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ENVIRONMENTAL CRISIS ASSOCIATED WITH SAND HARVESTING ACTIVITIES IN AWKA NORTH SETTLEMENT AREA IN ANAMBRA STATE, NIGERIA

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ABSTRACT

Sand harvesting activity in Awka North Local Government Area of Anambra State, Nigeria has been a major economic operation for over forty years. The indiscriminate sand harvesting operation in Anambra State's fragile geology has grossly affected the living conditions and environment of the people. The study was carried out to assess the environmental impacts of sand mining on the housing area and environment in Awka North Local Government Area. The study employed survey method, field observation; in-depth interviews and 400 questionnaires were randomly sampled. The results showed that 38% of the sampled population strongly agreed that their buildings were threatened by sand mining in the area. 35% strongly agreed that their infrastructures like electricity lines, roads and drainages were affected by the mining activities. It was found out that the mining processes are indiscriminately carried out with no post mining treatment and management of mined areas. The abandoned sites have caused massive damage to the landscape, infrastructures and buildings in the area. Human lives and properties have become threatened as a result of sand mining. Presently, mining operations have ceased in the area, though the negative effects have not. It is recommended that laws governing mining operations be enforced. With sustainable efforts made to reinforce the geotechnical conditions of the area to protect the vulnerable state of the human life, buildings and the environment.

KEYWORDS: Sand harvesting, mining, environment, housing development, management and sustainability.

INTRODUCTION

Sand mining is the process of removal of sand and gravel for the construction of buildings and roads (NCF, 2016). The construction industry is one sector that has created huge opportunities for both skilled and unskilled labour in Nigeria and beyond. The nature of its extraction has become an environmental issue as the demand for sand increases in the construction industry. Sands are not only on the world's beaches but also in microchips, telephones and German motorways. Around 30 billion tons of sands are used to make cement every year (allAfrica, 2017). The demand for sand for the construction of roads and buildings had increased sand prospecting and mining activities. All new cities require voracious amounts of sands. Every apartment block, skyscraper, office tower and shopping mall that gets built anywhere from Beijing to Lagos is of concrete, which is essentially just sand and gravel glued together with cement (The Guardian, 2017). This no doubt, has led to an increased demand for sand mining activities in Nigeria and Anambra State to be precise, with its attendant economic blessings and environmental consequences following.

As a global activity sands/stones are mined in different parts of the United States of America (USA), in Florida, Georgia, North and South Carolina, Virginia, and New Jersey and is typically followed by re-vegetation practices and long term monitoring (Saunders and Clemons, 1991). In Australia, sand mining has been carried out on both its East and West coasts. There are also mining of sands along the coast of Brazil in South America, Asia, India, Malaysia and Nigeria (Erskine and Green, 2000 and Kondolf, 1994, Akanwa et al, 2017).

The global urbanization boom is devouring colossal amounts of sand which is the key ingredient of concrete and asphalt. 3 million tons of sand was mined in Zanzibar between 2005 and 2015, this equals around 120,000 full truckload of sand (Department of forestry, 2015). The United Nations Environment Programme (UNEP, 2014) estimates around 40 billion tons of sand are processed worldwide every year. However, sand is a finite commodity alongside coal, natural gas and oil, sand is one of the world's non-renewable resources.

Awka –the State Capital of Anambra, is rich in kaolin, clay, lead/zinc, limestone, iron ore, glass, phosphate, gypsum, lignite and sand with an almost 100 per cent arable soil (Sweet Crude Report, 2012). Upon the creation of Anambra State in August 1991 with Awka as its Capital, the State's economy had witnessed steady development and growth. made a tremendous shift in the status of the State from its rural nature to its current state as a bustling growing Capital City with a teeming population of more than half a million people (National Population Commission, 2006). An aspiring goal to provide infrastructural services and coordinate all building development activities of the private sector, parastatals and government agencies became expedient within the Capital Territory.

This has increased the demand for sands both through legal and illegal means of extraction; hence, accrued negative impacts became unavoidable. These impacts severities are dictated by various factors which include; whether the mine is working or abandoned, the mining methods used, and the geological conditions of the area (Fox 1996, UNESCO, 2003).

Prior to the development of the Akwa as the State's Capital Territory substantial levels of unorganized sand extraction has been predominant for a long period of time in Awka North LGA that served as a remote area then. The inception of Awka in 1994 as the Capital City required the need to keep up with this new transformation. This required the provision of adequate housing to accommodate its teeming population not just within the Awka alone, but adjoining LG areas were owning private property and housing would be affordable became attractive too.

Clearly, adequate housing became a major problem in the city with legion of people competing for few expensive houses. The in flock of people into the area accelerated the mapping out of new housing layouts that would accommodate government workers and business people. Unfavourably, the new housing layouts were developed within sand-mined areas that provided the city with sand materials used to develop and shape its structure. Awka North LGA due to its

proximity to the city was chosen as one of the six local government areas that make up the Awka Capital Territory. Awka North is an area of 352km² (See fig. 1 and 2). The towns that make up the local government are Awba Ofemili, Ugbene, Ebenebe, Achalla, Urum, Amansea, Amanasa, Amanuke, Isu Aniocha, Mgbakwu and Ugbenu. The first sand mine is located at Latitude N 6° 14 37.25' and Longitude E 7° 3 24.38'. The second sand mine is located N 6° 14 51.55' and Longitude 7° 3 16. 79' (See Figure 4). Both sites are surrounded by Mgbaukwu to the North, Okpuno to the South, Ezinhitte to the East and Nnodu to the West along Mgbaukwu road.

Sand harvesting have been carried out in the area for over 40 years before its closure. The study area is made up of sixty thousand, seven hundred and twenty eight persons, with twelve thousand, five hundred and sixty-two persons (National Population Census, 1991). The population is largely rural and notable for the production of rice, cassava, yam, plantain, garri and other crops. The inhabitants of the area include government workers, farmers, traders and Business people.

The geology of the area is the Imo Shale which underlies the Eastern part of the State, particularly in Ayamelum, Awka North, and Oruma North LGAs. Next in the geological sequence, is the Ameke Formation, which includes Nanka Sands, laid down in the Eocene. Its rock types are sandstone, calcareous shale, and shelly limestone in thin bands (See Fig.5). Needless to say, with high annual rainfall in the area, ranging from 1,400mm in the North to 2,500mm, the fragile geology is seriously threatened with gully erosion. Although, the area falls within the natural vegetation marginally the tropical rainforest type (See fig. 3); however, because of the high population density in the state, most of the forests have been cleared for settlement and cultivation.

However, the negative externalities of sand mining have been widely studied (Wille and Garrod, 1999; Mossa & Mclean, 1997; Heath et al, 1993; Veiga et al, 1997, Warhust, 1994, 1996 and Akanwa et al, 2016 among others). They confirm that sand mining causes erosion, collapse of buildings and

infrastructures, create visually unpleasant landscapes, ill-health, sociological and ecological problems. The Guardian (2017) reported that from Cambodia to California industrial-scale sand mining is causing wildlife to die, local trade to wither and bridges to collapse. Also, sand mining caused a bridge to collapse in Taiwan in 2000, in 2001 another bridge collapsed in Portugal as a bus was passing over it and 70 people were killed.

Generally, environmental impacts of sand mining are disastrous and could lead to soil erosion, formation of sinkholes, destruction of landscape, loss of bio-diversity, deforestation, loss of tree species, coastal erosion and loss of aquatic lives (Punch Nigeria, 2017, Collins et al, 1990, Akanwa et al, 2016, Jafaru ,A,M, 2009 and Akanwa et al, 2017). The Process also diminishes and endangers the supply of natural resources available to the local communities and thereby increasing their poverty levels, environmental and social problems (Jafaru et al, 2009 and Langer, 2003). This is need for sustainable practice of sand mining considering that the practice is a non-renewable resource activity that has significant and irreversible environmental impacts on fragile ecosystems (SoE 2003).

The concept of sustainable development highlights the need of meeting the demands of the present generations without compromising the ability of the resource base to meet those of the future generations (Agenda 21, 1997). However, development processes are at a stage which land use interests such as mining, agriculture, tourism, ranching, wildlife management, forestry, water conservation, manufacturing, human settlements and infrastructure development are conflicting. This is exacerbated by the mismatch between population and economic growth together with inadequate policies governing land use. Additionally, existing policies and programmes are either poorly implemented or lack harmonization and coordination in developing countries like Nigeria.

The conservation of natural resources is vital since, sand is a non-renewable resource. There should be a common concern for mankind and is an integral part of the development process. It links traditional efforts to the goal of using

economic resources in a sustainable manner. Its implementation has suffered some inadequacies especially those governing management of the resources base resulting in wide spread environmental degradation.

Hence, the central thrust of this study is to assess the impact of sand harvesting activities in Awka North LGA on housing development and the environment that prompted this study.

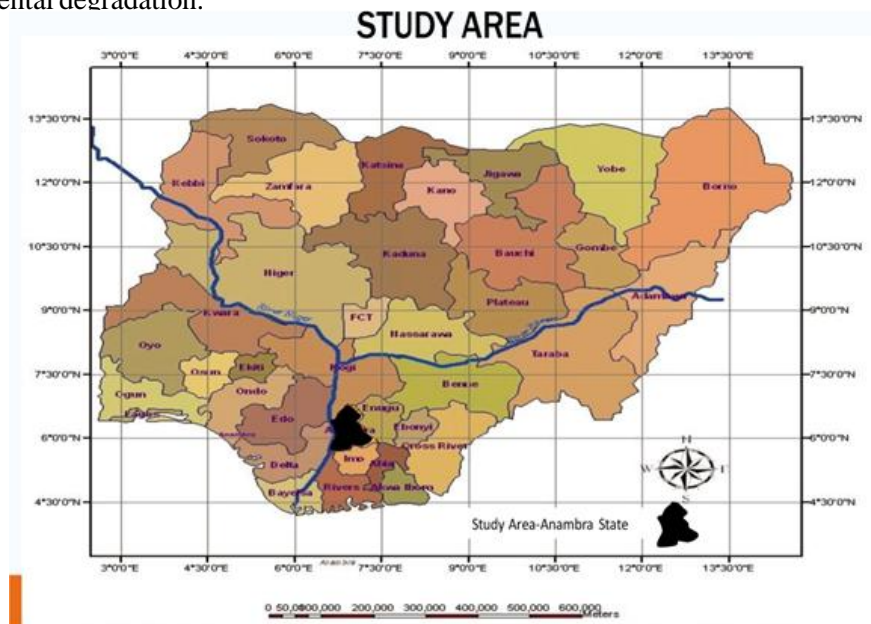


Figure.1: Map of Nigeria showing Anambra State
Source: National Geo-Hazard Centre, Awka



Figure 2: Showing the Map of the Study Area
Source: Google Map (2017)

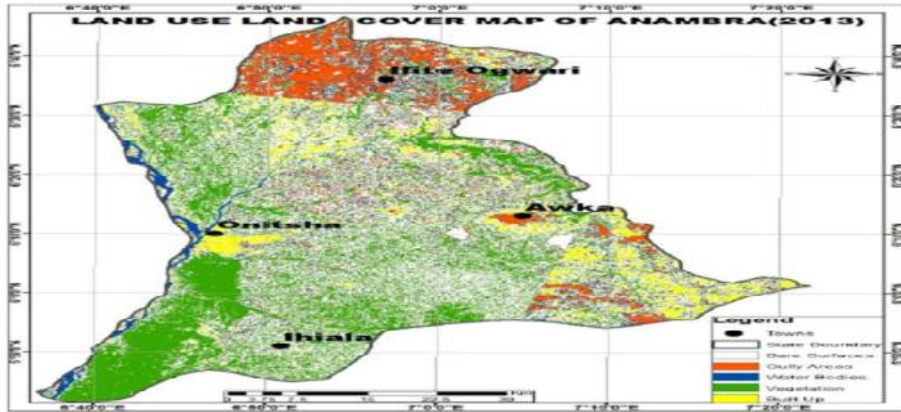


Figure 3: Land use /Land cover of the Study Area
Source: National Geo-Hazard Centre, Awka (2017)

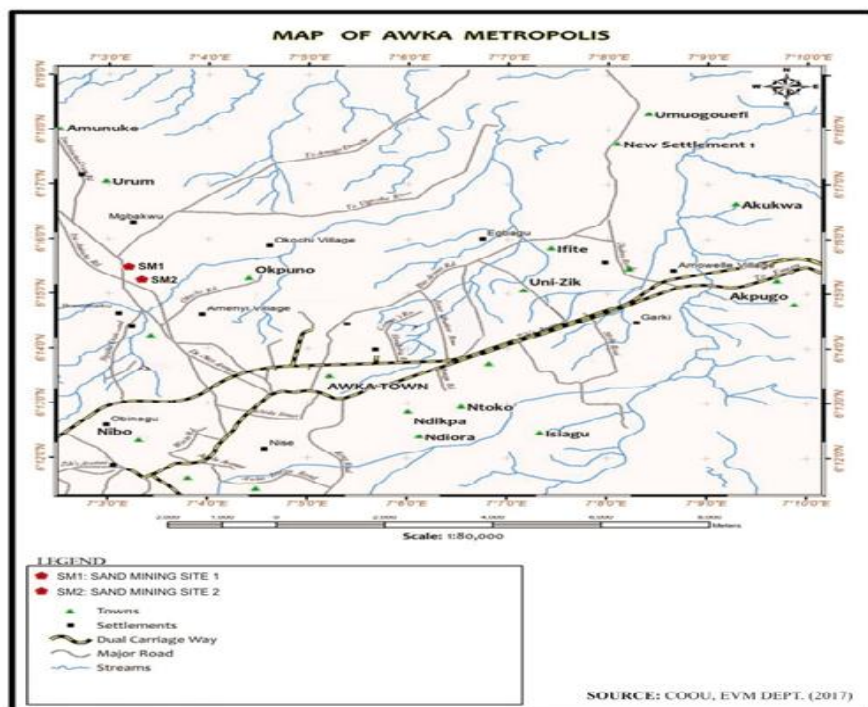


Figure 4: Street Map of Awka Showing location of Mining Sites.

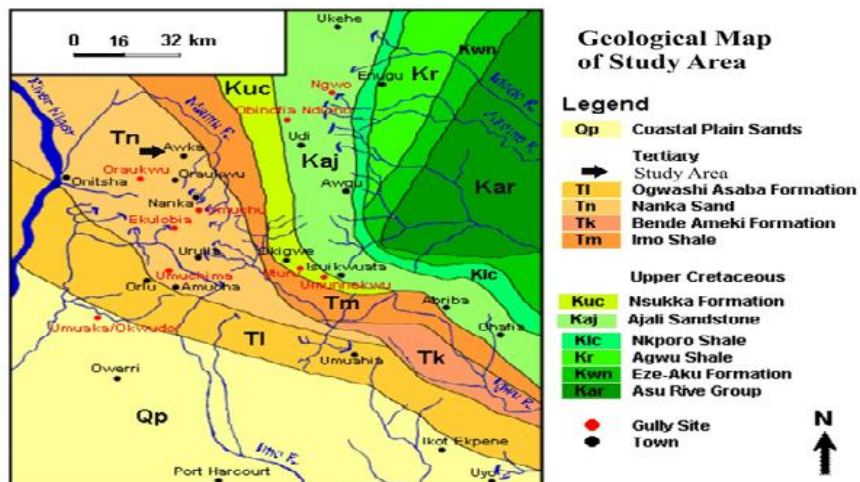


Figure 5: Geological Map of the study Area
Source: National Geo-Hazard Center Awka, 2017

MATERIALS AND METHODS

The data for this study was collected through survey method which includes direct field observation, questionnaire administration; in-depth interviews and photograph recording. 400 questionnaires were distributed, but 390 were finally recovered, analyzed based on the effect of sand harvesting activities on housing and the environment. The census data was collected from the National Population Commission office in Awka, Anambra State.

The field visits were carried out to properly observe the existing conditions and interview individual landowners and landlords, and selected inhabitants of the study area living within the sand mines. Representatives from relevant departments and agencies in respect of sand and quarrying mining and other land use management systems were also included. The aim of this selection was particularly to give broad views on the prevailing issue.

For individual landowners, landlords and community members, interviews were also used to this the approach allows a more in-depth investigation into the unique experience of each interviewee (Huntington, 2000). It allows people to speak for themselves without their answers being biased by predetermined hypothesis-based questions (Huntington, 2000; Rubin, J and Rubin, S, 2005) . Most of the questions raised during the interview were to elaborate and/or clarify the interviewee's understanding of a point or to direct them to the aim of the study.

The Garmin eTrex GPS was used to obtain the coordinates of the location of both sand mines. Geographical Information System and Global Positioning System were used for producing the map of the area and fixing the geographic positions of the locations of the sand sites respectively. The

data so collected was collated and analyzed for the two sand mines at Awka North Local Government Area.

RESULTS AND DISCUSSION

A total of 400 questionnaires were administered. However, 390 were returned and analyzed to assess the impacts of sand mining activities on housing development and the environment. Two hundred and sixteen (55%) and one seventy-four were females (45 %). The respondents were categorized into 5 main age classes, which included (less than 20 years), (20-30 years), (31-40), (41-50) and (more than 50 years). Most of the respondents were between 31 and 50 years (See Figure 5.1) below.

The young and old expressed different perceptions and interests on sand mining activities in the study area. Respondents within age brackets of less than 20 years and those aged over 50 years showed less concerns when compared to those in the 31-50-age bracket. Gender of the respondents also showed varied expressions on environmental degradation caused by the sand mining activities. The men expressed their woes on the severe damage of sand mining activities on their buildings and lands. Since most of them owned buildings and lands in the area. The men noted that there were no guidelines in existence to guide mining activities. Most of the women interviewed were more concerned that the mining activities had increased the distances covered to the market, the loss of animals due to pits created during sand harvesting, taking their children to school, visiting friends, their farm lands were affected, and also restricting their movement to only during the day. This no doubt, establishes the need for policy makers, natural resource managers and planners to develop policies on sand mining and rehabilitation that are guided to cover all gender-related perception and interests.

Table 1.1: Gender of the Respondents

Gender	Frequency	Percentage (%)
Male	216	55
Female	174	45
Total	390	100

Source: Researcher's fieldwork, 2017.

Table 1.2.: Age Distribution of Respondents

Age(years)	Frequency	Percentage (%)
Less than 20	25	6
20-30	33	9
31-40	127	33
41-50	122	31
More than 50	83	21
Total	390	100

Source: Researcher’s Fieldwork, 2017

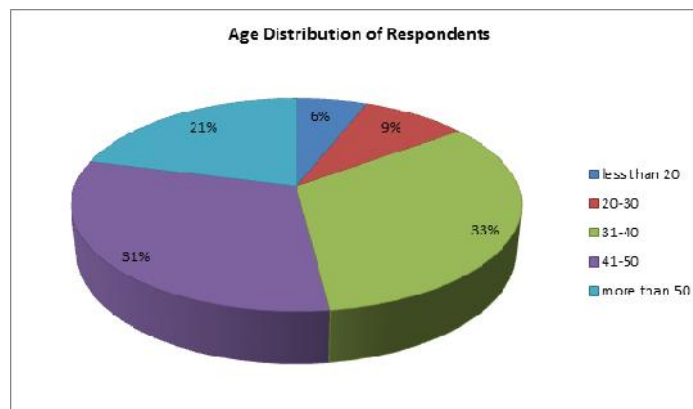


Fig.5.1: Showing Age Distribution of the Respondents.

Source: Researcher’s Fieldwork, 2017.

The perception of the residents on sand mining activities and their attendant impacts on housing development and the environment were sought. Table 1.3 showed that 148 respondents representing 43% of the entire sample size strongly agreed that the sand mining activities affected the buildings and the environment. Also 113 respondents representing 29% agreed to this effect. 47 respondents representing 12% of the sample size

strongly disagree while 62 respondents representing 16% disagree with the assertion that sand mining activities affect the housing and the environment. 20 respondents, representing 5% were undecided (See Fig.5.2) below. This indicates that a large percentage of the sampled population agree that buildings in the study area are seriously affected by the past sand mining operations.

Table 1.3: Sand harvesting and its Effect on the Housing Development.

Responses	Frequency	Percentage (%)
Strongly agree	148	38
agree	113	29
Strongly disagree	47	12
Disagree	62	16
Undecided	20	5
Total	390	100

Source: Researcher’s Fieldwork, 2017.

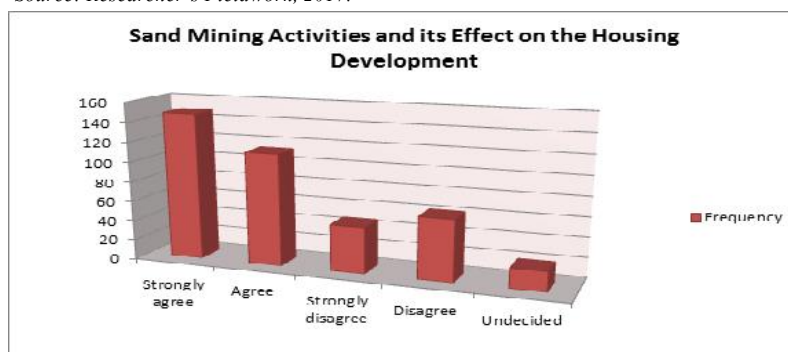


Fig.5.2: Showing Sand Mining Activities and its Effect on Housing Development.

Source: Researcher’s Fieldwork, 2017.

Also, the perception of residents on the ability of sand harvesting activities to affect housing infrastructures was obtained. Table 1.4 showed that 144 respondents and 115 respondents representing 35% and 31% respectively strongly agreed and agreed to the assertion that sand mining activities is a threat to housing infrastructures. Also, 59 respondents and 50 respondents, representing 15%

and 13% respectively strongly disagreed and disagreed. 22 respondents, representing 6% were undecided (See Fig 5.3) below. This result showed that a large number of the residents agree that housing infrastructures like electricity poles, drainages, cables and roads have been affected by sand harvesting.

Table 1.4: Sand Harvesting affects Housing Infrastructures.

Responses	Frequency	Percentage (%)
Strongly agree	144	35
Agree	115	31
Strongly disagree	59	15
Disagree	50	13
Undecided	22	6
Total	390	100

Source: Researcher’s Fieldwork, 2017

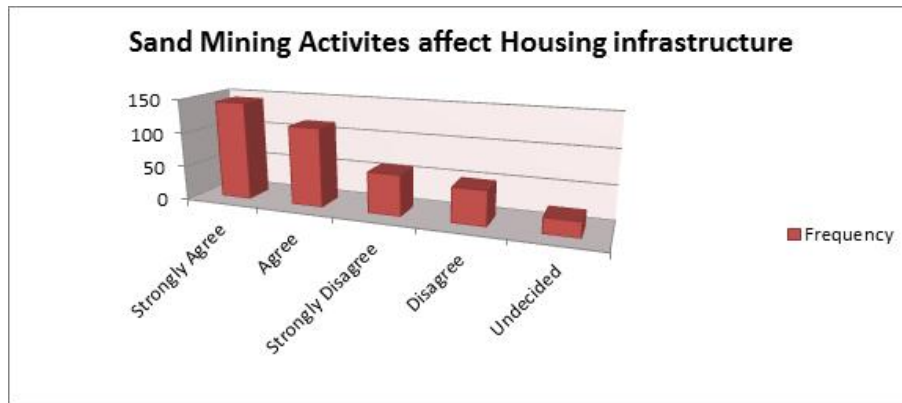


Fig.5.3: Shows that Sand mining affects housing infrastructure

Source: Researcher’s Fieldwork, 2017.

Findings from the study showed that sand mining activities have been carried out for over 40 years in the area before its closure. Presently, sand mining activities have ceased, but their effect over the years has become a major issue for the residents in the area. It was observed that the two sand mines were situated in the vicinity of settlement areas, where other activities like agriculture, block molding business and grazing takes place. This area used to be a rich forest area considering that the study area is located in the tropical rainforest zone (See Fig. 3). Also, findings revealed that sand extraction is done by open cast mining method. In this method, the ground vegetation is cut to clear the land. The topsoil is then removed. Pits are then dug into the ground to reach the quality sand deposits. Finally, the sand is loaded into Lorries for transportation and trading purposes. Off road

movement of trucks and other vehicles in the area causes further damage to the vegetation and ecology of the area. However, the study area has little vegetative cover and soils are fragile and therefore, susceptible to disturbances from erosion.

It has left significant alteration of the original landscape, topography, vegetation and huge disturbances on the settlement in the area. The study carried out by Akanwa et al, (2016) on the effects on opencast mining confirmed this finding.

It is unfortunate, that the buildings, lands and farms have been grossly affected with most of them at the verge of total collapse. The walls of Doro Gardens a recreation resort has partially collapsed as a result of sand mined within the location (See plate1). A part of the village town hall has also collapsed leaving only a part of it hanging. Another adjoining residential three-storey

building is seriously threatened and at the slightest movement of sands by heavy rainfall may collapse (See Plate 2 and 3) residents have made several reports to governing authorities to stop sand extraction in the area. Presently, the uncontrolled sand extracted has ceased, but the remains of forty (40) years extraction is yet to be dealt with and an impending total collapse in the nearest future is expected (See plate3 and 4). These present problems are confirmed by other studies reviewed (Willis et al, 1999;Mossa et al, 1997 and Akanwa et al, 2016). Obviously, the area is in dire need of quick sustainable management strategies by government to remedy the situation.

However, apart from the fact, that past sands harvested affected housing and the environment in the area; these problems are exacerbated by the geologic formation of the area - Nanka Sands that is highly unstable (See fig. 5). Its prominent features indicates that it is loose, friable, permeable, hence, easily erodible and susceptible to landslides and gully erosion as confirmed by the study carried out on the South-Eastern geology by Egboka et al, (2016) and Akanwa et al, (2011). It is unfortunate that these activities have been carried out with disregard to environmental guidelines, sustainable mining practices with exception to strict enforcement of rules on soil extraction process despite complaints from residents and concerned individuals over the years.



Plate 1: Showing the collapsed walls of Doro Gardens due to sand mined activities



Plate 2: Showing another collapsed fence of the village town hall at Awka North due to sand mined activities.



Plate 3: Showing a threatened residential building located within the mined area.

Furthermore, apart from the threatened buildings, findings also indicated that sand mining has affected housing infrastructures in the area. Infrastructures like electricity poles and lines, cables, roads, drainages and water supply (boreholes) in the area (See Fig. 5.3 and Plate 4).

The sampled population and interviewed property owners and residents indicated that this has affected the supply of electricity to the area, most of the wells located within the mining area are polluted and movement is restricted due to affected roads/pathways makes it difficult around settlement.



Plate 4: Showing an affected electricity Pole in the area at the point of collapse

A respondent indicated during the interview that most of the buildings and infrastructures affected become difficult for landlords to rent it. Due to the unrestricted sand mined in the area most

of the buildings, walls, bridges and infrastructures have exposed foundations that are no longer firmly supported even to the point where parts of the walls have partially collapsed. Additionally, the presence

of unsightly excavated pits and trenches renders the landscape and vicinity of the area unattractive for human habitation. This therefore, can deny landlords not only environmental benefits, but social as well as huge economic benefits.

CONCLUSION\RECOMENDATION

Sand harvesting operation, undoubtedly has brought wealth, employment opportunities and physical development to Anambra State, but simultaneously has led to extensive environmental degradation and most especially a threat to human dwellings. Environmental problems associated with sand mining have been felt severely because of the area’s fragile geology and ecosystems; and richness of biological and cultural diversity. The indiscriminate sand mining activities, absence of post mining treatment and management of mined areas are making the fragile ecosystems more vulnerable to environmental degradation, leading to threatened buildings and human life.

Due to the nature of mining that has removed all the sand up to the bedrock level in the area. The chances of natural vegetation recovery on the abandoned sand mines to help safe guard the buildings will be problematic. It may take several decades or more for the vegetation to recover on these sites. These large de-vegetated areas are a major threat both ecologically (e.g. both flora and fauna) and economically (e.g. less attractive for tourism and human habitation).

With the local communities’ limited economic and technical resources, they will not be able to afford alternatives to the existing natural resources or to pay the cost of restoring the environment to its former levels of productivity. A need therefore arises to collect baseline data for documenting status, monitoring, resilience and reinforcing existing buildings and informing policy development for sustainable utilization of natural resource.

REFERENCES

1. *Agenda 21 (1997) Natural resources of sustainable development in Iceland. Retrieved July p, 2009 from <http://www.org/esa/agenda21/natlinfo/countries.iceland/natur.htm>.*
2. *Akanwa, A.O., and Ikegbunam F.I. (2017) Adverse Effects of Unregulated Aggregate Exploitation in South-Eastern Nigeria. EPRA International Journal of Research and Development (IJRD), Vol 2 (3), Pp 167-177*

3. *Akanwa, A.O., Onwuemesi, F.E., Chukwura, G.O and Officha, M.C. (2016) Effects of Open Cast Quarrying Technique on Vegetation Cover and the Environment in Ebonyi State. American Science Research Journal of Environmental Technology (ASRJET); Vol 21, No.1, pp 227-240.*
4. *Akanwa, A.O., Onwuka, S.U., Okoye, A.C and Onwuemesi, F.E (2011). Assessment Of Groundwater Quality around Open Waste Dump Sites in Ifejiika and Obosi in Anambra State: Anachem Journal 2011, Vol 5 (1): 903-910*
5. *Allafrica (2017) Africa-Sand Mining Decimates African Beaches.*
6. *Collins, B and Dunne, T(1990) Fluvial Geomorphology and River-Gravel Mining. A Guide for planners, Case Studies Included Special Publication,98 California Dependent of Conservation Division of Mines and geology.*
7. *Department of Forestry and Non-Renewable Natural Resources Official Statistics Zanzibar, Tanzania.*
8. *Egboka, B, C , Okeyeh, E.I (2016) The Impacts and Implications of Anthropogenic Forces on Unstable Geologic Platform in parts of Anambra and Imo states, South-Eastern, Nigeria. International Journal of Environmental Protection and Policy. Vol(4),Pp 104-110.*
9. *Erskin, W.D and Green, D (2000) Geomorphic Effects of Extractive Industries and their Implications for River Management: The case study of the Hawkesbury-Nepean River, Ne South Wales. In Brizga, S and Finlayon.B (Eds), River Management: The Australian Experience(Pp 123-149). Chichester, UK: Wiley.*
10. *Fox, (1996) Comparison of Regeneration Following Burning, Clearing or Mineral Sand Mining at Tomago NSW: Structure and Growth of Vegetation. Austral Ecology, Vol 21, (2), Pp 184-199.*
11. *Heath, M.J; Merefield, J.R and Parthankar, A.G (1993) Environmental Impact of Mining on Tropical Forest. Mining Environmental Management, 37, 14-16.*
12. *Huntington, H.P(2000) Using Traditional Ecological Knowledge in Science: Methods and Applications. Ecological Applications, 10, 1270-1274.*
13. *Jafaru,A, M (2009) Assessment of Sociological and Ecological Impacts of Sand and Gravel Mining- A Case Study of East Gonja District (Ghana) and Gunnarsholt (Iceland).Land Restoration Training Programme, keldnaholt, 112Reykjavik, Iceland.*
14. *Kondolf, G.M (1994) Geomorphic and Environmental Effects of In-stream Gravel Mining. Landscape and Urban Planning, 28, 225-243.*
15. *Langer, W.H, (2003) A General Overview of the Technology of In-stream Mining Sand and Gravel Resources Association. Environmental Impact U.S Geological Survey Open File Report 02-0153, 44pp.*

16. Mossa, J and Mclean, M (1997) Channel Planform and Land cover Changes on a Mined River Flood Plain. Amite River, Louisiana, USA. *Applied Geography* 17(1), 43-53.
17. National Population Commission (NPC, 1991) *Nigerian Population Report, Abuja Nigeria.*
18. Nigerian Conservation Foundation (NCF, 2016) *NCF Expresses Concern Over Sand Mining in Lagos. Punch last Assessed 5th March, 2017*
19. Punch Nigeria (2017) *Nigerian Conservation Foundation Expresses Concern over Sand Mining in Lagos state, Nigeria.*
20. Rubin, .J and Rubin, S, (2005) *Qualitative Interviewing : The Art of Hearing Data.* California, Sage Publications, Thousand Oaks.
21. Saunders, C.L and Clemons, C.L(1991) *Mineral Sand Extraction and Land Reclamation on a relict Beach Ridge Clay Country, Florida.* In: *Proc. The National Association of State Land Reclamation Annual Conference.* Orlando, FL.
22. Sweet Crude Report (2012). *A review of Nigeria Energy Industry Anambra Government Plans Massive Solid Minerals Exploitation.* last assessed March 8th, 2017).
23. *The Guardian* (2017) *Sand Mining: The Global Environment Crisis.* Last Assessed Feb 27th, 2017.
24. UNEP (2014) *UNEP Global Environmental Alert Service: Sand, Rarer Than One Thinks.* <http://na.unep.net/geas/archive/pdfs/GEAS-Mae=rch2014-sand=Mining.pdf>.
25. UNESCO (2003) *Monitoring Beach Changes as an Integral Component of Coastal Management. Final Report,* UNESCO, Paris, 90pp. <http://www.unesco.org/csi/pub/mon.htm>.
26. Veiga, M.J and Bunoff, C (1997) *UNECA Centers: A Solution to Reduce Mercuey Pollution from Artisinal Gold Mining Activities.* *UNEP Industry and Environment.*
27. Warhust, A (1994) *Environment Degradation from Mining and Mineral Processing in Developing Countries. Corporate and National Policies.* Paris Development Center, OECD.
28. Warhust, A (1999) *Environmental Regulation, Innovation and Sustainable Delopment.* In (eds) *Mining and Environment: Case Studies.* International Development. Research Center.
29. Willis , K.G and Garrod, D (1999) *Externalities from Extraction of Aggregates Regulation by Tax or Land use Control Resource Policy,* 25, 77-153.