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Land use/Land cover changes due to Quarrying in Odeda Local Government Area of Ogun State, Nigeria: An Assessment and Implication for Rural Livelihood

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Abstract: *Quarrying activity is one of the major causes of land use /land cover changes in Nigeria with effects on the natural ecosystems. This study employed Landsat TM:1984, 2000 and OLI/TIRS2014 to assess land use and land cover changes due to quarrying activities in Odeda, Ogun State, Nigeria. A supervised method classification was employed using the Maximum likelihood algorithm. Area covered by quarry sites decreased from 52.26 hectares in 1984 to 114.206 hectares by 2000 and then 240.759 hectares in 2014. On the other hand, light forest, which had largest cover of 637.282 hectares in 1984 reduced to 614.678 hectares in 2000 and drastically to 326.517 hectares by 2014. Land degradation, dust, noise and vibration originating from quarries are major environmental impacts of quarry operations in the area. Enforcement of regulations and laws through effective monitoring by the required institutions will create a balanced and sustainable environment.*

Keywords: *GIS and remote sensing, Land degradation, Landsat OLI/TIRS, LULC, Quarrying*

INTRODUCTION

Patterns of land cover change in most tropical developing countries relate significantly to anthropogenic impacts and are extremely complex, with changes occurring across multiple spatial and temporal scales [1]. Land use/cover change is the response of the increased use of nature to meet the numerous diverse human survival and developmental needs [2]. The main driving forces of land cover change are technology capacity, socioeconomic organization, level of development and culture [3]. Understanding the dynamics and trends in land use and land cover change is a first step in decision making to combat the negative effects of the process. Quarrying is one of the major anthropogenic causes of land use/land cover changes. It involves the excavation of rock stones such granite, sandstone, limestone, perlite, marble, ironstone, slate, rock salt and phosphate rock in different parts of the world for construction purposes [4-5]. Quarrying activities however have many negative impacts on the environment. The potential impacts usually associated with quarry operations include blasting vibrations, noise, fly rocks, dust, localized surface and groundwater contamination to the damaging effects of airborne pollutants on the regional ecosystem [6]. Air pollutants such as dust are unhealthy particles (solids, liquid gas mixtures) that are liable to harm both living and non-living things [6]-[7]. The main source of airborne particulate matter include the following activities: site clearing, road construction, top soil stripping and dumping, open pit drilling and blasting, stripping, loading and haulage [8]. Some of the environmental disturbances created by quarrying are caused directly by engineering activities during aggregate extraction and processing. The most obvious engineering impact of quarrying is a change in geomorphology and conversion of land use, with the associated change in visual scene [8]-[9]. Concerns have been raised by the people living in quarry sites about the impacts of dust, run-offs and vibrations from quarrying activities on the health and well-being of the communities. Due to constant traffic of heavy dumpers and lorries to and from quarry sites, people who live near are likely to develop asthma or other respiratory diseases while their lungs development may also be stunted [10]-[11]. Quarry activities have also produced an ever-growing number of abandoned quarry pits that are quickly filled up with water and become suitable habitats for freshwater snails that in turn acts as intermediate host for Schistosoma haematibium that eventually contributes to the prevalence of urinary problems in people [10]. The results of past studies on the environmental effects of quarrying activities suggest a drawback in rural livelihood such as a trend of declining crop output on farms within a close radius to quarries [9]-[11]. The vast potential for negative impacts of quarrying activities upon the environment has created an urgent need for the creation of a comprehensive view of land cover/use change in the study area. Presently, quarrying activity is the major source of environmental degradation within the study area and the extent of the changes in land use in the area and their time of occurrences are not well known. Such studies will assist land managers in understanding the impact of mining activities on the human beings within this area, and in the formulation of future management decisions.

Preserving the environmental resources while maintaining or enhancing the economic and social benefits from their use is a present day challenge. For this reason, there is a need to understand the pattern and trends of LULC changes on the local, regional and global scales. Land use/cover changes have been in the lime light for reasons of importance attached to its impact on the earth and its occupants [1]-[2]. Overall, these changes have significant short and long-term impacts on the functions of the physical, chemical and biological components of earth. By understanding the driving forces of land use development in the past, managing the current situation with modern GIS tools, and modelling the future, it is possible to develop plans for multiple uses of natural resources and nature conservation. The main advantages of remote sensing are its ability to cover large areas, high temporal frequency, and lower cost compared to ground based investigation and monitoring [1], [5]. A number of published papers have demonstrated the usefulness of monitoring the environmental impact of mining using various remote sensing methods [9]-[11]. This study assessed of land use / land cover changes due to quarrying activities in Odeda Local Government Area, Ogun State, Nigeria between 1984-2014 using Remote Sensing and GIS techniques.

RESEARCH METHODOLOGY

Odeda Local Government is one of the twenty (20) Local Governments in Ogun State, Nigeria. The local government area is located between 7°13' and 7°30' N of latitude, 3°11' and 3°46' E of longitude (Figure 1) and covers a total land area of about 1,560 km² and a population of 109,449 according to the 2006 population census (NPC, 2006). The study area is predominantly rural with about 25-30 semi-urban areas and 860 villages and hamlets. Quarrying of granite occurs in many parts of Odeda LGA to provide construction material and for the generation of economic revenue for the people. With the growing demand for construction materials due to rapid population growth and urban expansion, increasing number of quarries were established contributing to the drastic change in land cover in the area. Granite extraction in the study area is conducted by open pit mining method. The stones are blasted with explosives and then crushed into various sizes before transportation out of the quarries. In the process, the original vegetation is destroyed, and the overlaying soil is removed. Particulate matter, noise, vibrations and run-offs are impacting negatively on the health and property of the people living around the cluster sites. These are most likely to generate environmental problems such as cracks in buildings (which may collapse and destroy life), outbreak of malaria infection and other water-borne or water- related diseases, loss of fauna and flora (biodiversity), land degradation and decline in crop yield. Governments of nations in the world to protect the environment from such hazards have adopted environmental safety laws and edicts. Most of the identified problems of quarrying activities on land use land cover persist in Odeda local government due to the abuse of the laws by quarry operators to maximise profit. The abuse is paramount in Nigeria and Africa.

Material and Method

Data Source

The data collection involved the acquisition of Satellite Imageries of the study area (Table 1). The Landsat imageries were downloaded from the official website of Global Land Cover

Facility (GLCF) – (*http://www:glcf.umiacs.umd.edu*). The GLCF is hosted by the University of Maryland, USA. It provides earth science data and products to help better understanding of the global environmental systems. Satellite imageries (LANDSAT) for 1984, 2000 and 2014 of Path 191 and Row 055 were downloaded and processed for further use in this study (Table 1).

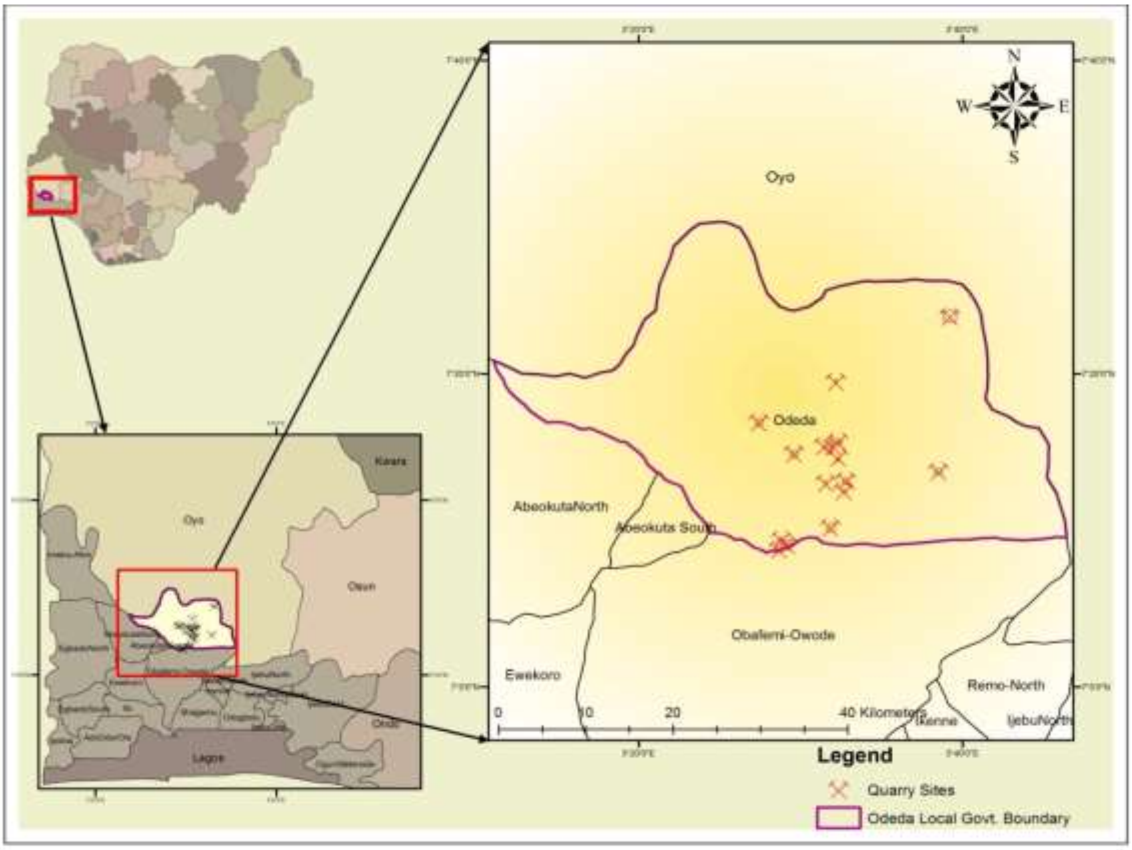

Figure 1 : Map of Odeda local government area in Ogun State, Nigeria showing locations of major quarries

Table 1: The properties of the Landsat images used

Name	Spatial Resolution(m)	Path	Row	Period
Landsat TM	30m	191	055	1984/04/18
Landsat TM	30m	191	055	2000/02/06
Landsat OLI/TIRS	30m	191	055	2014/12/07

Sixteen quarries were selected in the study area (Table 2). The selection criteria were based on their current functionality. All the sixteen quarries are functionally active with production going on as at the time of the study. Ground truthing information was combined with the classified images to assess the accuracy of image classification. Field survey was carried out to get first-hand information about the study area. Landsat TM (Thematic Mappers) and OLI/TIRS (Operational Land Imager/Thermal Infrared Sensor) for the year 1984, 2000 and 2014 were used for classifying the study area into quarry Site, degraded forest, light forest and water body. Rectification, classification, GIS integration and presentation were applied to dataset in order to achieve the objectives of the study. Moreover, ground truth data and topographic maps supported all processes in the methodology. In the rectification process, the mathematical relationship between the addresses of pixels in an image and the corresponding coordinates of those points on the ground were established using geometric model. Coordinates of Ground control points (GCPs) were obtained from topographic maps and first order polynomial equations were used as geometric model.

Table 2: Name and Location of Selected Quarries in Odeda Local Government Area

S/ No	Name of quarry	Location	Longitude	Latitude
1	AGI	Otere	7.16895	3.53093
2	CAPITAL	Olodo	7.15634	3.48021
3	CNC	Orile-Ilugun	7.32517	3.53698
4	CROWN	Odeda	7.39316	3.65369
5	DE- CROWN	Odeda	7.25782	3.54023
6	DLK	Oluwo	7.25245	3.52655
7	ENPTECH	Banja	7.14561	3.47579
8	FAM	Banja	7.14957	3.48629
9	HAB	Arege	7.22943	3.64138
10	KEPXING	Ososun	7.20876	3.54361
11	MSALG	Ekaa	7.25561	3.53491
12	NAGOCTEC	Odeda	7.21671	3.52626
13	OBA	Odeda	7.24186	3.53664
14	S & D	Iporo&Igodo	7.24593	3.49278
15	SJA	Malaaka	7.27789	3.45808
16	WESTERN	Ososun	7.22401	3.54482

Image Processing

The study area was extracted from Landsat TM and OLI/TIRS by clipping the vector map of the study area to Landsat imageries; band Seven, four and one for Landsat TM and band seven, five and two for Landsat OLI/TIRS were stacked and clipped to study area vector map shapefile for further processing in ArcGIS 10.0 where histogram equalization was carried on the stacked or composite image to make it clearer. Effective image processing is critical to successful urban land use land cover mapping [12]

Image Classification

The process of sorting pixels into finite number of individual classes, or categories of data, based on their data file values may be described as multispectral classification. Image classification involves the training of computer to recognize patterns in the remotely sensed image. Training is the process of defining the criteria by which the patterns are recognized. A supervised method was utilized because it permits selection of pixels that represent pattern or land use features that is recognizable or identifiable with the use of other source such as ground truth data. Knowledge of the data, and of the classes desired, is required before classification. Having trained the computer, the system thereafter uses a special program to determine the numerical signatures and for each training class. Each pixel in the image was therefore compared to the signatures and labelled as the class it most closely resembles digitally. The process was done with ArcGIS 10.0 software.

Supervised Classification

Supervised classification is the process is the process of using samples of known identity to classify samples of unknown identity. Samples that have known identity are located within training areas. Training areas are regions on the image that can be clearly matched to areas of known identity on the ground; they therefore typify the spectral properties of the on-ground areas they represent. Supervised classification can also be said to be a type of semiautomatic multi-spectral image interpretation in which the user supervises feature classification by setting up prototypes (collections of sample points) for each feature, class, or land cover to be mapped. Four land use classes were used for the classification (quarry site, degraded forest, light forest and water body

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Change Detection

One of the prerequisite for understanding environmental changes is the use land change detection modeller (LCM). Change detection analysis was carried out on Landsat images of different years (i.e. 1984, 2000 and 2014) to analyse the pattern and trend of change analysis in the study area. The Quarry Site, degraded forest, light forest and water body of the three different years were used and compared from the classified images so that the dynamic changes and the characteristics of environmental changes could be recognized.

Land Change Modeller (LCM)

Among several available land use modelling tools and techniques, some of the most commonly used models are embedded in IDRISI, such as, Land Change Modeller, Markov Chain, CA_Markov, GEOMOD, and STCHOICE. In this study, Land Change Modeller (LCM), Markov and CA_Markov were used. Change Analysis and Map Transition Option in LCM is a mapping tool to visualize the change that occurred from all the other land classes to the built-up, bare ground, water-body, thick forest and light forest class and predicting the course of change into the future. Modelling using LCM requires mainly two time categorical maps. The classified maps of 1984 (time-1) and 2014 (time-2) were used as inputs for the Change Analysis Tab of IDRISI, which enabled the understanding of the gains and losses and the transition of areas among the land use land cover classes; and to quantify the changes that occurred from time-1 to time-2 [13]. Results of the quantified and analysed data can be presented in a chart and/or map outputs. In this study, GIS is used for analysing and visualising the classification of results obtained by remote sensing technology. Classification results of the remotely sensed images dated 1984, 2000 and 2014 in vector format were imported to the GIS into two different layers including land cover classes-water body, degraded forest, light forest and quarry site and sub-layers. Overlay analyses was executed on these layers for detecting the changes of the quarry areas. Visualisation of the analysed results was considered as another important issue in the study.

RESULTS AND DISCUSSION

Thematic maps emphasizing the changes in the quarry areas and showing the direction of the extension of the quarrying activities were designed to understand the results of the study. Figure 2 shows the true colour composite of the 1984, while Figure 3 shows the classified image of the same period.On the composite map, the red and pink colour indicate the quarry sites (including rock outcrops and bare ground), the blue colour indicates the water body and the green colour indicates the vegetal cover (degraded and light forest).

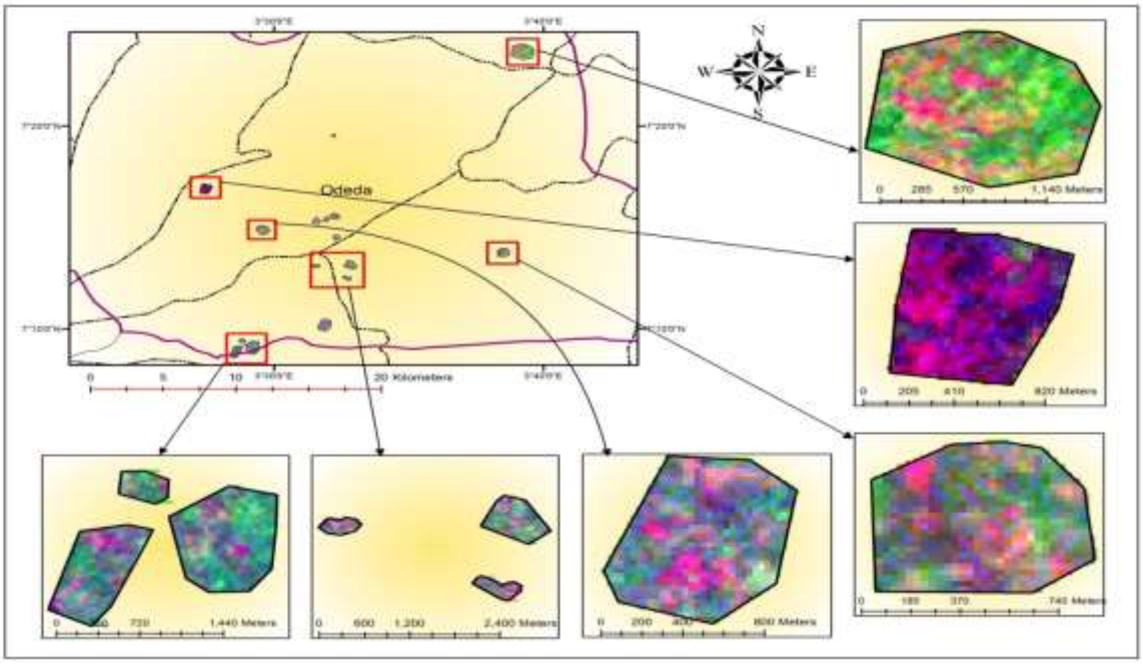

Figure. 2: True colour composite of 1984 Landsat imagery in Odeda Local Government Area, Ogun State, Nigeria

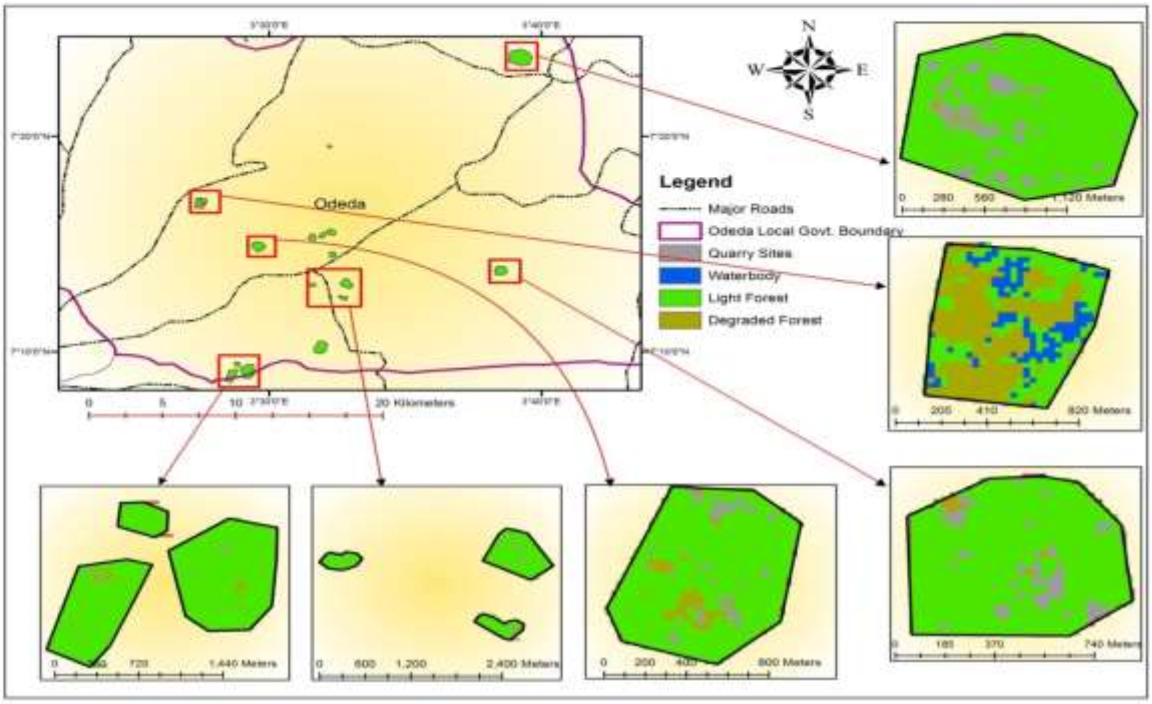

Figure 3: Classified images of 1984in Odeda Local Government Area, Ogun State, Nigeria

In the classified image of 1984, the quarry sites covered the land area of 52.26 hectares. Light forest had the largest percentage of the land cover in the environment at that period (637.3 hectares), while degraded forest area was about 40 hectares. Water body covered the total area of 4.6 hectares. Figures 4 and 5 respectively shows the true colour composite and classified image of 2000. In the classified image of 2000, the quarry sites covered the land area of 114.2 hectares. Light forest was about 614.8 hectares and degraded forest area was about 5 hectares. In the same period, water body covered the total area of 0.18 hectares.

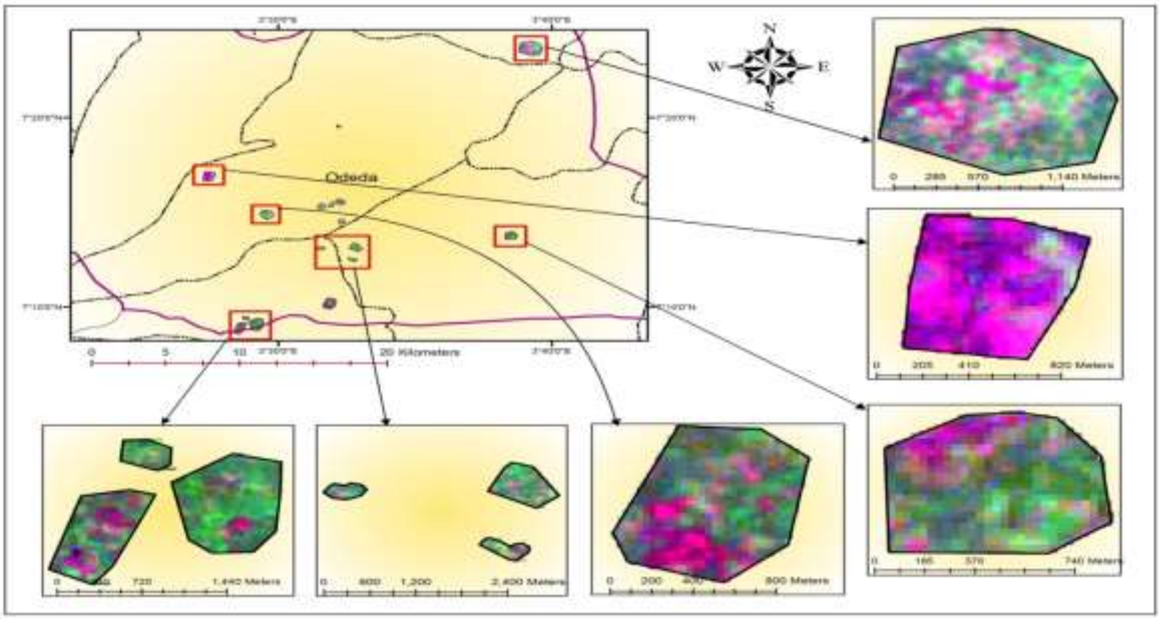

Figure 4: True colour composite of 2000 Landsat imagery in Odeda Local Government Area, Ogun State, Nigeria

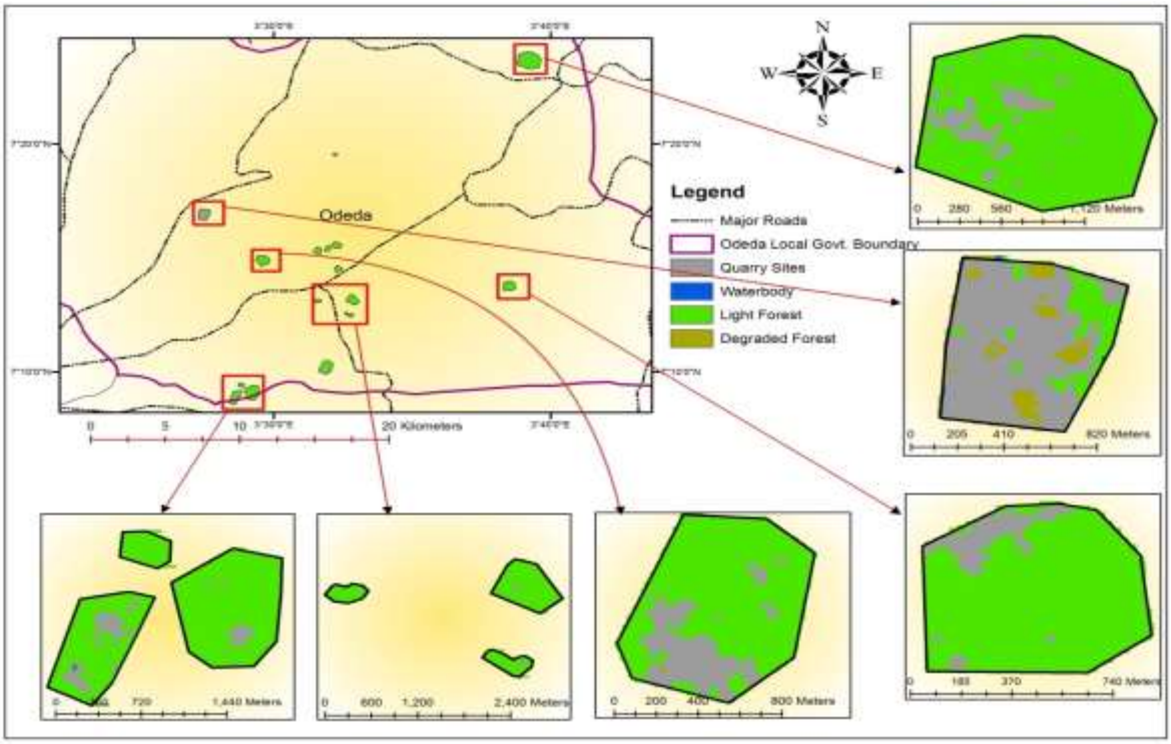

Figure 5: Classified image of 2000 in Odeda Local Government Area, Ogun State, Nigeria

The true colour composite and classified image of 2014 are shown in Figures 6 and 7 respectively.

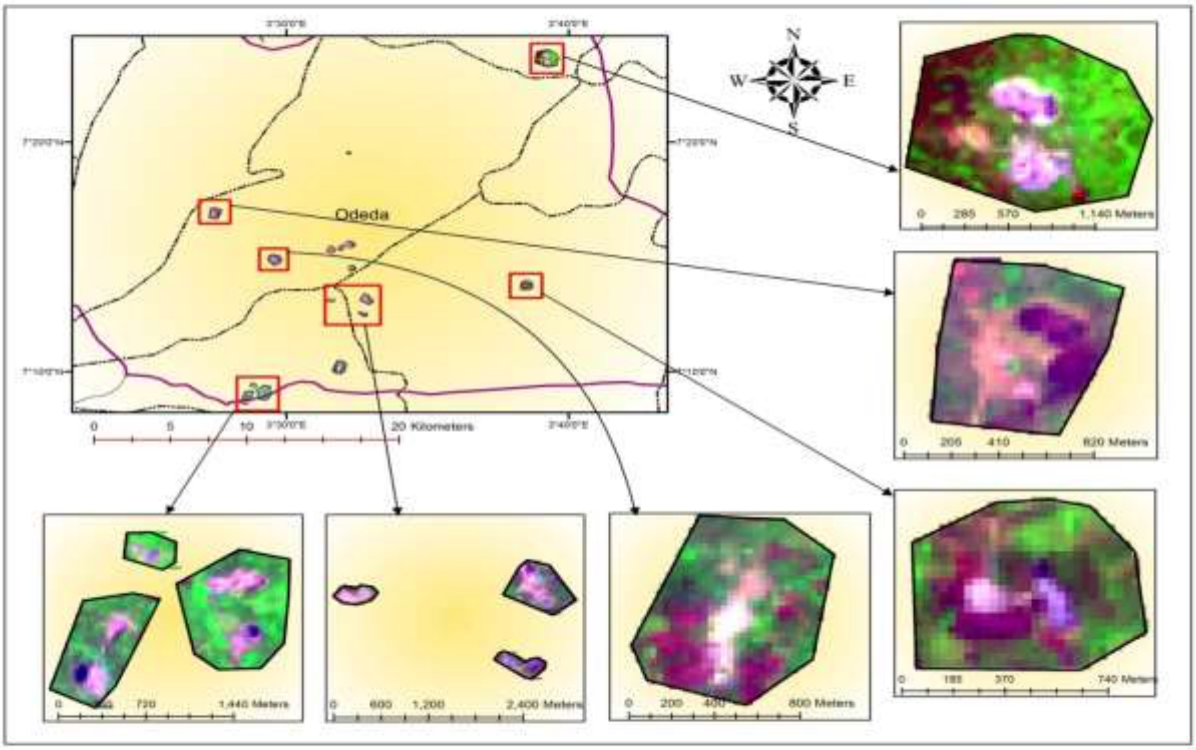

Figure 6: True colour composite of 2014 Landsat imagery in Odeda Local Government Area, Ogun State, Nigeria

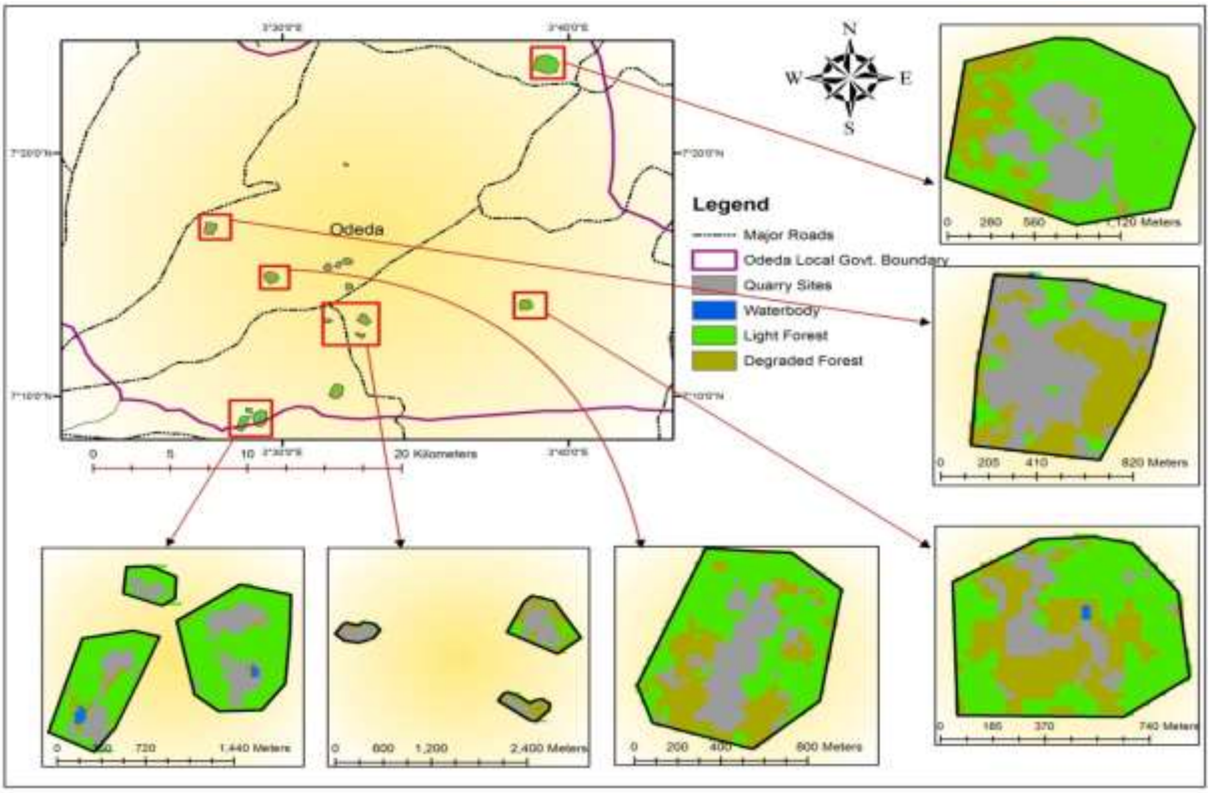

Figure 7: Classified images of 2014 in Odeda Local Government Area, Ogun State, Nigeria

In the classified image of 2014, the quarry sites had an area of 240.8 hectares while light forest was 326.5 hectares and degraded forest was 165.136 hectares. It was observed that light forest decreased from 1984 to 2014, while the quarry sites increased in the area covered (Figure 8). It can be deduced that increase in the quarrying activities in the study area has a major impact on the other land use land cover classes.

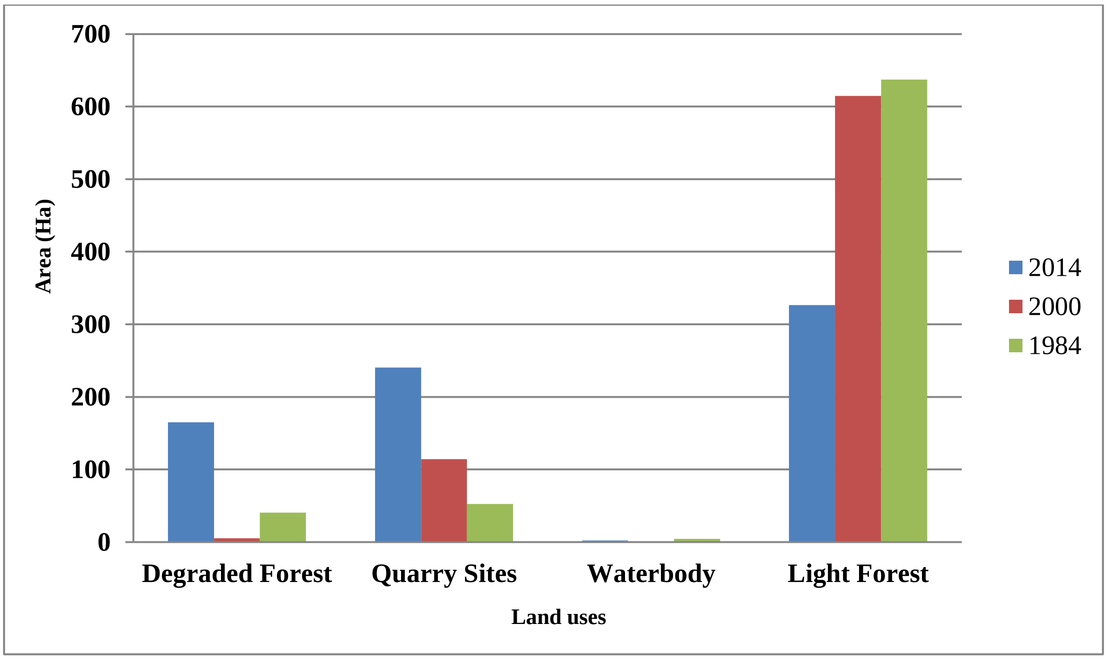

Figure 8: Area covered by different landuse/landcover in 1984, 2000 and 2014 in Odeda Local Government Area, Ogun State, Nigeria

Changes detected over the quarry site and its environs

Tables 3, 4 and 5 below shows the size, proportion and percentage change in land use / land cover around in the study area between 1984 and 2014.

Table 3: Size and proportion of land cover between 1984 and 2000 in Odeda Local Government Area, Ogun State, Nigeria

Land cover types	Area in 1984		Area in 2000			
	Ha (A)	%	Ha (B)	%	Difference B-A (Ha)	% Change
Quarry Sites	52.26	7.12	114.206	15.55	61.946	50
Degraded Forest	40.358	5.50	5.373	0.73	-34.985	28.24
Light Forest	637.282	86.77	614.678	83.70	-22.604	18.25
Water body	4.537	0.62	0.18	0.02	-4.357	3.52
Total	**734.437**	**100**	**734.437**	**100**		**100**

N.B + is increase - is decrease

The area extent of the quarry site, degraded forest, light forest and water body as at 1984 are 52.3 ha, 40.4 ha, 637.3 ha and 4.6 ha respectively, which became 114.2 ha, 5.4 ha, 614.7 ha and 0.18 ha respectively in 2000 and 240.759 ha, 165.136 ha, 326.517 ha and 2.025 ha respectively in year 2014. The percentage change in the quarry site, degraded forest, light forest and water body between 1984 and 2000 were 50%, 28.24%, 18.25% and 3.52% respectively. It was 30.09%, 19.91%, 49.60% and 0.40% respectively between 1984 and 2014.

Table 4: Size and proportion of land cover between 2000 and 2014 in Odeda Local Government Area, Ogun State, Nigeria

Land cover types	Area in 2000		Area in 2014			
	Ha (A)	%	Ha (B)	%	Difference B-A (Ha)	% Change
Quarry Sites	114.206	15.55	240.759	32.78	126.553	21.96
Degraded Forest	5.373	0.73	165.136	22.48	159.763	27.72
Light Forest	614.678	83.70	326.517	44.46	-288.161	50
Water body	0.18	0.02	2.025	0.29	1.845	0.32
Total	**734.437**	**100**	**734.437**	**100**		**100**

N.B + is increase - is decrease

Land Change Modeller (LCM)

Gain and losses in different land uses between 1984 and 2000, 2000 and 2014 are shown in Figure 9. Twenty-two (22) hectares was lost in degraded forest and 68 hectares was gained from other land use/land cover while 113 hectares loss and 47 hectares gain were observed over light forest. 8 hectares loss and 20 hectares gain were noticed over water body, 45 hectares were loss, and 53 hectares gain for the quarry site. Vegetation area encompasses all the areas containing the vegetal cover; both degraded forest, light forest, cultivated and uncultivated land while quarry site comprises of the particular location where the granite quarrying activities were taken place. The result shows that quarrying and mining activities contribute to the changes in the land use pattern in the study area [11], [15]-[17].

Table 5: Size and proportion of land cover between 1984 and 2014 in Odeda Local Government Area, Ogun State, Nigeria

Land cover types	Area in 1984		Area in 2014			
	Ha (A)	%	Ha (B)	%	Difference B-A (Ha)	% Change
Quarry Sites	52.26	7.12	240.759	32.78	188.499	30.09
Degraded Forest	40.358	5.50	165.136	22.48	124.778	19.91
Light Forest	637.282	86.77	326.517	44.46	-310.765	49.60
Water body	4.537	0.62	2.025	0.29	-2.512	0.40
Total	**734.437**	**100**	**734.437**	**100**		**100**

N.B + is increase - is decrease

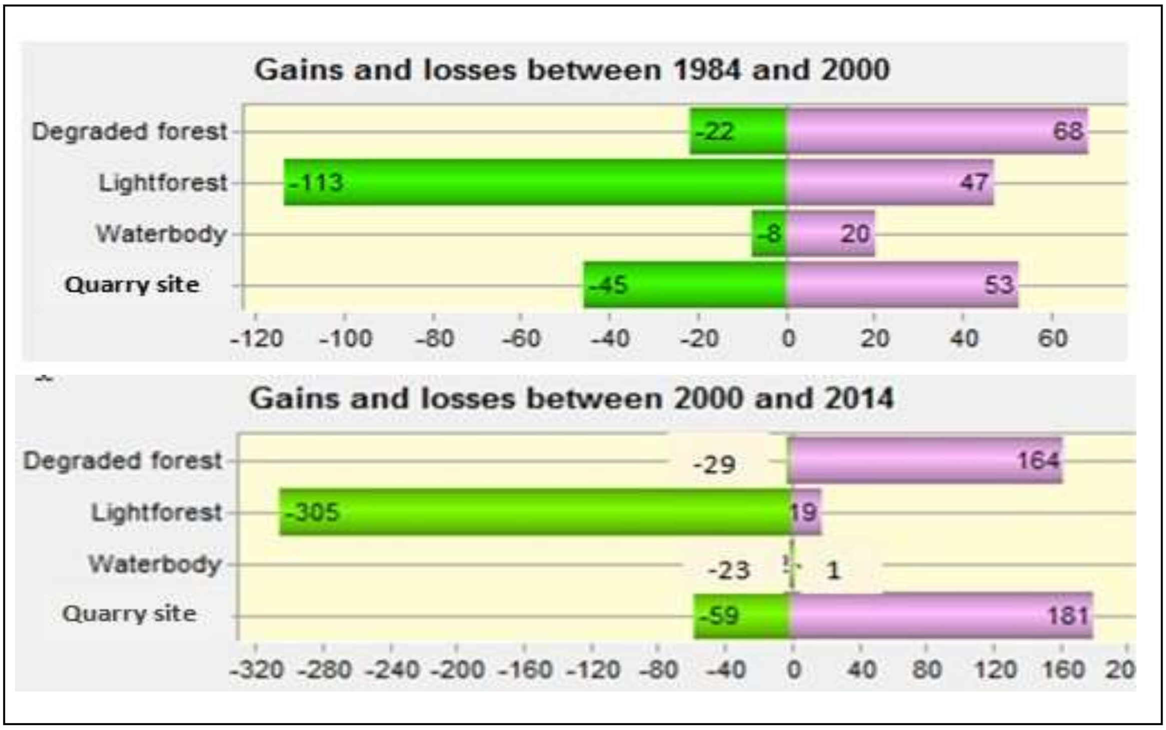

Figure 9. Change in area covered of different Land use Land cover from 1984-2000 and 2000-2014 in Odeda Local Government Area, Ogun State, Nigeria

In the period between 2000 and 2014, 29 hectares was lost in degraded forest and other land use/land cover types gained 164 hectares, while 305 hectares loss and 19 hectares gain were observed in the light forest. Twenty-three (23) hectares loss and 1 hectare gain were noticed over water body and 59 hectares were lost and 181 hectares gained by the quarry site. The existing situation and the inferences drawn from the quarrying activities within the study area have impact on the land use/land cover changes as well as the entire residents as a whole. For instance, Abule Eiye and Malaaka, which are communities located very close to De- Crown Quarry site and SJA quarries in Odeda Local Government Area are constantly faced with the problem of dust pollution, noise, vibration and other related problems due to the quarrying activities. In a related study, Mouflis *et al.* [18] assessed the environmental impact of marble quarries on the landscape of the Greek island of Thasos by employing remote sensing, landscape metrics, and view shed analysis. The results showed that marble extraction activities had an impact on the ecology and landmass re-uses [18]. Land use/land cover changes are critical issue that degrade biodiversity and create impact on human life [19]. It should be noted that great environmental consequences could result with the continuous decline in the forest resources with gradual reduction of biodiversity and landscape complexity and a higher vulnerability to natural hazards [20]-[22]. Quarrying activities can have direct and indirect impact on sediment loading and stream flow. Barasa et al. [23] corroborate this in the study of artisanal gold mining and their impact on sediment loading and stream flow in the Okame River catchment in Uganda. . The use of explosives to execute blasting activities in the quarries always leads to concern its effect on the environment. For instance, vibrations of the ground induced by blasting in the different quarries are fundamental problems in the quarrying industry in the study area and these have caused severe damage to residence and other properties nearby [6], [11], [17], [24[]. Blasting of rocks propagate seismic waves through the rocks causing destruction of along their path. Buildings located in these directions are affected by the propagation of seismic pulses. In addition, fly rocks are considered the most undesirable movement of rocks during the blasting activities because it can cause severe injuries to the people in open fields. One of the biggest negative impacts of quarrying on the environment is the damage to biodiversity as a wide range of living species, including fish, insects, invertebrates, reptiles, birds, mammals, plants, fungi and even micro-organisms are disturbed by the removal of their habitats [11],[21],[24]. Quarrying substantially modifies the routing of recharge and water quality degraded. large amount of silt and other effluents from quarries pollute rivers as well as underground water bodies within and far beyond the boundaries of the quarry area thus affecting rural livelihood [16], [19]. Quarry activities have also produced an ever-growing number of abandoned quarry pits that are quickly filled up with water and become suitable habitats for freshwater snails that in turn acts as intermediate host for *Schistosoma haematibium* that eventually contributes to the prevalence of urinary problems in people [7].

Quarrying with consequent losses in land area: Implication for food security and rural livelihood

In this study, findings show a sizable (about 25%) loss in land area due to quarry activities in the study area. A major consequent impact in any area with similar activities. Loss of land area with potential for arable cropping and conservation of forest ecosystem may likely impact on food security and human livelihood in the predominantly rural community in the study area. Another impact is attributed to the generated particulate matter (dust) because of the different activities associated with the quarry industries, which may lead to respiratory diseases. Quarrying activities in the study area have serious environmental impacts such as scarification of the land, deforestation, changes in landscape structure, influence over geomorphological processes and hydrological river regime, chemical pollution of soil and watercourses, influencing soil production capacity. These impacts directly affects the rural livelihood in different ways productivity is reduced on farmlands, houses destroyed and increase in the burden of diseases [25]. Deforestation is one of the most significant environmental impacts of quarrying in the study area. Deforestation causes increased erosion not only in the locality, which is intended for the quarry but also the wider surroundings. Quarry activities also affect geomorphological processes and this is manifested by both acceleration and deceleration of some processes such as weathering and mass movement [22], [25]. All these pose problems to sustainable livelihood of the surrounding rural communities [27]-[28].

CONCLUSIONS AND RECOMMENDATION

The study highlighted the land use/land cover changes due to quarrying in Odeda Local Government Area of Ogun State, Nigeria, assessing the implication for rural livelihood. Environmental impacts of quarrying activities have been an issue of public concern, which have arose widespread global interest. Despite the growing importance of quarrying for granite in the study area, there has been an increasing concern over environmental impacts associated with the activities and this makes environmental sustainability in the industry crucial. The study revealed potential human health impacts from quarrying of granite in the study area, especially during the blasting process. Results showed that most buildings that fall within buffer zone to quarry site have high risk of environmental problems such as air pollution, noise pollution and health effects.

Diseases associated with air pollution include silica containing dust, chronic airways obstruction and bronchitis, tuberculosis and lung cancer. The study recommends a vibration control study, which can play an important role in the minimization of environmental effects of blasting in the quarries. Furthermore, there would be a need for total relocation for the residents that falls buffer zones to reduce health risk problems. Policy measures should be put in place to ensure that the environmental effects of mining activities are reduced to the barest minimum. In addition, regular monitoring visits to quarry sites should be undertaken routinely to minimize the negative effects of quarrying operations on humans and the environment.

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