

# Effects of Open Cast Quarrying Technique on Vegetation Cover and the Environment in South-Eastern Nigeria

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## Abstract

Quarrying activities happen to cause huge losses in land and vegetation cover due to the fact that its operations are usually on a large scale and the sites are abandoned after the resources have become depleted. This study examined the open cast quarrying technique and also the spatial pattern of the quarrying activities and their locations in the study area. Direct field measurement was utilized for the study using a Surveyors tape to measure the lateral extent of degraded land. Garmin eTrex GPS receiver was used to obtain the co-ordinates of the quarry sites. Geographical Information System and Global Positioning System were used for producing a map of the area and fixing the geographic positions of the locations of the quarry sites respectively. The data so collected were collated and analysed for 27 quarry locations selected from six local government areas where quarrying activities are heavily concentrated and currently active. The result of the study obtained from the principal component analysis showed that there is a significant pattern in the quarrying activities and their locations with explained variance of (82.91 %). The spatial pattern and locations of the quarrying activities in the study area showed: Ohaukwu (11), Ivo (2), Ishielu (1), Ezza North (5), Afikpo North (4) and Izzi (4).

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The parameters that described the pattern of quarrying activities were: the area of pit covered (0.91), percentage of quarrying area (0.93), numbers of pit covered (0.83), and villages involved (0.64). The study also revealed that the total area of vegetation cover destroyed was 402.855 hectares. Field measurements showed that the percentages of land lost in the local government areas where quarrying activities are intensified are as follows: Ohaukwu 28.7%, Ishielu 9.3%, Ivo 35.2%, Afikpo North 14.7%, Ezza North 8.0% and Izzi 3.7%. The study recommended that the Government and public agencies concerned should develop and enforce policies and strategies to achieve a balanced, coordinated and sustainable development in the State.

**Keywords:** Open cast; environment; quarrying activities; principal component analysis; vegetation cover; landscape and degradation.

## **1. Introduction**

Open cast or surface mining requires extensive blasting and removal of rock, soil and vegetation in order to reach the mineral deposits underneath the earth [27]. The purpose of quarry blasting is to fracture or fragment the rock mass to enable excavation. Explosives are used to blast the rocks apart. It is the most commonly employed for detaching large blocks of stone, which are then split and broken into smaller stones by wedges or by the plug-and-feathers method, or crushed by a heavy steel ball weighing several tons. In open pit quarrying, the drill holes are put down to the depth to which it is required to break the rock and are then partly filled with some explosive as it is discharged by blasting [13].

The enormous explosions associated with open pit quarrying have been known to crack foundations of buildings, slope instability and destroy drilled wells miles away [18]. The works of some scholars [1,6,8,15] indicate that blasting is one of the basic operations of surface quarrying, which has environmental effects especially if settlements exist around the working field and the vegetation of an area is mostly affected.

Surface quarrying technique has serious impact on all landscape components and functions, leading to significant alteration of the original landscape. Once quarrying operations start, the landscape development in progress is disturbed, the original ecosystems are removed, the topography is significantly altered, the basic ecological relations are unchangeably disrupted, and biodiversity is decreased [19, 28].

These factors consequently lead to total ecological destabilization, elimination of the aesthetic values and decrease in the recreational potential of the area.

The traditional opencast quarrying practices have caused the destruction of land resources including: denudation of vegetation cover, creation of grossly uneven topography, loss of soil fertility, surface crusting and soil erosion.[9, 28] Land is one of the most critical resources for the rural poor dependent on farming for their livelihoods. Today, about 2 million hectares of agricultural lands are lost every year due to anthropogenic influences which affect the ecosystem and cause severe land degradation [10, 23]. Open cast quarrying activities represents a major perturbation to the natural landscape, creating significant impacts on the soil, vegetation, fauna and habitat loss [3, 25, 31].

Quarrying and mining activities are destructive enterprise [26] and involve the complete destruction of the habitat of the area where they take place [6].

The quarrying of hard rock invariably involves blasting and the generation of noise and some dust. Danger and damage from the flying rocks in rock blasting have been a serious problem ever since blasting was introduced [11]. Not only have men been killed and injured but also buildings, equipment and materials have been damaged [30]. Fletcher and D'Andrea [12] observed that flying rock which travels beyond the protected blasting area caused 25% of the blasting accidents in U.S. surface mining/quarrying. An analysis of blasting accidents in Indian mines indicated that more than 40% of fatal and 20% of serious accidents were caused by flying rocks [4].

Quarrying activities have altered vegetation cover all over the world such as forested regions of the Appalachian Mountains[22], Netherland [16], Ghana[17], Germany[24], Nigeria [29] among others.

Land clearing primarily for quarrying activities is perhaps the most important cause of environmental degradation, loss of species, and depletion of ecological communities worldwide [14, 20].

## **2. Study area**

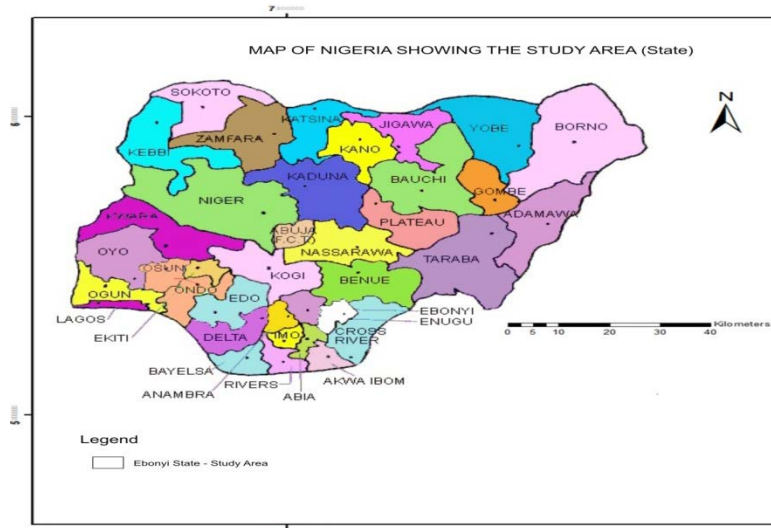
The study area is Ebonyi State located in the south eastern region of Nigeria. It is bounded to the north by Benue State, to the west by Enugu State, to the east by Cross River State and to the south by Abia State. The State is situated between longitudes 7° 30' and 8° 30'E and latitudes 5 ° 40' and 6 °54'N. It has a land area of 5,935 sq. Km and it a population of 2,176, 947 based on the 2006 census. It has an annual growth rate of 3.5% per annum [32].

Ebonyi's population is largely rural, it has an average rurality index with an estimated 75 percent of the population (over 1.2 million people) living in rural areas.

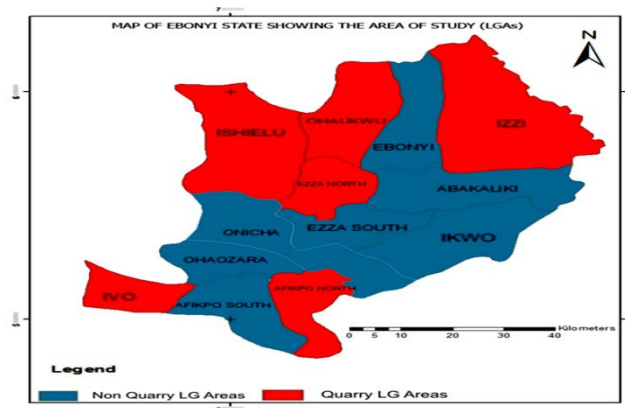
The climate is situated within the Warm-Humid Equatorial climatic belt. It falls within the rainforest belt of Eastern Nigeria. The area is characterized by high relative humidity of about 75% and surface temperature of about 27° to 30°C. The rainy season begins between March 1st and March 11th and ends between November 8th and November 18th.

The area has an average temperature of 28°C [2]. The average annual rainfall is about 2250mm, and the average annual temperature is about 27°C. The area lies in the rain forest/ savannah vegetation. It is made up mainly of hydromorphic soils which consist of reddish brown.

They are gravely and pale coloured clayey soil and loamy clayey soil, shallow in depth, and of shale parent material. It falls within the Asu-River Geologic Group (Lower Cretaceous), Eze-Aku shale formation and Nkporo Formations. The state also has great potential for solid minerals exploitation and mineral-based industries. The issue of land degradation has surfaced as an emerging phenomenon, which impacts negatively on the biodiversity and the vegetation.



**Figure 1:** The Map of Nigeria showing the location of Ebonyi State.



**Figure 2:** The Map of Ebonyi State showing the Area of Study (LGAs)

### 3. Materials and methods

The data for this study was collected through direct field observation, oral interview, photography and measurements. Data was analyzed using principal component analysis. The need to establish that there is a significant spatial pattern in the quarrying activities and their locations in the study area necessitated the adoption of the analytical tool. The Garmin eTrex GPS receiver was used to obtain the coordinates of the quarry locations. The census data were collected from the National Population Commission office, Ebonyi State. Then field visits to site was carried out to obtain ground control points for georeference and ground truth sampling. The Surveyors measuring tape was used to calculate the extent of vegetation cover degradation as result of quarrying in the area. Geographical Information System and Global Positioning System were used for producing a map of the area and fixing the geographic positions of the locations of the quarry sites respectively. The data so collected were collated and analyzed for 27 quarry locations selected from six local government areas where quarrying activities are heavily concentrated and currently active.

#### 4. Results and discussion

The results and discussion of findings are presented accordingly. The input variables were numbers of pits, area of pits and percentage area of quarrying areas. The input data for principal component analysis (PCA) are shown in Table 1 below.

**Table 1:** Principal Component Analysis of the pattern of quarrying activity location in the study area. **Source:** Surveyor's Computation, 2016.

L.G.A	Villages/ Communities	No of pits	Area of pits (m <sup>2</sup> )	% Area of quarrying areas
Ohaukwu	Akpeagu Amofia (pit 1,2)	2	72900m <sup>2</sup>	0.12
Ohaukwu	Umuaguma (Pit 3)	1	53550m <sup>2</sup>	0.01
Ohaukwu	Ndiagu idiaka (Pit 4-10)	7	977050m <sup>2</sup>	0.16
Ohaukwu	Aguachi ukwuagba (Pit 11)	1	53550m <sup>2</sup>	0.01
Ivo	Amokwe (Pit 12)	1	945000m <sup>2</sup>	0.29
Ivo	Amaeze (Pit 13)	1	477000m <sup>2</sup>	0.15
Ishielu	Nkalagu (Pit 14)	1	377325m <sup>2</sup>	0.04
Ezza North	Amaeze (Pit 15-17)	3	271800m <sup>2</sup>	0.08
Ezza North	Enyim umuagharu (Pit 18)	1	12600m <sup>2</sup>	0.004
Ezza North	omege umuagharu (Pit 19,20)	2	39425m <sup>2</sup>	0.01
Afikpo North	Akpoha Iibi	3	56340m <sup>2</sup>	0.01

	(Pit 21-23)			
Afikpo North	Amasiri (Pit 24)	1	31950m <sup>2</sup>	0.005
Izzi	Ezzagu inyamagu (Pit 25-28)	4	153000m <sup>2</sup>	0.01

The output data from the PCA are shown in Table 2 below. The entire variables of quarrying activities measured were reduced into two variables from the principal component analysis used in the test.

**Table 2:** Rotated Component Matrix of Pattern of Quarrying Activities Distribution. **Source:** Researcher’s SPSS PCA, 2016

	Component	
	1	2
No of Pit	.307	.833
Area of Pit	.917	.285
Percentage of Quarrying Area	.939	-.040
Villages	-.556	.644

Table 3 below showed the explained variance of 82.912% from the study variable which is significant.

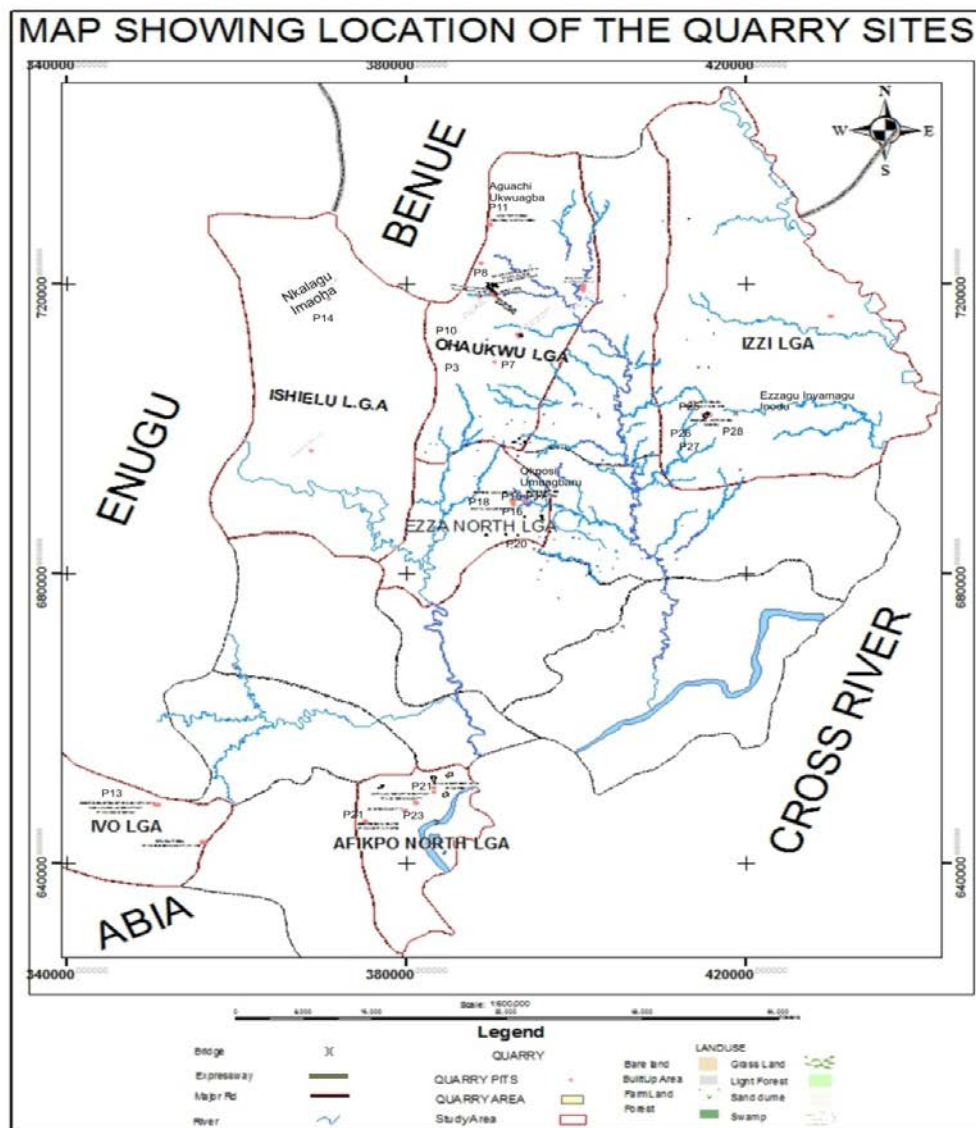
**Table 3:** Showing the Total Variance Explained. **Source:** Researcher’s SPSS PCA, 2016.

Components	Initial Eigen values			Rotation sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	2.141	53.524	53.524	2.126	53.139	53.139
2	1.176	29.388	82.912	1.191	29.773	82.912
3	0.596	14.900	97.812			
4	0.088	2.188	100.000			

P<0.05 (significant at the 0.5 level)

Therefore, the null hypothesis which states that “There is no significant pattern in the quarrying activity location in the study area is rejected. Consequently, the alternate is accepted. This implies that there is significant pattern in the quarrying activity location in the study area.

The quarrying activity map of the study area in fig. 3 showed the six local government areas where the 27 quarry sites are located. It showed the areas with large and small concentration of pits. It also showed the extent, distribution of quarry activities and the local government areas that have been greatly affected by quarrying activities in Ebonyi State. Subsequently, the photographs showing the conditions of the sites are presented.



**Figure 3:** Map showing the GIS location map of quarrying Activities in the Ebonyi State. **Source:** Inforgraph Consultants Nigeria, Limited, Enugu, 2016



**Figure 4:** Large expanse of vegetation cover and land is destroyed at Ali Ogbagu in Umuaguma community at Ohaukwu LGA. **Source:** Photographed by Author, 2016.



**Figure 5:** Community Pit at Akpeagu Amofia showing damaged landform and changed landscape. **Source:** Photographed by Author, 2016.



**Figure 6:** Quarrying activities have altered the local vegetation cover in Ezzagu Community. **Source:** Researcher's Fieldwork, 2016

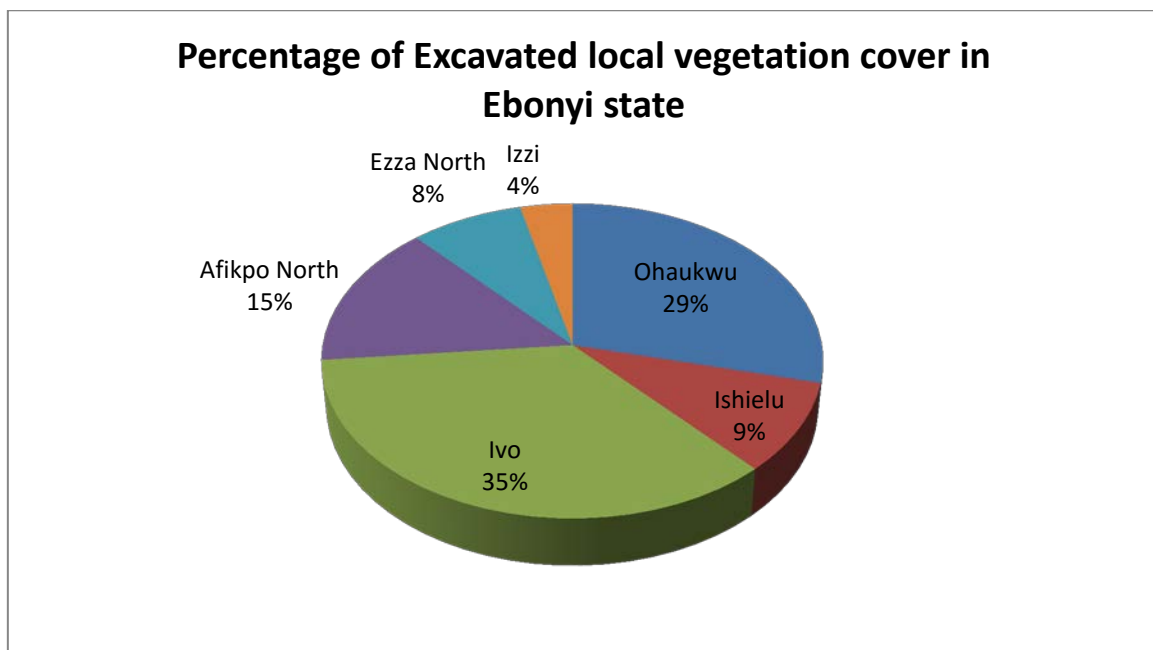
Table 4 shows the total area of vegetation cover lost due to quarrying activities and their percentages respectively in each of the Local Government Area of Ebonyi State. Ivo L.G.A has the largest amount of vegetation loss with 35.2% and Izzi LGA has the lowest vegetation loss of 3.7%. A total of 40,286 hectares of



vegetation cover has been lost in Ebonyi State due to quarrying operations.

**Table 4:** Percentage of Excavated Vegetation by Quarrying Activities. **Source:** Author’s Fieldwork, 2016.

Active Quarry Areas	L.G.A	Total Area Of vegetation lost by Quarry pits	% of area occupied by the quarry pits	Total Area of L.G.As
Ohaukwu		1,157050m <sup>2</sup>	28.7	597010762m <sup>2</sup>
Ishielu		377325m <sup>2</sup>	9.3	1043345732m <sup>2</sup>
Ivo		1,422000m <sup>2</sup>	35.2	322711402m <sup>2</sup>
Afikpo north		595350m <sup>2</sup>	14.7	553091458.5m <sup>2</sup>
Ezza North		323825m <sup>2</sup>	8.0	328019911m <sup>2</sup>
Izzi		153000m <sup>2</sup>	3.7	1156262332m <sup>2</sup>
Total		4,028,550m <sup>2</sup>	100	4,000,441,598



**Figure 7:** Showing the Percentage of Excavated Vegetation Cover in Ebonyi State. **Source:** Author’s fieldwork, 2016

The Principal component analysis technique employed in the test yielded an explained variance of 82.9 per cent. The total variance explanation of 82.912% entailed the significant pattern of quarrying activities distribution. The significant variables in component 1 are area of pit covered (0.917) and percentage of quarrying area (0.939), while the significant variables in component 2 are number of pit covered (0.833) and villages involved (0.644). The significant variables in component 1 and 2 are known as **derided parameter**. The components of

derived parameter are related consequently named **quarrying area magnitude**. The quarrying area magnitude is responsible for the rate of de-vegetation in the study area.

The explained variance of 82% further explains the extent and distribution of quarrying activities in the area. The spatial pattern and locations (LGA) of the quarrying activities in the study area shows that Ohaukwu has eleven quarries, Ivo has two quarries, Ishielu has one quarry, Ezza North has five quarries, Afikpo North has four quarries and Izzi has four quarries. Ohaukwu LGA has the highest number of pits covered and villages involved. Ivo LGA has the highest area of pit covered and percentage of quarrying area in the study area. This is followed by Afikpo North, Ezza North, Ishielu and Izzi LGA. Furthermore, the quarrying activity location map (Figure 3) of the study area showed the spatial pattern in the quarrying activity locations in Ebonyi State. It showed the six LGAs where the 27 sites and quarrying activities are prevalent. Field observations and oral interviews from villagers indicated that open cast method was generally used in the excavation of rocks in all the quarrying sites studied. It was also confirmed by the officials that the companies use the open cast approach which involves the use of explosives in blasting of rocks.

Obviously, open cast method has had serious effect on all landscape and vegetative components and functions in the study area. This had led to significant alteration of the original landscape, biodiversity loss and land degradation in the area. Blasting of rocks has to take place for quarrying operations to commence. The process disturbs the landscape as the original ecosystems are removed and the topography is significantly altered. The basic ecological relations are unchangeably disrupted, and biodiversity is decreased.

The existing condition of the area showed a high level of land deformation in the study area. The results from this study are of great importance in the management of the environment, precisely on land use/ land cover planning and conservation. This is because land resources must be safeguarded from the menace of quarrying activities emanating from unscientific extraction of rocks. Sustainable practices and precautionary measures should be taken into consideration prior and after quarrying operations.

This result is in agreement with the study of George *et al* [9]. Their study discovered that extraction of marble in Greece takes place by open cast quarries in hill slopes. They identified that original landform is permanently altered and the original vegetation cover is destroyed. These findings could also be linked to the study carried out by Cement Corporation of India Limited [7]. They maintained that open cast quarrying technique employed during the limestone processes resulted in huge environmental effects. These are evident in the removal of large soil mass, change in landscape and displacement of flora and fauna including human from their natural habitats. Again, the study carried out by the author in [21] also confirmed that activities like blasting and drilling operations are accompanied by significant noise and vibration which can disrupt terrestrial and wildlife habitats. These studies consent to the fact that open cast method contributes immensely to loss of vegetation cover. The quarrying operations by foreign and private companies make use of sophisticated machines and equipment. These are used for drilling, crushing and grinding to explore the rock buried underneath the earth.



**Figure 8:** A quarry site at Ohaukwu LGA where sophisticated machines are employed. **Source:** Photographed by Author, 2016

Also, the quarry location map show that areas where quarrying operation are active the lands are heavily degraded. First, removal of the top soils, trees and vegetation with heavy machines deprives the land of its nutrients and renders the land infertile for agricultural purposes. For instance, at Amaeze in Ishiagu area located at Ivo LGA, there were areas where the land had been covered by rocks and other debris from quarrying activities. These have not only impeded plant growth on the land but has also rendered the surface rugged, making it impossible for farming activities to take place there.

In addition, respondents complained that pits and heavy holes/trenches are created as a result of these activities, and such areas eventually become inaccessible to the people as they become fatal zones. Field observations confirmed this as such pits were observed at Akpeagu Ukwuagba and Afikpo North with depths ranging from about 50-75m deep. They are either covered with rocks or water (which render the land infertile) or are converted into waste pits and other toxic materials are deposited. There were scenes of rock piles close to villages such as Okposi, Ibbi, and others. Scenes of death trapped pits and rugged surfaces were also observed at a location close to the Eser/James Company at Ivo LGA.

This study showed that open cast system of quarrying which employs the use of explosives to extract rocks and hence, disturb the vegetation cover. This activity significantly accelerates erosion, land degradation and loss of farmlands around these communities.

It is quite unfortunate that even though many residents are aware of the negative effects of quarrying in causing land degradation and destruction of vegetation cover of the land, no serious intervention measures have been put

in place on a sustainable basis to arrest the menace. They need to fulfill their custodial obligations to protect their traditional lands. This is because their lands and vegetation reflects their identity, culture and their history. This should never be lost irrespective of economic benefits and social developments accrued to them. .

Findings from the field measurements indicated that there has been large scale exploitation of limestone and granite in Ebonyi state. 402.855 hectares of arable lands that have been destroyed by excavation of rocks. Ivo LGA happened to have the highest vegetation loss of 1422000m<sup>2</sup> represented by 35%. Also, Izzi LGA has the lowest vegetation loss of 153000m<sup>2</sup> represented by 4% in the area. This research inferred that based on the findings that the continuous quarrying of rock resources in the area has had a resultant negative effect on the arable lands and vegetation. Considering that the residents are predominantly farmers EBSEEDS, (2004) indicated that agriculture constitutes about 90% of the State's GDP with 75% of the population engaged in farming and being largely rural with an estimated 60% per cent (over 1.2 million people) living in rural area. The loss of farmlands, soil destruction can affect agricultural production and cause a setback in the economy, income and the primary occupation of the inhabitants.

## **5. Conclusion and recommendation**

The study has systematically identified that open cast system of quarrying causes massive damage to land and vegetation cover. It also identified the spatial pattern of quarrying activities in the six Local government Areas for Ebonyi State where quarrying activities are concentrated and active. It also explained the quarrying area magnitude responsible for the extent, distribution and the rate of de-vegetation of quarrying activities in Ebonyi State. The area extent of quarrying activities in Ebonyi state is 402.855 hectares to the degree of (0.1%) as clearly indicated by the GIS map of the area.

However, if extraction of stone continues at the unprecedented rate without the strict enforcement of government policies, guidelines and monitoring the present status may pose a serious threat to vegetation cover. This is contrary to the goal of sustainable development and may further escalate other environmental problems. Moreover, the contribution of this study is the development of a reliable and sophisticated quarry activity location map due only to the local vegetation cover under risk.

Open pit quarrying method was mostly employed during the quarrying process in Ebonyi State. It is mostly associated with massive environmental damage to the vegetation cover. However, there is need to reduce its negative effects on the environment by paying close attention to geology of the area, geotechnical planning, scheduling of earthmoving equipment, drill and blast technology and safety through constant monitoring and improvement.

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