Journal of Engineering and Architecture
June 2019, Vol. 7, No. 1, pp. 39-50
ISSN: 2334-2986 (Print), 2334-2994 (Online)

Published by American Research Institute for Policy Development
DOI: 10.15640/jea.v7n1a5
URL: https://doi.org/10.15640/jea.v7n1a5

Assessment of Sustainable Sand Provision for Construction Projects in Nigeria

Abdulhakeem Garba[1], Maryam Baba Mairami[2] , Muinat Omolara Sanni[3]

Abstract

Construction base materials such as timber and sand have been experiencing depletion in recent times. Due to this factor sand, particularly its mining and extraction has impacted negatively on the environment through the destruction of beaches and endangering the ecosystem they protect and escalated the cost of construction. This study aimed to examine sustainable sand provision for construction projects in Nigeria. The study adopted the survey approach with respondents comprising construction practitioners. One hundred and fifty structured questionnaires were distributed out of which 107 responded representing 71%. Descriptive statistics was used for analysis. Typical findings reveal that the primary source of sand currently used for construction in Nigeria is river. Most prevailing negative consequences experienced include soil erosion, depletion of sand and increasing the cost of construction. The most favourable preventive measures include enacting a government policy regulating the mining of sand and issuing legislation requiring the use of alternatives to sand among others. The most presently utilized alternative resource to sand is quarry dust and construction and demolition waste. The reasons for lack of adoption of other alternatives include non-availability and lack of awareness. In the future, respondents indicated that they are likely to adopt some of the alternatives.

Keywords: Sand, Construction Materials, Sand Wars, Sustainability, Sand Alternatives, Nigeria.

Introduction

The existing practice reveals that construction industry utilises a wide range of materials that are either locally or internationally sourced depending upon the kind of construction ranging from mud houses, bricks and blockhouses, roads, and other modern infrastructure that use high-end materials. Examples of such materials include wood, plastics, glass, metals, soil, cement, blocks etc. The pressing problem that the industry is facing is the sources that the materials are obtained from (Smart Bricks, 2017).

Sand is the third largest exploited natural resource globally (Brandt, 2018). It also occupies a major position among the various resources utilised by the construction industry (Witschge, 2017).The world's use of sand and gravel for concrete was estimated at between 25.9 to 29.6 billion tons in 2012 alone (Aljazeera, 2017). The manufacturing industry uses it also for glass, electronics and aeronautics (GreenFacts Scientific Board, 2018). Both sand and gravel are taken for granted, and comments about their importance are made by Kiran Pereira(founder of sandstories.org) *"It's almost become like air, the air we breathe, we don't think too much about it, but you can't live without it*". While sand is considered an abundant resource, however, its mining occurs at a rate speedier than its natural renewal rate (Aljazeera, 2017).

[1] Department of Quantity Surveying, School of Environmental Design, College of Environmental Studies, Kaduna Polytechnic, Kaduna, Nigeria. E-mail: hakeemgarba@gmail.com, +2348035993246

[2] Department of Quantity Surveying, School of Environmental Design, College of Environmental Studies, Kaduna Polytechnic, Kaduna, Nigeria. E-mail: mairamim@yahoo.co.uk

[3] Department of Quantity Surveying, School of Environmental Design, College of Environmental Studies, Kaduna Polytechnic, Kaduna, Nigeria. E-mail: Muinat.sanni@gmail.com

Sand is widely used for a lot of items by man. However, the Construction industry is the leading sector that consumes it the most. In building an average house 200 tons of sand is required approximately, for a hospital, 3,000 tons are required; while 12,000,000 tons are required to construct a nuclear plant (Witschge, 2017). Sand is used to provide strength and bulk to asphalt and concrete. It is also used for decorative purposes in landscaping. Specific type of sand is used for the manufacture of glass and as moulding for metal casting (Brandt, 2018).

Several countries are facing a major problem of scarcity of sand. These include Singapore that imports 35 million cubic metres of sand despite spending heavily on reclamation of land from the sea. China's Pyongyang Lake is considered the world's major sand mine; itis estimated that 236 million cubic metres of sand is extracted from it, adversely affecting the landscape to the north of the lake (Aljazeera, 2017). Vietnamese farmers living in the Mekong Delta are plagued by the increasing salinity of river water killing rice production (Stonberg, 2017).

Sand scarcity may not be unconnected with increasing construction activities but also variation in rainfall as a result of global warming. According to data from the climate change knowledge portal of the world bank group there has been a steady rise and fall in average rainfall in Nigeria in the last decade. Typical values include 93.3mm in 2000 rising to 102 mm in 2008 and dipping down to 81.3mm in 2015 (World bank group, 2019).

In Kabale community of Uganda landslides are becoming more frequent due to the mining of sand and stone quarrying. The workers are aware of the negative consequences, however, this does nothing to deter them as it is their primary means of livelihood, legislation was recently introduced banning the mining of sand as it involves the use of child labour, but without suitable alternatives the practice continues (Asinwe, 2019)

Sand supply diminishes as a result of inaccessibility of rivers by excavating equipment during the peak of the rainy season in Nigeria. This has lead to the stockpiling of sand during the non-rainy season. However, in recent times, the amount of rainfall exceeds the normal rainfall season due to climate change, leading to scarcity thereby increasing the cost of sand. The scarcity of sand has also triggered smuggling bands known as sand mafias. These bands plunder beaches and rivers for sand. The sand mafias in India control a lot of the construction material trade, construction and the government through their political contacts (Sumaira, 2017) resulting in increased pressure on the world's beaches.

A global wave of gang violence has emerged from illegal sand mining. An incident that happened in South-east Nairobi saw two Kenyan truck drivers meet sudden death in the hands of a mob of local youths (Beisier, 2017). "*As the price of sand goes up the mafias get more involved*" says Pascal Peduzzi (researcher for the United Nations). Every year criminal gangs dig up countless tons of sand to sell on the black market. Half of the sand used for construction in Morocco comes from illegal mining. In Malaysia, dozens of officials were charged with corruption in exchange for allowing illegally mined sand smuggling (Beisier, 2017).

In Nigeria, Sanda Aguila Foundation have reported several incidents of negative consequences of sand mining occurring in the last few years. These include Akwa Ibom State experiencing considerable damage to the environment and threatening the foundation of some critical assets such as Mkpok bridge in Onna Local Government Area and the Calabar-Itu bridge. Lagos State recently introduced legislation banning the dredging of the state's shorelines citing environmental concerns. The Niger State Government also prohibited the dredging of sand in the 25 local governments in a bid to save communities from ecological disaster.

Sand

Sand is a natural unconsolidated granular material. It is composed of grains that range in size from $^{1}/_{16th}$ of a millimetre to 2millimetres. The grains are either mineral particles, rock fragments or biogenic in origin (Sepp, 2015). Granular materials finer than sand are called silt. Coarser material is referred to as gravel. Table 1 shows grain size classification scheme for sediment grains (Taylor, 2012).

Table 1: Grain size Classification Scheme (Source: Taylor, 2012)

Mm	Φ	Class terms	Sub-classification
		Boulder	
256	-8	Cobbles	
128	-7		
64	-6	Pebbles	
32	-5		
16	-4		
8	-3		
4	-2	Granules	
2	-1		
1	0	Sand	Very coarse
0.5	1		Coarse
0.25	2		Medium
0.125	3		Fine
0.0625	4		Very Fine
0.0312	5	Silt	Coarse
0.0156	6		Medium
0.0078	7		Fine
0.0039	8		Very Fine
		Clay	

Formation of Sand

Sand is mainly formed as a result of the chemicalor physical breakdown of rocks known as weathering. Chemical weathering is most efficient in humid and hot climates (Moore & Braucher, 2008). Physical weathering dominates in cold and dry areas. Dunes are the significant sources of sand. Dunes are formed using three things (Ronca, 2008) which are a considerable amount of loose sand in an area with little or no vegetation like a coast, dried up river, lake or seabed; a wind or breeze to transport the grains of sand and An obstacle that will hinder the movement of sand causing it to lose momentum and deposit.

Where these three variables happen simultaneously, dunes are formed. As the wind picks up the sand, the sand rises above the ground through saltation, creep and suspension processes. Once in motion, it will continue to move until an obstacle obstructs its movement. The heaviest grains settle against the obstacleand small ridges are formed. The lighter grains are deposited on the other side of the obstacle. The wind crests and the light grains cascade down the slip face like an avalanche forming a dune after the grains have collapsed under their weight. The pile stops collapsing when the slip face reaches the right angle of steepness(called angle of repose) which ranges from 30 to 34 degrees (Ronca, 2008).

Transportation of Sand

Another source of sand is through the process of sedimentation. Sediments are collections of grains of pre-existing rocks, fragments of dead organisms or minerals precipitated. The term sediment is attributed to loose, unconsolidated material. Sediments can be classified as clastic, biological and chemical (Taylor, 2012). Clastic sediments are composed of particles from pre-existing rocks (igneous, metamorphic or sedimentary). The particles are transported away from the site by water, wind or ice and will ultimately settle out and accumulate in a range of continental or marine environments. Biological sediments are derived from remains of dead organisms such as shells and plants or build-up framework building organisms such as coral reefs. Chemical sediments are formed by chemical processes as a result of precipitation of minerals from the water body (Taylor, 2012). Sand as a clastic sediment is transported by bodies of water, wind or ice. Gravity also plays a role in transport. This mostly occurs on steep slopes and is the first stage of erosion and transport of weathered material. Materials move down slopes through rock falls, landslides, soil creep and slumping. In rock falls, consolidated material falls and breaks up into a jumble of material at the base of a cliff or steep slope. Water is the most common medium for sediment transport. The flow occurs in channels or current generated by wind and tides. If the movement is fast enough, it can transport sediments for hundreds of kilometres before deposition takes place (Loomis, 2018).

Several anthropogenic activities have had negative impacts on sedimentation. Such activities can be direct or indirect. Direct activities include the engineering of water bodies (dams and reservoirs). Indirect include changes in catchment characteristics (mining and urbanisation). Dams and reservoirs have been constructed for regulation of water and hydroelectric energy generation. These have increased tremendously in the last 50 years. They have a marked impact upon water flow and hence sedimentation within the catchment area. The most significant impact is the trapping of sediment behind the dam and the reduction of sediment load of rivers downstream (Moore & Braucher, 2008).

Urbanisation also has some effects on sedimentation in water bodies. Water courses are engineered by channelisation and construction of culverts; land surfaces are paved over. This result in decreasing the amount of sediments supplied to receiving water bodies. Similarly, loss of vegetation reduces the storage capacity of the water. The quality of the deposits is also affected by urbanisation. Deposits can be contaminated by sewage, industrial pollution and vehicular pollution leading to the generation of noxious methane gas (Taylor & Owens, 2009).

Types of Sand used for construction

Sand used in construction is classified as fine sand, medium sand and coarse sand. Fine sand has a diameter between 0.075 to 425mm. Medium-sized sand has a diameter of 0.425 to 2mm while coarse sand has a diameter of 2mm to 4.75mm. Sand used in construction must be clean, free from waste, stone and impurities (Anime-Edu-Civil, 2017).

Pit sand is procured from deep pits of abundant supply and red-orange, its sharp angular grain makes it convenient for use in concrete. River sand is procured from rivers, streams and banks. It has rounded grains and is generally white-grey and is used for plastering work. Sea sand is taken from seashores and is brown with fine circular grains. It is salty owing to its source, and it absorbs moisture from the atmosphere attracting dampness. It is because of its salty nature that it is only used for local purposes instead of structural construction (Eazyhomes, 2015).

Sustainability of Sand

Sand is a key resource for urbanisation, electronics, land reclamation, coastal restoration and hydraulic fracturing. Sand mining accelerated rapidly since the year 2000. It now rivals fossil fuels and biomass as the most exploited natural resource on earth. The demand for sand will increase as cities grow and per-capita consumption increases (Brandt, 2018). Extraction of sand is interconnected to environmental and sustainability challenges (Brandt, 2018). These include maintaining diversity, preventing vector-borne diseases and natural hazards, water and food security and population migration.

Negative Consequences of Sand Mining

According to Sanda Aguila Foundation (2016) negative consequences of sand mining include:

i. destruction of beaches and the ecosystems they protect,
ii. loss of habitat for marine species offshore and onshore
iii. change in water flow, flood regulation and marine currents
iv. increased erosion of the shoreline, changes in delta structures, lowering of the water table, salinisation of groundwater and arable soils and pollution of rivers;
v. impacts on coastal infrastructure and embankments;
vi. effects on climate directly through transport emission and indirectly through cement production;
vii. social and political turmoil due to illegal sand mining leading to corrupt practices; Economic losses through tourist abandonment.

Singapore is a country with a sand addiction. Its population increased nearly two-fold between 1990 and 2017 (from 3 million to 5.6 million). The city land area has also grown through extensive land reclamation from 581.5 sq.km in 1960 to 719.7sq.km in 2017 (24% increase). Reclaiming a sq.km of land from the sea costs translates to the extraction of 37.5 million cubic meters of sand. In July 2017, Cambodia banned the sale of sand to Singapore on environmental grounds. Malaysia, Indonesia and Vietnam had imposed sanctions on sand exports. These restrictions have given rise to illegal smuggling trade by sand mafias. Similarly, in India, illegal sand mining costs the government $2.3billion a year in Tamul Nadu (Aljazeera, 2017).In China, dredging of sand from the seabed is destroying flora and fauna, mining of beaches and oceans contributes to erosion. In Indonesia, several islands have disappeared due to sand mining. Meanwhile, policymakers have been slow to respond to the urgency of the situation (Witschge, 2017).

Alternatives for Sand

Demand for sand is very high in developing countries to satisfy infrastructure growth. Research has been conducted into finding alternatives to river sand and these are presented thus

Copper Slag

A study carried out by the Central Road Research Institute of Indiashowed that copper slagmay be used as an alternative to river sand as fine aggregate in concrete without any loss in compressive and flexural strength (Sankh, Biradar, Nagathan, & Ishwargol, 2014). Such concretehas exhibited 20% higher strength than that of conventional cement concrete of the same grade.

Granulated Blast Furnace Slag

As a by-product during the production of steel, granulated blast furnace slag can be used as an alternative for sand (Sharma, 2017).As the replacement level of GBFS increases the compressive strength of cement mortar increases.

Quarry Dust

On a construction site, about 20 to 25% of total materials produced in crushers are left out as waste material quarry dust. Quarry dust, when mixed with fly-ash, is an excellent replacement for sand. It has the additional benefit of increased workability, reduction of cement consumption, increased sulfate resistance, increased resistance to the alkali-silica reaction and decreased permeability (Chandana, Katakam, P.Sri Lakshmi, & Rao, 2013).

Construction and Demolition Waste

Construction and demolition waste generated can pose an environmental challenge. Recycled sand and aggregate from construction and demolition waste have 10-15% less strength than concrete. It can, therefore be used in non-structural applications like flooring and filling (Akaninyene, 2012).

Manufactured Sand

Artificial sand is fast emerging as an alternative for river sand. It is manufactured by crushing granite or basalt rock through a three-stage crushing process. The end-product is sand that is free from impurities. Having been produced under controlled conditions, it is free from silt and organic impurities that hinder the setting time and compressive strength of concrete (Govind, 2016).

Washed Bottom Ash

Washed Bottom Ash is gotten as waste material from coal in thermal power plants. The mechanical properties of concrete made with 30% replacement of river sand with washed bottom ash by weight have an optimum usage in concrete to get required strength needed (Syarhu, Sani, Muftah, & Muda, 2010).

Foundry Sand

Foundry sand is gotten from discarded material from the metal industry. Currently, there are no disposal mechanisms, but research has shown that up to 50% foundry sand can serve as for economical and sustainable development of concrete (Vijul, Nilay, & Jayeshkumar, 2013)

Spent Fire Bricks

Firebricks are waste material gotten from foundry beds and walls and lining of chimneys adopted in industries. These can replace sand as fine aggregate in concrete (Keerthinarayana & Srinavasan, 2010)

Sheet Glass Powder

Attempts have been made to replace sand with waste glass. However, these have been found to crack, thus limiting its usage in concrete (Mageswari & Vidivelli, 2010)

Methodology

The study proceeded to gather primary data through a survey of contractors, subcontractors, consultants and suppliers of construction materials in Nigeria. A structured questionnaire was formulated and administered to the respondents. This was done for fast administration, achieving cost savings, considering the convenience of respondents and for easy generalization of findings. Random sampling was adopted. Section A of the questionnaire elicited the bio-data of the respondents which include educational qualification, the profession of respondent, years of experience, nature of projects worked upon and location of respondent.

Section B sought to ascertain the sources of sand used by the respondents. It went further to ascertain the negative consequences of sand mining being experienced in their respective localities and the impact of such consequences on project performance. Suggestions as to preventive measures against the negative consequences were also elicited, likelihood of adoption of alternatives to river sand. It then concluded by ascertaining the effectiveness of the alternatives to river sand that are currently in use and their availability within the study area.

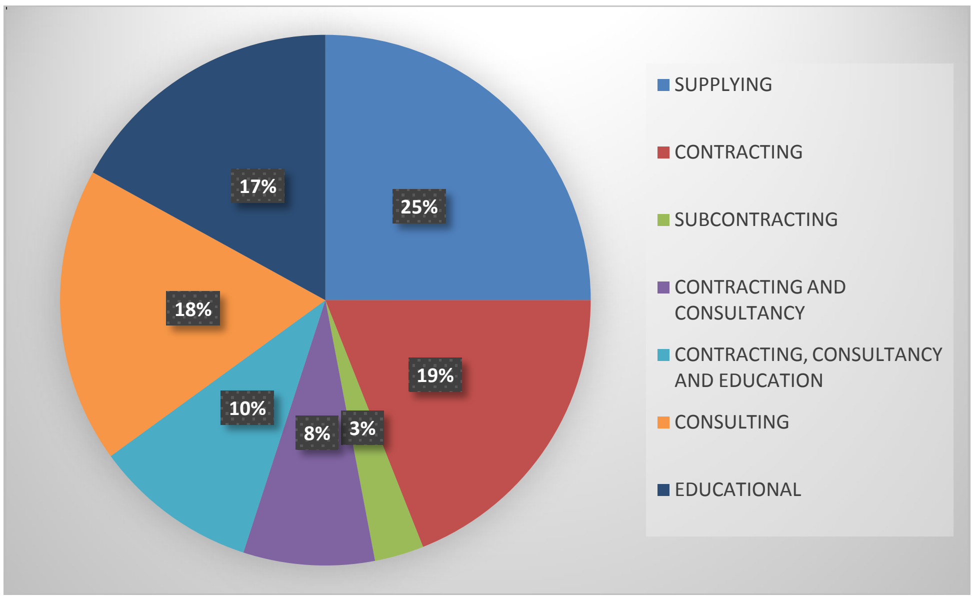
For analysis, Percentages were used for presenting the demographics of the respondents. For questions adopting the Likert scale format; weighting was used for analysis with the highest having 5 points and lowest having 1 point. The mean of points for each response was calculated using $\sum fx/\sum f$. where $\sum fx$ is the sum of the points and $\sum f$ number of respondents. A grand mean was calculated as the average of all the means for each question/table. Those with mean above the grand mean denoting agreement, high level of impact, likelihood of adoption of alternatives to sand, effectiveness of alternatives used and availability of the alternatives. Those with mean below the grand mean denoting disagreement, low level of impact, unlikelihood of adoption of alternatives to sand, ineffectiveness of alternatives used and non-availability. Ranking of responses was done from highest to lowest.

Presentation of Results

Section A:

150 questionnaires were administered with 107 returned corresponding to 71% response rate. 28% having a PhD, 23% having a Master of Science, 21% having a Higher National Diploma and Bachelor of Science and finally, 8% having a Post Graduate Diploma. 35% are quantity surveyors, 26% builders, 21% architects and 19% civil engineers. 26% have 11 to 15 years working experience, 22% 21-25 years, 20% 16-25 years, 12% 6-10 years, 11% over 25 years and 8% 0-5 years of experience. 55% of respondents have worked on building construction projects, 18% have worked on Civil Engineering projects, another 18% have worked on both civil engineering and building construction projects, 8% have worked on building construction as well as mechanical and electrical projects. The location of respondents have spanned across the 6 geo-political regions of Nigeria.

Figure 1: Services Rendered by Respondents



25% are suppliers of construction materials, 19% are contractors, 18% offer consultancy services, 17% are in education, 10% provide contracting, consultancy and educational services, 8% offer contracting and consultancy services and 3% are into subcontracting. Hence, majority of the respondent are into supplying and contracting.

SECTION B

Source of Sand

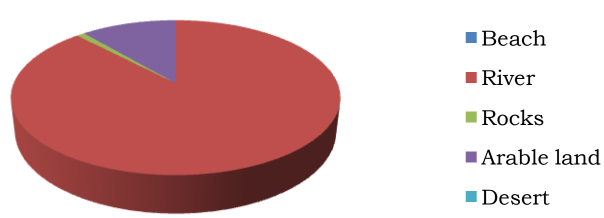


Figure 2: Source of Sand

88% of respondents source their sand from rivers, those that sourced from arable land are 11% while sourcing from beaches and deserts are not done at all. This implies rivers are the major source of sand in the country.

Negative Consequences of Sand Mining

Table 2: Negative Consequences of Sand Mining

Q8 The following are negative consequences being experienced as a result of sand mining in your locality

	SUGGESTION	SA	A	UD	D	SD	∑fx	∑f	Mean	Remark	Rank
		5	4	3	2	1					
i	Depletion of sand	76	31	0	0	0	504	107	4.71	Agreed	1
ii	Soil erosion	77	21	0	0	9	478	107	4.47	Agreed	2
iii	Increasing the cost of construction	37	61	1	3	5	443	107	4.17	Agreed	3
iv	Change in water flow and marine currents	20	61	18	8	0	414	107	3.87	Agreed	4
v	Loss of aquatic life	21	53	21	3	9	395	107	3.69	Agreed	5
vi	Destruction of beaches and the ecosystems they protect	27	48	4	26	2	393	107	3.67	Agreed	6
vii	Formation of sinkholes	46	19	6	27	9	387	107	3.62	Agreed	7
viii	Coastal erosion	27	40	20	11	9	386	107	3.61	Agreed	8
ix	Spreading of vector-borne diseases	24	43	0	31	9	363	107	3.39	Disagreed	9
x	Lowering of the water table	18	19	51	19	0	357	107	3.34	Disagreed	10
xi	Economic losses through tourist abandonment	11	29	42	16	9	338	107	3.16	Disagreed	11
xii	Deforestation	30	19	10	29	19	333	107	3.11	Disagreed	12
xiii	Loss of biodiversity	10	28	36	23	10	326	107	3.05	Disagreed	13
xiv	Soil contamination	9	21	31	30	16	298	107	2.79	Disagreed	14
xv	Corrupt practices resulting from social and political turmoil	9	11	31	33	23	271	107	2.53	Disagreed	15
	Grand Mean								**3.54**		

Key: SA: Strongly Agree; A: Agree; UD: Undecided; D: Disagree; SD: Strongly Disagree.

The most experienced negative consequences of sand mining is depletion of sand, followed by soil erosion, while the least experienced are soil contamination and corrupt practices resulting from political and social turmoil. This slightly differs from the report of Beisier (2017) and Stonberg (2017) that opined corrupt practices involved in sand mining as the most experienced negative consequence.

Degree of Impact of Negative Consequences

Table 3: Degree of impact of negative consequences

NO	SUGGESTION	VH	H	UD	L	VL	∑fx	∑f	Mean	Remark	Rank
		5	4	3	2	1					
i	Soil erosion	72	24	4	7	0	470	107	4.39	High	1
ii	Depletion of sand	52	24	2	29	0	414	107	3.87	High	2
iii	Increasing the cost of construction	31	51	0	24	1	408	107	3.81	High	3
iv	Change in water flow, flood regulation and marine currents	53	22	2	10	20	393	107	3.67	High	4
v	Formation of sinkholes	31	33	3	31	9	358	107	3.35	High	5
vi	Lowering of the water table	21	42	4	21	19	334	107	3.12	High	6
vii	Coastal erosion	11	40	2	36	18	305	107	2.85	Low	7
viii	Destruction of beaches and the ecosystems they protect	15	31	2	34	25	292	107	2.73	Low	8
ix	Deforestation	11	42	2	18	34	293	107	2.74	Low	9
x	Loss of aquatic life	10	32	1	32	32	274	107	2.56	Low	10
xi	Economic losses through tourist abandonment	10	33	2	32	30	276	107	2.58	Low	11
xii	Loss of biodiversity	2	31	0	41	33	249	107	2.33	Low	12
xiii	Soil contamination	10	13	0	44	40	230	107	2.15	Low	13
xiv	Corrupt practices resulting from social and political turmoil	0	17	0	55	35	213	107	1.99	Low	14
xv	Spreading of vector-borne diseases	1	24	6	28	48	205	107	1.92	Low	15
	Grand Mean								**2.93**		

Key: VH: Very High; H: High; UD: Undecided; L: Low; VL: Very Low.

Soil erosion and depletion of sand have the highest negative impact uponsustainability and provision. In contrast, spreading of vector-borne diseases has the least impact. This slightly indicates that scarcity of sand as a result of excessive rainfall in Nigeria may not be generic in the country.

Preventive Measures against Negative Consequences

Table 4: Preventive Measures against negative consequences

NO	SUGGESTION	SA 5	A 4	UD 3	D 2	SD 1	∑fx	∑f	Mean	Remark	Rank
i	Government policy regulating mining of sand	88	16	2	0	1	511	107	4.78	Agreed	1
ii	Issuing legislation requiring using alternatives to sand	49	46	11	1	0	464	107	4.34	Agreed	2
iii	Involving law enforcement officers in the fight against corrupt practices in sand mining	51	41	2	12	1	450	107	4.21	Disagreed	3
iv	Imposing taxes on sand miners	35	59	12	0	1	448	107	4.19	Disagreed	4
v	Regulating the building of dams and reservoirs	48	34	12	12	1	437	107	4.08	Disagreed	5
vi	Limiting the export of sand to other countries	51	22	14	20	0	425	107	3.97	Disagreed	6
	Grand Mean								**4.26**		

Key: SA: Strongly Agree; A: Agree; UD: Undecided; D: Disagree; SD: Strongly Disagree.

The most favourable preventive measure against the identified negative consequences is having a government policy regulating the mining of sand while the least favourable is limiting the export of sand to other countries.

<u>Level of Adoption of Alternatives to River Sand</u>

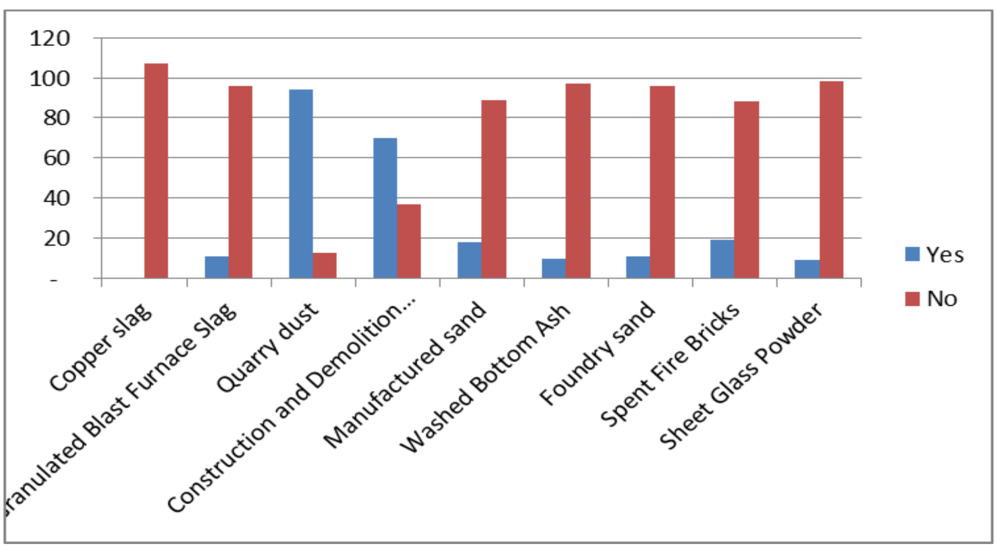


Figure 2: Level of adoption of Alternatives to River Sand

Quarry dust and Construction and Demolition Waste are the alternatives currently most adopted due to availability and effectiveness. While other alternativesare minimally/notadopted due to non-availability and lack of awareness of these materials in the country

Likelihood of Adoption of Alternatives

Table 5: Likelihood of Adoption of Alternatives

NO	ALTERNATIVE	VL 5	L 4	N 3	UL 2	VUL 1	∑fx	∑f	Mean	Remark	Rank
i	Quarry dust	95	6	1	3	2	510	107	4.77	Likely	1
ii	Construction and Demolition Waste	84	18	1	2	2	501	107	4.68	Likely	2
iii	Foundry sand	31	24	19	18	15	359	107	3.36	Unlikely	3
iv	Spent Fire Bricks	28	34	12	8	25	353	107	3.30	Unlikely	4
v	Manufactured sand	38	26	2	11	30	352	107	3.29	Unlikely	5
vi	Washed Bottom Ash	28	27	10	23	19	343	107	3.21	Unlikely	6
vii	Granulated Blast Furnace Slag	29	16	21	13	28	326	107	3.05	Unlikely	7
viii	Sheet Glass Powder	19	24	12	8	44	287	107	2.68	Unlikely	8
ix	Copper slag	10	25	21	18	33	282	107	2.64	Unlikely	9
	Grand Mean								**3.44**		

Key: VL: Very Likely; L: Likely; UD: Undecided; UL: Unlikely; VUL: Very Unlikely.

The two most likely adopted alternatives to sand are quarry dust and construction and demolition waste. Other alternatives are not likely to be adopted despite their level of utilization in other locations/countries all over the world.

Effectiveness of Alternatives Used

Table 6: Effectiveness of Alternatives Used

NO	SUGGESTION	HE 5	E 4	UD 3	IE 2	HIE 1	∑fx	∑f	Mean	Remarks	Rank
i	Quarry dust	75	5	4	0	23	418	107	3.91	Effective	1
ii	Construction and Demolition Waste	49	17	5	2	34	407	107	3.80	Effective	2
iii	Spent Fire Bricks	18	29	2	4	54	308	107	2.88	Ineffective	3
iv	Granulated Blast Furnace Slag	18	22	0	4	63	241	107	2.25	Ineffective	4
v	Washed Bottom ash	0	40	0	4	63	223	107	2.08	Ineffective	5
	Grand Mean								**2.99**		

Key: HE: Highly Effective; E: Effective; UD: Undecided; IE: Ineffective; HIE: Highly Ineffective.

Among the alternatives currently used, quarry dust and construction and demolition waste are the effective ones. While SpentFire Bricks, Granulated Blast Furnace Slag and Washed Bottom Ash are considered by respondents as ineffective.

Discussion of Findings

The major contribution of this study is that it brings to light the likelihood of depletion of sand to construction practitioners. It reinforces the report by Sanda Aguila Foundation (2016) that the major consequences of sand mining by order of priority are soil erosion, depletion of sand and increasing the cost of construction among others. In contrast, the study differs from the report by suggesting the most favourable preventive measure are enacting government policy banning mining of sand while simultaneously encouraging use of alternatives.

Conclusions

The major source of sand used by respondents within Nigeria is river. Negative consequences experienced in sand mining having a high impact include depletion of sand, soil erosion and increased cost of construction among others. Preventive measures that can be taken include enacting a government policy regulating the mining of sand, issuing legislation requiring the use of alternatives to river sand for construction among others. Among the alternatives to river sand, Quarry Dust, Construction and Demolition Waste are the ones mostly adopted. Main reasons for not adopting other alternativeness to river sand are non-availability and lack of awareness.

Alternatives that can be used in place of river sand include quarry dust, construction and demolition waste. Due to non-availability the other alternatives cannot be used.

Recommendations

Preventive measures against negative consequences in sand mining include enacting government policy against sand mining, issuing legislation requiring the use of alternatives to sand. Corrective measures that can be taken include encouraging the use of quarry dust and construction and demolition waste as a replacement to river sand for construction. Setting up factories where sand can be manufactured in order to improve availability. Minimizing waste of construction and demolition waste and other alternatives. Providing adequate sensitization on the benefits of alternatives to sand for construction to improve awareness.

Further studies should investigate strategies for motivating construction practitioners towards the utilization of the identified alternatives. This study is also limited to data collection and analysis; therefore, further studies should test and validate the outcomes of the work in coming years.

References

Akaninyene, A. U. (2012). Recycling Demolition Waste Sandcrete Blocks as Aggregate in Concrete. *ARPN Journal of Engineering and Applied Sciences, 7*, 1111-18.

Aljazeera. (2017, December 13). Sand Wars. Mumbai, Maharashtra, India.

Anime-Edu-Civil (Director). (2017). *Classification of Sand/Types of Sand/Construction Sand* [Motion Picture].

Asinwe, E. (2019, March 11). Kabale bans sand mining and stone quarrying . Kabale, Uganda.

Beisier, V. (2017). *He who controls the sand: the mining mafia's killing each other to build cities*. Retrieved August 16, 2018, from The Guardian: https://www.the guardian.com

Brandt, J. (2018). *Sand Sustainability-Are we running out of sand?* Retrieved August 8, 2018, from Human environment Systems: http://www.boisestateuniversity/humanenvironmentsystems.com

Chandana, S., Katakam, B. K., P.Sri Lakshmi, S. T., & Rao, S. K. (2013). Partial Replacement of Sand with Quarry Dust in Concrete. *International Journal of Innovative Technology and Exploring Engineering (IJITEE), 2*, 254-258.

Eazyhomes. (2015, March 12). *Improtance of Sand in Construction.* Retrieved August 8, 2018, from Eazyhomes Corporation Website: https://www.eazyhc.com/blog

Govind, R. (2016, May 13). *An alternative to sand in construction.* Retrieved August 13, 2018, from The Hindu: https://www.thehindu.com/todays-paper/tp-features/tp-propertyplus/an-alternative-to-sand-in-construction/article5618568.ece#top

GreenFacts Scientific Board. (2018). *The mining of sand, a non-renewable resource*. Retrieved August 16, 2018, from GreenFacts-Facts on Health and the Environment: https://www.greenfacts.org/en/sand-extraction

Kano, M. A. (2018, September 2). *Deforestation: Nigeria has lost 96% of its forest.* Retrieved January 28, 2019, from Vanguard: https://www.vanguardngr.com

Keerthinarayana, S., & Srinavasan, R. (2010). Study on Strength and Durability of Concrete by Partial Replacement of Fine Aggregate using Crushed Spent Fire Bricks. *Bulletin of the Polytechnic Institute of Jassy, 64*(68), 51-64.

Loomis, J. (2018). *Observe How Sediment is Transported by Flowing Water.* Retrieved August 16, 2018, from Mcdougal Littel: A Houghton Mifflin Company: https://www.classzone.com/visualizations

Mageswari, M., & Vidivelli, B. (2010). The use of sheet glass powder as fine aggregate replacement in concrete. *The Open Civil Engineering Journal, 4*, 65-71.

Mfon, P., Akintoye, O. A., Mfon, G., Olorundami, T., Ukata, S. U., & Akintoye, T. A. (2014, May 5). Challenges of Deforestation in Nigeria and the Millenium Development Goals. *International Journal of Environment and Bioenergy, 9*(2), 76-94.

Moore, K. E., & Braucher, O. (2008). Sedimentary and Mineral Dust Sources of Dissolved Iron to the World Ocean. *Biogeosciences*(5), 631-656.

Okeke, C. (2018, August 27). *Nigeria: Is Nigeria Losing War Against Deforestation?* Retrieved from all Africa: https://www.allafrica.com/stories

Ronca, D. (2008, October 27). *How Sand Dunes Work.* Retrieved August 7, 2018, from How Stuff Works: https://science.howstuffworks.com/environmental/earth/geology/sanddune

Sanda Aguila Foundation. (2016, April). *Nigeria-Akwa Ibom: Illegal Sand Mining Threatens Calabar-Itu, Mkpok Bridges*. Retrieved August 8, 2018, from Coastal Care: http://www.coastalcare.org/2016/04/nigeria-akwa ibom: Illegal Sand Mining Threatens Calabar-Itu, Mkpok Bridges

Sankh, A. C., Biradar, P. M., Nagathan, S. J., & Ishwargol, M. B. (2014). Recent Trends in Replacement of Natural Sand With Different Alternatives. *IOSR Journal of Mechanical and Civil Engineering* , 59-66.

Science Clarified. (2006). *Transporting Sediments*. Retrieved August 16, 2018, from Sediment and Sedimentation: http://www.scienceclarified.com/everyday

Sepp, S. (2015, December 5). *What is Sand*. Retrieved August 7, 2018, from Sandatlas: http://www.sandatlas.com

Sharma, R. S. (2017, August 17). *What is the best replacement for sand*. Retrieved August 13, 2018, from Quora: https://www.quora.com/what is the best replacement for sand

Smart Bricks. (2017, November 30). *7 Most Commonly Used Construction and Building Materials in India*. Retrieved August 21, 2018, from Go Smart: http://www.go-smartbricks.com

Stonberg, J. (2017, April 17). *Sand Mining Part 2: The Story of a Conflict Mineral*. Retrieved August 16, 2018, from Resileince: https://www.resilience.org/sandmining

Sumaira, A. (2017). *Sand Mafias*. Bombay: Awaaz Foundation.

Syarhu, M., Sani, H. M., Muftah, F., & Muda, Z. (2010). The properties of special concrete using washed bottom ash (wba) as partial sand replacement. *Intrenational Journal of Sustainable Construction Engineering and Technology, 1*(2), 65-78.

Taylor, K. G. (2012). Sediments and Sedimentation. In J. Holden, & J. Holden (Ed.), *An Introduction to Physical Geography and the Environment* (3rd ed., pp. 244-267). Edinburgh: Pearson Education Ltd.

Taylor, K. G., & Owens, P. N. (2009). Sediments in Urban River Basins: A review of sediment-contaminant dynamics in an environmental system conditioned by human activities. *Journal of Soil and Sediments*(9), 281-303.

Vijul, P. D., Nilay, J., & Jayeshkumar, P. (2013). Techno-economical study of rigid pavement by using used foundry sand. *International Journal of Engineering Trends and Technology, 4*, 1620-28.

Witschge, L. (2017, December 26). *Running out of sand*. Retrieved August 7, 2018, from Aljazeera: http://www.aljazeera.com

World bank group. (2019, March 12). *Average Monthly Temperature and Rainfall for Nigeria from 1901 to 2015*. Retrieved from Climate Change Knowledge Portal fpr Development Practitioners and Policy Makers: http://www.sdwebx.worldbank.org/climate change