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Trend of traffic on inland waterways of Port Harcourt urban coastal environment: a comparative safety imperative for a Ghanaian coastal regional province

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Abstract

The purpose of the study is to compare mobility and access in Sub- Saharan Africa urban cities of Nigeria and Ghana by analysing trends and accident probabilities on the inland waterways to improve safety standards. Primary data from100 respondents through structured data and interview from boat and ferry operators were used. The responses were ranked on a four-point scale based on the selected routes' average accident probabilities in percent: Very Safe {0-20}, Fairy Safe {21- 50}, Unsafe {51- 80}, and Very Unsafe {81- 100}. Secondary data from the National Inland Waterways Authority (NIWA) and Ghana Maritime Authority (GMA) and the Volta Lake Transport Company (VLTC) were subjected to probability, percentage and trend analysis. Results indicate that in the Niger delta for every journey there is approximately 59% likelihood of fatal accident; while on the Volta Lake there is a likelihood of 7% fatal accident occurrence. The trend of traffic was high in the Niger delta noticeably in the routes of Akwa- Ibom. Cross Rivers and Rivers State. The Volta Lake recorded high traffic volumes on the routes of Yeji,Tapa Abo and Bidi on market days while on non-market days, Makango. Kwamekrom and Kpechu had high passenger volumes. Estimated annual passenger traffic on the Niger delta routes outweighed that on the Volta Lake routes on a ratio of 4:1. Safety analysis further reveals that the water ways of Port Harcourt in Rivers state were unsafe for travel while the water ways of the Volta Lake were relatively safe as revealed by the average probability ratio of 8:1 in comparative terms. The log linear regression analysis reveals a price elasticity of demand for boat transport of 1.00 and 0.97 for the selected route of Port Harcourt Nigeria and Volta Lake, Ghana respectively. It further supports the fact that more passengers were responsive to travel by waterways in Nigeria than Ghana. The study concludes that waterways of Niger delta basin have high risk indices and likelihood of accident occurrence than the Volta basin; and recommends that VLTC and NIWA should invest optimally and partner with the private sector to enforce and regulate the waterways operations so as to increase safety and mobility of users of the waterways.

Keywords: Accident; Inland waterways; Mobility; Probability; Safety

1. Introduction

Mobility and access to affordable as well as safe transport alternatives form one of the invaluable but basic necessities of man through the ages. Inland water transport (IWT) systems arguably are a prominent alternative, especially within the littoral states and regions of Nigeria and Ghana. This mode of transport which have existed for centuries in various nations including developed and less developed countries, provide a link between the rural and urban settlements. Globally, there has been increasing efforts among nations of the world geared towards improvement of IWT systems.

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This is due largely to its perceived role in globalization occasioned by the significant relationship between transport and economic development.

Therefore, Inland water transport plays a vital role in economic development especially for remote rural areas, while the potential role of this sector depends considerably on the specific regional contest such as geographical conditions, level of road development and socio-economic conditions. Pinto (2010) amongst other works has highlighted some unique characteristic and enormous benefits of inland water transport (IWT) in the following manner:

Inland water transport (IWT) routes are developed along existing rivers, canals and waterways and unlike road and rail. The per kilometre cost of development of a waterway is insignificant when compared to that of an equivalent length or traffic capacity of rail or highway. The maintenance cost of a waterway is also less compared to the corresponding cot of rail or road; likewise the time taken to develop waterway routes is similarly negligible.

IWT provides a service that is far more environment friendly than either road or rail because in the context of damage caused to the fragile ecosystem by economic development, it is impossible to overestimate the important of this factor. Road transport in particular, relies exclusively on fossil fuels which are not only polluting, but also finite in character.

IWT plays a major service by tackling congestion on roads, thus reducing accidents and the horrendous loss of life they cause- also time management through just in time services hindered by traffic congestions. Hence, IWT remains in most situations the least costly, least energy consuming and least hazardous mode of transportation.

However, despite the vital role of this sector, inland water transport (IWT) systems have not yet achieved full potential in most regions of the globe, especially the developing countries and most importantly, the sub- Saharan African countries of Nigeria and Ghana. Aside its neglect, IWT seems to be outside the mainstream transport and development planning often overshadowed by other sectors such as road transport with some challenges facing the sector as noted by UNESCAP (2010).

Comparatively, we may note that similar to Nigeria, Inland waterways transport operations in Ghana is faced with a lot of constraints with respect to safety issues. While Nigeria's IWT is regulated by the National Inland Waterways Authority (NIWA) wherein the littoral states manage the operations with private partnerships; Ghana's Inland water transport system on the other hand, is managed by the Volta Lake Transport Company which has been in operation for decades.

Therefore this research would attempt to establish trends of traffic and passengers on selected water ways of both countries' coastal region in order to ascertain safety standards and associated risks on the waterways for proffering sustainable solutions to identified safety issues.

1.1. Aim and Objectives of Study

The aim of this study is to compare the trend of traffic on the Inland waterways of Port Harcourt in Niger Delta basin, Nigeria and those of the Volta Basin, Ghana respectively in order to reveal the need for safety measures on the waterways. The specific objectives include to:

- reveal the trend of traffic on the IWT routes on the Niger delta basin, Nigeria and Volta basin, Ghana.
- estimate the probability of accident occurrence on the Niger delta basin, Nigeria and Volta basin, Ghana.
- evaluate the minimum safety implications for operators and users of the waterways of both countries.
- determine the extent of the demand for boat services and ridership on the Port Harcourt waterways route and Volta lake routes.

1.2. Research Questions

The following questions shall guide our empirical findings and inferences of the study:

- What is the trend of traffic on the IWT routes on the Niger delta basin, Nigeria and Volta basin, Ghana?
- Could the probability of accident occurrence on the Niger delta basin, Nigeria and Volta basin, Ghana be estimated?.
- What are the minimum safety implications for operators and users of the waterways of both countries?
- Is the demand for boat services and ridership on the Port Harcourt waterways route and Volta lake routes significant?

1.3. Hypotheses

The following possible inferences may be drawn from the fourth objective and associated research question, that:

- Ho_1: the demand for boat services and ridership on the Port Harcourt waterways route is not significant.
- Ho_2: the demand for boat services and ridership on the Volta lake routes is not significant.

2. Review of Related Literature

2.1. Routine Activity Concept and Theory

The routine activity theory is a sub- field of crime and opportunity theory that focuses on situations of crimes. It is also an offshoot of the socio-structural theory, advanced by Marcus Felson and Lawrence E. Cohen in their explanation of crime rate change in the United States 1947- 1974. It is however a new paradigm and a Meta-theory in the 1970s crime discourse.

The routine Activity Theory explains crime as a product of the combined result of three essential elements:

- Potential offenders or persons who are motivated to commit crimes.
- Suitable targets that is the presence of the things that are of some economic value and which can be easily transported.
- Absence of capable guards or persons who can prevent a crime from taking place.

The foregoing propositions put forward the factors by RAT crystallize the factors that prompt the occurrences of pirate attacks in Niger Delta waterways and it attendant threat on the waterways. Principally, the availability of suitable targets (oil water transport) according to the routine theory is a motivator and sustained factor. Too, the adequacy and unavailability of competent security networks to safeguard the territorial waters of the study area. Based on this, the Routine Activity Theory concerned itself with explicating the individual motivational factors in crime causation which other traditional sociological theories of crime do not. Its main preoccupation is to emphasize how ordinary or normal lawful, conventional, routine activities of individuals increase the probability of criminal activities.

Routine Activity Theory is used in safety and security studies to buttress the fact that for an attack to be carried out, there must be suitable target(s), that is, the presence of things that are of economic value, it also posits that absence of capable guards or persons who can prevent a crime from taking place makes a person or an area vulnerable to attacks. In the same vein, Dike et al. (2018) emphasizes the need for safety precautions across all transport modes.

From the above, it could be deduced that the economic endowment of Niger Delta region, that is, natural resources like crude oil in the area is the reason why piracy, kidnapping, militancy, arm robbery and other criminal activities continue unabated in the region. Also the absence of security protection to prevent these criminals for having their way is also responsible for the incessant attacks.

2.2. Empirical Review

Inland waterways transport has been a major means of movement especially for riverine communities of Nigeria and Ghana, for many decades; and providing strategic link between rural communities and urban centres. To this effect, many studies have revealed the methods of operation and regulations in both countries including other African countries, to show the similarities, differences and operational constraints as well as possible solutions for Inland waterways operational problems. In view of this, Nwankwo Ukoji (2015) in their work entitled '*Boat accidents in Nigeria: General trends and risk factors'* revealed that 180 boat accidents occurred along the waterways between the months of June 2005 and May 2015, resulting to 1607 facilities within the period in Nigeria. The results showed that the causative factors ranged from militancy, piracy, negligence, turbulent weather to wreckages. They concluded that insecurity occasioned by piracy, militancy and armed robbery had significant contribution to boat accidents, since there were reduced facilities and accidents during the amnesty period of 2009, which later rose at the collapse of the amnesty thereafter when different militant and armed groups sprang up in the Niger Delta area.

On the other hand, Boadu, Otoo, Boateng and Koomson (2020) conducted a study on Inland Waterways Transportation (IWT) in Ghana using Volta Lake Transport as case study. The result of their analysis showed that the major constraints to optimal IWT operations were administrative, that of market, logistics and technical constraints of which market constraints ranked highest with 9 respondents followed by logistics with 7 administrative with 5 and the lowest being technical constraint with 4. This may imply that the Volta Lake Transport (VLTC) offers relatively sound technical service to customers with a resultant effect and lower fatalities. They concluded that smooth IWT operations in Ghana would require institutionalization and proper regulations, dredging or periodic maintenance of navigational channels, improvement of logistics and infrastructional development, including an integrated transport planning.

Haule and Olagunju (2014) in their comparative report on safety of life in Nigeria and Tanzania Maritime law and practice; '*entitled coffin boats and state's responsibilities for safety of navigation*' reviewed the case of marine accident involving MV Guarara of the Nigerian National Shipping Liner (NNSL) in 1990 which they assert occurred off the Portuguese coast, highlighting the immediate and remote cause of the accident with high fatalities. Their analysis showed that the vessel was not sea worthy. They further revealed panoply of boat accidents in the internal waters of both countries and what the national laws of the countries held on them in comparison with existing international laws, regulations and treaties.

Suleiman (2016) in his safety analysis entitled '*Pragmatic analysis of safety and security in Tanzania maritime logistics*' considered evidence from Zanzibar passenger ferry boat in Tanzania and revealed that a number safety and security issues were responsible for marine accidents in Tanzania. These factors include lack of information on how to escape during emergencies, lack of notification and marking of the position of safety gadgets on board ship and passenger ferries; inadequate numbers of surveillance camera, absence of security personnel and routine patrol to prevent terrorist attacks. The results further revealed that hazardous cargo was not separated from other cargo which could lead to explosion and finally that in most cases passengers lacked proper understanding of the competence of the boat/ferry operators and crews. Hence, security was not satisfactory. To this end, significant gap exist in the body of knowledge of the reviewed literature in respect of the non quantification of accident probabilities and indication of safety standards and implications for the surveyed waterways in both countries, which this research tends to bridge.

3. Material and methods

3.1. Description of the Study Area

3.1.1. Nigeria and Waterways of the Niger Delta area

Nigerian is located on longitude 9.0820° N and latitude 8.6753° E and has two major seasons, the dry season and the rainy season. The dry season starts from November and ends in March while the rainy season starts from April to October.

However, the research would concentrate on the inland waterways provided by the Niger delta basin and the Volta basin for ease of data collection and relative survey. Hence Nze et al (2018) deductively describes the area politically known as the Niger delta as situated within the south-south, partly south-East and South-West geopolitical regions of Nigeria. It extends over 70,000km^2 and accounts for about 7.5% of Nigeria's land mass. Historically, the Niger delta consists of the present day Bayelsa, Delta and Rivers states, Abia, Akwa-Ibom, Cross Rivers, Edo, Imo and Ondo states.

Port Harcourt is the capital of Rivers state and the most developed urban centre of the state as well as the Niger Delta area in the South- South, partly South- East and south- West sub regions of Southern Nigeria. It has several inland water ways transport routes.

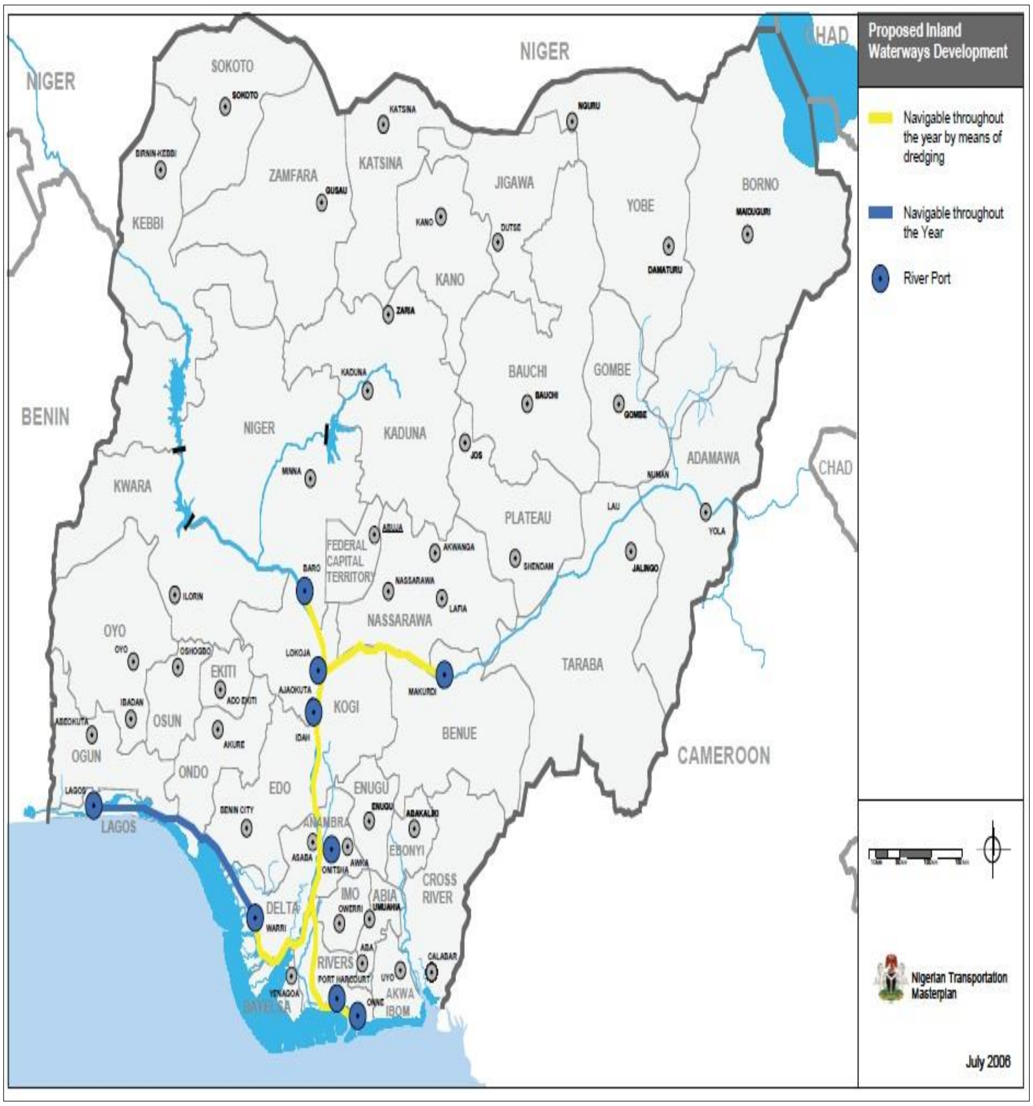
It is not a subject of argument that waterways are invaluable to the Nigeria's economy. This is supported by the fact that Nigeria is richly endowed with waterways spanning 10,000 kilometres within which 3,800 kilometres are navigable seasonally. It is also pertinent to note that twenty eight of the Nigeria's 36 States can be accessed by water.

The Rivers Niger and Benue constitute the major channels for inland navigation which include but not limited to the Cross River, Port Novo- Badagry-Lagos waterways, Lekki and Lagos Lagoons, Ogun-Ondo waterways, Benin river, Escravos channel, Nun River, Imo River, Orashi river, Ethiope River Ugwuta lake, Lake Chad and the numerous creeks in the Niger delta. The following constitute the waterways of the Niger delta area of the South- South and South Eastern region of Nigeria:

- The waterway from Warri along the Forcados River, through Frukana, Siama. Bomadi. Angalabiri. Patani. Torofani. down River Nun to Agberi, Kiama. Sabagreia. Gbaran Creek, Agudama, Ekpetional into Ekole Creek to Yanaka. Yenegoa, Sangala to Mbiakpaba. onto Okokokiri, Ofokpota, Olagaga. Nembe, Adema. Agoribiri Creek to Egbema, Degema, Sombreiro River to Hanya Town, Ogbakiri to Port Harcourt.

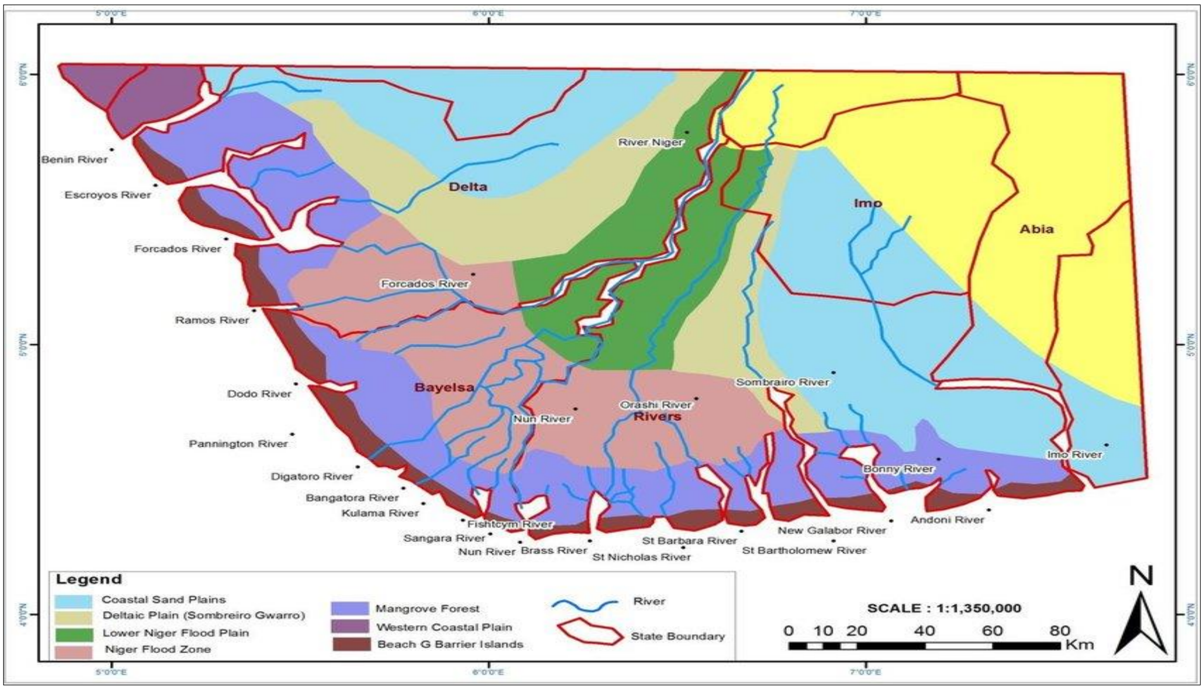
- The waterway from Port Harcourt, through Amadi Creek down Bonny River, into Opobo Channel Adoni River, through Andoni Flats, Tellifer Creek, Imo River. Shooter Creek. Kwa Ibo Creek, Kwa Ibo River, Stubbs Creeks. Widenham Creek, Effiat-Mbo Creek, Cross River estuary to Oron and Calabar.
- Rivers Benin. Ethiope, Ossiomo. Onne, Aba. Azumini, Olomum. Siluko, Talifa, Forcados, Penington, Escravos, Warri, Ramos, Dodo, Bonny, Middleton, Fishtown, Sengana, Brass of Nicholas, Santa Barbara. San Batholomew, Sambriero, New Calabar, Mbo, Rio del Rey, Uruan, Akwayafe.
- Creeks Odiama, Agamama Tora, Nembe, Krakama, Buguma, Bille, Finima, New Calabar, Ekole, Cawthprne Channel, Ikane-Bakassi, Omu, Kwato (Gwato), Adagbrassa, Chananomi, Okpoko, Jones Kulama, Ikebiri, Nikorogba, Sagbama, Egbedi, Kolo, Laylor, Hughes Channel.
- Lakes Mahin, Oguta, Osiam Ehomu.
- The Orashi River from Oguta Lake to Ebocha, Omoku, Kreigani, Moiama., Okariki, Egbema, Sombreiro River.

It is worthy to note that the longest river in Nigeria are the Niger River and its tributary, the Benue River but the most used, especially by larger powered boats and for commerce, are in the Niger Delta and all along the coast from Lagos Lagoon to Cross Rivers as shown in figures 1 to 3.



Source: Google.com

Figure 1 Map of Nigeria showing the navigable inland waterways



Source: Google.com

Figure 2 Map of Niger Delta showing the rivers and waterways

Source: Google.com

Figure 3 Map of Rivers state showing the waterways of Port Harcourt

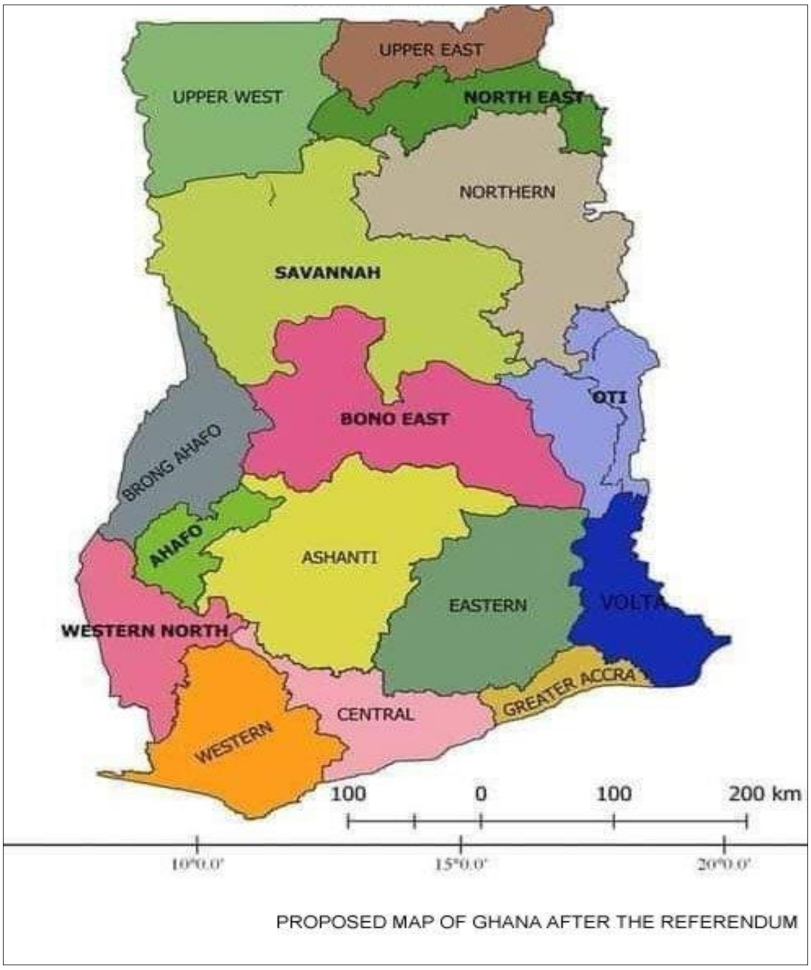
3.1.2. Ghana and the Waterways of the Volta Region

Ghana is a West African country in Africa along the Gulf of Guinea. It is situate in the centre of Gulf of Guinea coast and has 2,420 km of land borders with three countries: Burkina Faso (602 km) to the North, Ivory Coast (720km) to the West, Togo (1098km) to the East; Gulf of Guinea and Atlantic Ocean to the South. Ghana lies on longitudes 12^0 and 20N. Politically, Ghana has sixteen regions and each comprises of a number of Districts.

The Volta region is one of the sixteen regions with the world's largest man- made lake, the Volta Lake. The Volta Basin covers about 45 percent of the nation's total land surface. Its northern section, which lies above the upper part of Lake Volta, rises to a height of 150 to 215 metres (492 to 705 ft) above sea level.

Available records have proven that inland navigation on the Volta River has changed significantly since 1964. Construction of the dam at Akosombo, about 80 kilometres (50 mi) upstream from the coast, created the vast Lake Volta and the associated hydroelectric project. The Black Volta River and the White Volta River flow separately into the lake. Before their confluence was submerged, the rivers came together in the middle of Ghana to form the main Volta River.

The Oti River and the Daka River, the principal tributaries of the Volta in the eastern part of Ghana, and the Pru River, the Sene River, and the Afram River, major tributaries to the north of the Kawhu Plateau, also empty into flooded extensions of the lake in their river valleys. The lake is navigable from Akosombo through Yeji in the middle of Ghana. A 24-metre (79 ft) pontoon was commissioned in 1989 to link the Afram Plains to the west of the lake with the lower Volta region to the east. Figures 4 and 5 shows the map of Ghana with her regions and the Volta region with her waterways respectively.



Source: Google.com

Figure 4 Map of Ghana showing the constituent regions

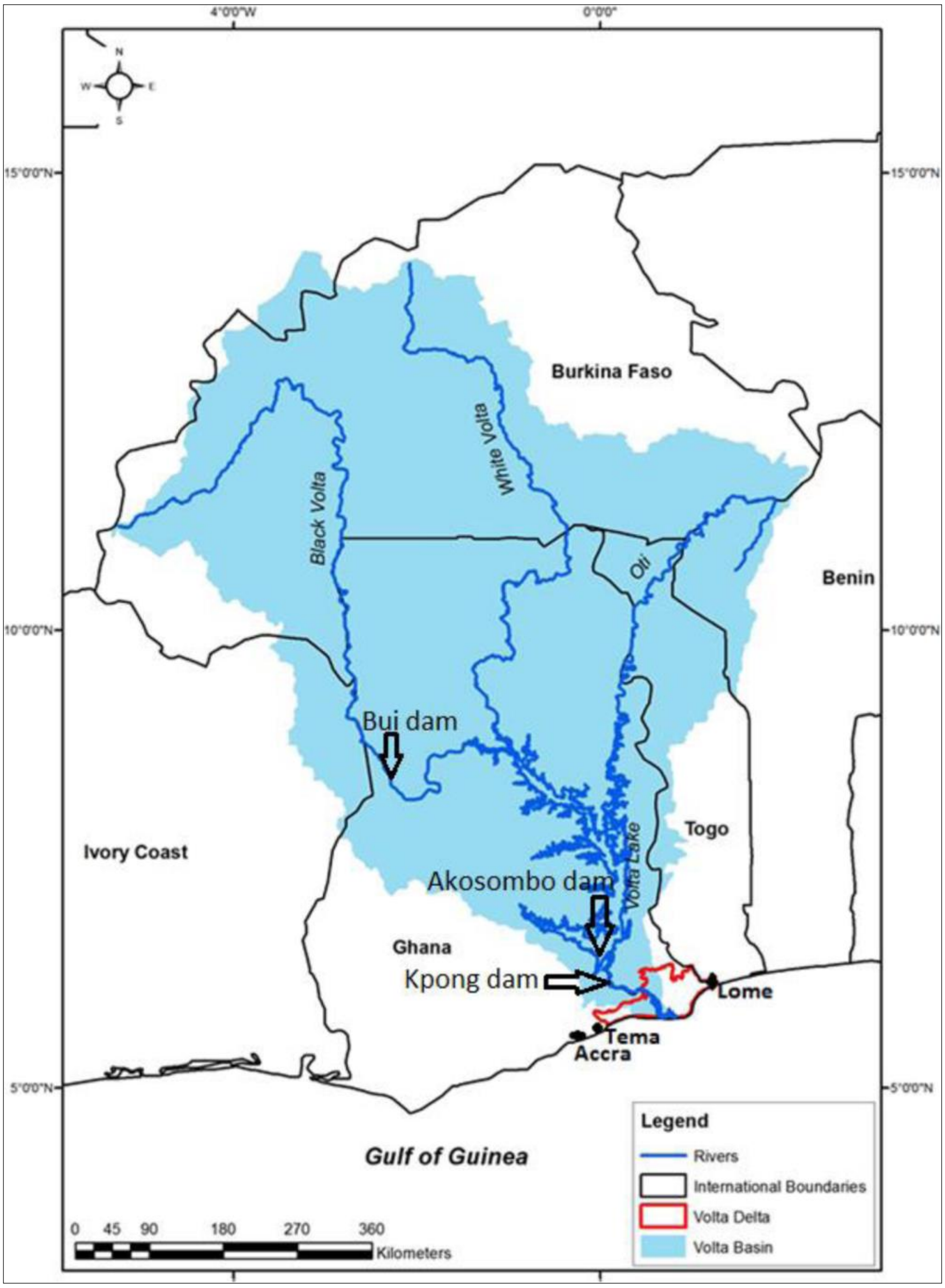


Figure 5 Map of the Volta Region showing the Volta Basin and waterways

3.2. Methods of Data Analysis

3.2.1. Primary Data Methods

Primary data was extracted from100 respondents (40 for Volta Lake routes,60 for Port Harcourt routes in Niger Delta) through structured data form and interview from boat and ferry operators on the sampled water ways of both countries. The Sample size was determined through application of Taro Yamane formula considering the population of the Niger Delta area and Volta Region respectively as 30,000,000 and 1,561,040.The Taro Yamane formula is applied thus:

For the Niger Delta basin Samples;

$$\frac{n}{1+N(e)^2} \ldots\ldots(3.1)$$

Where

N = total population size (59654)

1 = a constant

e^2 = level of significance (0.05)

Using n = $\frac{n}{1+N(e)2}$

$$n = \frac{30000000}{1 + 30000000(0.05)^2}$$

$$= \frac{30000000}{1 + 30000000(0.0025)}$$

$$= \frac{30000000}{1 + 75000}$$

$$= \frac{30000000}{75001}$$

$$= 399.99$$

$$\approx 400$$

Since the Niger Delta population outweighs that of the Volta Region in the ratio of 18:1, we therefore apply 18% of the sample size of Niger Delta routes for Port Harcourt routes because of high patronage of IWT in Rivers State considered as the maritime hub of the Niger Delta area; Hence 18% of 400 = 72. This number of survey instrument was distributed within the Port Harcourt area with a return response rate of 83% given a workable sample size of 60. The remaining sample of (400 - 72) 328 was evenly distributed among the remaining eight states of the Niger Delta; giving a sample size of 41 each.

For the Volta Lake area Samples;

$$\frac{n}{1 + N(e)^2}$$

Where: (3.1)

N = total population size (1,651,040)

1 = a constant

e^2 = level of significance (0.05)

Using n = $\frac{n}{1+N(e)2}$

$$n = \frac{1651040}{1 + 1651040(0.05)^2}$$

$$= \frac{1651040}{1 + 1651040(0.0025)}$$

$$= \frac{1651040}{1 + 4127.6}$$

$$= \frac{1651040}{4128.6}$$

$$= 39.97$$

$$\approx 40$$

Hence this number of survey instrument was distributed in the Volta Region with a response/ return rate of 100%; giving a workable sample of 40.

The responses from survey instrument which centred on safety issues on the waterways were ranked on a four point scale based on the selected routes' average accident probabilities in percent:

Very Safe {0-20}, Fairy Safe {21- 50}, Unsafe {51- 80}, and Very Unsafe {81- 100}.

3.2.2. Secondary Data Methods

The method of data analysis adopted in this paper is descriptive. Table and graph are used to establish trends in passenger and boat traffic as well as journey time on the waterways of Niger Delta area and specifically Port Harcourt in Rivers State, Nigeria; while that of Ghana centered on the Volta region and specifically on the waterways of the Volta river and lake. Averages are derived from total summation with respect to the number of observations, considering the formula for computing arithmetic mean of ungrouped data as stated in Panneerselvam (2013):

$$X^{-} = \frac{\sum_{i=1}^{n} xi}{n} \qquad \text{..................(1)}$$

where X^{-} is the arithmetic mean; $x_{i,\ the}$ ith observation; and n, the total number of observations.

Probability Analysis is designed to model the probability of response to a stimulus. Since the probability of an event must lie between 0 and 1, it is impractical to model probabilities with linear regression techniques, because the linear regression model allows the dependent variable to take values greater than 1 or less than 0. Probability is therefore a numerical value that measures the uncertainty that some events will occur based on the current operations. The probability of success or failure in a single trail is usually expressed in a ratio form (Nworuh, 2001):

P (successful outcome) = no.of successful outcome / no. of possible outcomes ………(3.1)

P (unsuccessful outcome) = no.of failure outcome / no. of possible outcomes……..(3.2)

Hence, probability is a relative measure of success or failure to the total possible outcome of the event, as denoted mathematically:

{No. of successful outcome} + {No. of failure outcome} = [No. of possible outcome] …….(3.3)

Furthemore, a loglinear regression method is applied to the transformed operational data for both countries to derive demand functions respectively for revealing price elasticities for the individual waterways. Thus the general loglinear demand function is adopted for the Port Harcourt Waterways:

$$\log_{10} TIN = \beta_o + \beta_1 \log_{10}NOP + \beta_2 \log_{10}NOB + \varepsilon \qquad \text{……… (3.4)}$$

where, TIN is the effective demand for boat transport in the selected Port Harcourt waterways route , NOP and NOB is the availability of passengers and Boat services respectively on that route.

In addition, the following structural form for the Volta Lake routes will be used:

$$\log_{10} TRF = \beta_o + \beta_1 \log_{10}NOP + \beta_2 \log_{10}NOB + \varepsilon \qquad \text{……………… (3.5)}$$

where, TRF is the effective demand for boat transport in the Volta Lake waterways route , NOP and NOB is the availability of passengers and Boat services respectively on the routes.

4. Results

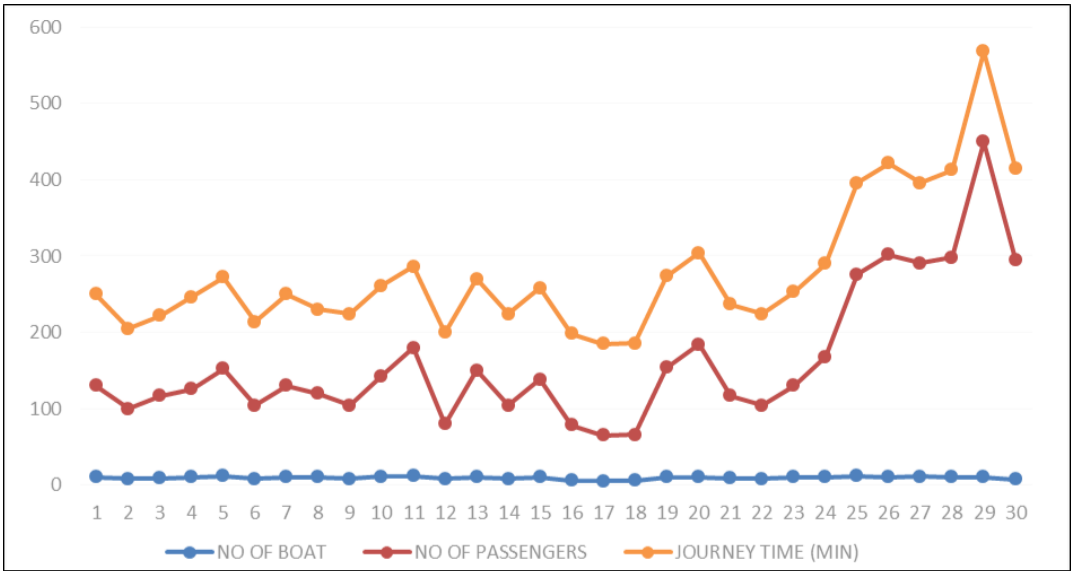
4.1. Nigeria Scenario

Table 1 IWT Daily Operational Characteristics in Rivers State (Port Town Beach Jetty- Bonny Main Jetty)

Day	No of Boat	No of Passengers	Transport Fare (@2000 NGN)	Fuel Cost (@ 1.5l = 6,500 NGN)	Other Cost (NGN)	Journey Time (Mins)
1	10	120	240,000	65,000	1,000	120
2	8	92	184,000	52,000	1,500	105
3	9	108	216,000	58,000	1,300	105
4	10	116	232,000	65,000	500	120
5	12	140	280,000	78,000	600	120
6	8	96	192,000	52,000	500	110
7	10	120	240,000	65,000	1200	120
8	10	110	220,000	65,000	1100	110
9	8	96	192,000	52,000	900	120
10	11	132	264,000	71,500	750	118
11	12	168	336,000	78,000	1000	106
12	8	72	144,000	52,000	600	120
13	10	140	280,000	65,000	0	120
14	8	96	192,000	52,000	700	120
15	10	128	256,000	65,000	0	120
16	6	72	144,000	39,000	0	120
17	5	60	120,000	32,500	500	120
18	6	60	120,000	39,000	0	120
19	10	144	288,000	65,000	1000	120
20	10	174	348,000	65,000	0	120
21	9	108	216,000	58,500	1000	120
22	8	96	192,000	52,000	850	120
23	10	120	240,000	65,000	1100	123
24	10	158	316,000	65,000	500	122
25	12	264	528,000	78,000	1500	120
26	10	292	584,000	65,000	500	120
27	11	280	560,000	71,000	2000	105
28	10	288	576,000	65,000	1500	115
29	10	440	880,000	65,000	1200	118
30	7	288	576,000	45,500	700	120
Total	278	4,578	9,156,000	1,805,500	24,000	3519

Source: Computed by Researcher from Field Survey, 2022

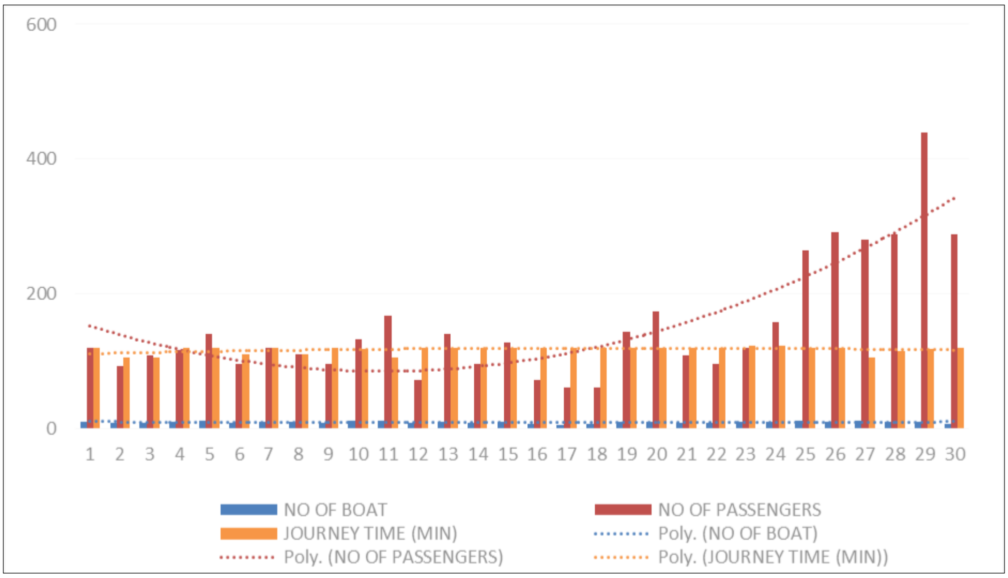
Table 1 shows the operational characteristics of the Inland waterways of Rivers state represented by the Port Town Beach Jetty- Bonny Main Jetty waterways. A total of 278 boats, 4578 passengers used the waterways within a 30- day period of survey. A total of N9, 156,000.00 was generated from fares and cost of fuel of about N1, 805,500.00 and other operational cost of N24, 000.00. Total journey time was 3519 minutes for a one- way navigation.



Source: Computed from Field Survey, 2022

Figure 6 Trend of IWT Operational Characteristics in Rivers State (Port Town Beach Jetty- Bonny Main Jetty)

Figure 6 shows the pattern or trend of all the operational characteristics for the Port Town Beach Jetty- Bonny Main Jetty route. The trend reveals points of peak and through for the sampled route. While boat traffic remained almost constant, passenger traffic and journey times shared similar trend, with a sharp fall on the last day of the month. This may imply that oil exploration activities and educational activities from the Delta College of Marine Technology spike movements based on monthly needs as salaries are paid and the fall represents relaxations from travel within month ends or perhaps national holidays.



Source: Computed from Field Survey, 2022

Figure 7 polynomial charts of IWT Operational Characteristics in Rivers State (Port Town Beach Jetty- Bonny Main Jetty)

Figure 7 is the polynomial chart showing the IWT operational performance in Rivers state. While the passenger traffic took the normal parabola, journey times took a somewhat inverse shape of a parabola, having points of intersection on the 4th and 18th day of the month. This gives a better clarification to the performance of the factors. However, boat traffic took a little curve to indicate a gradual rise towards the days of the month end, showing that more travelers embarked on journeys towards the month end within the route.

Table 1a The model summary output from the logarithm transformation of table 4.1 which gives an R^2 value of 1.00. This implies that there is about 100% model fit without a standard error estimate of 0.2%. This further explains that the data obtained from boat operations in the IWT of Port Harcourt may have produced unbiased econometric estimate

Model Summary				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	1.000a	1.000	1.000	.002

a. Predictors: (Constant), NOB, NOP

Table 1b Coefficients[a]

Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**T**	**Sig.**
		B	**Std. Error**	**Beta**		
1	(Constant)	1.474E-010	.002		.000	1.000
	NOP	2000.000	.000	1.000	446801290.382	0.000
	NOB	-1.115E-011	0.000	0.000	0.000	1.000

Dependent Variable: TIN; Key: TIN represents effective demand for boat ride or services on the waterway; NOP represent the supply or available passengers per time on the Port Harcourt waterways route; NOB represents the supply or available boats per time on the Port Harcourt waterways route

Table 1b reveals the parameter estimates of the logarithm transformation of the data on table 4.1. The t- statistic shows that the number of passengers is significantly explained in the demand for boat services and increased ridership on the Port Harcourt waterways route. The t-test value is greater than 2 as it falls within the critical region of normal distribution curve and hence we reject the null hypothesis that the demand for boat services and ridership on the Port Harcourt waterways route is not significant. The relationship is represented in the model:

$$\log_{10} TIN= 1.474^{-10} + 2000 \log_{10}NOP - 1.115^{-11}\log_{10}NOB \quad \ldots\ldots\ldots\ldots\ldots (4.1)$$

This equation can be re written as:

$$\log_{10} TIN= 1.474^{-10} + 2000 \log_{10}NOP - 1.115^{-11}\log_{10}NOB \quad \ldots\ldots\ldots\ldots\ldots \quad (4.2)$$

And for the standardized beta coefficient, we have:

$$\log_{10} TIN= 1.474^{-10} + 1 \log_{10}NOP \quad \ldots\ldots\ldots\ldots \quad (4.3)$$

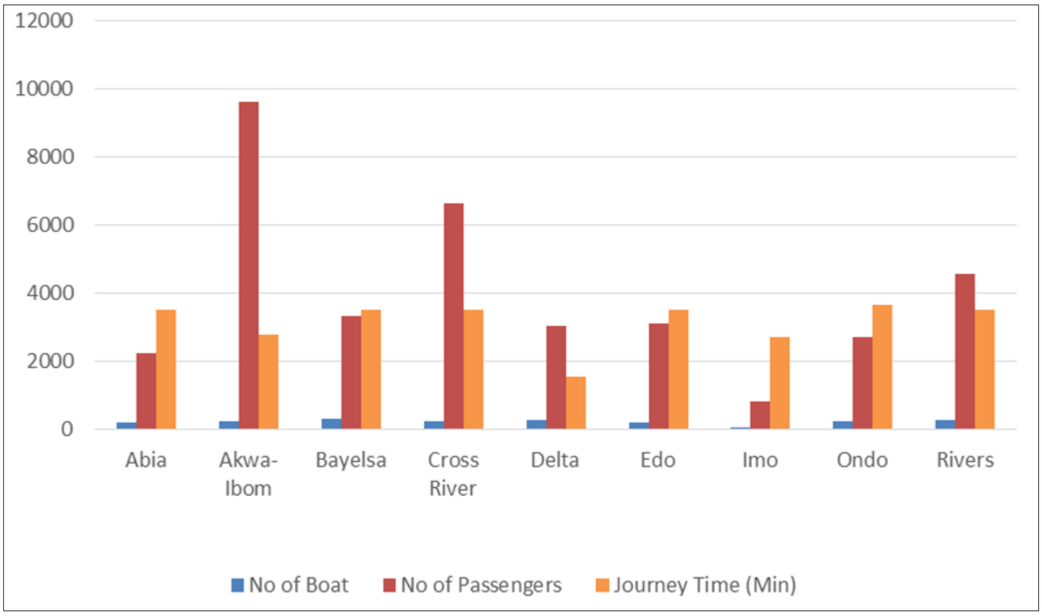
The functions represented by equations 4.1 and 4.2 reveals that availability/ supply of passengers on the Port Harcourt waterways route is price elastic. This means that the more the availability of passengers with effective demand for the each trip, the more income accrues to the boat owners. However, considering the standardized beta coefficients of the model in equation 4.3, we may infer that the demand for boat ridership is unit elasticity, given that for every unit increase in passengers, there is a corresponding 0ne unit increase in price. The function also reveals that the availability of boat services is price inelastic, which implies that the more the availability of boat the less the price charged for the service in that route per time. Also an increase in demand for boat services will lead to a correspondent increase in the fare which invariably leads to increase in the income of the boat owners. The relationship further reveals an increased ridership arising from the push in demand and supply for the services.

Table 2 IWT Monthly Operational Characteristics of the selected Niger Delta basin routes

Niger Delta Basin	No of Boat	No of Passengers	Transport Fare (@#1500-3500)	Fuel Cost (@ 1.5l = #6,500)	Other Cost (#)	Journey Time (Min)
Abia	192	2239	3358000	1245000	28000	3,529
Akwa- Ibom	234	9619	4253400	1521000	28000	2786
Bayelsa	320	3336	6499200	2002000	21400	3499
Cross River	259	6625	19875000	1813500	32000	3531
Delta	266	3047	3476717	1619700	93470	1563
Edo	194	3099	6198000	1261000	27500	3516
Imo	80	834	1417800	507000	20400	2711
Ondo	228	2704	5264000	1580000	26700	3650
Rivers	278	4578	9156000	1805500	24000	3519
Total	2,051	123,081	59,498,117	13,354,700	301,470	28,304

Source: Computed by Researcher from Field Survey, 2022

Table 2 shows the aggregate data on the IWT operational characteristics of the selected routes on the Niger Delta basin, derived from the selected route performance of each state in the Niger Delta area. Boats employed during the survey period summed up to 2051 with passenger traffic of 123081 persons who paid a sum total fare of N59, 498,117.00. However, fuel cost totaled N13, 354,700.00 and other operational cost of N301, 470.00. Total journey time was 28304 minutes. This aggregate date is a representation of the operational characteristics of the IWT in the entire Niger Delta States. This further creates a scenario of the mobility and ridership of the people of the Niger Delta, which as shown is very significant. However, it is equally evident that the natural endowment of waterways is underutilized due to negligence on the part of government leading to the lack of interest in investment by the private sector. The aggregate data further reveals the enormous potentials in these waterways which could chart a new course for the region if the waterways are dredged and maintained for increased patronage and traffic. Hence adjacent communities would benefit significantly due to ripple effects from investments and connectivity leading to their economic development and growth.



Source: Computed by Researcher from Field Survey, 2022

Figure 8 Aggregate data on IWT Operational Characteristics of the selected Niger Delta basin

Figure 8 gives a pictorial representation of the IWT operational performance over the survey period. It is evident that Akwa- Ibom state had the highest passenger traffic followed by Cross River state and Rivers State. Journey times were higher in Edo, Ondo Abia and Rivers States respectively. The reason could not be far from the huge tourism potentials of Cross River State and the emerging tourism and economic potentials of Akwa- Ibom State coupled with Oil exploration activities of Mobil -a multinational Oil and Gas company and as well as the increase IWT potentials of the states as evidenced in their governments efforts to boost the sub- sector in the respective states.

Table 3 Boat and Ferry Accident Fatalities on Waterways of Niger Delta basin from 1997 to 2022

S/N	Date	Time of Day Occur	Type of Boat/	location of Misharp	Non-fatal accident	Fatal accident	Total no of passenger	Probability
	9/16/1997	13:20hrs	Ferry boat	Portharcourt	70	130	200	0.65
	9/12/1999	12:40hrs	Wooden ferry Mr. Akasa	PH-Nembe creek	200	200	400	0.50
	9/16/1999	12:30hrs	Speed boat	Calabar river	07	05	12	0.42
	5/5/1999	16:45hrs	Speed boat	Calabar river	09	03	12	0.25
	9/16/1999	16:40hrs	Speed boat	Calabar river	06	05	11	0.46
	9/16/2000	13:00hrs	M/F Ife	Okirika	0	12	12	1
	2/1/2000	16:30hrs	Speed boat	Ocean/cross river	0	14	14	1
	7/27/200	14:25hrs	Ocean vessel	Calabar river	15	02	17	0.12
	11/4/2000	18:30hrs	Speed boat	Bonny	15	04	19	0.21
	17/5/2000	15:20hrs	Speed boat	Bonny	07	20	27	0.74
	16/6/2000	20:00hrs	Speed boat	Bonny	08	20	28	0.71
	12/08/200	20:00hrs	M/F Ife	Okirika	08	20	28	0.71
	2/08/200	16:30hrs	Speed boat	Calabar beach	12	0	12	0
	2/2/2001	16:25hrs	Ocean Vessel	Calabar River, Oron	0	17	17	1
	24/11/2002	16:25-16:30hrs	M/F Oron	NIWA waterfront Calabar	04	09	13	0.69
	12/11/2002	15:25hrs	Wooden boat	Brass & Akassa	0	40	40	1
	12/11/2002	15:25 – 16:30hrs	M/F Oron	Niwa waterfront calabar	04	09	13	0.69
	10/12/2003	17:50hrs	Ferry boat	Eastern Nigeria	0	150	150	1
	10/13/2003	15:50hrs	Wooden boat	Abonnema waterways	15	04	19	0.44
	02/08/2005	16:00hrs	Canoe boat	Lower niger	28	27	55	0.49
	7/17/2005	10:30hrs	Wooden boat	Onitsha water	0	40	40	1
	5/18/2005	12:45hrs	Wooden boat	Umuanankwo, Onitsha	115	35	150	0.23
	4/16/2005	14:50hrs	Ferry boat	Port Harcourt	0	13	13	0.1
	8/3/2005	18:20hrs	Wooden boat	Okitipapa, ondo state	25	10	35	0.29

	7/7/2005	18:50hrs	Wooden boat	Ayeforo, waterways, ondo state	155	45	200	0.23
	2/12/2005	16:25hrs	Wooden boat	Igbokoda, ondo state	130	20	150	0.13
	9/17/2005	17:40hrs	Wooden boat	Okirika river state	09	04	13	0.31
	1/11/2006	13:25hrs	Wooden boat	Ogboye, warri	02	12	14	0.86
	7/31/2006	14:50hrs	Wooden boat	Ogbe-ijoh waterside Delta state	08	04	12	0.33
	8/10/2008	6:00hrs	Speed boat	Epellema – Opobo River state	0	06	06	1
	12/3/2008	9:20hrs	Fibre boat with outboard Engine	Igbokada, Ondo state	0	20	20	1
	5/13/2008	7:50hrs	Wooden boat	Angalabric, Bayelsa state	02	03	05	0.60
	12/15/2011	11:30hrs	Wooden boat	Ngbuodohia waterway rumudumeni PH	10	30	40	0.75
	12/15/2011	9:00hrs	Wooden speed boat	Ngbuodoham waterway rumudumeni, PH	04	38	42	0.91
	4/24/2012	8:40hrs	Speed boat	Ogriagbene, bomadi Delta state	0	05	05	1
	7/10/2014	17:30hrs	Wooden boat	Ikumoro side, Cross river	05	06	11	0.55
	7/3/2014	10:20hrs	Wooden boat	Oziza afipko	04	04	08	0.50
	4/15/2017	5:30hrs	Wooden boat	Oguta – Orashi	06	12	18	0.67
	4/6/2017	18:33hrs	Wooden boat	Eko plaform, bonny Rivers state	06	07	13	0.54
	8/26/2017	6:25hrs	Wooden boat	Ogwu-ikpele,ogbam Anambra state	11	04	15	0.27
	13/02/2018	8:35hrs	Wooden boat	Warri - Burutu	05	06	11	0.55
	09/05/2018	12:14hrs	Wooden boat	Warri – Odimodi	10	04	14	0.29
	06/07/2018	10:45hrs	Wooden boat	Agge – Ogulagha	14	02	16	0.13
	04/03/2019	18:24hrs	Speed boat	Warri – Agge	09	04	13	0.31
	26/07/2019	18:42hrs	Wooden boat	Warri – Okerenkoko	06	08	14	0.57
	30/9/2019	10:11hrs	Wooden boat	Warri-Okokodiagbene	14	10	24	0.42

Source: Probabilities computed by Researcher from National Inland Waterways Authority (NIWA) Accident Data Base

Table 3 shows the Statistics of Boat and Ferry Accidents and Time of Occurrence on Water Ways in Niger Delta. It also shows their respective probabilities otherwise percentage fatalities from 1997 to 2022. We could deduce from the table that the highest fatalities recorded by the National Inland Waterways Authority (NIWA) as 100% occurrence was at Okirika in Rivers state, Ocean mouth in Cross River state, Calabar River at Oron in Akwa Ibom state, Anambra River in Eastern Nigeria, Brass/ Akassa river in Bayelsa state, River Niger at Onitsha in Anambra state and Delta State, Port Harcourt river in Rivers state, Epellema – Opobo in Rivers state, Igbokada in Ondo state, and Ogriagbene, Bomadi in Delta state. Lower fatality rates of 21% were recorded at Bonny River and 13% at Agge – Ogulagha; while zero fatalities were recorded on the incident at Calabar beach only.

Table 4 Safety Imperatives on the Niger Delta basin routes

Niger Delta Basin	**No of Boats Surveyed**	**No of Operators trained**	**Presence of Navy/ Joint Task Force(JTF)**	**Range of Probability**	**Average**	**Safety Assessment Based on Probability ranking**
Abia	11	187	Yes	0.49- 0.50- 1.00	0.995	Very unsafe
Akwa-Ibom	14	802	Yes	0.27- 1.00	0.635	Unsafe
Bayelsa	19	278	Yes	0- 0.60	0.60	Unsafe
Cross River	15	552	Yes	0-0.12- 0.25-0.42- 0.46- 0.69- 1.00	0.49	Fairy safe
Delta	120	254	Yes	0.23- 0.33- 0.42- 0.49- 0.55- 0.57-0.86- 1.00	0.556	Unsafe
Edo	11	258	Yes	0.13- 0.29- 0.55	0.323	Fairy safe
Imo	5	70	Yes	0.49- 0.67- 1.00	0.72	Unsafe
Ondo	109	225	Yes	0.13- 0.23- 0.29- 1.00	0.413	Fairy safe
Rivers	16	382	Yes	0.10- 0.21- 0.31- 0.44- 0.50- 0.54- 0.65- 0.71- 0.74- 0.75- 0.91- 1.00	0.572	Unsafe
Total	320	3008				
Average	36	334			0.589	Unsafe

Source: Computed by Researcher from Field Survey, 2022

Table 4.4 shows the safety assessment of the waterways of the Niger Delta basin. It is revealed that on the average, Abia state waterways have the highest probability of accident occurrence of 0.995 and thus very unsafe to travel. The safety implication is that for every travel, there is a certainty of fatal accident occurrence on the waterways. This is followed by the waterways of Imo, Akwa- Ibom, Bayelsa, Rivers and Delta states which were assessed to be unsafe with corresponding average probabilities of 0.72, 0.64, 0.60, 0.57 and 0.56. Others were assessed to be fairly safe and they are the waterways of Edo, Ondo and Cross Rver states with average probabilities of 0.32, 0.41 and 0.49 respectively. Conclusively, the entire waterways of the Niger delta basin were rated to be unsafe having an average probability value of 0.59 which implies that for every journey undertaken on the waterways, there is a 59% likelihood of fatal accident occurrence.

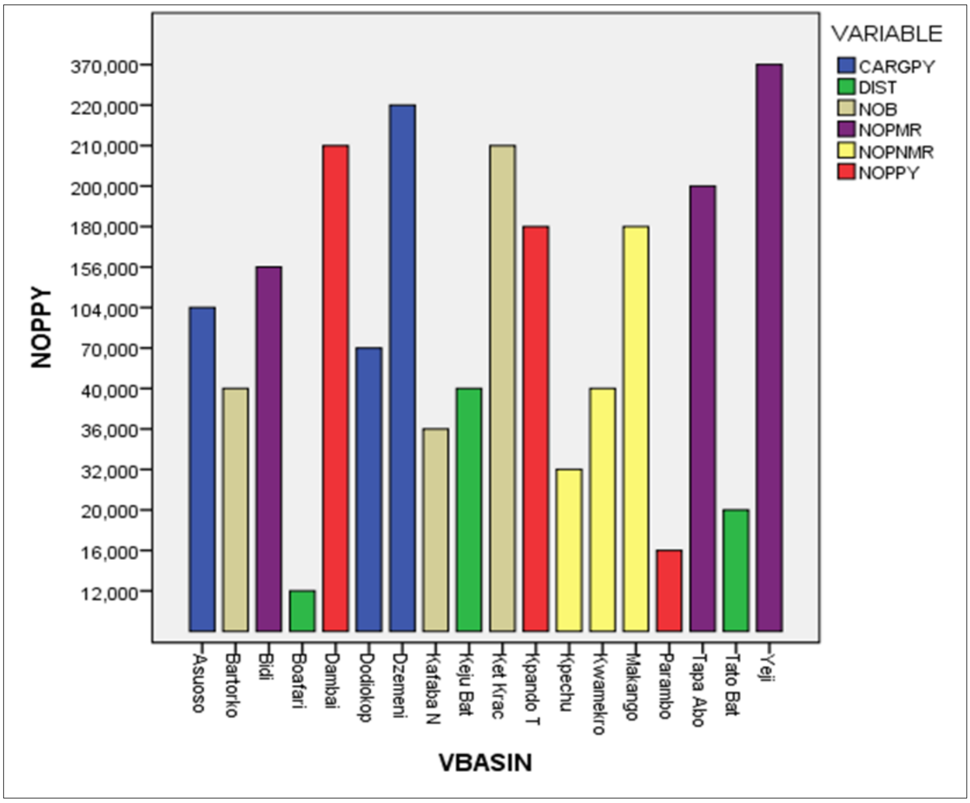
4.2. Ghana Scenario

Table 5 Monthly Operational Characteristics of IWT on the Volta Basin

Riverside Area	Distance k(Km)	Number of Boats	Number of Passengers on market days	Number of Passengers on Non-market days	Passengers per year	Cargo per year	Transport Fare on Market Day per passenger (Ghc)
Keju Bater	79	4	320	480	40000	538	1600
Kafaba No.2	93	3	240	480	36000	447	1200
Yeji	120	80	6400	1000	370000	7640	64000
Makango	120	30	2400	1200	180000	3165	24000
Parambo	128	4	320	0	16000	364	1280
Asuoso	170	20	1600	480	104000	1994	8000
Boafari	183	3	240	0	12000	273	960
Ket Krachi	213	40	3200	1000	210000	4002	32000
Bidi	213	24	1920	1200	156000	2619	19200
Kpechu	18	2	160	480	32000	356	1600
Dambai	37	25	2000	1000	210000	4002	8000
Dodiokope	37	-	0	1400	70000	510	0
Tato Bator	219	5	400	0	20000	455	1600
Bartorkope	220	5	400	480	40000	629	2000
Tapa Abotoase	267	35	2800	1200	200000	3620	11200
Kwamekrom	284	4	320	480	40000	538	1600
Kpando Takor	308	30	2400	1200	180000	3165	28800
Dzemeni	354	45	3600	800	220000	4384	43200
Total	3063	359	28720	12880	2136000	38701	250240
Percentage			69.0%	31.0%			
Average	170	20	1596	716	118667	2150	

Source: Computed by Researcher from Roche (2014)

Table 5 shows the operational characteristics of inland waterway transport on the Volta River. The traffic trend reveals that more passenger and cargo traffic were prominent on market days being a major origin to destination attraction. Terminals at Yeji, Dzemeni, Tapa Abotoase and Ket Krachi recorded higer number of passenger and boat traffic during the market days while Dodiokope and Kpechu recorded the least on market days with 0 and 160 passengers respectively. An average distance of 170 kilometers was covered with 20 boats conveyed 1596 passengers on market days and 716 passengers on non market days via the Volta Lake within the period. Therefore, passenger traffic takes a percentage share of 69 and 31 on market days and non market days respectively.



Key: CARGPY- Cargo per year; DIST: Distance; NOB: Number of boat; NOPMR: Number of passengers on market days; NOPNMR: Number of passenger on non market days; NOPPY: Number of passengers per year

Figure 9 Bar graph representing the traffic trend on the Volta Lake

The boat, cargo, and passenger traffic as estimate by Roche (2014) is represented in figure 10 which further supports the interpretations of table 4.5 that revealed Yeji as the highest generator of traffic on market days.

Table 5a Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.966a	0.933	0.929	0.17196

a. Predictors: (Constant), Log10NOP

Table 4.5a shows the model summary output from the logarithm transformation of table 4.5 which gives an R^2 value of 0.966. This implies that there is a 96.6% model fit to the observed data with a sampling error of 3.4%. This percentage is unexplained variation in the demand for boat services in the surveyed route. This further explains that the data obtained from boat operations in the Volta Lake routes may have produced unbiased econometric estimates.

Table 5b ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.181	1	6.181	209.033	0.000b
	Residual	.444	15	0.030		
	Total	6.625	16			

a. Dependent Variable: Log10TRF; b. Predictors: (Constant), Log10NOP

Table 5b reveals the analysis of variance and estimates obtained from the transformation of table 4.5. The F ratio here shows the effect of the independent variables (number of passengers) on the dependent variable (demand for boat services and ridership) on the Volta Lake routes. The table further reveals an F ratio value of 209.033 is greater than 1 and therefore may imply the absence of any sampling error. From the level of significance, it may be inferred that out of

100 cases the mean difference of 16 tends to be genuine which further supports rejection of the null hypothesis that the demand for boat services and ridership on the Volta lake routes is not significant.

Table 5c Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	0.236	0.248		0.948	0.358
	Log10NOP	1.191	0.082	0.966	14.458	0.000

a.Dependent Variable: Log10TRF; Key: TRF represents effective demand for boat ride or services on the waterway.; NOP represent the supply or available passengers per time on the Port Harcourt waterways route

Table 5c reveals the log linear parameter estimates obtained from the transformation of table 4.5. The t- statistic shows that the number of passengers is significantly explained in the demand for boat services and increased ridership on the Volta Lake routes. Analysis further indicate that the t-test value of 14.458 is greater than 2 as it falls within the critical region of normal distribution curve and hence we reject the null hypothesis that the demand for boat services and ridership on the Volta Lake routes is not significant. The relationship is represented in the model:

$$\log_{10} TRF = 0.236 + 0.966 \log_{10} NOP \quad \ldots\ldots\ldots\ldots\ldots (4.4)$$

This equation can be re written in approximation as:

$$\log_{10} TRF = 0.24 + 0.97 \log_{10} NOP \quad \ldots\ldots\ldots\ldots\ldots \quad (4.5)$$

It could also be represented as:

$$\ln TRF = 0.24 + 0.97 \ln NOP \quad \ldots\ldots\ldots\ldots\ldots \quad (4.6)$$

This function reveals that availability/ supply of passengers on the Volta Lake routes is price elastic. This means that the more the availability of passengers with effective demand for the each trip, the more income accrues to the boat owners. More so, an increase in demand for boat services will lead to a correspondent increase in the fare which invariably leads to increase in the income of the boat owners. The model equally reveals an increased ridership occasioned by the push in demand and supply for boat services.

Table 6 Estimated Annual Passenger and Cargo Traffic on Volta Lake

	VLTC	Informal Service	Total (Estimated @2.5% growth rate)	
			2012	**2022**
Passengers	647000	2400000	2727000	3408750
Cars	57000		57000	71250
Cargo (Tonnes)				
Cement	43000		43000	53750
Diesel oil& Kerosene	88000		88000	110000
Fish, Yams,Cassava etc.	6000	112000	118000	147500
General Cargo	6000		6000	7500

Source: Computed by Researcher from Roche (2014)

Table 6 shows estimated passenger and cargo traffic considering the Roche (2014), an estimate was made for 2022 values @ the rate of 2.5 %.

Table 7 Boat Accident Fatalities on Inland Waterways Transport on the Volta Lake (1990- 2012)

Date of Accident	Type of Boat	Market Centre	Fatality	Probability
April 1990	Wooden (Open)	Yeji	46	0.12
April 1995	Wooden (Open)	Kpando Torkor	100	0.26
March 1997	Wooden (Open)	Kpando Torkor	6	0.016
June 1999	Wooden (Open)	Abotoase	70	0.18
Sept. 1999	Wooden (Open)	Dzemeni	5	0.013
Jan. 2001	Wooden (Open)	Yeji	7	0.018
April 2001	Wooden (Open)	Yeji	6	0.016
April 2002	Wooden (Open)	Abotoase	50	0.13
April 2006	Wooden (Open)	Abotoase	10	0.026
August 2006	Wooden (Open)	Yeji	27	0.07
August 2009	Wooden (Open)	Ket Krachi	6	0.016
Oct. 2009	Wooden (Open)	North Dayi	18	0.047
Sept. 2011	Wooden (Open)	Abotaose	21	0.054
Dec. 2011	Wooden (Open)	Abotaose	4	0.0104
Feb. 2012	Wooden (Open)	Ket Krachi	10	0.026
Total			386	1.00

Source: Ghana Maritime Authority (2012)

Table 7 shows the fatal accident statistics on the Volta Lake from 1990 to 2012 which reveals the type of boat involved in the accident. The table further reveals the probability estimates for each accident occurrence and the corresponding routes or place in which the fatal accident occurred. The values show that Kpando Torkor followed by Abotoase and Yeji had higher likelihood of fatal accident occurrence with 26%, 18% and 12% respectively while Dzemeni recorded the lowest fatal accident of 1.3%.

Table 8 Safety Imperatives on the Volta Lake

Boat Station	No. of Boats Surveyed	No. of Personnel Trained	Presence of Naval Task Force	Range of Probability	Average	Safety Assessment Based on Probabilities
Kpando- Torkor	10	86	Yes	0.016-0.26	0.21	Fairly Safe
Dzemeni	10	166	Yes	0-0.013	0.013	Very Safe
Dambai / North Dayi	6	45	Yes	0-0.047	0.047	Very Safe
Ketekrachi	6	80	Yes	0.016-0.026	0.021	Very Safe
Yeji	52	151	Yes	0.016-0.018-0.07-0.12	0.056	Very Safe
Tapa Abotoasi	23	164	Yes	0.0104-0.026- 0.054- 0.13- 0.18	0.08	Very Safe
Total	107	692				
Average	18	115			0.0711	Very Safe

Source: Compiled from Ghana Maritime Authority (2012).

Table 8 shows the safety assessment of the waterways which was revealed by the average probabilities of fatal accident occurrence on the routes. All the routes were assessed to be Very safe with lower likelihood of fatal accident occurrence but Kpando Torkor that was assessed to be Fairy safe with average likelihood of fatal accident occurrence of 21%.

5. Discussion of findings

Inland waterways transport is perceived to be the most economical and environmentally friendly means of transporting person and cargo. The economies of scale are equally achieved by the transport of larger volume of cargo through a long distance at a cheaper cost as compared to other modes of transport. In line with the routine activity theory, every activity- in this case transport of persons and cargo via the inland waterways is associated with risk which this study has made sufficient attempt to analyse in order to give empirical answers to the research questions raised in the course of this study to which we are set to validate in the following manner:

- What is the trend of traffic on the IWT routes on the Niger delta basin, Nigeria and Volta basin, Ghana?
- Could the probability of accident occurrence on the Niger delta basin, Nigeria and Volta basin, Ghana be estimated?
- What are the minimum safety implications for operators and users of the waterways of both countries?
- Is the demand for boat services and ridership on the Port Harcourt waterways route and Volta lake routes significant?

First, the trends of traffic on the selected inland waterways need not to be overemphasized. The study recorded significant trends on the waterways for the survey period. Figures 7, 8 and 9 give a pictorial representation of the IWT operational performance over the survey period in the Niger Delta basin, Nigeria. It is evident that the waterways of Akwa- Ibom state had the highest passenger traffic followed by Cross River state and Rivers State. The times of travel were higher in Edo, Ondo Abia and Rivers States respectively. This was revealed by the utilization of bar graphs and trend lines as well as polynomial trend graph. On the other hand, the Volta Lake recorded significant trends, especially on market days leading to high mobility in the area. The traffic trend reveals that more passenger and cargo traffic were prominent on market days being a major origin to destination attraction. Terminals at Yeji, Dzemeni, Tapa Abotoase and Ket Krachi recorded higer number of passenger and boat traffic during the market days while Dodiokope and Kpechu recorded the least on market days. Annual passenger traffic was extrapolated from the monthly totals for Niger Delta (123081* 12 = 1476972) and Volta Lake (28720*12 = 344640) which gives a ratio of 4:1. The outcomes corroborate with the work of Rahman (2017) that analyzed passenger vessel accidents in Bangladesh, which utilized graphical approach to illustrate the trend of accident occurrence and passenger traffic on the waterways.

Second, accidents on the inland waterways like similar events are probability-based predictions. Hence the entire waterways of the Niger delta basin were rated to be unsafe having an average probability value of 0.59 which implies that for every journey undertaken on the waterways, there is a 59% likelihood of fatal accident occurrence.

The Volta Lake values show that Kpando Torkor followed by Abotoase and Yeji had higher likelihood of fatal accident occurrence with 26%, 18% and 12% respectively while Dzemeni recorded the lowest fatal accident of 1.3%. Comparatively, it was revealed that the average probability of fatal accident on the routes of Niger Delta basin to that of the Volta Lake is in the ratio of 8:1 (0.589:0.0711). This further buttresses the fact that more accidents occurred on the sampled waterways of the Niger Delta basin than that of the Volta Lake. The findings relate to the works of Boadu et al (2021); and Nwankwo and Ukoji (2015), that analysed inland waterways transportation in Ghana concentrating on Volta Lake Transport; and General trends and risk factors associated with boat accidents in Nigeria respectively.

Third, safety issues need not be over emphasised when analysing mobility and access in developing countries. Our analysis considered the average probabilities of fatal accident occurrence on the inland waterway routes in the Niger delta and Volta Lake to reveal the safety standards on the routes. In the IWT operations of the Niger Delta basin, it is revealed that on the average, the waterways have the highest probability of accident occurrence of 0.995 and thus very unsafe to travel. The safety implication is that for every travel, there is a certainty of fatal accident occurrence on the waterways.The Ghana scenario reveals that all the routes were assessed to be Very safe with lower likelihood of fatal accident occurrence but for Kpando Torkor that was assessed to be Fairy safe with average likelihood of fatal accident occurrence of 21%. In comparison, our analysis show that the routes of the Volta Lake were safer than those of the Niger Delta basin, primarily due to the fact that there were more policy implementation on inland waterways regulations in Ghana than Nigeria. Our results are in tandem with that of Sumabe (2013), who studied Livelihood impact of boating accidents on the Volta Lake, considering some selected communities in the Volta region.

Fourth, the t- statistic from table 4.1b shows that the value is greater than 2 and hence falls within the critical region of normal distribution, implying the rejection of the null hypothesis that the demand for boat services and ridership on the Port Harcourt waterways is not significant. Equations 4.1, 4.2 and 4.3 reveal that availability/ supply of passengers on the Port Harcourt waterways route is price elastic. This means that the more the availability of passengers with effective demand for the each trip, the more income accrues to the boat owners. However, considering the standardized beta coefficients of the model, we may infer that the demand for boat ridership is unit elasticity, given that for every unit increase in passengers, there is a corresponding one unit increase in price. The function also reveals that the availability of boat services is price inelastic, which implies that the more the availability of boat the less the price charged for the service in that route per time. Also an increase in demand for boat services will lead to a correspondent increase in the fare which invariably leads to increase in the income of the boat owners. The relationship further reveals an increased ridership arising from the push in demand and supply for the services.

On the other hand, the t- statistic on table 4.5b for the Volta Lake model shows a high degree of significance as the value is greater than 2 and also falls within the critical region, leading to the rejection of the null hypothesis that the demand for boat services and ridership on the Volta Lake routes is not significant. The function represented in equations 4.4, 4.5 and 4.6 reveals that availability/ supply of passengers on the Volta Lake routes is price elastic. This means that the more the availability of passengers with effective demand for the each trip, the more income accrues to the boat owners. More so, an increase in demand for boat services will lead to a correspondent increase in the fare which invariably leads to increase in the income of the boat owners. The models equally reveal an increased ridership occasioned by the push in demand and supply for boat services. The results are in tandem with some of the outcomes of Kwame (2008) that studied frequent boat accident on the Volta Lake of Ghana, using Tapa Abotoase in the Jasikan District of the Volta Region as case study.

6. Conclusion

It is concluded that the inland waterways of Niger Delta, Nigeria and the Volta Lake, Ghana witnessed significant trend in passenger and cargo traffic within the study period. More so, the IWT operations in the Niger Delta had more likelihood of fatal accident occurrence over the operations on the Volta Lake. Finally, safety assessment of the waterways of both countries shows that operations on the Volta Lake were safer than those of Niger Delta basin. Results from respondents show that more users and operators on the Volta Lake were more in conformity to the available safety regulations as compared to the users and operators on the routes of the Niger Delta basin who seldom conform to safety standards. We therefore, recommend a more robust regulation of the waterways in Ghana by the Volta Lake Transport Company (VTLC) and in Nigeria by the National Inland Waterways Authority (NIWA) to create room for adequate enforcement of laws to create more secured access and thus boost mobility within the Sub-Saharan Africa. Having noted that the waterways of the Volta Lake were safer than that of the Niger Delta, NIWA should invest optimally and partner with the private sector to enforce and regulate the waterways operations so as to increase safety and mobility of users of the waterways in Nigeria, since it has been established that the demand for boat services and ridership in both countries waterways are price elastic.

Compliance with ethical standards

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References

[1] Boadu, S., Otoo, E., Boateng, A., and Koomson, D.A. (2020). Inland Waterway Transportation in Ghana: A case study of Volta Lake Transport. International Journal of Transportation Science and Technology, 10 (2021) 20-33.

[2] Dike, D.N., Akponye, M.C., and Nze, I.C. (2018). Assessment of motorists' compliance to seat belt regulation in Nigeria. International Journal of Engineering Technologies and Management Research, 5(3), 166- 180.

[3] Haule, R. and Olagunju, G.A. (2014). Coffin boats and state's responsibility for safety of navigation in internal and coastal waters: an examination of safety of life in Nigeria and Tanzania maritime law and practice. Rulala University College, St. Augustine University of Tanzania.

[4] National Inland Waterways Authority, NIWA (2006). Harnessing the Potentials of Inland Waterways Transport in Nigeria. NWA bulletin. Lokoja.

[5] https://niwa.gov.ng/nigerian-waterways/

[6] Kwame, A.P. (2008). Frequent Boat Accidents on the Volta Lake of Ghana. A case study of Tapa Abotoase in the Jasikan District of the Volta Region. MSc. Thesis: Department of Geography, Norwegian University of Science and Technology (NTNU), Trondheim, Norway.

[7] Nwankwo, U.V. and Ukoji, U.V. (2015). Boat Accidents in Nigeria: General Trends and Risk Factors. Journal of Advanced Research in Humanities and Social Sciences, 2(3&4), 1- 9.

[8] Nworuh, G.E. (2010). Fundamentals of Applied Quantitative Techniques for Management Decisions. Ambix Printers, Owerri.

[9] Pinto, M.P. (2010). IWT-Cost Effect and Eco-friendly Option. APH, New Delhi.

[10] Panneerselvam, R. (2013). Research Methodology. PHI Learning Private Limited, Delhi- 110092.

[11] Rahman, S. (2017).An Analysis of Passenger Vessel Accidents in Bangladesh. Procedia Engineering, 194,284- 290.

[12] Roche (2014). Consultancy Services for Preparation of a Medium-Term Master Plan For Transportation On The Volta Lake and its Surrounding Region (RFP No.: MOT/IDA/TSP/QCBS/S/2) Draft - Master Plan, Republic of Ghana.

[13] Suleiman M. (2016). Pragmatic analysis of safety and security in Tanzania maritime logistics: evidence from Zanzibar passenger ferry boat Tanzania. International Journal of Economics, Commerce and Management, iv (7), 651-663.

[14] Sumabe, N.I. (2013). Livelihood impact of boating accidents on Volta Lake: a Case of Abotoase, Kpedzi, Tsevi, and Agyatakope Communities in Ghana. MSc. Thesis: Department of Sociology and Human Geography, University of Oslo.

[15] United Nation Economic and Social Commisson to Asia and Pacific, UNESCAP (2010). Economic and Social Survey of Asia and the Pacific 2010. https://www.unescap.org/resources/economic-and-social-survey-asia-and-pacific-2010