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WATERWAYS QUANTIFICATION AND EVALUATION FOR UTILIZATION MAXIMIZATION OF FRESH WATER BODIES IN THE MAINLAND AND ISLANDS OF WEST AFRICA

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Abstract: This work underscore the growing global interest in regional natural waterways and their potential exigency in transforming logistic capabilities. The main intent of this work was to quantify and evaluate the waterways of freshwater bodies in the selected areas. Upon pre - site scientific field survey of the study sub - areas, otherwise the concerned countries, their geocodes were deployed in the acquisition of the geo - coordinates while their primary and secondary data for the quantified waterways were decoded with necessary evaluation. Total waterways value of 16663 km, with average of 1111 km, and waterways to land area ratio of 15:1459625 on total, and 1:293 on average were obtained for the fifteen countries in the mainland of West Africa. Nigeria possessed the highest waterways capacity in West Africa with 8600 km, and, with waterways to land area ratio of 1:107, and also with the ratio of waterways of Nigeria to the whole mainland - land area of West Africa recording 1: 568. The republic of Togo had the smallest waterways capacity in West Africa recording 50 km, with ratios of 1:1136 waterways to the land area of Togo, and waterways of Togo to the whole mainland - land area of West Africa, at 1: 9770. Mali recorded the only country in West Africa that possessed more waterways than the land area with ratio of 1:0.6. Also, in the islands of West Africa, Cape Vade and Saint Helena possessed 4,033 and 410 sq. Km land areas respectively with little or no quantifiable waterways. Conclusively, the continental sub area possessed one of the most waterways utilizable freshwater resources in Africa and global.

Keywords: Waterways; Freshwater Bodies; Youthful River; Mature River; Old River; Rejuvenated River etc.

I. Introduction

This work deciphered on waterbodies quantification and evaluation of waterways for utilization maximization in the selected regions. Evaluation of this sort provide precision and avenue for proper utilization plan. According to Barahman, (2025), Africa is a “hidden treasure of the world economy', following the fact that

'there are over one trillion dollars' worth of projects underway across Africa in fields such as dam construction, renewable energy, and contracting,' pointing its underdevelopment to 'limited infrastructure and technological capacity". It is however a no doubt, that West Africa is blessed with utilizable freshwater resources. African freshwater body (Congo) records the deepest river in the world, measuring 220 meters (720 feet) in depth (NGS, 2025). Though it is not domicile in West Africa. The Nile in Africa about 6,650 kilometers (4,135 miles) long is the longest rivers in the world (NGS, 2025). West Africa has the second longest river in africa (Niger river). Also, Randall, (2018) reported that "Rivers and streams cover more of the Earth than previously thought". The above mentions are a few exemplary accomplishment prior waterbodies quantification and evaluation, for future endeavors.

Waterways are natural or artificial navigable waterbodies upon which water flows. It can be expressed as a line or polyline in GIS (Lee, 2023). Waterways are categorized in the case of the category rivers as natural (NWB), heavily modified (HMWB) and artificial (AWB) water bodies (Cron *et al.*, 2018). According to KCG, (2025), classification apply to waterways in terms of small waterbodies as natural stream, a modified stream, or an artificial ditch. For instant, Cron *et al*., (2018), reported that nearly 80% of the German federal water bodies are designated as heavily modified and artificial. This signifycantly point to about 20 % utilization of natural waterbodies in the area. Waterways are vital for economic and social activities, supporting transportation, trade, and community livelihoods (Okolotu, 2024), as well as dams application, agricultural production, general conveyance of aquatic and other products. Rain otherwise precipitation also travel through the hydrological cycle to seas, rivers or lakes. Standardization procedures for quality control, establishable with the assistance of international organizations, governmental bodies, and other research institutions (Okolotu *et al*., 2024), in waterways works are welcoming for future advances in continental and global output. Waterways are improveable prior means of engineering works (dredging, rock blasting, channeling, installation of ripraps and locks, *etc*). Healthy waterways support many environmental values such as native fish, riparian vegetation, habitat for plants and animals, drought refuges and rare or threatened species (VSG, 2023). Ownership of waterways have been appropriated to the private and public in some countries especially in western countries of the world. Such appropriation gives the owner necessary legal rights of ownership to maintain, access and even regulate charges for access even though the owner is not the passage authority. Within the West African countries, mostly the estuaries region where coastal beaches are privatized, demand for rights of navigation and public rights of way are financially tagged in some places. Previous waterways literatures include; Loo and Clarke, (2017), Kaaristo, (2018), Reid, (2021), Babatunde *et al*., (2023), Kuzmanović, (2023), Meshel, (2023), Monteiro and Patrício, (2024), *etc*., signifying the diverse importance of these waterways both to the environment and livelihood.

Freshwater bodies are known for the absence of salt substances which provide opportunities that seas and oceanic waterbodies may not offer. Freshwater typically has an average salinity of less than 0.5 parts per thousand (ppt), while saltwater bodies such as oceans have an average salinity of around 35 ppt (Ozioko *et al.*, 2024). Waterbodies accumulates from a source otherwise headwater like basins and others. Freshwater bodies generate from outflow of seas, and they move towards the lower slope directions. Rainfall and groundwater add to the volume increment of freshwater bodies while they flow till an outflow into the ocean. According to NGS, (2025), frreshwater bodies have been notably associated to the world's first great civilizations like the Nile in Egypt, the Sindu (Indus) in southern Asia, the Tigris and the Euphrates in the Middle East, and the Huang

(Yellow) in China. The longing and attraction of life to freshwater bodies points to its level of significance. Infact, about 95% of Egypt population lives within 20 kilometers (12.4 miles) of the Nile river (NGS, 2025), spooning its importance. Various previous studies on freshwater related works abound, like: Cavin, (2017); Hildrew, (2018); Dudgeon, (2020); Dodds &, Whiles, (2020); Suring, (2020); Oberdorff, (2022); Sarika, (2022); Babushkin *et. al.,* (2023); Smol, (2023); Sailu &, Unnisa, (2024); Valdovinos &, Fierro, (2024); *etc.* Globally, freshwater bodies storages are presented in figure one (1) below;

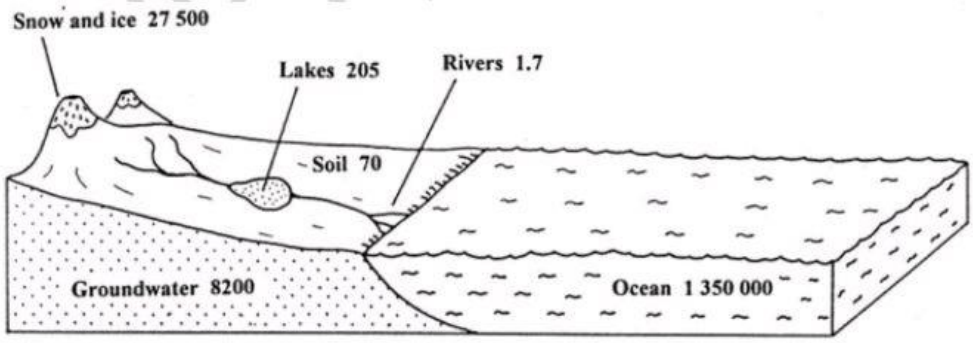

Figure 1: Major global storage of freshwater on earth (all values in thousands of km^3) (Pokorný, 2005)

Also, the global river and stream surface map showing the regions with high and low water existence prior colour thickness is presented in figure two (2) below;

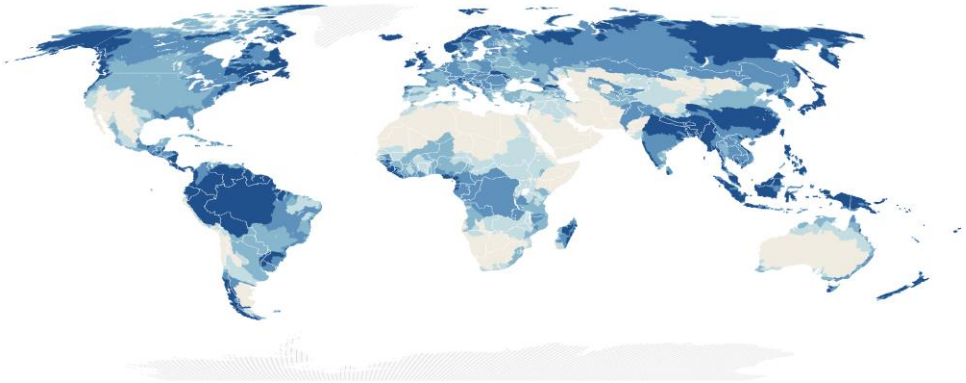

Figure 2: Global River and stream surface map (EO - NASA, 2018)

A river is an integral part of the environment and ecology in the basin or watershed (Das, 2018). According to NWE, (2024), classes of rivers prior their visualatory gradient attributes include; youthful river, mature river, Old River, and, rejuvenated river. This classification is associated with river or stream lifecycle maturity stage or river course.

Youthful River is a river with a steep gradient that has very few tributaries and quick flows. This creats narrow, deep valleys and waterfalls (Admin, 2024). Its channels erode deeper rather than wider. It is otherwise refered to as young landscapes rivers (Endreny, 2024). The river is usually small and flows down steep slopes with lots of energy, with river features attributively formed by the processes of erosion (FVC, 2024).

Mature river is a river with its gradient less steep than its previous maturity stage as a youthful river. Mature river is otherwise called middle aged or mature landscapes (Endreny, 2024). Its channels erode wider rather than deeper (NWE, 2024). In the mature stage of a river, the slope becomes gentler and the river becomes much wider as it is joined and fed by many tributaries (FVC, 2024). The river at this point begins to carry eroded load

from further upstream, and thus discharge more and flow more slowly. Lateral erosion domination over vertical erosion, river valley widening, meanders development due to lateral erosion and deposition, floodplains formation due to sediments deposition, wider valleys prior gentle slopes are associated with this stage (Admin, 2024).

Old River is a river with a low gradient and low erosive energy and thus, are usually characterized by flood plains. The low gradient allow the river to have a very large volume of water with a heavy load and dominant deposition, while, meanders and ox-bow lakes, natural levees and deferred tributaries, braided channels, flood plains as well as deltas are the major characteristics of this old age stage (Matsanga, 2024). At this old age stage, the river is usually at its widest while the land is at its flattest, entailing that the river need to work very hard to make its way to the sea, because, the main agent at work in this stage is deposition (FVC, 2024).

The three major stages of river are presented in figure three (3) below;

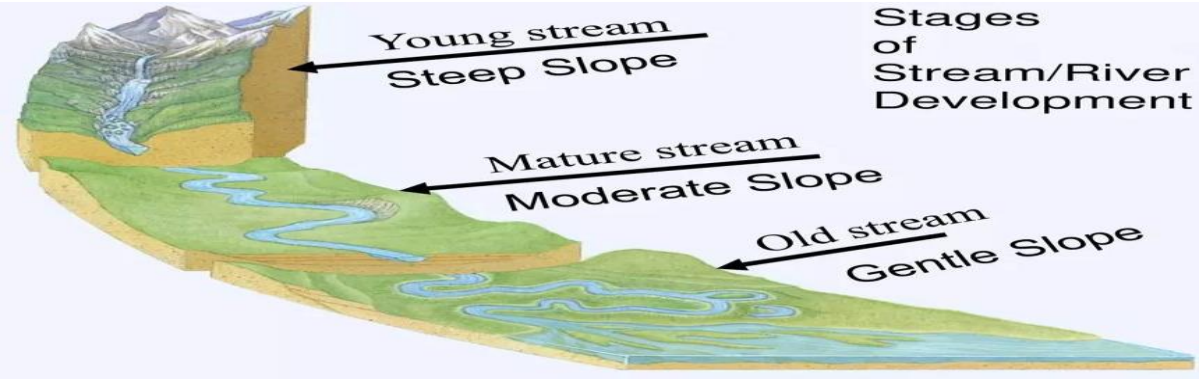

Figure 3: Slope attributes description in river or stream stage development (Rodriguez, 2021)

Rejuvenated river is a river that developed advantageous changes through natural or artificial means that restores its youngness capabilities. Shekhar, (2016), pointed that river rejuvenation is achieved by restoration to its acceptable historical state. The gradient is raised by tectonic uplift due to tectonic change (where land is uplifted after plate movement or volcanic activity). Climatic change (glaciations and rainfall change), changes due to positive sea level rises in relation to the land, or negative sea level fall in relation to the land (fall in sea level or a rise in the level of the land possesses dramatic effect on a river's journey to the sea) (Rodriguez, 2021). In this class of river, the stage of maturity is not the factor of classification but changes in soil or water level which influences the routing or forceful re - routing of river water to the ocean and sea.

II. Materials

The major materials used in this work are the study areas otherwise mainland and islands of West Africa (West African countries). Africa is the second largest of the seven continents on earth. It is positioned by the right side (east) of the Atlantic Ocean and American two continents, left side (west) of the Indian Ocean and Asian continent, top side (north) of the Antarctica and Australia, and downside (south) of European continent. It was previously joined with the present Asian continental land mass. It possesses subregions like the western Africa, central Africa, eastern Africa, northern Africa and southern Africa.

The basic attributes of the countries in these regions are embedded in the table one (1) below;

Table 1: Latitude, longitude, and boarders of regional countries

S/N	Region	Latitude	Longitude	Borderlands
1	Nigeria	10.0	8.0	Benin, Niger, Chad, and cameroon
2	Republic Of Niger	16.0	8.0	Algeria, Benin, Burkina Faso, Mali, Nigeria, Libya, as and Chad
3	Burkina Faso	13.0	- 2.0	Benin, Ghana, Ivory Coast, Mali, Togo, Niger,
4	Ivory Coast	8.0	-5.0	Burkina Faso, Ghana, Guinea, Mali, Liberia
5	Liberia	6.5	-9.5	Guinea, Ivory coast, Sierra Leone
6	Gambia	13.5	-16.6	Senegal, Guinea Basua
7	Republic Of Guinea	11.0	-10.0	Guinea Basua, Ivory Coast, Mali, Sierra Leone, Liberia, Senegal
8	Republic Of Guinea Basua	12.0	-15.0	Senegal, Guinea
9	Republic Of Mali	17.0	-4.0	Senegal, Guinea, Algeria, Burkina Faso, Ivory Coast, Mauritania, Niger
10	Republic Of Senegal	14.0	-14.0	Guinea, Guinea Basua, Mali, Gambia, Mauritania
11	Republic Of Togo	8.0	1.2	Ghana, Benin, Burkina Faso,
12	Islamic Republic Of Mauritania	20	-12	Mali, Senegal, Algeria, Western Sahara
13	Republic Of Benin	9.5	2.5	Togo, Burkina Faso, Niger, Nigeria
14	Sierra Leone	8.5	-11.5	Guinea, Liberia
15	Ghana	8	-2	Ivory Coast, Burkina Faso, Togo
16	Cape Vade	16	-24	None (Central Atlantic Ocean)
17	Saint Helena	- 15.95	-5.7	None (Southern Atlantic Ocean)

Also, these tabulated study area can be located in figure four (4) below;

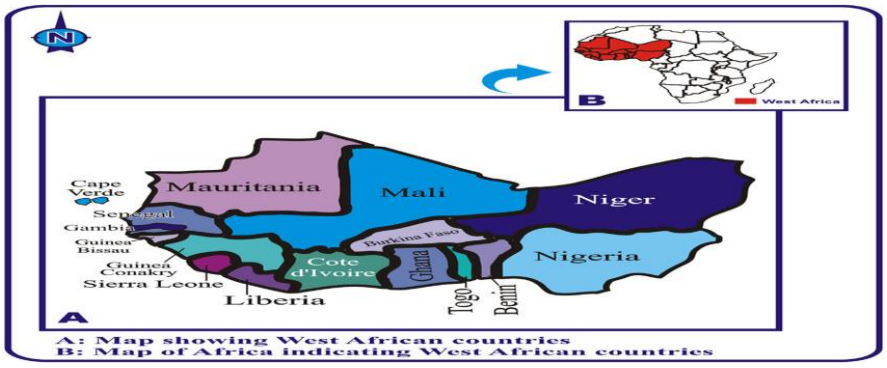

Figure 4: Map of West Africa and African continent (Okoroiwu *et al*., 2021)

West Africa has two types of land, describable as mainland and island. Mainland refers to the major land area that can be seen in the countries or continental map at zoom scale. Figure four (4B) above is a typical example. Island is a land area surrounded by water like Cape Vade located by the left side of the mainland of west Africa

and Africa. The island country is own by Africa and thus, forms part of West Africa, though, it is separated from other countries in the continent by the Atlantic Ocean. Cape Vade can be seen in figure four (4A) above. Saint Helena is another West African island country located in the southern Atlantic Ocean towards Angola. The Niger River, Senegal River, Gambia River, and the Kolenté river otherwise Great Scarcies river, are the main rivers in west Africa.

III. Methods

In this work, earthed region quntifyably - overlayed by waterways of freshwater bodies within the selected study areas were evaluated upon primary data collection and secondary data generation. Geocodes of the selected study area were actualized using appropriate scientific site survey and Atlas GIS, for precise geographical location prior their geo - coordinates values. The width, depth, and length of the waterways otherwise the scale were used in obtaining waterways readings. These were utilizably deployed in necessary evaluation leading to the expected conclusion.

IV. Results

The results obtained from this work are presented in table two (2) below;

Table 2: Mainland - land area, and waterways

S/N	Region	Land Area (sq. Km)	Waterways quantified (km)
1	Nigeria	923, 768	8,600
2	Republic Of Niger	1, 267,000	300
3	Burkina Faso	274,200	-
4	Ivory Coast	322,460	980
5	Liberia	111,370	-
6	Gambia	11,300	390
7	Republic Of Guinea	245,857	1,300
8	Republic Of Guinea Basua	36,120	-
9	Republic Of Mali	1,240	1,800
10	Republic Of Senegal	195,190	1,000
11	Republic Of Togo	56,785	50
12	Islamic Republic Of Mauritania	1,030,700	-
13	Republic Of Benin	112,620	150
14	Sierra Leone	71,740	800
15	Ghana	239,460	1,293
Total		4,888,480	1,6663
Av.		325,899	1,111

Island results are presented in table three (3) below;

Table 3: Island land area, waterways, and ratio

S/N	Region	Land Area (sq. Km)	Waterways Geomass (km)	Land Area to Waterways Geomass ratio
1	Cape vade	4,033	-	4033:0
2	Saint Helena	4,10	-	410:0
Total		4443	-	4443:0
Av.		2,222	-	2222:0

Land area to waterways ratio results are presented in table four (4) below;

Table 4: Results of land area to waterways ratios

S/N	Region	Land Area to Waterways Geomass ratio	Mainland - Land Area to Waterways ratio
1	Nigeria	107:1	568:1
2	Republic Of Niger	4223:1	16295:1
3	Burkina Faso	274200:0	4,888,480:0
4	Ivory Coast	329:1	4988:1
5	Liberia	111370:0	4,888,480:0
6	Gambia	29:1	12864:1
7	Republic Of Guinea	189:1	3760:1
8	Republic Of Guinea Basua	36120:0	4,888,480:0
9	Republic Of Mali	0.6:1	2716:1
10	Republic Of Senegal	195:1	4888:1
11	Republic Of Togo	1136:1	9770:1
12	Islamic Republic Of Mauritania	1030700:0	4,888,480:0
13	Republic Of Benin	751:1	32590:1
14	Sierra Leone	90:1	6111:1
15	Ghana	185:1	3781:1
Total		1459625:15	19652251:15
Av.		293:1	4400:15

Waterways ratio to land area is presented in figure five (5) below;

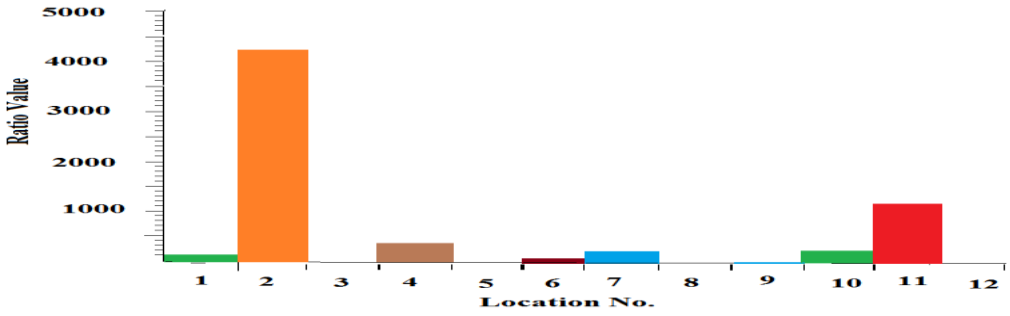

Figure 5: Waterways ratio

Land area values in the mainland of study areas are presented in figure six (6) below;

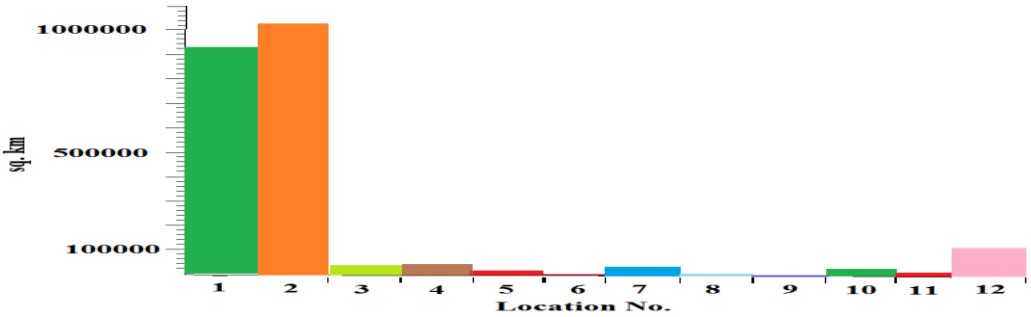

Figure 6: Land area values in the mainland of study area

Waterways values in the mainland of the study area are presented in figure seven (7) below;

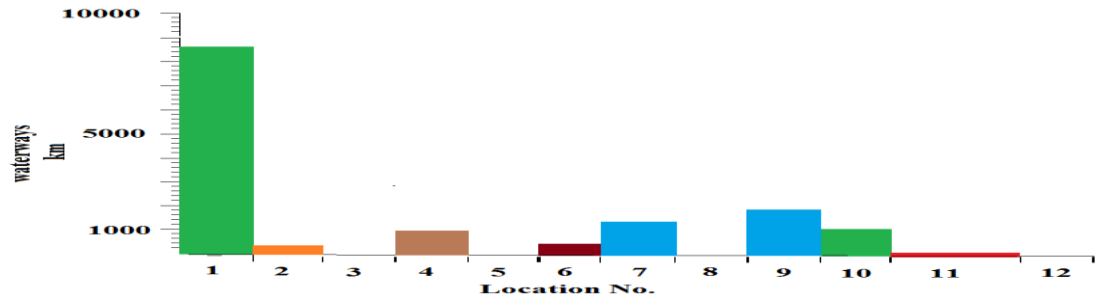

Figure 7: Waterways values in the mainland of the study area

V. Discussion

It can be seen from results obtained that Nigeria possess the highest waterways capacity among the regions with Togo as the least. Nigeria possesses the highest waterways in West Africa with 8600 km. This value is 1950 km bigger than the longest river in the world, otherwise Nile which records 6,650 km. This indice that Nigeria is the most abundantly endowed with water resources in West Africa. Also from results obtained, Nigerian waterways to land area ratio is 1:107, and to the whole West African mainland - land area (4,888,480 sq. Km) is 1: 568. The republic of Togo is the least in waterways value with 50 km with waterways to land area of 1:1136, and ratio of 1: 9770 to the West African mainland - land area. Waterways to land area ratio of Mali recorded 1:0.6, making the republic the only country in West Africa that possess more waterways than land area. Almost half and quarter of Mali territory is possess by waterways, making this work an arc lamp for their national utilization of waterways resources.

In the island of West Africa, Cape Vade possesses 4,033 sq. Km land area, with little or no quantifiable waterways. This is so, considering the all-round bordering by the Atlantic Ocean. The ocean however provide them adequate sea water resources. Saint Helena had 4, 10 land area with no measurable waterways. The three territory island (St. Helena, Ascension and Tristan da Cunha) inversely receive adequate salt water resources from the ocean. Most islands are small in land area and thus, the sea water that surrounds their land becomes the only water resources naturally available to them.

Also, the results values presented in kilometers and square kilometers are convertible to other scientific and international (S.I) units depending on the usage requirements. These data will enable future waterways major and micro routes projects within the subregions and Africa at large. Such projects necessitate advancement in major national river dredging as well as national relations among countries within the regions. Constituting,

Implementation and enforcement of policies and laws at various levels to sustainably manage freshwater bodies while maintaining balance in the needs of communities, businesses, and the environment (UNW, 2024; Okolotu *et al.,* 2025) are kinly ideal for conservation of these natural resources.

VI. Conclusion

The total waterways value of West African mainland is 16663 km with an average of 1111 km. The fifteen countries possess a waterways to land area ratio of 15:1459625 with average of 1:293. Nigeria is endowed with the highest waterways resources in West Africa. Togo has the least waterways resources in West Africa. While some countries in the mainland (Burkina Faso, Liberia, Republic of Guinea Basua, and, Islamic Republic Of Mauritania), and Island (Cape Vade, and Saint Helena), had none. The area is substantially equipped with utilizable freshwater bodies in its mainland. This work makes a trend for soil and water engineers and other professionals relative to water resources, in making valuable decision prior coastal engineering works.

Authors Contribution

Okolotu G.I (Conceptualization; Funding; Investigation; Validation; Writing Original Draft; *etc*). Oluka S.I (Visualization; Writing Review; *etc*). Akwenuke O.M (Writing Review; *etc*). Udom E.A (Data Curation; Writing Review; *etc*).

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