Marine Ecosystem Management: The Role of Geospatial Experts from Southern Nigeria's Perspective

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Keywords: Marine ecosystem, pollutions, anthropogenic activities, geospatial experts, sustainable use

Abstract
Marine ecosystem is the most important ecosystem in the world. Presently, the ecosystem is being threatened by pollutions caused majorly by anthropogenic activities such as agricultural, mechanical, engineering, among other land use related activities. The study looked at the various land uses which are practically designed and mapped by geospatial experts and how they can contribute to marine pollution. The study was designed and carried out using both primary and secondary data. Interviews, random group discussions (RGDs) and focus group discussions (FGDs) among selected experts in the field of environmental management were conducted. Other literature on related subject matter was also consulted. Some of the activities of geospatial experts in environmental management in the area of fight against climate change, water pollution, city planning, among others, aimed at improving the quality of the earth resources and sustainable use which may affects the marine ecosystem if abuse were identified, queried, and discussed. The views and responses of the experts were analyzed thematically. The general view of the respondents is that the role of geospatial experts in the pre-developmental, developmental and post developmental stages of any construction is sacrosanct, and if ignored or abused can lead to environmental hazards which may ultimately pollute the ocean. In reducing ocean pollution, or in ecosystem management, the role of geospatial experts is basically advisory which can be ignored by the relevant authorities. Conclusively, the world needs clean and healthy oceans to support the health and survival of all the organisms that make up the marine ecosystem. Looking at the benefits offered by the marine ecosystem, there is the need to engage all stake holders through collaborative efforts or approaches to ensure that all forms of threats posed to the marine ecosystem as a result of negligence in various anthropogenic activities are checked or eliminated.

Ọkpụrụkpụ okwu di mkpa *(Keywords):* Gburugburu mmiri oshimiri, mmetọ, ọrụ mmadụ, ndị ọkachamara ihe gbasara ala, iji na-adigide

Na nchikọta *(Abstract)*
Usoro gburugburu ebe obibi nke mmiri oshimiri bụ gburugburu ebe obibi kacha mkpa n'ụwa. Ka ọ dị ugbu a, a na-eyi gburugburu ebe obibi a egwu site na mmetọ nke ihe omume ụmụ mmadụ na-akpata dịka ọrụ ugbo, ịrụzi ụgbọ ala, injinia na ihe omume ndị ọzọ metụtara iji ala. Ihe omumu a lere anya n'ojiji ala di iche iche nke ndi okachamara ihe gbasara ala na-emeputa ma dezie, ya na ka ha nwere ike isi tinye aka na mmetọ mmiri oshimiri. A haziri ma jiri akọrọngwa edemede nke mbụ *(primary)* na nke abụọ *(secondary)* mee ya. Ajụjụ ọnụ, mkparịta ụka otu *(RGDs)* na mkparịta ụka otu uche *(FGDs)* n'etiti ndị ọkachamara ahọpụtara

na ngalaba nlekọta gburugburu ebe obibi ka e mere. A tụlekwara akwụkwọ ndị ọzọ gbasara okwu metụtara ihe edemede a. Ụfọdụ n'ime ọrụ ndị ọkachamara ihe gbasara ala na njikwa gburugburu ebe obibi na-alụ ọgụ megide mgbanwe ihu igwe, mmetọ mmiri, atụmatụ obodo, na ndị ọzọ, nke ebum n'obi ya bụ iji kwalite àgwà nke ihe onwunwe ụwa na iji nọgide na-eji nke nwere ike imetụta ihe ndị dị ndụ n'oké oshimiri ma ọ bụrụ na achọpụtara mmegbu, jụrụ ajụjụ ma kparịta ụka. A tụlere echiche na nzaghachi nke ndị ọkachamara na isiokwu a. Echiche izugbe nke ndị na-aza ajụjụ bụ na ọrụ nke ndị ọkachamara ihe gbasara ala na mmalite mmepe, mmepe na emepecha nke ihe owuwu ọ bụla bụ ihe na enweghi ngbaghasị, ma ọ bụrụ na eleghara ya anya ma ọ bụ mebie ya nwere ike ibute ihe egwu gburugburu ebe obibi nke nwere ike mebie oké oshimiri. Na ibelata mmetọ oke oshimiri, ma ọ bụ njikwa gburugburu ebe obibi, ọrụ ndị ọkachamara ihe gbasara ala bụ inye ndụmọdụ, nke ndị nwe obodo nwere ike ileghara anya. N'ikpeazụ, ụwa chọrọ oke oshimiri dị ọcha ma dị mma iji kwado ahụike na nlanarị nke ihe niile dị ndụ na-emejupụta gburugburu ebe obibi mmiri. N'ileba anya na uru nke usoro gburugburu ebe obibi nke mmiri oshimiri na-enye, ọ dị mkpa itinye aka na ndị niile na-ekere òkè site na imekọ ihe ọnụ ma ọ bụ ụzọ iji hụ na a na-enyocha ma ọ bụ kpochapụ ụdị egwu ọ bụla na-ebute imetọ gburugburu mmiri oshmiri n'ihi nleghara anya na ọrụ dị iche iche nke ndi mmadụ.

1. INTRODUCTION

The world is yet to come to terms with global warming necessitated by climate change and population increase. One of the consequences of climate change and population increase is seen more in natural and anthropogenic modifications on land surfaces leading to severe flooding, soil erosion and sedimentation in some parts of the world (Pietsch and Mabit, 2012). The World population is growing at an alarming rate at 8 billion as of 2022 (www.worldometers. info/world-population) with an estimate of reaching 10 billion by 2056. These two phenomena have raised concern and pressure on available surface and groundwater, land (Modares and da Silva, 2007), as well as the marine ecosystem resources (FAO, 2017).

The marine ecosystem is one found in or at the salt water surroundings, meaning that it cut across the whole world especially where oceans exist, from a beach front to the ocean depth. The marine ecosystem includes 'rocky shores, sandy beaches, mangroves, salt marshes, coral reefs, kelp forests', polar ecosystems, deep sea, and 'hydrothermal vents' with their associated marine lives which include Algae, Plankton, birds, fish, Sea turtles and mammals (Biotic); and the 'rocks and sands' (Abiotic) that exist there. The oceans cover about 70 to 71 per cent of the entire earth, so most part of the earth surface is made up of marine ecosystem (www.nationalgeographic.org/encyclopedia/marine-ecosystems/).

1.2 Marine Ecosystem Pollution

Marine ecosystem pollution is made up of solid and liquid wastes, mostly emanates from the land which is eventually washed by runoffs or blown by wind into the oceans. Ocean pollution majorly results from the abuse of the environment, which negatively affects the health of all the organisms in the ecosystem (Landrigan et al., 2020), and subsequently the economic structures worldwide to the tune of about 21 billion Euros (Beaumont et al., 2019). Marine ecosystem pollution has become a great challenge in the world today. The oceans are

being ‘flooded’ with two major kinds of pollutants which are chemicals (solutes from land surface runoffs, stream dredging, Nitrogen and Sulfuric oxide, ocean acidification, oil spillage, over exploitation, chemical contamination, or nutrient pollution); and trash (solid wastes such as ocean waste dumping, waste from ships, plastics and other wastes) (Eriksen et al., 2013; Estahbanati and Fahrenfeld, 2016; Browne et al., 2011). These have become a concern for health, the environment, and the world economy (Beaumont et al., 2019). Pollution occurs from abuse of harmful material such as overuse of fertilizer and burning of farmlands which can lead to concentration of chemicals on lands and in the atmosphere that later get down to the oceans. Concentration of chemicals – ‘nitrogen and phosphorus’, in oceans’ shores promote the growth of algae, which are toxic to marine life and harmful to wildlife as well as humans.

Waste littering, poor waste management, and Storms are responsible for debris accumulation, 85 per cent of which are generated from land. These debris are plastic bottle and caps, polyethylene shopping bags and food wrappers, healthcare wastes, beverage bottles, discarded fishing materials among others (Boucher and Friot, 2017; Singh et al., 2020; Watt et al., 2021). Plastic wastes are particularly problematic as pollutants because they are non-degradable materials and so are long-lasting. Plastic material take decades to decompose, and poses dangers to both humans and animals. The debris can entangle and injure some sea animals, while some may mistake disintegrating plastic materials for food. Some organisms feed on broken-down micro and nano plastics, and absorb the chemical contents into their bodies. Micro and nano plastics are tiny, less than 5 mm (0.2 inches) and 0.1 μm in size (Cózar et al., 2014; Corcoran et al., 2015), and have been found in marine species like Plankton, Whales (Van Cauwenberghe et al., 2013; Rochman et al., 2014; Setälä et al., 2014; Desforges et al., 2015), and eventually humans (https://www.un.org/pga/73/plastics/; Schwabl et al., 2019; Ibrahim et al., 2021; Revel et al., 2018).

1.3 Marine Ecosystem and Man

The oceans contain sea life from everything, microscopic organisms - zooplankton to the largest mammals on earth - whales, from the odd and dull-coloured to the glimmering, from the coldest to the warmest, and from the shallow and lighted to the deepest and darkest parts of the earth. Oceans are the most important part of all the earth's ecosystem - sources of ‘biodiversity, food, and life’. More than 40 per cent of the people globally settle within the 100 kilometers range of the oceans. Sustainable use of the oceans’ resources is critical to ensuring food security around the world (FAO, 2017). According to FAO (2017), Life could not exist without the many benefits that the oceans provide and some of them are listed as follows:

1.3.1 Employment: Fishing and other aqua-related activities presently engage directly about 56 million people**.** Additionally, a large number of people are indirectly employed as handlers, processors and distributors. Altogether, fishing activities support the existence of about 880 million people - 12 per cent of the global population.

1.3.2 Source of food: The oceans are important sources of sea food. Oceans contain about 80 per cent of the earth’s biodiversity **as** the largest ecosystem on earth – the marine ecosystem. Fish provides about 20 per cent of non plant protein to about 3 billion people out of which

ten species account about 30 per cent of the 'ocean-captured', while another ten species also account for about 50 per cent of aquacultural produce.

1.3.3 Renewable energy: Oceans waves and tides potential sources of renewable energy. Technologies have been developed to harness waves and tides energy and offshore wind mill to generate electricity.

1.3.4 Climate regulator: Oceans regulate our climate. The oceans absorb about one-quarter of the anthropogenically released carbon in the environment, making them more pronounced 'carbon sink', however, with limited ability to now absorb more. The oceans also absorb and store more than 90 per cent of the excess heat as a result of global warming which support the heating and cooling effects of the ocean currents that regulate the global temperatures to support life.

1.3.5 Weather variations: Oceans influence the weather. The oceans are heated by the sun, to initiate surface water evaporation which when condenses form clouds that trigger rainfall - the water cycle. This is how moisture is being recycled. They also contributes to initiating and encouraging wind, thunderstorms and hurricanes that produce rainfalls that millions of people rely on for rain-fed agriculture, aquifer and stream recharge, for drinking, and other domestic and industrial use.

1.3.6 Medicinal properties: It has been discovered by scientists that some marine organisms such as marine bacteria, sea-weeds and crabs have useful medicinal properties and can produce substances that can be used for antibiotic, anti-cancer and anti-inflammatory drugs

1.3.7 Health and well-being improvement: Clean oceans can influence and improve human health and others well-being. Water is known to calm and reduce anxiety, having access to blue spaces - ocean water front has a therapeutic effects on the social and mental well-being of people.

Unfortunately however, some anthropogenic activities are threatening the oceans. Over-fishing and some adverse method of fishing (use of chemicals) is causing decline in fish population, threatens the supplies of nutrition that are accessible only through sea food as well as changing the marine food webs. About 85 per cent of the oceans' pollution is from the land, and it endangers the sensitive coastal zones that are vulnerable to these pollutants. Variations in the climate, global warming and their impacts, such as increasing temperature and ocean acidification, are negatively affecting the survival of some of the marine species. Lackadaisical attitude of developers and unguided coastal infrastructural developments (sea ports, resort centers, etc) are also destroying some important parts of the marine ecosystem. Hence the need to question and emphasize on the role of geospatial experts in sustainable environmental management and land space uses.

2. RESEARCH METHODOLOGY

2.1. Sampled location: Southern Nigeria

The sampled location chosen is Southern Nigeria. It lies between latitudes 4º 00′ and 14º 00″ N and longitudes of 3º 00′ and 15º 00′ E and covers about 189,596 km^2 of landmass (https://citypopulation.de/php/nigeria-admin.php). The river system drains south, directly or indirectly into the Atlantic Ocean. The streams pass through the forest, agricultural lands and some industrial complexes (where they are likely to pick up pollutants) before finally reaching the ocean (Figure 1).

The sampled location shares boundary in the north with Kwara, Kogi, and Benue States which form part of the central States in Nigeria; with Cameroun and Benin Republic at the east and west respectively and in the south with Atlantic Ocean. It has a projected population of 94,493,400 as at 2022 (NPC, 2006; https://citypopulation.de/php/nigeria-admin.php). Southern Nigeria is home to 3 out of the 4 industrial zones in Nigeria (the western industrial zone: Lagos, Ibadan, Abeokuta, Epe, Ilorin, and Ewekoro; the southeast industrial zone: Onitsha, Port Harcourt, Oji River, Enugu, Aba, Umuahia, and Calabar; and the mid-west industrial zone: Benin City, Sapele, and Warri); and location of sea ports in Nigeria (Iloeje, 1981; Bloch et al, 2015).

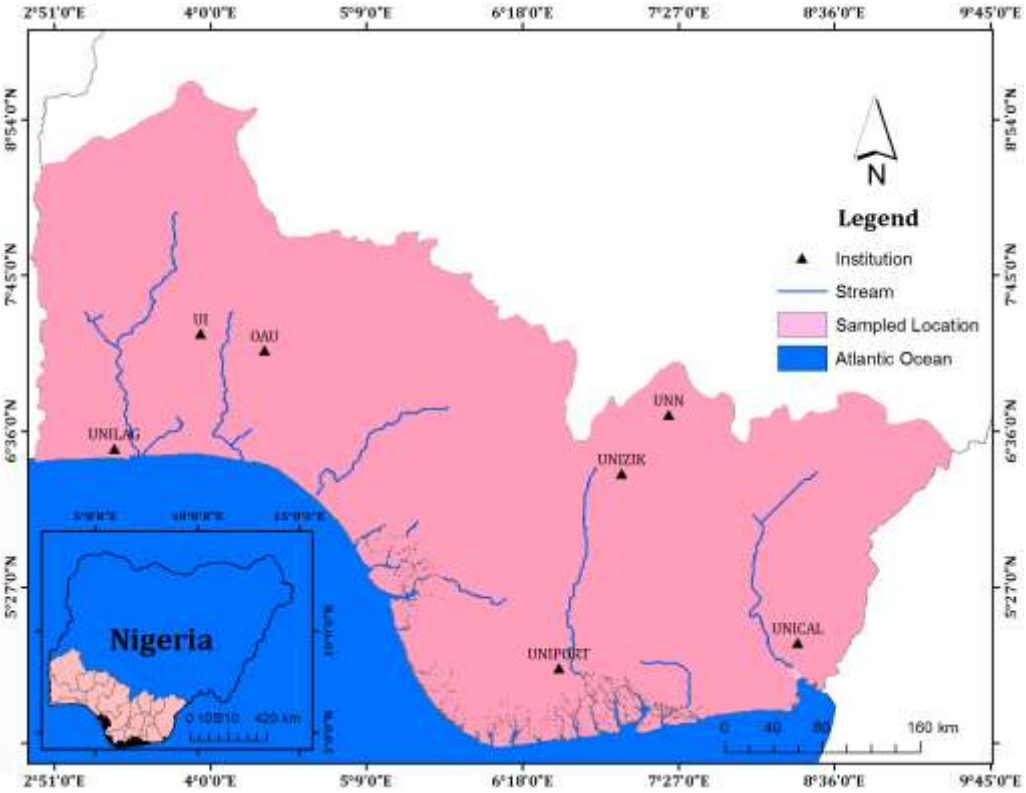

Fig 1: Sampled location

2.2 Method of data collection and characteristics of the sampled respondents

The study used primary and secondary data. Primary data were from interviews, focus group discussion (FGD) and random group discussion (RGD) – this group is made up of young surveyors, who are waiting in line in a surveyor's office to be attended to, interaction with them by one of the authors happened by chance. Secondary data were photographs and related materials extracted from the internet and other literature.

The sampled population consisted of 30 participants out of which 21 responded. Having been recommended that at least a minimum of 12 samples are deemed sufficient for qualitative analysis (Clarke and Braun, 2013; Fuggard and Potts, 2015; Guest, et al, 2006); 21 respondents in this case was seen to be adequate to make generalization. The focus group

discussion (FGD) and random group discussion (RGD) were made up of 4 sample sizes each comprises of young surveyors of ages between 30 and 35 years old. The discussions were carried out separately with one of the authors as the moderator. The discussions were based on the modus operandi of geospatial experts in their various fields of endeavours and 10 questions were raised regarding the impacts of geospatial experts on sustainable and suitability of land uses. The groups cumulatively recommended the 30 experts to give detailed responses to the questions. The questions are: *'What is the role of geospatial experts in the environment; how do they contribute to environmental management; what is their role in the fight against climate change; what is their contribution to city planning; are they involved in transport infrastructure planning and design; are they involved in the three stages of development; is their activities contributing to surface water pollution/quality; what roles do they play to contribute to reducing ocean pollution; is there any platform through which to make recommendations the relevant authorities; and in the event of deviations, can they enforce obedience to land use rules?'*

2.3 The choice of sampled population

The aim of this study is to examine the in-depth understanding and perceptions of geospatial experts in Southern Nigeria and their roles and level of awareness in the environmental dangers being posed mainly through anthropogenic activities – which in the long run affect the marine ecosystem. This study is qualitative in nature. Geospatial experts from various universities in Southern Nigeria – University of Nigeria, Nsukka (UNN), Nnamdi Azikiwe University, Awka (UNIZIK), University of Ibadan, Oyo (UI), University of Lagos, Lagos (UNILAG), University of Calabar, Calabar (UNICAL), University of Port Harcourt, Choba (UNIPORT), Obafemi Awolowo University, Ile-Ife (OAU), who are either senior academic or non academic staff of the universities, aged 45 years and above were selected randomly and reached out on a one-to-one (10 physical and 20 phone calls) interviews. The interview was conducted by one of the authors in an open–ended question and answer format.

Table 1: Characteristics of the Sampled Population with Assigned Institution's codes

S/No	Institution	Number of Selected Population	Code	Specialty	Responded	Declined	Number of Selected population Responded	Number of Selected population Declined
1	UNN		UNN 1	Surveyor	yes	-		
2			UNN 2	GIS Expert	yes	-		
3			UNN 3	GIS Expert	yes	-		
4			UNN 4	GIS Expert	yes	-		
5			UNN 5	Cartographer	yes	-		
6			UNN 6	Surveyor	yes	-		
7			UNN 7	Surveyor	yes	-		
8		8	UNN 8	Urban Planner	yes	-	8	-
9	UNIZIK		UNIZIK 1	Surveyor	yes	-		
10			UNIZIK 2	Surveyor	yes	-		
11			UNIZIK 3	Surveyor	yes	-		
12			UNIZIK 4	Surveyor	-	yes		
13			UNIZIK 5	Surveyor	yes	-		
14		6	UNIZIK 6	Surveyor	-	yes	4	2
15	UI		UI 1	GIS Expert	-	yes		
16			UI 2	GIS Expert	yes	-		
17			UI 3	GIS Expert	-	yes		
18			UI 4	GIS Expert	yes	-		
19			UI 5	GIS Expert	yes	-		
20			UI 6	GIS Expert	-	yes		
21			UI 7	GIS Expert	-	yes		
22			UI 8	GIS Expert	yes	-		
23		9	UI 9	GIS Expert	yes	-	5	4
24	OAU		OAU 1	Urban Planner	yes	-		
25			OAU 2	GIS Expert	-	yes		
26			OAU 3	Urban Planner	-	yes		
27		4	OUA 4	GIS Expert	yes	-	2	2
28	UNILAG	1	UNILAG 1	Urban Planner	-	yes	-	1
29	UNICAL	1	UNICAL 1	Agro-forester	yes	-	1	-
30	UNIPORT	1	UNIPORT 1	GIS Expert	yes	-	1	-
	Total						21	9
	Percentage						**70**	**30**

The questions were 10 in number, which borders on the activities of geospatial experts as players on the environment and the ocean, and all the responses granted by the interviewees were audio recorded and later transcribed to ensure the accuracy of the interviewees' thoughts. Table 1 shows the characteristics of the sampled population with the institutions' identifiers' code.

2.4 Method of analysis

This study applied the use of deductive thematic analysis of the data collected. This is a sophisticated and reliable qualitative tool that helps in conducting a research in a "precise, consistent and exhaustive manner through interview, recording, systematizing, and disclosing the methods of analysis and the study results with enough detail to enable the reader to determine the credibility and validity of the process" (Nowell et al. 2017). Thematic analysis has been used extensively in so many researches which produced robust and convincing results (Chapman and Musselwhite, 2011; Fishman et al., 2012; Gössling et al., 2016; Hafner et al., 2017; Nikitas et al., 2018). The method chosen is "the six-step approach that involves: getting familiar with the data through transcription; generating initial codes; searching for themes; reviewing themes; defining and naming themes; and producing the final written output" (Braun and Clarke, 2006). The authors maintained and ensured that the responses manually extracted and interpreted, and the findings were based on the raw data from the interviewees, rather than their thoughts, impressions, and expressions throughout the analysis.

3. RESULTS AND ANALYSIS

This analysis followed after Musselwhite's (2006) which was not designed to accumulate and self-interpret data patterns but rather as was recommended, a course of weighing up the diversified issues and identify the structures which exist in the data that have the capacity to explain their intent, rather than seeking a wealth of evidence. The outcome of this qualitative analysis is based on the raw data generated so as to eliminate analyst-oriented biasness; thus the use of multiple extracts of the respondents for support of the authors' remarks. Vaismoradi et al. (2013) and Nikitas et al. (2019) were of the opinion that "the selection of the most characteristic and convincing individual responses is a prerequisite for adequately reporting thematic analysis findings; this is more fitting from quantitative approaches like theme counts and analyst-deduced summaries of quotes." There were ten questions from which responses and discussions form the core themes that this study's analysis identified as critical determining factors for decision-making on the position of the respondents. The themes are: *Space data experts; Environmental managers; Limiting climate change effects; City planning; Transport mode arrangement; Geospatial experts in the developmental processes; Environmental contamination and water pollution/quality; Ocean pollution remedying; Interactions with the relevant authorities; Enforcement agency.*

Table 2: Analysis of Respondents response

Themes	Description (Write up)	Direct quotes from participants
3.1 Space data experts	Geospatial experts comprises but not limited to Urban planners, Surveyors, GIS Experts, Architectures, Cartographers, Quantity Surveyors among others whose primary role is to plan the land spaces using space data for the general good of the public – *'welfare goods' [UNN 8].*	*"UI 2: the geospatial experts by their training have understanding of how the activity in space influence or affect events or phenomena in space and their goal is to be able to explain the contribution of space to both social and physical dynamics in the environment."* *"UNN 1: the roles of geospatial experts are too enormous to mention – they do echo sounding to determine ocean depth, measure and map ocean pathways, work on land and in the forest, involve in road construction, generates data for building setting-out among others".*
3.2 Environment managers	There can be no environmental management without the input of geospatial experts, their activities see to the planning, mapping, designing and parceling a land space to taste. They decide where relevant structures will be placed before they are transferred to the ground. Everything that is being done on the ground requires proper management, hence the need to determine proper use. [……] In the absence of engaging the services of geospatial experts in urban and or rural planning, the development of such areas will be haphazard with the characteristics of unsustainable way of living – in terms of access to clean water, and other social amenities which include waste generation and disposal as is the case in Makoko community, a small waterfront settlement in Lagos State (Fig 2a).	*"UNN 8: urban planner contributes to environmental management through his plans…..urban master plan, rural master plan, with specific allocation to specific interest – agriculture, industrial, housing, drainage, roads among others."* *"UI 2: geospatial experts would understand the possible interactions that exist between and among various variables contributing to environmental problems. They can reconstruct history of events and based on that forecast the future. They can credibly identify locations and localities in space that are exposed to multiple problems simultaneously and proffer solutions."*
3.3 Limiting climate change effects	Climate change is as a result of the variations in climatic element over a long period of time, some of which are caused by nefarious anthropogenic activities (Ndulue et al, 2021). It is the consequences of abuse by the industrial complexes, agro-allied concerns, and transportation among others, through emissions that cause green house gases as well as deplete the ozone layer.	*"UNICAL 1: Climate change is principally being made by incessant cutting down of trees, the incessant burning of spaces and lots more. People must not cut down forests to own farm lands, instead agro-forestry should be encouraged, where trees are allowed to grow with cultivated crops – in that way the trees are preserved and crops produced. Harvesting of trees in the forest should not exceed the increment."* *"UI 9: they can play a role in the fight against climate change because they can tell the sources of factors that affect the climate……they can also model the trend of the effects using spatio-temporal data, determine the rate of change, variations in vulnerability and so on. When the facts are known, amelioration measures by the relevant authorities to the causes of climate change will be direct."*
3.4 City planning	City planning is a necessity that if ignored, attracts chaos to city movement (mobility) and other social activities. The essence of city planning is to ensure that suitable space sizes and locations are assigned to various land uses. This can be done through the combine efforts of all geospatial experts, especially the town planners, surveyors, and the architects.	*"UNN 8: the town planners do not work alone in city planning; they involve sister professions who also make inputs that are subjected to scrutiny to ensure conformity and compliance for the public welfare."* *"UNIPORT 1: they need the skills that the geospatial experts can provide in city planning. Geospatial experts work with urban planners to help them to achieve their goals and objectives."* *"UI 4: these days we talk about smart city, without geospatial experts, you cannot plan a city because they have access to a wide view of data and be able to play with some geospatial models that helps in visualizing the intended program – practicability and predictability…if you can predict, forecast….you incorporate them to have a sustainable city – smart city."*
3.5 Transport mode arrangement	Transport routes – for vehicles, railways, airport tarmac and runways as well as seaports are designed and mapped through the	*"UNN 1: surveyors are the ones to initiate the road paths from the forest before any construction can take place, and it is their directives that other players in the construction of any transport*

	information provided by the geospatial experts. [……] The secondary drainages for the road infrastructures are designed in such a way that they are not channeled or connected directly to the streams.	*infrastructure follow, be it airports, seaports, railways, and communication and power lines,"* *"UNIZIK 3: absolutely, because transportation is the movement of goods - properties and humans from one point – position 'A' to another – position 'B'. The moment you mention position, the surveyors come in. What do you use for transportation? – let start with the road, before you do road design, the surveyor gets the map, marks the track, goes back to the site to get the topographic survey map of the place because you need to understand both the vertical and the horizontal curves on the proposed road pathway. He goes to set out the road after the engineers have designed the road, the positioning of the parks, lay-bys, and bus stops…."* *"UI 2: …we can monitor the flow of fluid….."* *"UNICAL 1: I do not need to be taught that the use of insecticides and herbicides used to clear bushes gets to the ground and water washes then into the streams and contaminate them. But we ensure strategies such that runoffs get into vegetated areas where the vegetation can sieve the generated runoffs…."* *"UNN 2: …they are the ones that set out the land for any construction, for instance, in constructing secondary drainage channels….runoff volume and drainage size are determine….interceptions or catchments can be created to prevent runoffs from entering the water bodies."*
3.6 Geospatial experts in the developmental processes	The role of the geospatial experts fit in all the three stages of development, there is the season of conceiving of ideas, ideas nurture and development and subsequent plan. The development stage involve when what is in the plan is transferred to the ground. There is the need for monitoring as well as assessment after the development – "*as built" [UNIZIK 3].* […….....] The geospatial experts should be involved in all the three developmental stages, but that is not the case in this part of the world, *"…..because of the parochial interest of the people in authority whose interests are self centered to the detriment of the general well being of the people [UNN 9]",* hence the down play of the roles of geospatial experts in most developmental agenda.	*"UNIZIK 3: however you want to handle development, the surveyor should be there….the role of the surveyor as long as planning and development is concern is unlimited. He is (should be) there from the beginning – he is (should be) there when you are developing - he is (should be) there after you have developed – he is (should be) there to also plan for the future – he is (should be) always there."* *"UI 4: in the three...You will need the person in pre – so that you know the type of interventions, during the implementation, you know whether you are going out of the box…, after is like trying to assess the level of….the degree at which you have achieved what your set goals are…."*
3.7 Environmental contamination and water pollution/quality	The activities of geospatial experts are not intended to pollute the environment rather they are meant to improve the environment and therefore cannot pollute surface water. However, there are some activities that can disturb the environment whose level of contribution to environmental contamination may be difficult to determine. Harmful materials being released in the environment can cause pollution. Clearing of boundary line, pegging, burying of beacons, echo sounding, underwater survey, among others can in some instances led to disturbances that can cause pollution,…*."any human being living on the planet can have impact on water pollution….your activities can directly or indirectly contribute to water pollution…as long as you are a homo sapiens…" [UNIPORT*	*"UNIPORT 1: as a geospatial expert, yes your work can lead to actually doing something – providing insight that can help…going to make decision about….improving water pollution."* *"UNN 5: contribute to water pollution; no….a cartographer with his map can identify sources of surface or even groundwater pollution…."*

	1].	
3.8 Ocean pollution remedying	Ocean pollution occurs as a result of nefarious anthropogenic activities being carried on lands and in the oceans. These pollutions that occur on the land are washed off by rainfall, get into the streams and subsequently into the oceans as micro and nano plastics and contaminate them. Activities of the geospatial expert cannot intentionally pollute or contaminate the environment as well as the surface water rather they are intended to improve environmental quality, surface water inclusive. Understanding the importance of the oceans and the need to make then pollution free, the following thoughts were suggested:	*"UI 9: geospatial experts can decipher things that ordinarily the eye cannot see because they have the capability of having access to many data sources. They can through the result of their geospatial analysis tell where contaminants are coming from. They provide information,…they provide decision support system."* *"UNN 3: geospatial experts are not policy makers, what they can do is to provide information…like in the case of oil spillages in Nigeria, they can point out where that is polluted, trace the source, even though they may not actually know the cause of the oil spillage."*
3.9 Interactions with the relevant authorities	There is need for interactions among players in the environment as well as the relevant authorities. There are various platforms through which geospatial experts can interact and make recommendations to the relevant authorities; however lack of synergy among the geospatial experts and the *"parochial interest" [UNN 9]* on the side of government that appoint people into offices in these ministries are hampering interactions.	*"UNICAL 1: there ought to be associations…., but the unfortunate thing is that whoever is in the government of the day downplays on such. Even if you have a representative from your place, disintegration has taken place,…the politicians do not see you as reasonable enough to advice them."* *"UI 2: very well, the geospatial experts can make recommendations…but cannot do that independently, whoever that is involved is working with a team….."* *"UNN 2: …through land reform committees…headed by surveyors…"* *"UNIZIK 1: surveyors can advice on the type of survey required for an area."*
3.10 Enforcement agency	Deviations from the plans and program of the geospatial experts in environment related matters have led to the abuse of land uses, hence the massive pollutions from industries, deforestation, erosion and contaminations from agro-allied industries, emissions from combustion engines especially in transport industries, indiscriminate dumping of wastes and poor waste management in cities, among others. All these abuses have contributed to land and streams pollution (waste) that finally gets to the oceans (Fig 2b). This begs for answers to the question, can geospatial experts enforce obedience to land use rules?	*"UNIPORT 1: a geospatial expert is not an enforcer….Every aspect of planning, implementation, monitoring can make use of the expertise of a geospatial expert, not enforcing…"* *"UNIZIK 3: they are not enforcement agents…."*

Fig 2a: Makoko Community
Source: Culled from Gbonegun, (2021)

Fig 2b: Floating Trash
Source: Culled from Tunnicliffe, (2017)

4. DISCUSSION

4.1 Geospatial Experts in Marine Ecosystem Management

Primary micro plastics are generated from industrial complexes, cities, and farmlands whose establishments are as a result of after thoughts of the environmentalists and the geospatial experts through consultations, planning and implementation of the plans for suitability and sustainable use of land spaces having considered all factors. The existence of reports from the literature about the generation of micro plastics suggests that there is a deviation from the planning and implementation of the plans developed by the geospatial experts.

In looking at marine ecosystem pollution presently and to proffer solution, there is the need to attribute the whole scenario to that of Cholera outbreak of 1854 in Soho, London, and John Snow's analysis and suggestions. John Snow was a medical doctor, but could not solve the problem of the cholera outbreak using his medical knowledge, rather he adopted geospatial knowledge. With his medical expertise, he knew cholera could come from water, so sources of water were identified. He looked at the number of the infected and the death; where they had occurred the most, and then looked at the sources of water closest to the area. The analysis carried out revealed that the water-pump closest to the area of highly infected individuals and highest number of death was contaminated – 'street-pump in Broad-street'. So the solution to the outbreak was not provided by John Snow's medical expertise, rather his application of geospatial knowledge, followed by strict adherence to his recommendation and advice - "Snow sought a meeting with the parish Board of Guardians who agreed to disable the pump" (https://www.bl.uk/collection-items/john-snows-account-of-the-cholera-outbreak-in-soho-london-1854).

In the same light, John Hopkins University used geospatial knowledge to produce a communication map using covid 19 data. The map showed the rate of contamination and transmission globally in the absence of drugs suitable for the pandemic, hence the need for alternative measures to containing the spread of the disease was presented by the world health organization (WHO) which came up with restriction measures. These measures which were announced in Wuhan, China; Italy; Spain; USA; and other affected countries in the world

however were initially resisted including in Nigeria, where the security agents were aiding and abating the disobedience of the restriction orders. Yet it was the adherence to the restriction and other measures recommended by WHO that led to the containment of the spread of the pandemic, proving that experts' advice and recommendation can provide solutions to problems where no other means are readily available.

Presently, environment managers comprising mainly the geospatial experts work assiduously to make the occupied land spaces safe, liveable, and sustainable. They have the expertise to identify sources of harmful pollutants from anthropogenic activities and other land uses which can pollute the environment – atmosphere (air), land (soil), vegetation (trees and grasses), and water (ocean) before the commencement of any development. Some of these impending hazards are identified when environmental impact assessments (EIA) are carried out in the area. They are also aware that ultimately, all the pollutants generated anywhere around the world will finally get to the ocean. However, geospatial experts like John Snow can only make recommendations, suggestions, and advice to the relevant authorities concerned, which in most cases are not adhered to. The cholera outbreak in Soho, London was contained because the people adhered to John Snow's recommendation, unlike presently, the relevant authorities and the people whose responsibilities it is to make and enforce environmental laws have failed to heed the advice and recommendations of geospatial experts on the dangers of various unsustainable land use activities capable of, or presently harming the environment - maybe because of other interests superior for them.

4.2 Marine Pollution: Prevention Measures and Clean up

Single-use disposable plastics are abundantly used globally. Initiating changes to this approach can be attainable but a long and challenging economic task. Cleaning up some items like chemicals may not be possible because of their nature. Some debris cannot float, and therefore are lost to the ocean depth. The ones that can float gather 'in large patches in ocean gyres'. "The Pacific Garbage Patch is one example of such a collection, with micro and nano plastics floating on and below the surface of swirling ocean currents between California and Hawaii in an area of about 1.6 million square kilometers, although its size is not fixed. These patches are more or less like Islands of trash" (https://www.un.org/pga/73/plastics/) and, according to the National Oceanic and Atmospheric Administration (NOAA), "more like flecks of micro-plastic pepper swirling around an ocean soup". Some solutions proffered so far are not adequate in combating marine pollution because some of the 'biodegradable' plastics can only break down at higher temperatures that can never be attained in the ocean (www.noaa.gov).

Nevertheless, many countries are now taking action. According to UN (2018) report, more than 60 countries have made laws reducing or prohibiting single-use disposable plastic (https://www.cbsnews.com/news/over-60-countries-introduced-bans-fees-single-use-plastic-waste/). The United Nations also through their Sustainable Development Goals of 2015 came up with 17 Goals of which number 14 is 'Life Below Water'. The Goal has 10 targets to be achieved by 2030. The first seven targets are 'Outcome Target' (https://sdgs.un.org/goals), (i) To Reduce Marine Pollution; (ii) To Protect and Restore Marine ecosystem; (iii) To Reduce Ocean

Acidification; (iv) For Sustainable Fishing; (v) To Conserve Marine and Coastal Area; (vi) To Remove Subsidies Contributing to Overfishing; and (vii) To Increase the Economic Benefit from Sustainable use of Marine Resources.
While the last three targets are 'Means of Achieving Target' which are: (i) To Increase Scientific Knowledge, Research and Technology for Ocean Health; (ii) To Support Small Scale Fishing; and (iii) To Implement and Enforce International Sea Laws.
However, according to the UN (2020) report on progress towards the SDG's, the current effort put towards protecting the oceans, marine environment and small scale fishing are not meeting the needed protection of the resources anticipated (https://unstats.un.org/sdgs/report/2020/The-Sustainable-Development-Goals-Report-2020.pdf).

3. CONCLUSION

The oceans are necessary for life on Earth, and they provide a number of ecological services that are crucial to human well-being. Food, climate regulation, and recreation are examples of these services. Yet, human activities such as overfishing, pollution, and climate change are placing enormous strain on marine ecosystems, which are increasingly at risk of collapsing. Globally, nations are coming to understand the importance of managing marine habitats sustainably in order to solve these issues. The newly signed United Nations Ocean Treaty, often known as the "High Seas Treaty," is a significant step forward in this endeavour. The treaty's goals include protecting marine biodiversity, ensuring the sustainable use and protection of marine resources, and improving scientific understanding and data exchange about the seas. To attain these objectives, towns and countries must invest in technology that aid in the management of marine ecosystems. Geospatial/Geographic Information Systems (GIS) and remote sensing infrastructure are two such technologies that can help. Geographic information systems (GIS) may be used to map marine ecosystems, identify essential habitats and species, and track changes over time. Remote sensing can give crucial data on ocean temperature, salinity, and other critical factors, allowing scientists to better understand the effects of climate change on marine ecosystems. These technologies can also help policymakers make educated decisions regarding marine management by providing them with the information they need. GIS, for example, can assist identify locations where fishing should be restricted to conserve vital ecosystems, remote sensing can help check quota compliance and many more. Moreover, technology can promote increased collaboration among maritime governance parties. Technology may assist develop trust and facilitate discussion among varied stakeholders, such as fishers, environmentalists, and legislators, by enabling access to data and information. Ultimately, technology-informed marine ecosystem management is critical for long-term development since it can assist and ensure the long-term health of marine ecosystems while also promoting human well-being. Cities and governments may take a significant step toward meeting the aims of the UN Ocean Treaty and safeguarding the seas for future generations by investing in GIS and remote sensing infrastructure.

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