

Assessment of Spectral Signature of Lagos Coastline Region

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Abstract

The increasing dynamics associated with coastal habitations have necessitated the need for an understanding of the changes that are taking place in this important natural environment. (Turner et al 1996). In recent times there has been an increase in the intensity, rate and rapidity of occurrence of dynamics associated with coastal environments (Passeri et al 2015). In this study, Satellite imageries covering 3 epochs (1986, 2000 and 2016) were utilized. Spectral signatures of Coastline areas in different periods were extracted through the classified features within the ArcGIS software to determine the minimum, maximum, mean and standard deviation of each band and reflectivity of each feature. The study shows spectral signature dynamics of Lagos coastline region are assessed. Also, change dynamics was carried out to see the obvious changes that had happened along the coastal region of Lagos.

I. INTRODUCTION

➤ Background

Coastline is the line of contact between land and the water body and constitute one of the most important linear features on the earth's surface, which has a dynamic nature (Winarso, et al., 2001). The coastline is the bridge between aquatic life and terrestrial life, and usually a fragile ecotone, which makes studies on coastline changes to be of immense benefit to the understanding of complex coastal ecosystems (Moore, 2000). Coastlines are widely used as ports for navigation and maritime commerce and are of economic value and critical to the socio-economic development of non-land-locked nations.

Coastline changes often result in erosion of coastal areas or accretion of sediments, depending on the dominant processes acting on the coastline. Human activities such as dredging, construction of breakwater infrastructure and physical development; mineral exploration, ports beach construction, removal of backshore vegetation, construction of barrages and coastal control impact coastal dynamism.

It should be noted that the changes in the coastline largely depend on its geology and geomorphology, tidal waves characteristics, changes in sea-level, and sediment transport by longshore currents. (Cowell and Thom 2006).

Several methods have been employed to study and monitor coastlines, which include traditional methods that

incorporate local observations and basic surveying techniques, historical coastline mapping and profiles, among others. (Chen 2003)

Other more recent methods include simulation of coastline changes using numerical models; combination of coastline survey using Global Positioning System (GPS) receivers; long-shore sediment transport using numerical modeling packages such as MIKE21 and LITPACK and airborne Light Detection and Ranging (LIDAR) survey methods. (Chen 2003). All these methods can be used with varying accuracy to determine the position of the coastline at specific time periods and to detect coastline changes over time. The use of satellite remote sensing techniques and geographic information systems (GIS) for the identification, mapping and analyses of coastline changes have gained prominence in recent years as high-resolution satellite data have become more readily available.

Long-term studies of coastline evolution involve the comparative study of the key points in the coastline over several periods of time and often involve the prediction of their future positions. Many coastal management programs have been assuming that long-term coastline change proceeds at a steady pace and consequently use average change rates. Although more recent empirical analyses show that coastline evolution is a more complex process and rarely follows a steady pattern (Zheng and Dean, 1997), the most reliable forecasting models are still based on the calculation of annual change rates. Several statistical methods are available to estimate annual erosion rates and forecast coastline positions such as endpoint

(EP), linear regression, time series analysis, and geostatistics. But the lack of a standard method for coastline displacement analysis among coastal scientists has resulted in the publication of a variety of data utilizing non-comparable measurement techniques and rate of change calculations that can be a problem comparing coastal changes from regional to national scales (Thieler and Danforth, 1994). In other words, different methods may lead to significantly different results.

In spite of the continuous improvements in coastline dynamics, assessing the spectral signature has proven to be a unique method of determining changes which has occurred.

Remote sensing plays an important role for spatial data acquisition from an economical perspective (Alesheikh, et al., 2003). Optical images are simple to interpret and easily obtainable. Furthermore, absorption of infrared wavelength region by water and its strong reflectance by vegetation and soil make such images an ideal combination for mapping the spatial distribution of land and water. These characteristics of water, vegetation and soil make use of the images that contain visible and infrared bands widely used for coastline mapping

(DeWitt, et al., 2002). Examples of such images are TM (Thematic Mapper) and ETM+ (Enhanced Thematic Mapper) imagery (Moore, 2000). Furthermore, a new semiautomatic approach for coastline extraction from TM and ETM+ imagery has been developed and presented.

Nigerian coastal littoral area comprises of more than 5,000 rural communities whose occupations include fishing, farming art and craft and petty trading (Fabiya and Oloukoi 2012). The activities of the rural coastal communities are affected by the changes in the coastal ecosystem since most of the population depend on nature for their survival. The coastal ecosystem is affected by several complexes and inter-connected physical, chemical, anthropogenic and biological processes occurring in the atmosphere, land and ocean. Some of these processes can be monitored in short term while others can only be assessed in climatic times at least over 35 years. The processes ultimately lead to modifications of coastal ecosystem, coastal morphology and coastal land masses.

Lagos coastal landscape is dynamic due to several natural and anthropogenic processes, because of varied processes that influence vegetation nutrients, plant productivity, soil fertility, water quality, atmospheric chemistry and many other local and global environmental conditions. Nigeria has a coastal stretch of about 853 kilometers which transverses different sub local ecosystem types and communities of diverse occupational and cultural orientation. Lagos coast belongs to the barrier coast section of the Nigerian coastline, and it comprises of the down drift side of the natural inlet into the Lagos Harbor, it also includes the Marina section, the Lagos Bar Beach section, Lagos harbor and The Eko Atlantic. The Eko Atlantic is believed to be another possible flagrant pressure to affect the Lagos coastline, it tends to be a

luxurious asset for now but poses future threat to the coastline of Lagos as a reclaimed land which has transformed marine and environmental impact assessment of the region.

➤ *Statement of Problem*

Current environmental debate, concern climate, together with predictions of causes and effects; especially with respect to coastal sea level rise and with notable consequences for management of beaches and coastal zones is of great concern. Coastal zones are often viewed as permanent assets, but they tend to be dynamic, responding to human activities and natural processes (Li 1998).

Kutchen (2010) observed further that these activities appear to conflict with one another and with the natural processes, thus disturbing the habitat and aggravating coastal erosion as observed along Lagos coastline.

Lagos coastline region provides a place of abode and recreation, means of livelihood and transport, dumpsite for residential and industrial discharges and a natural shock absorb to balance forces within the natural ecosystem.

The situation of Lagos coastline Region is becoming unbearable and pathetic; a vivid example is the gradual disappearance of open spaces, interesting scenery, pedestrian walkway, trees, shrubs, flowers and grasses being cut down, also the issue of seasonal and persistent flooding, ineffective waste management system, inadequate water, shipwrecks, sand mining activities, indiscriminate fishing activities are some of the characteristics that translate into the devastating effects on the Lagos coastline region. (Okude 2002)

Studies by the Nigerian Institute of Ocean and Maritime Research (NIOMR) on Lagos Coastline studies revealed that the barrier coastline in the western extremity housing the high real estate at Victoria Island and Lekki could lose well over 584- and 602-kilometer square of land from erosion and inundating and completely submerge the entire coastline system. Such an adverse impact will affect the residential. Commercial and tourist facilities in these areas, which are valued at well over 12 billion dollars. Already, an occurrence of 0.2 meters of sea level rise resulted in a loss of 3400-kilometer square of landmass to flooding. This is projected to affect about 18400-kilometer square of land with a 1-meter sea level rise.

The entire landscape of Lagos Coastline is changing rapidly, thus the need to monitor landscape changes is paramount, hence remote sensing becomes a common tool.

Remote sensing is the science (and to some extent, art) of acquiring information about the Earth's surface without being in contact with it. This is done by sensing and recording reflecting or emitted energy and processing, analyzing, and applying that information (Campbell 1987).

Remote sensing technique allows for observation and measurement of coastline without direct contact. The most widely used are aerial photographs taken from airplanes at relatively low speed and steady altitude. Aerial photographs can provide two or three-dimensional measurements and have the advantage of covering much larger areas than ground survey methods. Aerial photographs should be considered as historical records, since they represent objects at a given location at a precise time. But they also have some disadvantages, since they can only be taken in daylight and through clear skies (which makes them weather dependent), cannot properly represent objects in motion, and they require rectification to compensate for image distortions (Ritchie et al, 1988). Infrared aerial photography technology can capture images beyond the reach of the human eye. It is useful for coastline mapping. Over the last two decades there has been an increasing use of satellite imagery. Landsat and Spot and one-meter resolution Ikonos satellite images can be used to generate relatively accurate Coastal Terrain Models (CTM) (Li 1998).

Thus, Spectral signature can be used to determine the change dynamics that have occurred in Lagos coastline region, the knowledge of Spectral signature would enable us to know the feature which has changed, for instance, has waterbodies area has turned to an industry,

Each feature has its unique spectral number and by comparing the response pattern of each feature, we may be able to distinguish between features of both sensed images and notice the changes.

➤ *Significance of Study*

Coastline position changes can significantly affect human activities (Frihy and Lotfy, 1994). Some of the most obvious causes of coastal change are the sinking of lowlands due to subsidence, the silting and closure of ports, or the losses of land due to coastal currents. Human societies can create negative impacts of their own, such as the installation of heavy equipment and permanent infrastructure (such as roads and ports) along unstable coastlines, the extraction of underground resources in areas with propensity to subsidence, and the development of industries and residences in environmentally sensitive areas. The real importance of such studies is to avoid decisions based on insufficient knowledge, wrong assessments or arbitrary decisions, leading to losses in resources and infrastructure that could have been prevented.

Coastal behavior must be understood to avoid the mistakes of the past and ensure that the best uses will be selected for each place. Every step towards a better understanding of the dynamics of the Lagos coastline systems and forecasting its changes with the purpose of assisting in future developments will be one more step in the right direction.

The economic impact of coastal erosion processes across Nigeria is very significant. The Federal Emergency Management Agency estimates that the aggregated costs

related to erosion amounted to \$530 million/per year for homeowners on the coast (FEMA, 2000). The National Flood Insurance Program has been paying an average of \$80 million per year for erosion related damage. For many years, the main objective of research dealing with the reduction of economic losses caused by erosion in coastal zones was to decide which solution would be the most appropriate (Morton,1991).

➤ *Aim and Objectives*

• *Aim*

The aim of the research is to assess the spectral signature dynamics of the Lagos coastline region.

• *Objectives*

The objectives of the research are:

- ✓ To identify and map out the spectral signature of satellite images along Lagos coastal region between 1986 to 2016
- ✓ To relate the spectral signature to various landuse and landcover along Lagos coastline region for the study period 1986 to 2016
- ✓ To examine the dynamics of the various spectral signatures and associated classification between 1986 to 2016

➤ *Scope of Study*

The study focuses basically on the changes in spectral signature dynamics as a strong indicator for coastal disturbance influencing sea-level rise in Lagos and global environmental change. It also focuses on the effects of anthropogenic activities on the coastline resources, land and coastline degradation and its vulnerability to the human community around the study area.

➤ *Limitation to the Study*

The geometric complexity and fragmented patterns of coastlines tend to be a limitation to the study, other possible limitations are:

- The lack of timely coverage,
- The lack of geometrical accuracy unless ortho-rectified,
- The expense of the analytical equipment,
- The intensive nature of the procedure,
- The need for skilled personnel.

➤ *Study Area*

Lagos State is located approximately between longitude 20°42' and 30°22' and 30° 22'E and Latitude 10°22' and 60°42'N. The Lagos coastline region is considered a passive margin, having the characteristic element of an old geomorphologic structure. Major traits include the low gradient plains, a wide continental shelf with low slope, stable tectonics, fine and abundant sedimentation, and composite landforms of deltas and extensive barriers islands that cover more than 80 percent of its length. The relative location of a coastal system also influences its geomorphologic processes. The dominant movements in the atmosphere and the ocean determine the

intensity of currents, waves, tidal regime, and coastal and offshore ecology (Short, 1999).

It is firmly located within the tropical rainforest with well amplified vegetal classification ranging from saltwater swamp to margins of freshwater swamp. It also has a well extended coconut (sand) beach, especially along the Lekki Peninsula. Geomorphological, Bar beach has largely been controlled by coastal dynamics like intense wave climate consisting of plunging waves reaching an average of 1.5m high and semi diurnal tides with tidal range of 1m as well as longshore currents and the absence of large rivers discharging into the sea (Awosika and Folorunsho, 2011). It falls within two geological zones: Coastal sands and recent deposits. Climatic conditions are grossly affected by the oceanic atmospheric interactions and the movement of the ITCZ (Inter Tropical Convergence Zone). Awosika and Folorunsho, (2011) further noted that the movement of the ITCZ is associated with the warm humid Maritime Tropical (MT) air mass with its south-western winds and the hot and dry

continental (CT) air mass with its dry north easterly winds. To this end, the mean monthly temperature is about 30°C while the mean annual rainfall is 2000mm . Humidity is very high, 90-98% but the increasing high level of urbanization results in thermal discomfort, most especially in the metropolitan areas during the hot months. Water and wetlands cover over 40 percent of the total land area of the state and another 12 percent of the remaining 60 percent is subject to flooding. Sunshine hours in Lagos range between 3 hours every day in July, August and September and 6:43hours for every day in December. The longest day of the year is 12.22 hours long and the shortest day is 11.37 hours long. The longest day is 0.45hour longer than the shortest day. There is an average of 1885 hours of sunlight per year (of a possible 4383) with an average of 5.09 hours of sunlight per day. It is sunny 43% of daylight hours. The remaining 57% of daylight hours are likely cloudy or with shade, haze or low sun intensity. At midday the sun is on average 74.6°c above the horizon at Lagos (National Oceanic and Atmospheric Administration, 2016).

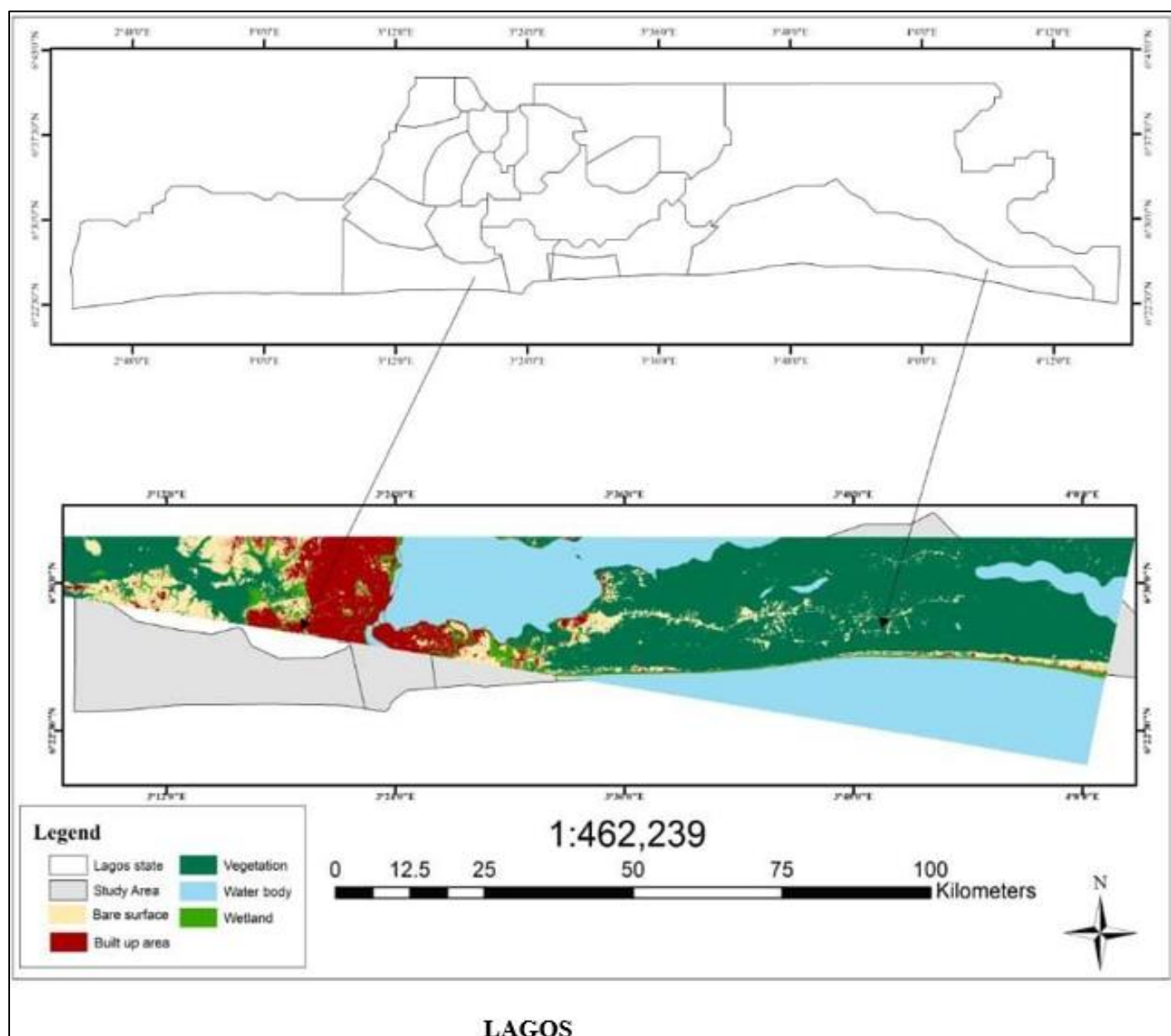


Fig 1 Study Area Map (Lagos Coastline Region- Ojo to Epe)

II. RESEARCH METHODOLOGY

➤ Methodology

The procedure adopted in this research entails description of spectral signature dynamics and the varied land use land cover dynamics of the study area over the studied period (1986-2017) as detailed in Fig 2

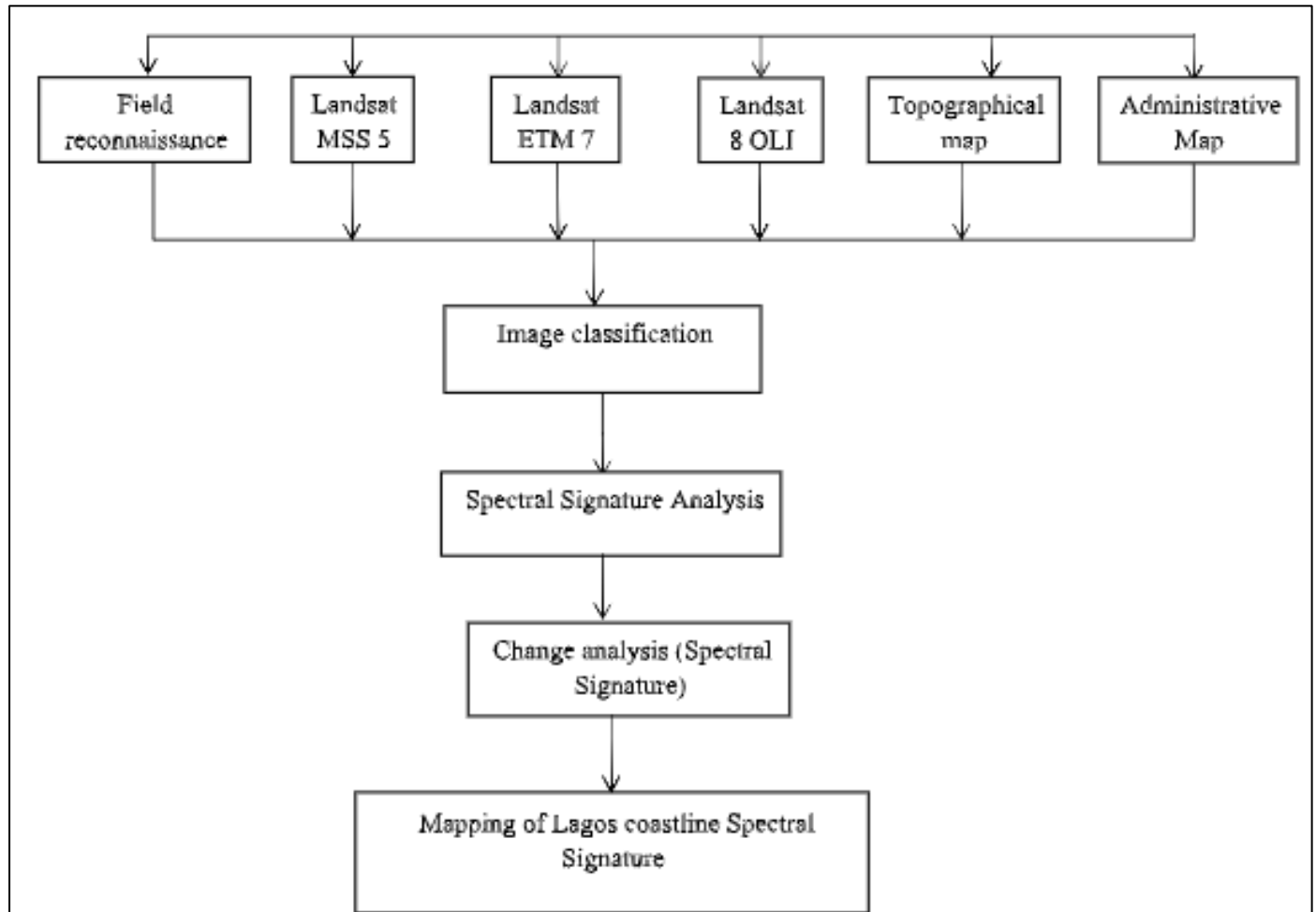


Fig 2 Research Methodology

➤ Data source

Spatial data used in this study are majorly Landsat imageries which were acquired for three epochs namely, 1986, 2000 and 2016 from the United States Geological Survey (USGS). The imagery was used to produce spectral signatures and schematic layers for the studied period, to identify the varied spectral dynamics in the study area. Table 3.1 shows the data used and their characteristics.

Table 2 Data Characteristics

Type	Path/Row	Acquisition Date	Resolution	Source
Landsat 5 MSS	191/055	24/12/1986	30m	USGS
Landsat 7 ETM	191/055	00/00/1998 07/12/2006	30m	USGS
Landsat 8 OLI	191/055	10/02/2016	30m	USGS

• Software Used

The software used for this research was ArcGIS 10.3, after the images were downloaded and unzipped, the software was launched and the metadata files for the individual years were added, the metadata file contained Multispectral, Panchromatic, Pan-sharpen and Thermal, the Multispectral was selected as it contained all the bands for the research. After this was done, the training samples

(region of interest) was created based on the prior knowledge about the study area and this was done by clicking image classification icon on the tool box, then training samples, after this was done, the features were represented, the features include; Water, Bare Surfaces, Built up Areas, Vegetation and wetlands using Andersons classification scheme as shown in Table 3, the represented features were saved.

Table 3 Land use Land cover

LULC Category	Mapping unit description	Reflectance	Code
Built-Up Area	All residential, commercial, transportation, industrial areas, infrastructure and institutions	Red	1
Wetland		Light green	2
Water Body	River, permanent open water, lagoon, lake canals etc.	Blue	3
Bare Surface	Earth and sand land infillings, construction sites, excavation sites, solid waste landfills open space and exposed soil.	Brown	4
Vegetation	Land covered with scattered vegetation, natural vegetation, thick trees, fallow land for the purpose of agriculture, flowers and grasses	Green	5

Source: modified from Anderson 1967

➤ Data Processing

• Bands Combination

For the research, band 7 4 2 (Far infrared, near infrared, Green) of Landsat 5 and Landsat 7 were used as composite bands for each year 1986 and 2000 respectively; while bands 8 5 4 (Far infrared, near infrared, Red) were used for Landsat 8 for the year 2016.

• Image Classification

For the classification of the image, supervised classification technique was used, and Maximum Likelihood classifier was used, this classifier was chosen because it considers the average and covariance of the class signatures when assigning each cell to one of the signatures represented in the signature file. For the classification to occur, the regions of interest were saved as signature file which was imputed into the maximum likelihood classification drop box, then the command was executed. However, the regions of interest signature file created were in raster format.

The statistics were obtained by clicking the Training Sample Manager and the region of interests highlighted, then the statistics icon was clicked and the table showing the minimum value, maximum value, mean value, standard deviation and DN values was saved.

• Spectral Signature Analysis

The spectral signature class was classified through the individual signature files created from the various bands of the satellite image. The signature files were explained through the different DN values which have the result of the observable reflectance on the band of the image; this is because the spectral reflectance of the satellite image is a direct response to the digital number, hence inference was made on it.

• Mapping of Lagos Coastline Signature

After the analysis had been carried out, symbology was done, this was to design the map to my specification by changing the colors. After this was done, the image was exported.

➤ Method of Data Analysis

• Overlay Analysis

The method of analysis carried out for this study was **overlay** operations, this was done by adding both the 1986

and 2000 polygon (vector) layers on same ArcGIS 10.3 environment, then the two polygons were appended together by intersection, this showed how the feature had changed from what it was in the previous year to what it is in the current year, same was done for the years 2000 and 2016.

• Change Detection

The spectral signature values for each of the epochs were computed and differences in the values between the 3 years under study were analyzed. This analysis was to show the losses and gains in the spectral signature between 3 years.

$$CD = S_p T_2 - \Delta S_p T_1$$

Where

$$S_p T_1 = \text{Initial year } S_p T_2 = \text{Later year.}$$

III. DATA ANALYSIS AND PRESENTATION

➤ Spectral Signature Distribution along Lagos Coastline Region

• Spectral Signatures Distribution of 1986

Spectral signatures distribution as shown in figure 3.1 across various bands of 1986 Landsat imagery depicts that in band 1, the features are closely inseparably built-up area reflected more than others with 0.574, followed closely by bare surface with 0.528, then wetland with 0.501, followed closely by water body with 0.494 and lastly by vegetation with 0.491. In band 2, built up area had the highest reflectivity of 0.542, followed by bare surface with 0.471, then wetland with 0.426, followed by water body with 0.418 and lastly by vegetation with 0.417. In band 3, built up area had the highest reflectivity of 0.667, followed by a water body with 0.604, closely followed by 0.585, then vegetation with 0.568 and lastly, wetland with 0.479. In band 4, built up area still maintained highest surface reflectance with 1.906, followed by water bodies with 1.874, closely followed by vegetation with 1.722, then Bare surface with 1.684 and finally, wetland the least with 1.266.

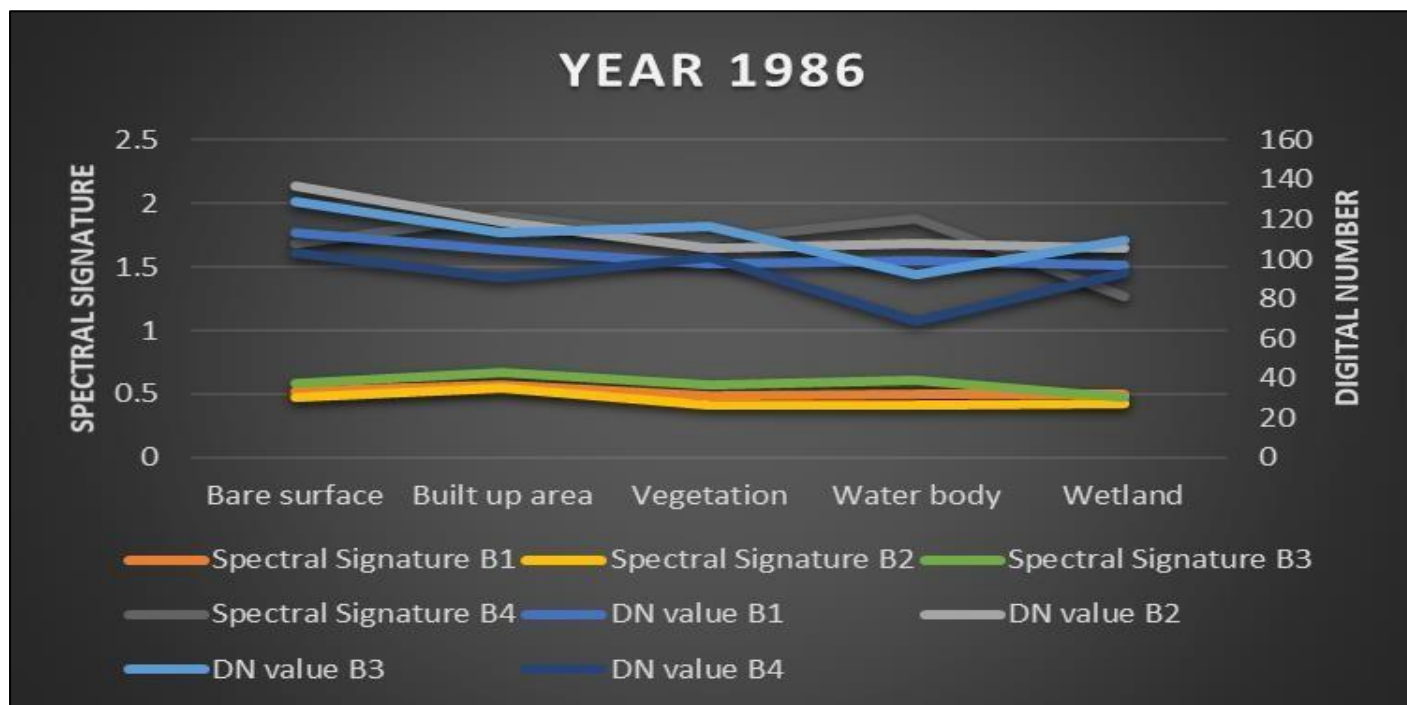


Fig 3 Digital numbers and Spectral Signatures of 1986 Landsat Bands

Fig 3 shows the spectral signatures of 1986 Landsat bands. Clearly, in band 4 the features are a bit more separable than other bands and all the features are above surface reflectance and in band 1 the features are all joined.

➤ Spectral Signatures Distribution of 2000

Spectral signatures distribution as shown in figure 3.2 across various bands of 2000 Landsat imagery depicts that in band 1, the features are closely inseparably where bare surface reflected more than others with 0.202, followed closely by built up area with 0.195, then wetland with 0.188, followed closely by water body with 0.187 and lastly by vegetation with 0.182. In band 2, bare surface had the highest reflectivity of 0.187, followed by built up area with 0.173, then wetland with 0.166, followed by water body with 0.157 and lastly by vegetation with 0.156.

In band 3, bare surface had the highest reflectivity of 0.189, followed by built up area with 0.168, then wetland with 0.149, followed by water body with 0.141 and lastly by vegetation with 0.139. In band 4, vegetation had the highest surface reflectance with 0.236, followed by wetland with 0.235, closely followed by bare surface with 0.230, then built up area with 0.182 and finally, water body the least with 0.126. In band 5, bare surface had the highest reflectivity of 0.275, followed by built up area with 0.183, then wetland with 0.170, followed by vegetation with 0.153 and lastly by water body with 0.076. In band 6, bare surface maintained the highest reflectivity of 0.230, followed by built up area with 0.150, then wetland with 0.093, followed by vegetation with 0.077 and lastly by water body with 0.051.

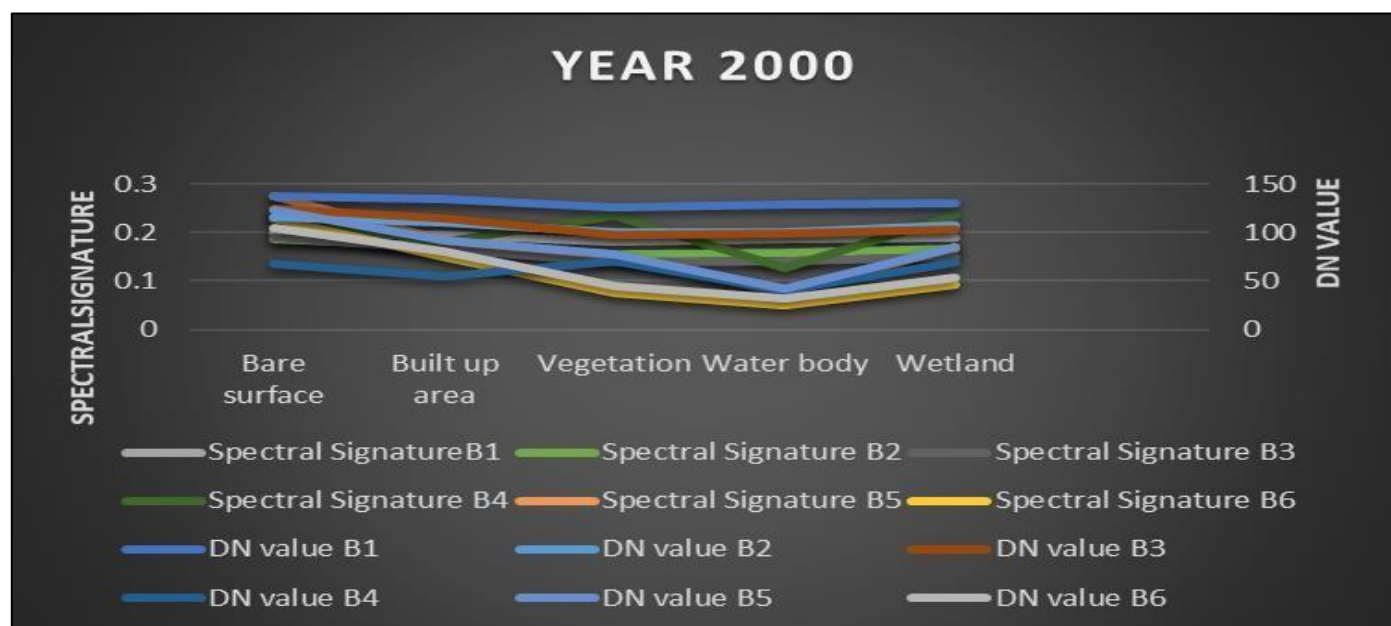


Fig 4 Digital Numbers and Spectral Signatures of 2000 Landsat Bands

Fig 4 shows the spectral signatures of 2000 Landsat bands. Clearly, in band 6 the features are clearly separated ranging from 0.05 to 0.23, the water body been the least and bare surface the highest. Features in band 5 are also separable than in band 4, built up area and water body are more separable than other features. In band 3, bare surface and built-up area are separable than other features but in band 1 and 2, all the features are inseparable and are above surface reflectance of 0.10.

➤ *Spectral Signatures Distribution of 2016*

Spectral signatures distribution as shown in figure 3.3 across various bands of 2000 Landsat imagery depicts that in band 1, the features are close where water body reflected more than others with 0.220, followed closely by wetland with 0.216, then vegetation with 0.197, followed closely by built up area with 0.194 and lastly by bare surface with 0.186. In band 2, wetland reflected more than others with 0.212, followed closely by water body with 0.185, then vegetation with 0.184, followed closely by built up area with 0.180 and lastly by bare surface with 0.171. In band 3, wetland reflected more than others with 0.214, followed

closely by water body with 0.170, then built up area with 0.163, followed closely by vegetation with 0.158 and lastly by bare surface with 0.149. In band 4, wetland reflected more than others with 0.230, followed closely by water body with 0.171, then built up area with 0.150, followed closely by vegetation with 0.138 and lastly by bare surface with 0.130. In band 5, wetland reflected more than others with 0.287, followed closely by bare surface with 0.275, then built up area with 0.234, followed closely by water body with 0.199 and lastly by vegetation with 0.118. In band 6, wetland reflected more than others with 0.337, followed closely by water body with 0.208, then built up area with 0.168, followed closely by bare surface with 0.159 and lastly by vegetation with 0.072. In band 7, wetland reflected more than others with 0.318, followed closely by water body with 0.184, then built up area with 0.105, followed closely by bare surface with 0.081 and lastly by vegetation with 0.050. In band 8, wetland reflected more than others with 0.0012, followed closely by built up area with 0.0011, then water body with 0.0011, followed closely by bare surface with 0.0011 and lastly by vegetation with 0.0009.

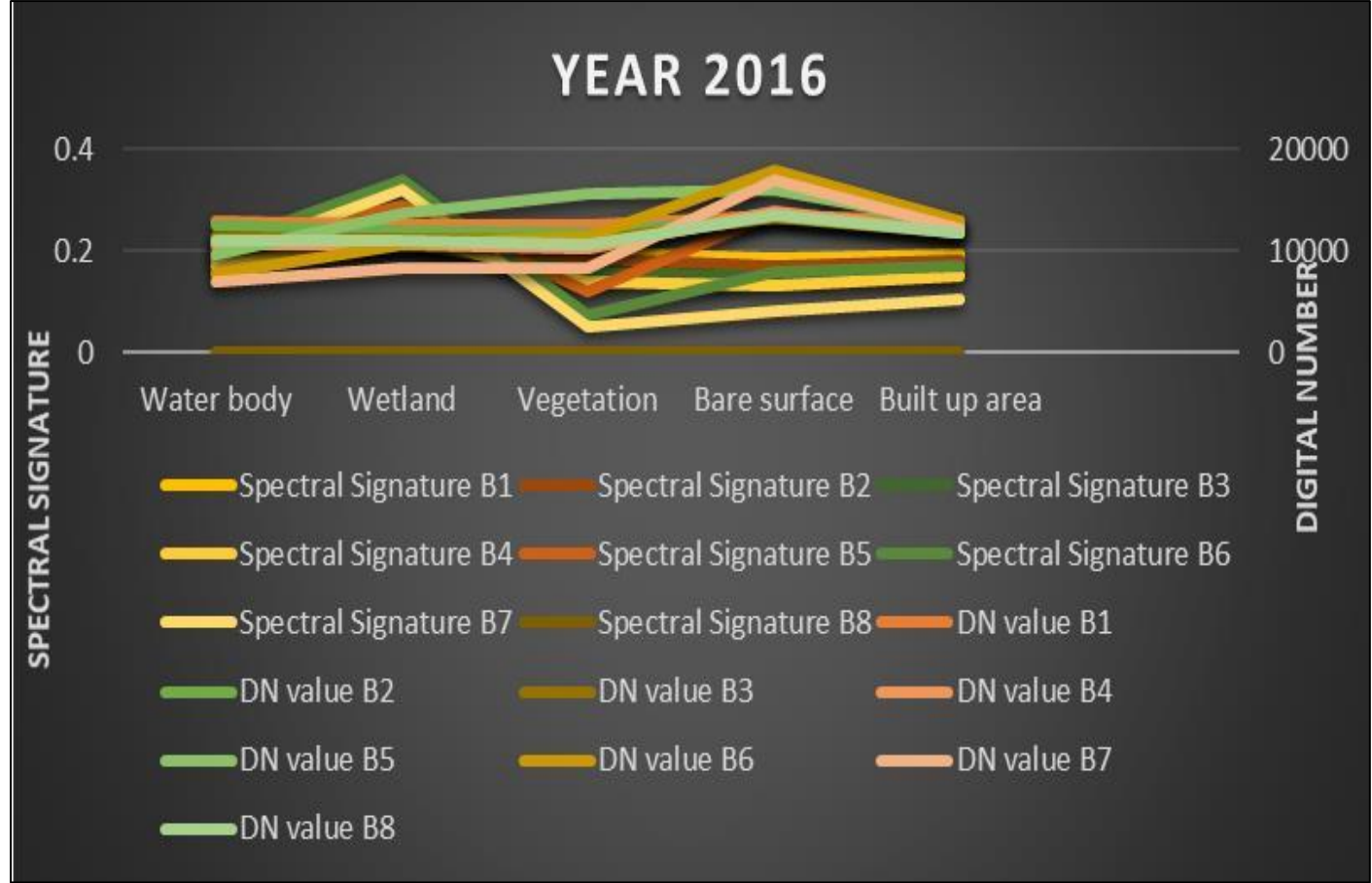


Fig 5 Digital Numbers and Spectral Signatures of 2000 Landsat Bands

Figure 5 shows the spectral signatures of 2016 Landsat bands. Clearly, in band 7 the features are separated and range from 0.05 to 0.33 where wetland is the highest and vegetation is the lowest, then in band 6, the features are separated except for bare surface and built-up area that are inseparable. Then in band 5, vegetation, water body and built-up area are separated but bare surface and wetland are inseparable but in band 4, water body and

wetland are separable but built-up area, bare surface and vegetation are inseparable. In band 3, wetland is separable from other features. Also in band 2, wetland is separable from other features and in the band 1, water body and wetland are inseparable from other features which are closely joined together and finally, in band 8 and all the features are all joined.

➤ Relationship between the Spectral Signature and Landuse

• Land use Land cover of 1986

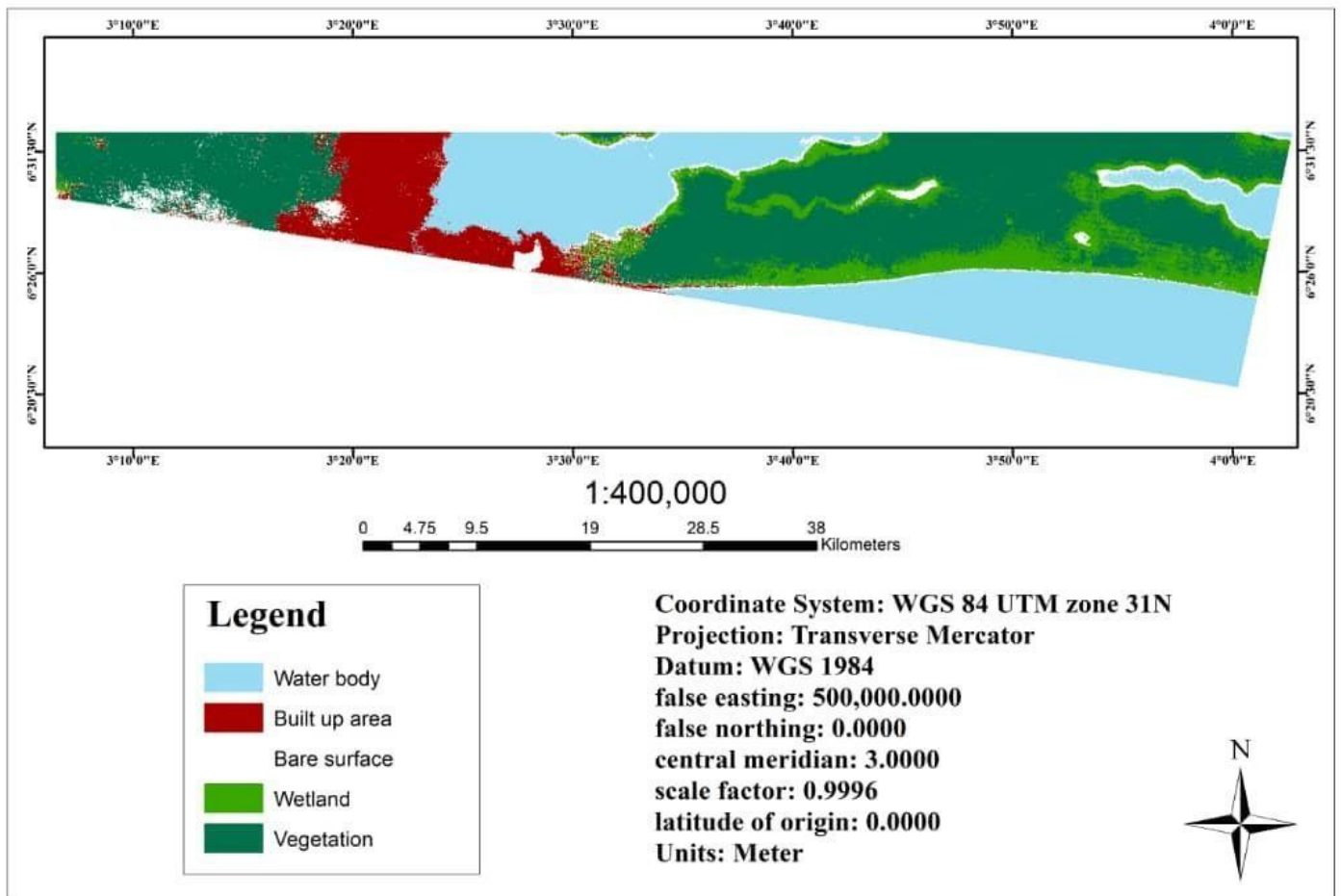


Fig 6 Landuse Landcover Map of 1986

As shown in figure 6, the wetland feature covers a total of 19.8% (106.68), vegetation covers 30.2% (162.3), built up areas cover 15.5% which is (83.4), bare surfaces cover 1%(5.3) and water body covers 33.5% (180.17). the minimum, maximum, mean and standard deviation values are shown in table 4 below.

Table 4 Minimum, Maximum, Mean and Standard deviation for year 1986

Band	Minimum	Maximum	Mean	Standard Deviation
Red	0	113	45.51	44.48
Green	0	142	56.03	53.93
Blue	0	153	57.52	54.92

- Land use Land cover of 2000

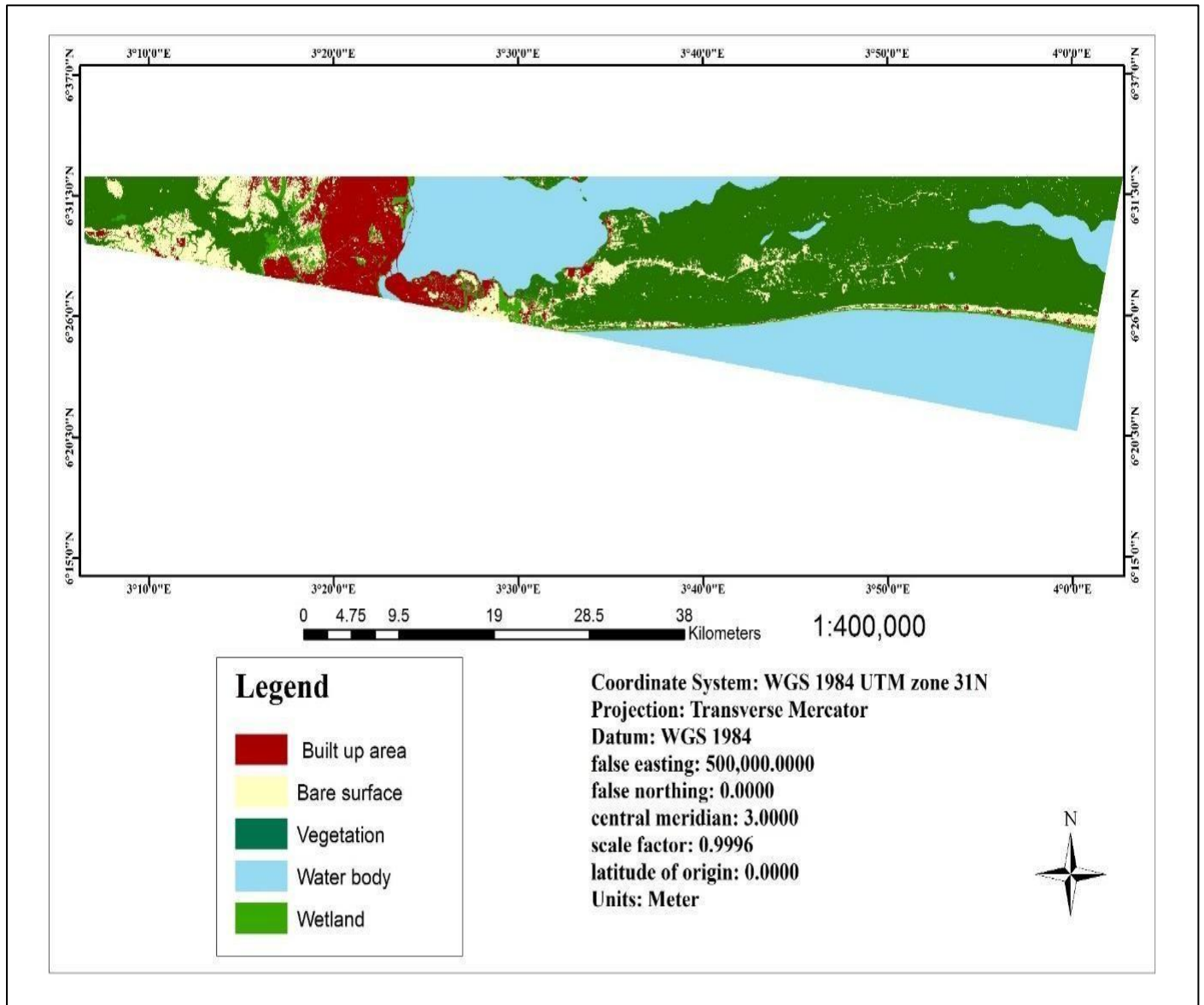


Fig 7 Landuse Landcover Map 2000

As shown in figure 7, the wetland feature covers a total of 10.5% (56.29), this is a decrease from the initial 19.8% of the year 1986, this shows that the wetland is gradually degrading, vegetation covers 26.8% (144.3), also there is a loss of vegetal covers, rebuilt up areas cover 18.1% which is (97.5), unlike the previous features, built

up areas increased, this is as a result of construction and urbanization, thus the area becoming dense, bare surfaces cover 8.6%(46.04) and water body covers 36.0% (193.83), the minimum, maximum, mean and standard deviation values are shown in table 5 below.

Table 5 Minimum, Maximum, Mean and Standard deviation for year 2000

Band	Minimum	Maximum	Mean	Standard deviation
Red	0	149	76.61	43.51
Green	0	132	77.17	44.41
Blue	0	151	96.12	56.23

- *Land Use Land Cover of 2016*

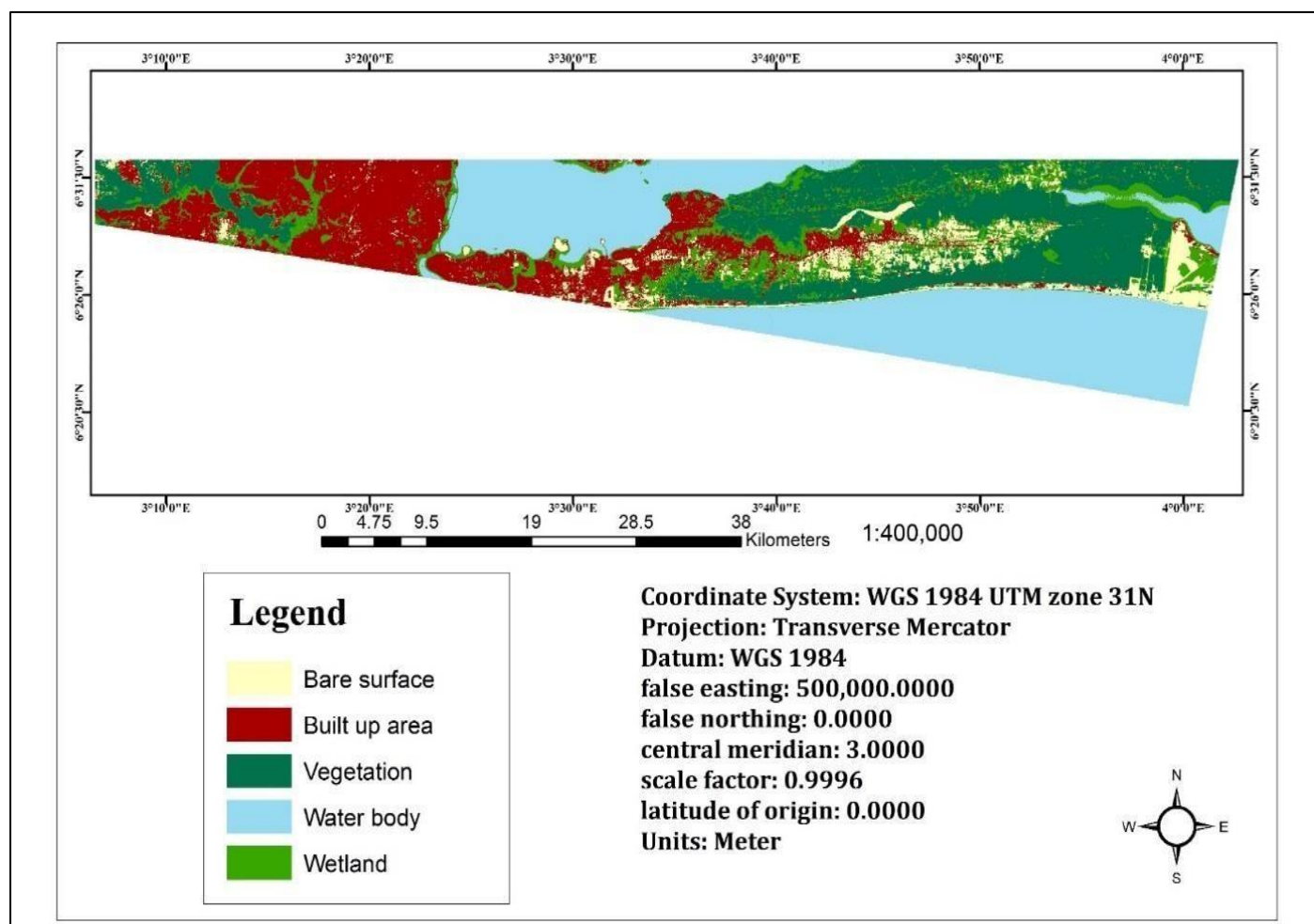


Fig 8 Landuse Landcover Map of 2016

As shown in figure 8, the wetland feature covers a total of 10.4% (55.72), vegetation covers 24.7% (133.07), also there is a loss of vegetal covers, rebuilt up areas cover 22% which is (118.36), built up areas increased at the rate

of 4% thus, the area is more dense than it was in the year 2000, bare surfaces cover 8.8%(47.17) and water body covers 34.1% (183.72), the minimum, maximum, mean and standard deviation values are shown in table 6 below.

Table 6 Minimum, Maximum, Mean and Standard deviation for year 2016

Band	Minimum	Maximum	Mean	Standard Deviation
Red	0	15673	11952	3177.82
Green	0	15952	11453.96	3052.96
Blue	0	16095	10638.05	2851.20

➤ *Change Dynamics of Spectral Signatures.*

- *Changes in Spectral Signatures from 1986 – 2016*

Table 3.4 and figure 3.7 represent the changes, gain and loss of land cover spectral signatures from 1986 – 2016. The areas along Lagos coastline are urban and to obtain urbanization certain spectral signatures represented by features are being converted from one land use or land cover to another. Owing to this fact, giving some features a negative sign indicates reduction or conversion. Conversion in the sense that nothing was lost. Table 3.4 shows that wetland as a land cover reduced over the years by 36.8% from 1986 – 2000 and by 1.3% from 2000 – 2016. Also, vegetation as a land cover reduced over the

years by 13.2% from 1986 – 2000 and by 25.7% from 2000 – 2016 this decline is because of anthropogenic activities as well as water body which was on the declining end from 2000 – 2016 by 23% but on the gaining end from 1986 – 2000 by 10%.

However, built up area as a land use increased over the years by 10.3% from 1986 - 2000 and by 47.4% from 2000 – 2016 which makes it the highest gainer, followed by bare surface which gained by 29.7% from 1986 - 2000 and by 2.6% from 20000 – 2016. Both bare surface and built-up areas gained over the year which indicate a character of urban growth and a typical character of most coastal regions.

Table 7 Changes in Spectral Signature from 1986 – 2016

Spectral Signature	1986		2000		2016		Changes 1986-2000	Changes 2000-2016	Changes 2016 and 1986
		% change		% change		% change			
Wetland	106.68	19.8	56.29	10.5	55.72	10.4	-50.39	-0.75	-50.96
Vegetation n	162.3	30.2	144.33	26.8	133.07	24.7	-17.97	-11.26	-28.23
Built up areas	83.4	15.5	97.5	18.1	118.36	22.0	14.1	20.86	34.96
Bare Surface	5.3	1.0	46.04	8.6	47.17	8.8	40.74	1.13	41.84
Water body	180.17	33.5	193.83	36.0	183.72	34.1	13.66	-10.11	3.55

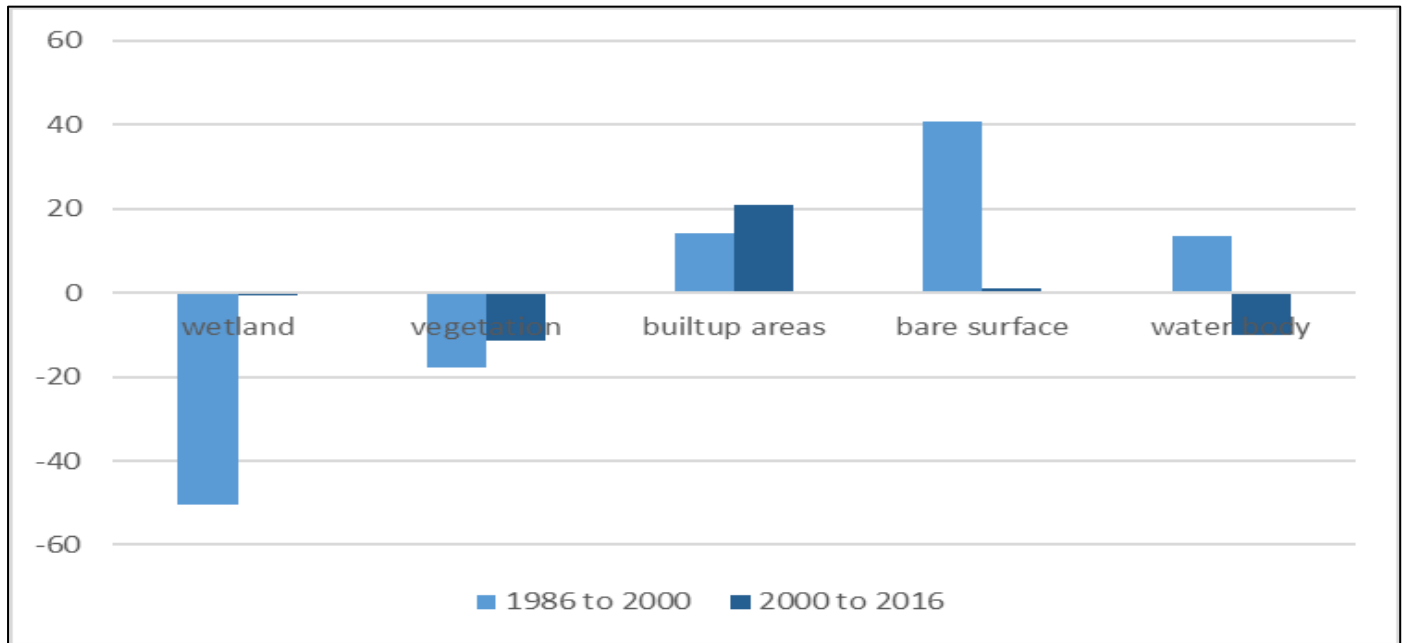


Fig 9 Changes from 1986 – 2016

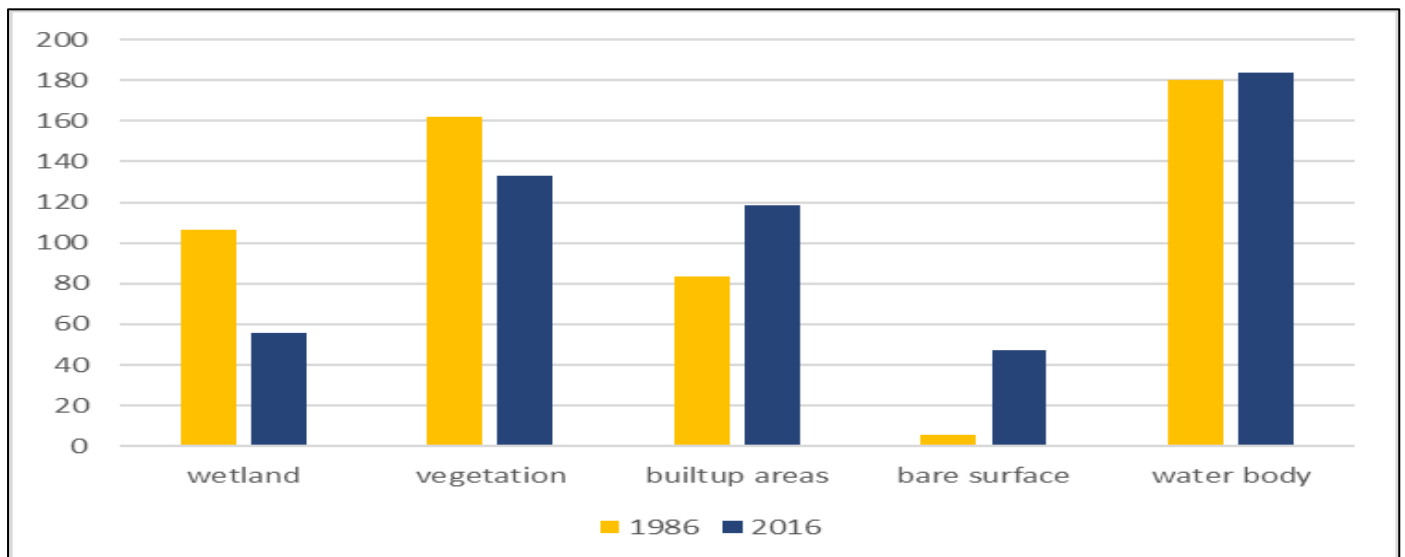


Fig 10 Changes from 2016 and 1986

- *Changes in Spectral Signatures from 1986 – 2000*

From figure 10 which reveals that between 1986 – 2000, wetland and vegetation decreased 36.8% and 13.2% respectively, loss of these land cover was because of demand

of residents, constructions of infrastructures and others to meet the ever-increasing population. Built up area also gained 10.3%, while water body gained 10%, and bare surface the highest gainer amounted to 29.7% from other land covers

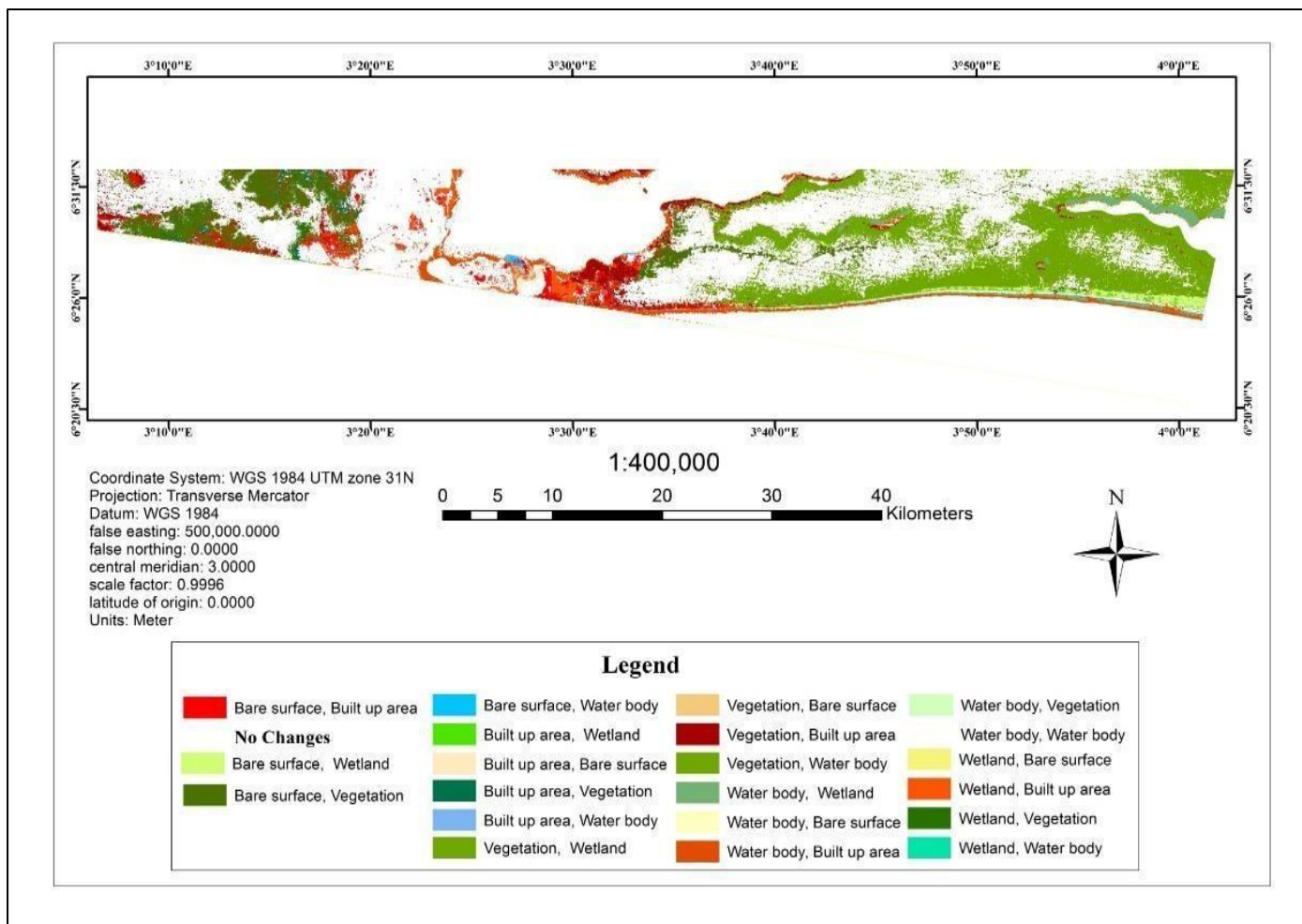


Fig 11 Map Showing the Spectral Signature Changes from 1986 – 2000

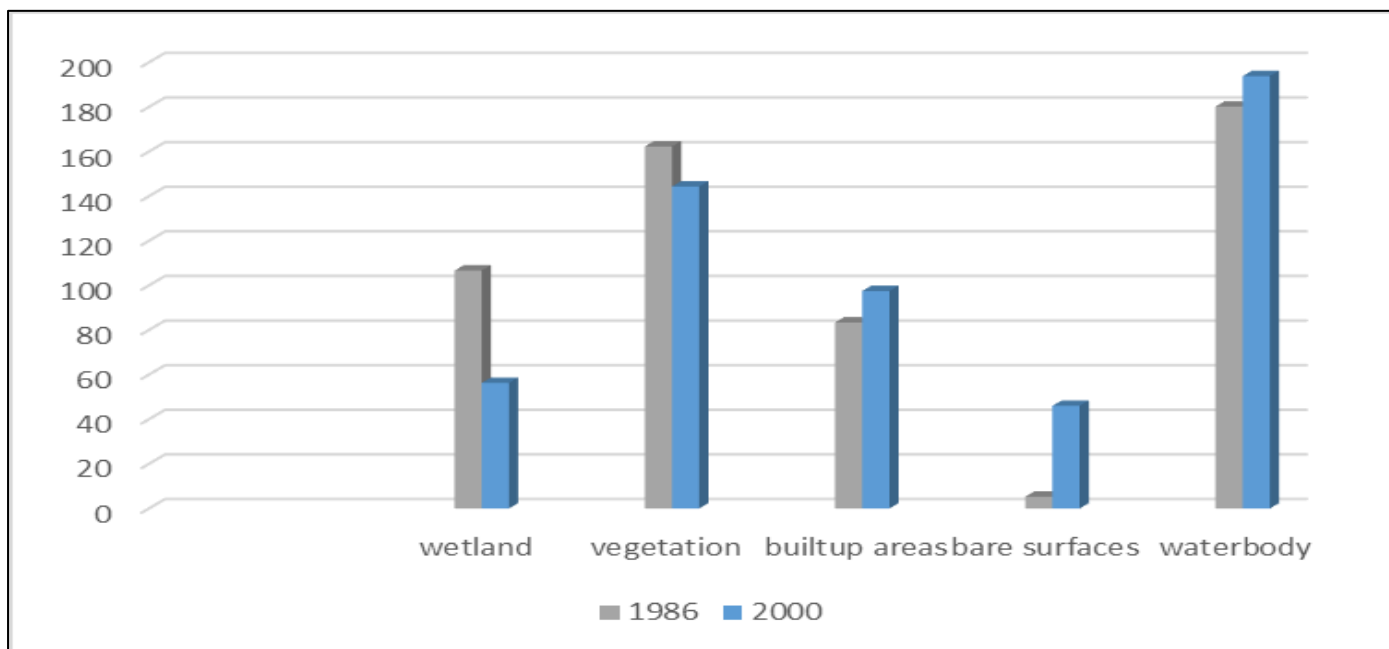


Fig 12 Changes in Spectral Signatures from 1986 - 2000

- Changes in Spectral Signatures from 2000 – 2016**

From figure 12 which reveals that between 2000 - 2016, wetland and vegetation decreased 1.3% and 25.7% respectively while water body also lost by 23%, loss of these

land cover was because of demand of residents, construction of infrastructures and others to meet the ever-increasing population. Built up area also gained 47.6% which is the highest gainer and bare surface.

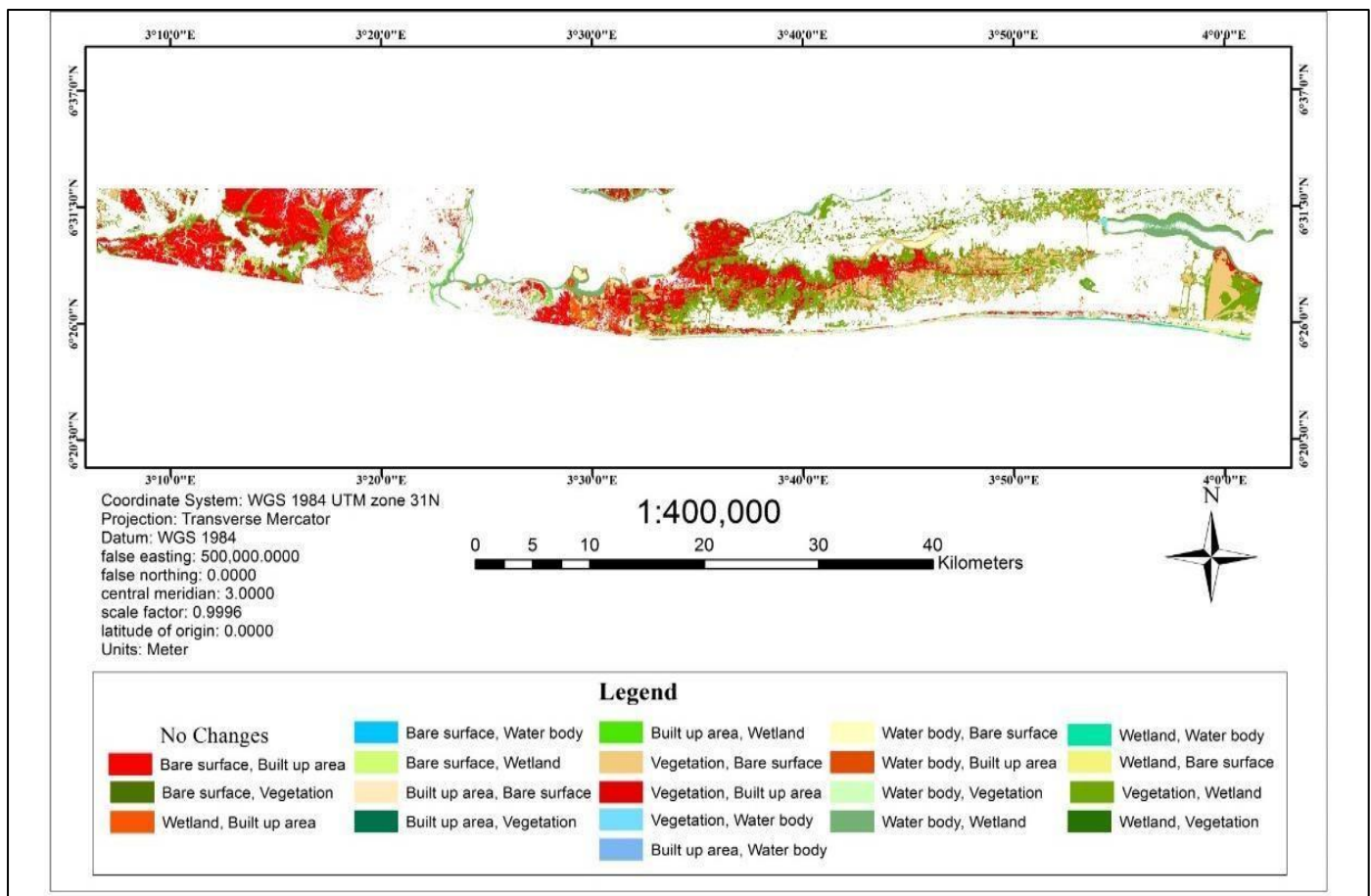


Fig 13 Map Showing the Spectral Signature Changes from 2000 – 2016.

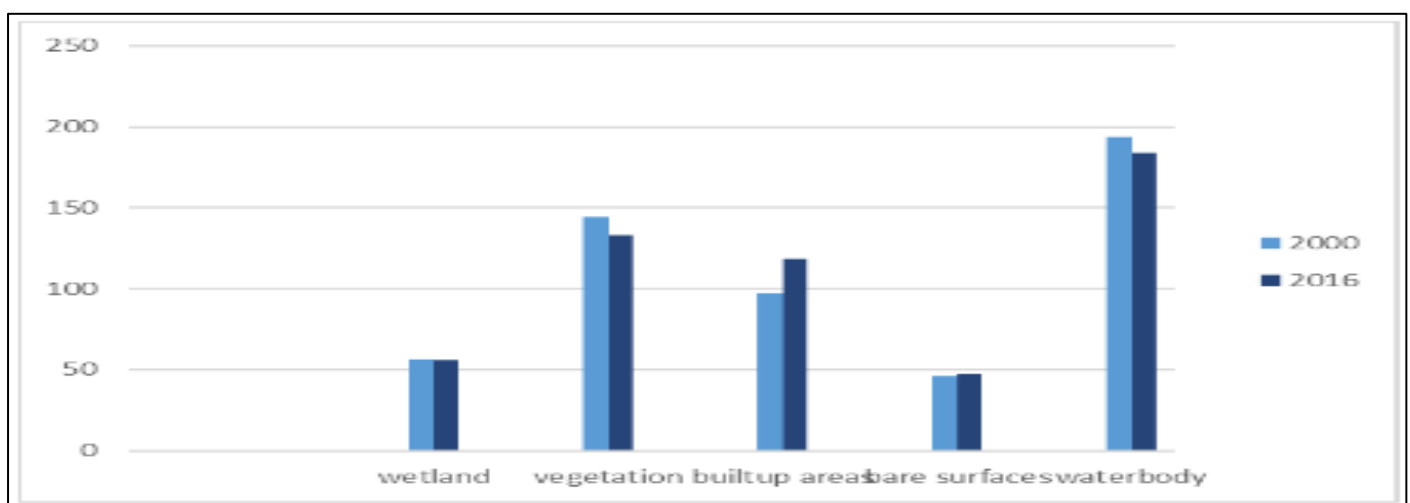


Fig 14 Changes in Spectral Signatures from 2000 – 2016

IV. SUMMARY, CONCLUSION AND RECOMMENDATIONS

➤ Summary of Findings

This research highlights the spectral signature dynamics of Lagos coastal areas analysis to classify land use land cover. The spectral analysis captures land use land cover classes in different spectrum (bands) and their spectral characteristics and how separable the classes are in different spectrum. Thus, this research emphasized the following findings:

- In 1986, all the features were separable, and they all had their highest reflectance in band 4 which is the

Near Infrared. And Landsat TM acquired had just four bands.

- In 2000, it showed not only that the features were separable in bands 5 and 6 but also the spectral variation tendency (ascending/descending).
- Also in 2016, all the features were separable starting from band 4 to band 7 but in band 8 they are all attached together, and the spectral variation had an ascending and descending flow.
- Suitable variable ranges determined by training samples are critical parameters for successfully implementing the spectral signature classification.

- It shows that spectral signatures research mineral can be located through this analysis only if one knows the characteristics of the mineral

➤ Conclusion and Recommendation

This research has shown the importance and ability of GIS and remote sensing in capturing and analyzing spectral signatures of coastland. The study aimed to assess the spectral signatures dynamics of Lagos coastland and indeed has shown all the reflectance of the land use land cover along the coast of Lagos. The spectral curve shape of one surface cover type is usually different from other covers. Spectral signatures derived from remotely sensed data could be applied to discrimination against surface objects. After careful research on the spectral signature on the coastland of Lagos, it is necessary to note that the primary aim for this research was to present a theory of image classification using spectral signatures, and only preliminary results were provided. So further studies could be done such:

- A Spectral Signature Shape-Based Algorithm for Landsat Image Classification.
- The concept of spectral shape can be well demonstrated in hyperspectral images. Therefore, the presented method will be more practically meaningful for hyperspectral data.
- The design of identification templates is, to some extent, subjective and restricts further development of this methodology. A necessity for further study is the development of an active machine learning method for determining the appropriate threshold in identification templates

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APPENDIX I

➤ Satellite Imagery Resolution

MSS(Multispectral Scanner)/ETM				OLI (Operational Land Imager)			
Number	Band width (μm)	Resol ution (m)		Number	Band width (μm)	Resol ution (m)	
				1	0.43-0.45	30	
1	0-5-0.6 MSS 0.45-0.52 ETM	60/30		2	0.45-0.51	30	Visible
2	0.6-0.7 MSS 0.52-0.60	60/30	Visible	3	0.53-0.60	30	
3	0.7-0.8 MSS 0.63-0.69 ETM	60/30		4	0.64-0.67	30	NIR
4	0.8-1.1 MSS 0.70-0.90 ETM	60/30	NIR	5	0.85-0.88	30	
5	1.55-1.75 ETM	30	SWIR - 1	6	1.56-1.66	30	SWIR - 1
6	10.4-12.5 ETM	60	Thermal-R	10	10.60-11.19	100m	TIR – 1
				11	11.50-12.51	100m	TIR – 2
7	2.08-2.35 ETM	30	SWIR - 1	7	2.11-2.30	30	SWIR
8	0.52-0.90 ETM	15		8	0.50-0.68	15	Panchromatic
				9	1.36-1.38	30	Cirrus

Note: NIR (Near Infrared); SWIR (Shortwave Infrared) ETM (Enhanced Thematic Mapper)