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SHORE RECLAMATION FOR AGRICULTURAL USE, A COMBAT TO SHORELINE EROSION

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Keywords: Shore Reclamation, Shoreline Erosion, Sea Level Rise, Dredging.

Abstract: Upon conduction of risk assessments (present and future) and soil type test, shore reclamation was conducted on selected plot at the study area prior dredging operation which was used to secure land that was mixed appropriately and cultivated to study the viability for agricultural production.

I. INTRODUCTION

However, globally it is estimated that about 60% of the population is dwelling in the coastal environments (Prasad and Kumar, 2014). This entails that, this study usefulness affects over half of the world population, and that tremendous pressure are exerted on the shores and its shorelines prior the human activities, which adds together with the natural physical processes that lead to the vulnerability of such areas to erosion and other related hazards.

Many human settlements are constructed in areas vulnerable to coastal erosion, with early estimates suggesting that around 70 per cent of the global coastline is eroding (UNISDER, 2017). In as much as our shores are diminishing in size, the need for more land increases day by day irrespective of the regular high rise of human population. The world population is on the increase even with a declining growth rate (Egharevba, 2009). And continuous increase in shoreline erosion and other environmental problem like global water rising (oceans and sea levels) gives birth to reduction of available land area (soil loss). Thus, eroded lands need shore reclamation as well as the currently available agricultural lands needs proper sustainability management (which shore reclamation also provides), so that mankind will have adequate land to serve agricultural needs of present and future generations.

Many agricultural lands as well as crops and animals have been washed off over the years especially during peak rainy season due to lack of efficient coastal protections measures. The manifestation of 2012 world flood menace which lead to displacements of agricultural products on farmlands near coasts, farms soil loss, and loss of lives and properties in Otu – Ogwu, Asaba Nigeria, and other coastal areas of Nigeria and the world, points that climate is changing and the fact (our coasts need protections) cannot be ignored.

Shoreline Erosion: Shore is the land within the boundary of a water body. It can be sea shore, river shore, stream shore, lake shore, e.t.c. The boundary of a shore where water body meets the land is called shoreline. It is the boundary between the on - shore

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and the off - shore. Shoreline erosion is part of the coastal erosion. Coastal erosion is a worldwide occurring event that exists in almost every country on planet earth where shoreline exists. Coastal erosion is a natural process that occurs whenever the transport of material away from the shoreline is not balanced by the deposition of new material onto the shoreline (UNISDR, 2017). This balanced can be maintained through shore reclamation.

Sea Level Rise: The land surfaces (lithosphere) and the water bodies (hydrosphere) make up the earth surfaces. A rise in hydrosphere (controlled by the sea water level) gives a reduction on the lithosphere (i.e., land loss along the shore), and vice versa. This is because sea level rise cause increase in ground water level, which leads to increase in the depth of other water bodies (rivers, streams, lakes, e.t.c). Continuous increment in the sea water volume occurs annually due to various activities. Because of slow inertia, long response time for parts of the climate system, it has been estimated that we are already committed to a sea – level rise of approximately 2.3 metres (7.5 ft) for each degree Celsius of temperature rise within the next 2000 years (Levermann et al., 2013). A major cause of sea level rise is the global climate change. Climate change affects agriculture in number of ways, including through changes in average temperatures, rainfall, and climate extremes (e.g., heat waves); changes in pests and diseases; changes in atmospheric carbon dioxide and ground – level ozone concentrations; changes in the nutritional quality of some foods; and changes in sea level (Hoffmann, 2013).

Shore reclamation: Shore reclamation for agricultural purposes is practiced in countries like Netherlands, China, Australia, etc. Its needs are required in coastal regions for more productive utilization of unusable land resources. Like mechanization and introduction of chemicals, it is an important factor in increasing agricultural production and promoting scientific and technological progress in agriculture (McGraw, 2003). It is a technique that guarantees creation of lands for many purposes like agriculture, construction, recreation, industrial and residential.

Shore reclamation can be grouped into on – shore reclamation (reclaiming land on coast, especially from water body towards the land) and off – shore reclamation (reclaiming land inside the water body). Land reclamation, usually known as reclamation, and also known as land fill is the process of creating new land from ocean, river beds, or lake beds (Encyclopedia, 2016). The term "reclamation" can refer to returning disturbed lands to an improved state (Powter, 2002). Reclamation is vital for provision of lands for agricultural purposes. This process converts once-unusable land into farmland that can be used for growing fruits, vegetables, and grains, and for raising livestock (Ritchiewiki, 2009).

Reclamation methods include; Draining of submerged wetlands is often used to reclaim land for agricultural use (Wisconsin, 2009). The simplest method involves simply filling the area with large amounts of heavy rock and/or cement, then filling with appropriate soil like clay and loam, and dirt until the desired height is reached. The process is called "infilling" and the material used to fill the space is generically called "infill" (Lambi, 2001).

Dredging and its Equipments: The major operation in shore reclamation is dredging. It is the process of unearthing aquatic beds by dragging to

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bring them to the surface using dredgers. Major dredging equipments are the hopper barge and dredgers. Hopper barge are carrying vessels or ships used to transport dredged materials to required location for discharge. Dredgers are machines used in harnessing earth materials from water bodies. The three main types of dredgers include; Trailing Suction Hopper Dredger, TSHD (This is mainly used for dredging loose and soft soils such as sand, gravel, silt or clay), Backhoe Dredger, BHD **(**This is basically a pontoon equipped with a hydraulic excavator which excavate the soil, and discharge it into a split hopper barge that is moored alongside the pontoon), Cutter Suction Dredger, CSD **(**This is equipped with a rotating cutter head, for cutting and fragmenting hard soils. The soil is sucked up by means of dredge pumps, and discharged through a floating pipeline and pipes on – shore to a deposit area. In some cases, the material is discharged into split hopper barges that are moored alongside the Cutter Suction Dredger. These split hopper barges unload the soil at the deposit area).

II. MATERIALS

Material: The materials used for this study include;

The Study Area: The study area, otherwise the ground base upon which this research project was conducted is a major material used for this work. The study area is Otu-Ogwu Section of The Niger River, in Asaba, the capital city of Delta State. Delta state is located in south-west of Nigeria, West Africa. Ahaba in Igbo language is from 'Ahabagom', meaning I have chosen well, a quote from the founding father (Nnebisi) of Asaba. Asaba lies approximately 60 degrees north of the equator and about the same distance east of the meridian; about 160 kilometres (100 mile) north of where the River Niger flows into the Atlantic Ocean (Wikipedia, 2016) i.e, 6°11′52.23″N 6°43′42.48″E/ 6.1978417°N 6.7284667°E

Beyond the water body of the study area "Otu – Ogwu" lies the shores of Anambra state. The boundary city of Anambra state towards delta is Onisha. Major island in the interstate Niger River section are; Mgba Agbara (indicated in the map by i), Mgba Obiocha (indicated in the map by ii), Mgba Okuta (located in the map by iii), and Mgba Odumodu (located in the map by iv). The study area (Otu – Ogwu section of river Niger) can be clearly seen in the satellite map presented in the figure below;

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Figure 1: Location of study area and Satellite Map showing Asaba and its section of River Niger.

Other materials include: caterpillar (used for soil mixture and leveling), organic manure (used to increase soil nutrients), NPK fertilizers (used to improve soil nutrients), yam seedlings and vegetables (used for viability study of the soil), site camera (used for site photographs), work book (used for data recording), mobile dredger (used for harnessing soil).

III. METHODOLOGY

Risk assessment (present and future) for the study area (Otu - Ogwu) was estimated as presented below;

Table 1: Risk assessments (present and future) conducted for the study area

S/N	Infrastructure	Hazard	Timeframe	Likelihood	Consequence	Risk
1	Beach side resort	Coastal flooding	Present	Unlikely	medium	Low
			2069	Possible	Major	High
2	Low lying houses	Coastal flooding	Present	Very likely	insignificant	Low
			2069	Very likely	major	High
3	Farm yield <30m to shoreline	Coastal erosion and flooding	Present	Very likely	major	High
			2069	Very likely	minor	Moderate
4	Buildings <50m to shoreline	Coastal flooding	Present	Very likely	insignificant	Low
			2069	Very likely	Catastrophic	Very high

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This hazard risk which is the potential damage occurrence from catastrophic events was obtained following PRIF (2017) method of computation using the below equation;

R = P x C ..... (Eq. 1)

Where;

R = Hazard risk

P = likelihood of an event occurring

C = Consequence of that event occurring.

Study Area Soil Type Test: Soil type was obtained using the Jar Test Procedure. Upon drying and weighing of 9 soil samples obtained from 36 sub - samples dug (15cm using soil auger) and packed to the laboratory (using plastic bags) from 9 different on - farm points within the site, 28g of each soil samples were poured into a transparent cylindrical container, filled with water (two third full) mixed with a half table spoon of laundry detergent (to aid well separation of soil components). Each container was shaken for a minute and kept undisturbed for 5days to allow settlement of particles in layers for observatory measurement of the height of each layers for their percentage computations, i.e. ratio of height of each component to height of the sample (in mm). The percentage height of each measured soil components were used to trace their soil type (using the lines from the percentage values on the textural class diagram below).

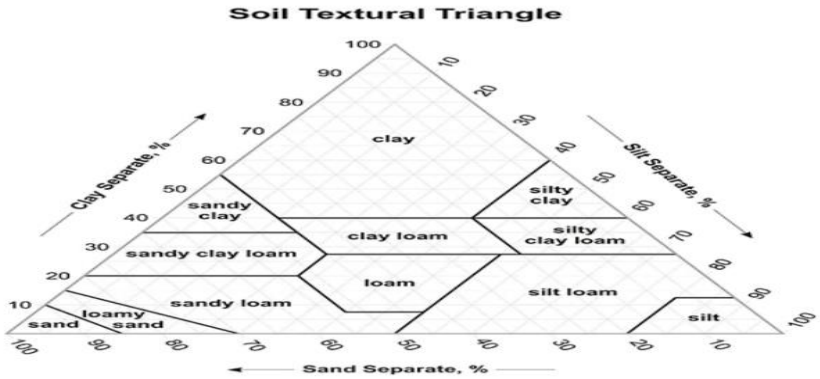

Figure 2: Soil textural class diagram (American Gardening Resource, 2019).

The various values are presented in the table below;

Table 2: Soil type computation

Samples	Replicates	% clay	% Sandy	% Silt	Soil type
1	4	47	51	2	Sandy clay
2	4	52	47	1	Sandy clay
3	4	49	49	2	Sandy clay
4	4	63	37	0	clay loam
5	4	97	2	0	clay
6	4	36	52	2	Sandy clay

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					loam
7	4	79	21	0	Sandy clay
8	4	41	56	3	Sandy clay
9	4	63	28	9	clay
Av.					Sandy clay

The research plan used in this study is presented in the figure below;

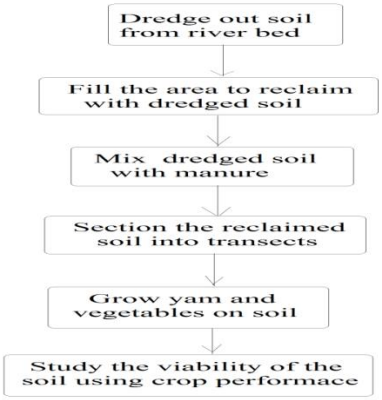

Figure 3: Experimental design for shore reclamation

Shore reclamation was carried out to test its potentiality as a remedial solution to shoreline erosion and related coastal soil loss cases.

Four mobile dredgers were used to dredge out sand from the river bed, this was used as infill on – shore to raise the soil elevation higher than the water level (leaving the water body retreating off – shore). 200 by 140 meters of land was obtained. The dredged soil was mixed with organic manure, NPK fertilizer and its original soil type collected from unaffected area using the caterpillar grader. 10: 10: 15 NPK ratio of 26 – 9 – 60 kg was applied on yam cultivated soil while 15:15:15 NPK ratio was applied on the rest soil. Yams and vegetables were grown for viability of the soil productivity. An image of the process of obtaining soil material from the water body through the process called dredging is presented in figure below;

Figure 4: Dredging operation showing four dredgers used (Photographed during site work)

Caterpillar was used in leveling the dredged sand on the beach for even slope and smoothness. It was also used for mixing the soil. This was done from inland progression towards the water body as the soil gets hardened upon levelling compression to avoid

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machinery sinkage. Image description of this process of levelling is presented in the figure below;

Figure 5: The Caterpillar used for soil leveling operation (photographed during site work).

Figure 6: Reclaimed Cultivated soil for soil productivity viability

IV. RESULTS

Shore reclamation proved a reliable method of re - securing agricultural land. The reclaimed land produced favorable crop yields. The viability properties as studied using the three cultivated crops are presented below;

Table 3: Viability data of cultivation on the reclaimed soil for the first cultivation season (2016).

S/N	Item	Crops Cultivated on The Reclaimed Soil		
		Yam	V1 (Tomato)	V2 (Ugbogodu)
1	Duration of Maturity (Months)	7 – 9	2-4	3
2	Viability of production on the reclaimed soil	Favorable	Favorable	Favorable
3	Area of reclaimed land cultivated (m)	100 by 40	50 by 40	50 by 40

Table 4: Viability data of reclaimed soil for second planting season (controlled) (2017).

S/N	Item	Crops Cultivated on The Reclaimed Soil		
		Yam	V1 (Tomato)	V2 (Ugbogodu)
1	Duration of Maturity (Months)	8	3	3
2	Viability of production on the reclaimed soil	Favorable	Favorable	Favorable
3	Area of reclaimed land cultivated (m)	50 by 40	20 by 40	20 by 40

Table 5: Viability data of reclaimed soil for second planting season (uncontrolled) (2017).

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S/N	Item	Crops Cultivated on The Reclaimed Soil		
		Yam	V1 (Tomato)	V2 (Ugbogodu)
1	Duration of Maturity (Months)	10	4	3
2	Viability of production on the reclaimed soil	Less Favorable	Favorable	Favorable
3	Area of reclaimed land cultivated (m)	50 by 40	30 by 40	30 by 40

V. DISCUSSIONS

Our environment is fragile and shore reclamation provides possible way of maintaining the balance of water to land ratio of the earth's components.

The shore reclamation carried out here is on – shore reclamation. The other type of shore reclamation (off – shore reclamation) is more intensive since more hopper barge is required for soil transportation into the chosen reclamation site. Also in off – shore reclamation, casting of rocks to serve as boundaries gives room for rock installation equipments which makes costs higher. This work was also made less laborious and less stressful because the reclamation was done as a progressive reclamation from the off – shore of the river banks to the on – shore coast.

Cultivated crops, i.e., vegetables and yam used to test the viability of the soil reclaimed are explain below;

Vegetables: Melon variety locally known as ugbogodu (a vegetable crop) and Tomato, used were cultivated by planting their seeds, and maturity period of 2 -3 months for harvest were recorded. Other vegetable crops like; onion, okra, pepper, amaranthus, carrot, corchorus olitorus (ewedu), e.t.c., could thrive in such soil.

Yam: A tuberous stable food crop with planting season of April, May and June while harvest is November, December and January. 120 – 140g seedlings (weighing 1.3 – 1.4kg) were planted directly in the soil. Maturity period was 7 – 9 months with the tubers weighing 6 – 8 kg. Some stayed 10 months before leaves turned brown.

From data gathered from local ship manufacturing companies (Spient Nigeria L.t.d Onitsha and GZ fabrications), dredger types were categorized according to their types and sub – types and are presented below;

i. Trailing Suction Hopper Dredgers.

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Table 6: Types of Trailing Suction Hopper Dredger.

S/N	Trailing Suction Hopper Dredger Type	Hopper Capacity (m^3)	Built In (year)
1	Cristobal Colon	46.000	2009
2	Leiv Eiriksson	46.000	2010
3	Vasco da Gama	33.000	2000
4	Charles Darwin	30.500	2011
5	Garardus Mercator	18.000	1997
6	Juan Sebastian de Elcano	16.500	2002
7	Pedro Alvares Cabral	14.000	2012
8	Bartolomeu Dias	14.000	2013
9	James Cook	11.750	1992
10	Filippo Brunelleschi	11.300	2003
11	Francis Beaufort	11.300	2003
12	Alexander von Humboldt	9.000	1998
13	Al – Idrisi	7.500	2012
14	Vitus Beringx	7.500	2012
15	Capitan Nunez	6.000	1997
16	Sanderus	5.300	1967
17	Francesco di Giorgio	4.400	2003
18	Taccola	4.400	2003
19	Manzanillo II	4.000	1988
20	De Bougainville	3.700	2006
21	De Laperouse	3.700	2010
22	James Ensor	3.600	1980
23	Amerigo Vespucci	3.500	1985
24	Alvar Nunez Cabeca de Vaca	3.400	2011
25	Sebastiano Caboto	3.400	2011
26	Pinta	3.400	1997
27	Nina	3.400	1997
28	Gallilei 2000	2.320	1979

ii. Backhoe Dredger (BHD)

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Table 7: Types of Backhoe Dredger

S/N	Backhoe Dredger Type	Bucket/ Grab Capacity (m^3)	Built In (year)
1	Postnik Yakovlev	15/25/40	2009
2	Mimar Sinan	15/25/40	2008
3	Vitruvius	15/25/40	2007
4	I1 Principe	5,8/19,5	2005
5	Gian Lorenzo Bernini	8,5/25	2014
6	Jerommeke	4,5/11,0	1994

iii. A Cutter Suction Dredger

Table 8: Types of Cutter Suction Dredger

S/N	Cutter Suction Dredger Type	Total Installed Diesel Power(KW)	Built In (year)
1	J.F.J. De Nul	27.240	2003
2	Ibn Battuta	23.520	2010
3	Zheng He	23.520	2010
4	Fernao de Magalhaes	23.520	2011
5	Niccolo Machiavelli	23.520	2011
6	Leonardo da Vinci	20.260	1985
7	Marco Polo	16.115	1979
8	Kaerius	8.330	2007
9	Hondius	8.330	2007
10	Vesalius	9.260	1980
11	Ortelius	5.140	1965
12	Dirk Martens	2.370	1972
13	Petrus Plancius	1.300	2008
14	Hendrik Geeraert	350	2006

VI. CONCLUSIONS

Reclamation is a practice that enhances usability of unusable land especially where less available land exist and should be applied in various areas even beyond agriculture. Thus, it provides solution to agricultural land shortage.

VII. RECOMMENDATIONS

Shore reclamation should be deployed for agricultural purposes for more useful utilization of unusable or abandoned land especially in coastal regions of Nigeria and the rest of the world.

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