70406

Chi Square = 43225.92969

```
          df =        16
   Cramer's V =         0.3918

Overall Kappa        0.1220
```

Table 8: Cross Tabulation: 1972/2000

Cross-tabulation of classification_2000 (columns) against classification_2004 (rows)

Cross-tabulation of classification_1972 (columns) against classification_2000 (rows)

	1	2	3	4	5	Total
1	7208	53	4	10441	0	17706
2	3384	379	265	45098	1	49127
3	68	15	122	2074	1	2280
4	11	0	115	283	5	414
5	15	0	528	176	160	879
Total	10686	447	1034	58072	167	70406

```
   Chi Square =    47819.41016
          df =        16
   Cramer's V =         0.4121
```

Cramer's V = 0.3433

Overall Kappa = 0.2204

The second operation is called cross classification. This can be described as a multiple overlay showing all combination of the logical and Operation. The result was a new image that shows the location of all combination of the categories in the original images. Cross classification thus produced a map representation of all none zero entities in the cross tabulation table.

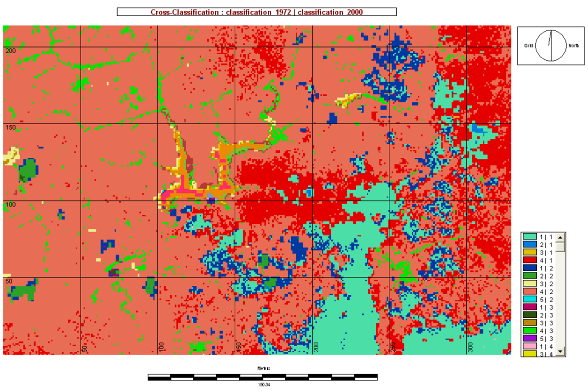


Fig 11 ***:Cross-Classification Image***

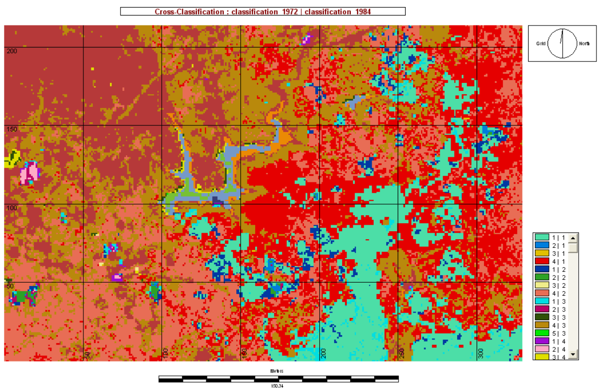


Fig. 12: *Cross-Classification Image (1972 & 1984)*

4.5 NORMALIZED DIFFERENCE VEGETATION INDEX (NDVI)

This is an excellent and widely used method for crop growth and condition assessment (Rahman, Islam and Rahman 2004). For this study NDVI calculation was performed to produce NDVI images for the three periods.

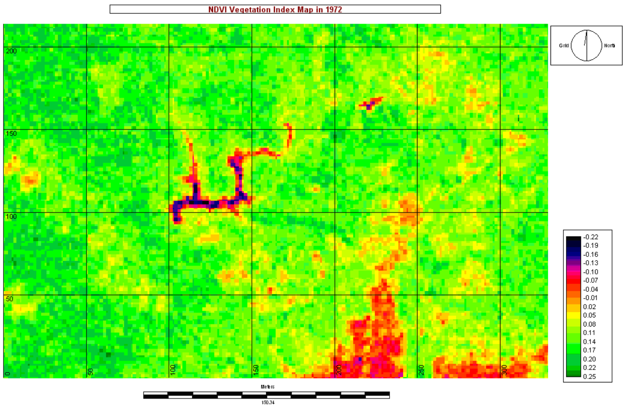


Fig. 14: *NDVI- Vegetation Index Map in 1972*

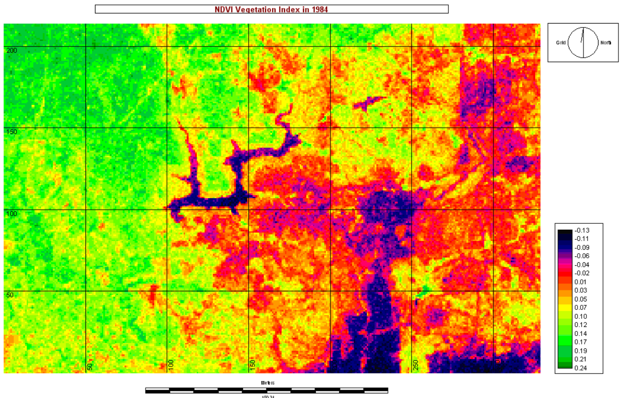


Fig. 15: *NDVI- Vegetation Index Map in 1984*

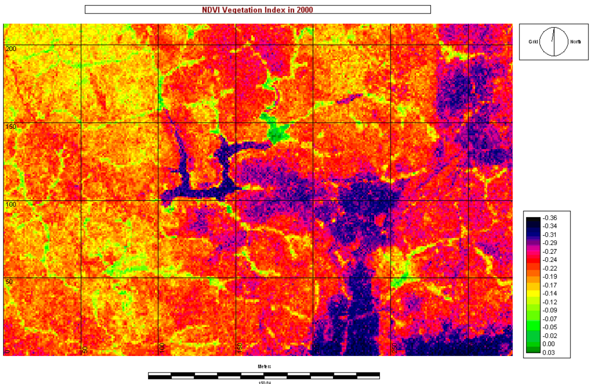


Fig. 16: *NDVI- Vegetation Index Map in 2000*

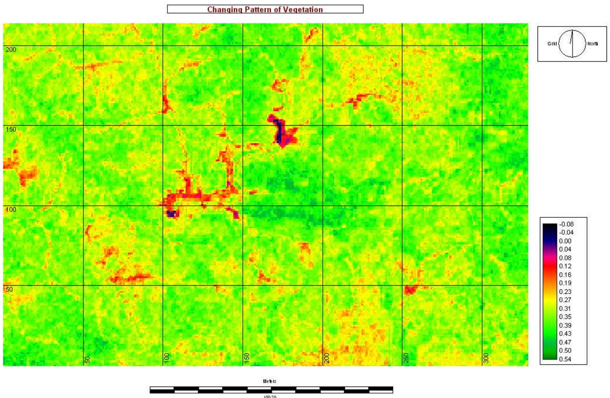


Fig. 17: *Overlay NDVI (1972 & 1984)*

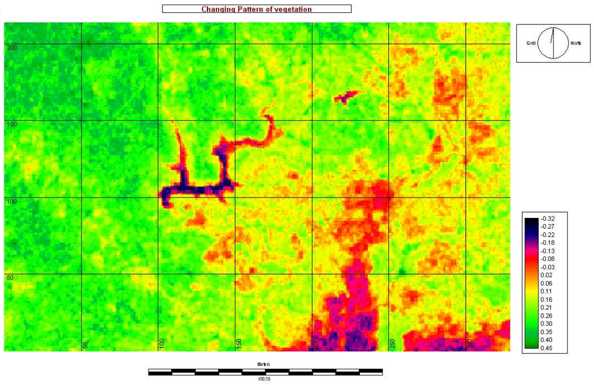


Fig. 18: *Overlay NDVI (1972 & 2000)*

The minimum and the maximum NDVI value for the three periods were calculated

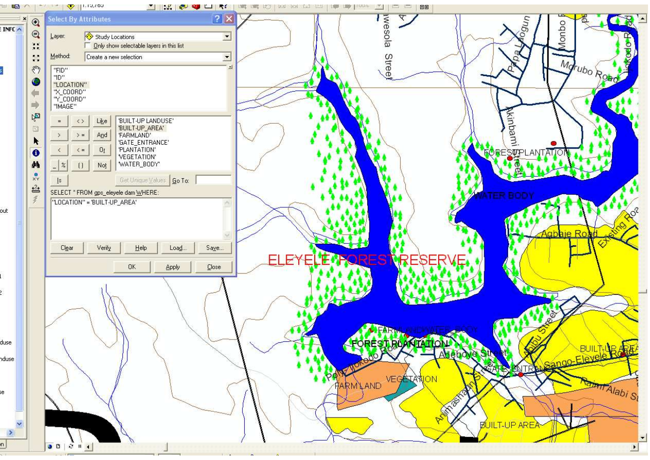
Table 9: NDVI Values

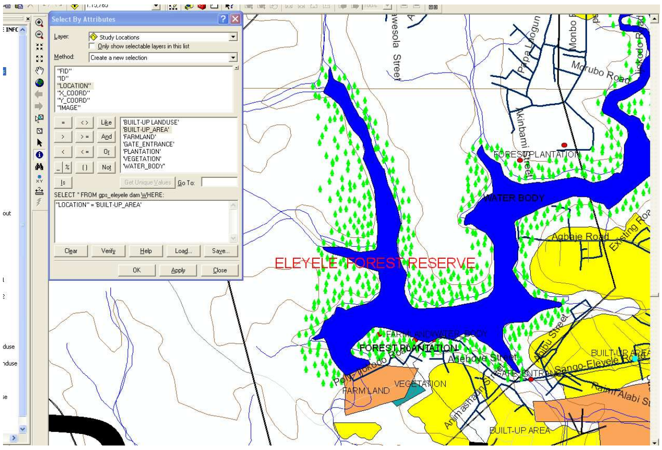
Satellite Image	Minimum	Maximum
Land Sat (TM) 1972	-0.22	0.25
Land Sat (TM) 1984	-0.13	0.24

Land Sat (TM) 2000	**-0.36**	**0.03**

4.6 DATABASE QUERY AND HOT LINKING

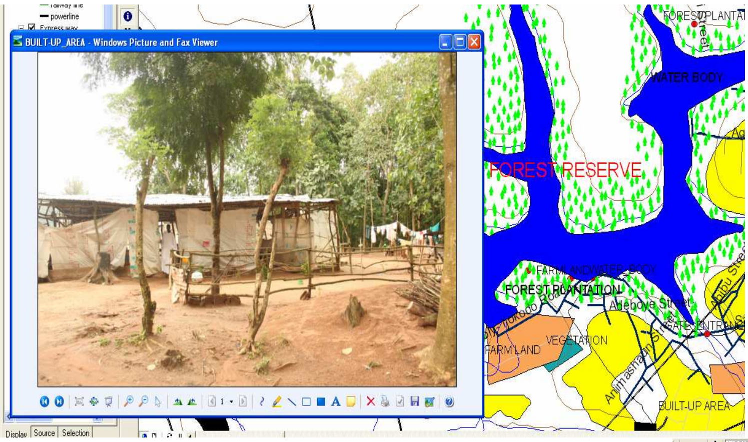
Hot linking refers to attaching detailed information related to photographs and objects. It is done for better visual appreciation of the condition of the study area. Some of the photographs of the forest reserve were attached as query object; thus gives the viewers and the management the picture of what is on the ground.





The photographs of the part of built up area and the farmland is hot linked.

Fig 19&20 shows Eleyele Forest Reserve information System. This was created in Arc GIS software.



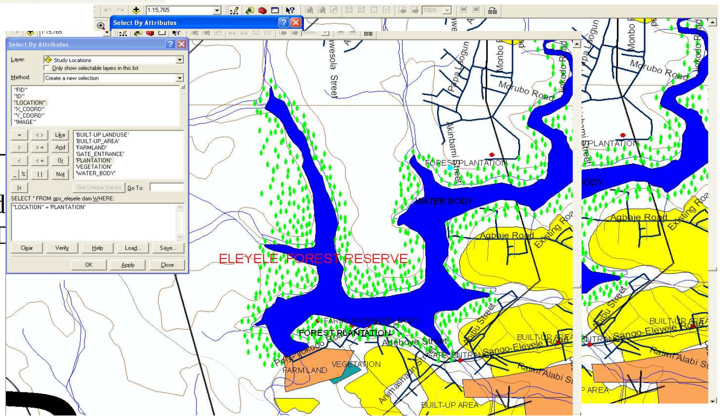


Fig. 19: Query Result and Photograph of built-up area

***Fig. 20:** Query, result and photograph of plantation*

4.7 MARKOV OPERATION

This is simply an operation in which the future state of a system can be modeled purely on the basis of the immediately preceding state. Markov chain analysis described land use change from one period to another and uses this as the basis to project future change. The Markov module under change/time series analysis under GIS analysis of Idrisi 32 was used. The first image (1972) as the earlier image and the second image (2000) as the latter image was inputted. The number of time period between the two images and the number of the projected year from the second image was also inputted. Ten years was used for both numbers of periods.

Table 10: Markov 1972/1984

Given : Probability of changing to :

Given	Cl. 1	Cl. 2	Cl. 3	Cl. 4	Cl. 5
Class 1	0.8140	0.1049	0.0811	0.0000	0.0000
Class 2	0.2015	0.3408	0.2557	0.2021	0.0000
Class 3	0.0000	0.0019	0.1327	0.2366	0.6287
Class 4	0.2450	0.2327	0.2869	0.2353	0.0000
Class 5	0.0000	0.0000	0.0056	0.0000	0.9944

Table 11: Markov 1972/2000

Given: Probability of changing to:

Given : Probability of changing to :

Given	Cl. 1	Cl. 2	Cl. 3	Cl. 4	Cl. 5
Class 1	0.8332	0.1647	0.0000	0.0010	0.0010
Class 2	0.0528	0.9197	0.0275	0.0000	0.0000
Class 3	0.0000	0.1521	0.2162	0.1931	0.4386
Class 4	0.1470	0.8082	0.0392	0.0056	0.0000
Class 5	0.0000	0.0000	0.0022	0.0146	0.9832

4.8 DISCUSSION OF FINDINGS

The 1972, 1984, and 2000 land use / land cover practice in this depleting Eleyele Forest Reserve were determined in order to ascertain the causes of deforestation. Five major classes were identified and classified as the land use/cover of all the five images as follows: built up areas, farmland, forest plantation, vegetation and water body. However, amongst these five major classes, three classes were identified as land use practices that is heavily depleting the reserve; they are built up area i.e. settlement, farmland and degraded forest which is called vegetation in this study. Fig. (4), (5), (6) and (7) illustrate this respectively. Built up area alone account for more than 15% of deforestation in 1972 and up to 25% in year 2000 while farmland account for more than 69.77% of deforestation in year 2000, vegetation account for more than 80% of deforestation in the study area. All these activities were leading to degradation of the forest plantation which is called deforestation.

AREA OF LAND USE / LAND COVER CLASSES LOST TO OTHER CLASSES

It was discovered that there is a large decrease in forest plantation between 1984 and 2000 from 0.8808 hectares of forest plantation (12.5%) to 0.0094 hectares of forest plantation (0.13%) which is a loss of about 0.8714 hectares or 12.37%. Also there was a tremendous decrease in vegetation from 1972 to year 2000 i.e. from 5.8 hectares of land in 1972 to 1.5 hectares in 1984 to 0.04 hectares in year 2000. This is as a result of vegetation classes being converted to farmland.

AREA OF LAND USE / LAND COVER CLASSES GAINED BY OTHER CLASSES

It was found that built up areas, farmland and vegetable increased tremendously in size from 1984 to 2000 (16 years) i.e. for good sixteen years so many buildings were constructed in the reserve, such as churches, mechanic workshop, bricklaying industries; at the same period of time farming activities was on the increase and vegetation size which occurs as a result deforestation was the order of the day. Built up area increased from 0.7762 hectares (11.02%) to 1.7706 hectares (25.14%), farmland area increased from 3.7080 hectares (52.66%) to 4.9127 hectares (69.77%), vegetation area increased from 0.414 hectares (0.59%) in year 2000 to 3.3142 (47%). The annual rate of increase of built up area, farmland area and vegetation was on the positive 0.2, 0.88 and 1.07 whereas the annual rate of increase of forest plantation was on the negative -0.04.

In 1972 vegetation occupied 82.48% of the total land area as a result of a prior harvesting of wood for timber. In 1984 deforestation for farmland took 52.66% of the total land area and contributed most to deforestation. This increase in agricultural activities continued in year 2000.

OVERLAY OF LAND USE MAP FOR CHANGE DETECTION

By overlaying the result of the classification, the maps of the occurred changes between 1972 to 1984, 1984 to 2000 and 1972 to 2000 are resulted as shown in figures 17 and 18. From these maps it can be seen how much of the reserve has been depleted, where the depletion has occupied and the type of land use practice in those area which must have caused the degradation.

Addition, the pattern and spatial distribution of the phenomenon is also illustrated. NDVI values range from -1.0 +1.0 NDVI values between -1.0 and 0 represent non vegetative features such as bare surface, built up area and water body concisely greater than 0 display vegetative cover. In other to find out the changing pattern of vegetation during 1972 and 1984 both images were crossed in Idrisi. Figure 14, 15 and 16. Figure 17 shows both periods of NDVI images 1972 and 1984 it shows that high reflectance of vegetation was seen in 1984 image of the study area with increase in NDVI values. Conversely vegetation reflectance is low in 2000 image likewise in NDVI value.

5.0 SUMMARY AND CONCLUSION

The 1972, 1984, 2000 TM satellite remote sensing data were used to identify, classify assess and interpret Eleyele Forest Reserve Plantation Degradation in North West Local Government of Ibadan in Oyo State of Nigeria. A GIS database of land use / land cover categories and their changes within 28 years (1972-2000) was generated and analyzed. The result showed that in general the forest plantation was retreating due to several anthropogenic activities of man such as illegal felling of wood, farming activities.

The rates at which the reserve is been degraded have made the area a shadow of their former selves. The local communities show that at the rate at which the degradation of the reserve is going on, the conversion of the forest plantation to a bare ground is just a matter of time.

From this study, Land Sat TM data are important sources of imagery data for mapping and monitoring the dynamics of land use / land cover in tropical rain forest.

5.1 RECOMMENDATIONS

Deforestation is not an unstoppable or irreversible process. Increased and concerted efforts in forest plantation 'rebirth' and rejuvenation will bring to use the type of forest reserve we envisaged. In order to reduce the effects of deforestation in Eleyele forest reserve in Ibadan Nigeria the study has the followings as its recommendations:

i. Government by way of policy should be strict in preserving forest reserves from illegal occupation.
ii. The promotion of alternative energy source for fire wood in order to reduce the pressure on the forest.
iii. Development and promotion of trade in non timber forest product to reduce the pressure on timber resources and to enhance rural livelihood.
iv. It is strongly recommended that any form of forest plantation degradation should be stopped forthwith, having realized the purpose for which the reserve was meant for.
v. The available vegetation area and the farmland must be converted into forest plantation of exotic fast growing species.
vi. Lastly, the technology of remote sensing and GIS should be employed in major studies, concerning national issue such as deforestation, desertification etc.

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BIOGRAPHICAL NOTES

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