

Naeem Shahzad *Editor*

Water and Environment for Sustainability

Case Studies from Developing Countries

 Springer

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Preface

This book is being published as an outcome of the 2nd International Conference on Water, Energy, and Environment for Sustainability (IC-WEES) 2022. With the growing global concerns about environmental degradation, depletion of freshwater resources, and climate change-induced disasters, the conference was focused on climate change, water, environment, and disaster risk reduction and their inter-relationship with each other. Major theme revolved around Climate, Environment and Water Nexus. Owing to the papers presented in the Conference the book title was further focused toward water and environment for sustainability.

A multidisciplinary understanding of water resources and environmental concerns is provided by water and environmental management to ensure sustainable development making the understanding of water resources and environmental concerns imperative. Despite considerable advancements in the science of water and environment and their close nexus over the past century to ensure sustainability, there are still a number of problems that the scientific community has to address.

Water bodies offer a variety of beneficial services to humanity owing to their environmental, cultural, and commercial significance as ecosystems. Owing to lack of check and balances and implementation issues, environmental degradation at a rapid pace further augmented by climate change, water quantity, water quality, ecosystem health, and ecosystem services are all faced with different challenges (such as global warming, changes in land use and cover, population explosion, nutrient and organic matter loading, water conservation projects, and other anthropogenic factors). This underscores the need of multidisciplinary research, accurate monitoring, and modeling of various water bodies as it is crucial for improving the management of water resources and ensuring sustainable water usage.

This book *Water and Environment for Sustainability* brings together thirteen papers on the theme of 'water resource and environmental management.' The purpose of this book is to present some of the latest research carried out in the area of water and environmental management to ensure sustainability in a dynamic situation with uncertainty.

Most Pakistani regions (including the northern glacial regions) are getting hotter with the spatial trends showing an increase of more than 0.05 °C/year in temperature

and depicting an increase of 5 °C/century, as described by Amjad (2022). In this paper, the author highlights that the indication of northern glacial regions and southwestern Baluchistan getting hotter and drier is quite an alarming situation for both these regions in the contexts of frequent and extreme flooding due to snowmelt in glacial regions and frequent and intense droughts in southwestern Baluchistan. The issue needs to be tackled immediately by relevant stakeholders, organizations, and departments.

Based on the water parameters obtained at several hydrological stations along the Brahmaputra River, India, the study's overall objective was to evaluate the evolution of water quality at spatial and temporal scales. According to the pollution sources listed, anthropogenic factors such as population growth, excessive consumption, overuse, chemical explosions, and subsurface mining are found to be the main causes of pollution in the catchment area Pranjali (2022). As per the findings, it is crucial to make sure that the hydrological forces trying to control runoff are understood and incorporated into the analysis in these days of increasing assessment complexity and reliance on computer data manipulation, rather than relying on more complex sets of parameters and relationships to explain runoff.

A comprehensive overview of the recent scientific research in the field of reservoir sedimentation estimation and management has been presented in the study carried out by Bilal (2022) which is very significant for flood management in downstream areas. The results of this study can serve as suggestions for the execution of operations to flush silt from reservoirs. Additionally, it is anticipated that the observations will be helpful for assessing future dam safety and danger as well as for ensuring reservoir operating sustainability through thorough sediment management leading to flood mitigation and management in the downstream areas.

The editors wish to thank all the authors of this book for contributing the high quality papers. We also like to express our gratitude to the referees for their quick and thorough reviews of the papers. Finally, we hope that the readers will find this book to be very helpful and will share our joy.

We hope this book will help us manage water resources efficiently through environmental preservation to achieve a healthy surroundings and a sustainable future for our future generations.

Finally, we would also like to thank the excellent editorial team of *Water and Environment for Sustainability* for their efforts and professional commitment.

Islamabad, Pakistan

Naeem Shahzad

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Socio-Economic Potentials of Nigerian Inland Waterways System for Sustainable Use



Solomon Usman Jatau, Araoye Olarinkoye Ajiboye,
and Babatope Gabriel Oni

1 Introduction

Transportation is vital to any economy as it is inseparably linked to other sectors of the economy. It is the vehicle for inter- and intra-country trade and the means of movement include air, pipeline, rail, ocean or Inland Waterways. Inland Waterways are any navigable body of water either natural or manmade such as rivers, canals or routes used for travel by water from the coast or shoreline to the interiors of a country. Inland water transportation (IWT) is, therefore, the utilisation of Inland Waterways for the movement of passengers and freight between inland ports, wharves or quays. Like any other mode or class of transportation, it facilitates the social and economic interaction of citizens and serves as a major catalyst for national development.

According to Lawal and Oluwatoyin (2011), countries with vast Inland Waterways have utilised it as an important factor in the development of their regions through oil exploration, the opening of new settlements and commerce and trade. Water transport being one of the cheapest modes of transport has the largest carrying capacity and is most suitable for carrying bulky goods over long distances. The development of navigable Inland Waterways has equally assisted nations to achieve several developmental goals and offers the most economical, energy efficient and environmentally friendly means of transporting passengers and freight. In most cases, it requires much less capital investment and maintenance than other transport modes. Despite evident lesser environmental impacts when compared to other competing modes, they have been rather neglected in many countries including Nigeria.

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Nigeria has the second longest length of Inland Waterways in Africa after Egypt. It has 8,600 km of Inland Waterways centred on River Niger and River Benue and their tributaries (Ndikom, 2008). The coastal waterways extend from Lagos State through Warri in Delta State to Calabar in Cross River State. The coastal ways from Lagos through the River Niger link up the Eastern part of the Country. The IWT operation is advantageous in terms of the costs of moving heavy traffic by road transport with an average share of about 1.6% of Nigeria's GDP. A single 15-barge load, for instance, is comparable to around 225 rail cars or 870 tractor-trailers. The transportation of tonnes of agricultural produce and imported items would gain most from this.

The Federal Government of Nigeria (FGN) established the National Inland Waterways Authority (NIWA) in 1997 as part of measures to promote Inland Waterway transport in Nigeria. According to Usman and Oyesiku (2015), the main responsibility of NIWA is to improve and develop Inland Waterways for navigation and provide an alternative mode of transportation of economic goods and persons among other things. NIWA has been able to partially dredge the lower Niger at Onitsha and has built inland ports at Lokoja, Baro, Oguta and Onitsha while the contract for the dredging of River Benue is under consideration. Most recently, the FGN is currently making efforts to dredge the Inland Waterway leading to the Warri Port as part of efforts to decongest the Apapa port which is the major challenge to the Lagos State traffic gridlock. Despite these achievements, IWT in Nigeria is underutilised and underdeveloped. As a result of the poor utilisation of water resources in Nigeria especially that of River Niger, the Federal Government of Nigeria (FGN) loses a lot of revenue which could accrue to boost the economic activities of the country.

2 An Analysis of Studies on Inland Water Transportation in Nigeria

The late Professor R. K. Udo carried out groundbreaking research on inland water transport in Nigeria in the 1970s. Water is one of the many natural resources that Nigeria possesses, according to Udo (1970), and the nation has the opportunity to provide the majority of West Africa's landlocked nations, including Burkina Faso, Chad, Mali and Niger, for greater economic gains. Iloje (1984) also noted that approximately 8000 kms of Nigeria's internal rivers are navigable and that the country is highly endowed with surface water resources.

Many other researchers, including Badejo (1997), have published on numerous IWT-related topics in Nigeria, including their history, benefits, management challenges and potentials. For instance, Badejo (1997) and Adams (1998) determined that the country's namesake river, the Niger, and its major tributary, the Benue, are the principal rivers whose channels provide the longest waterways into the country's hinterland. The fact that both rivers originate outside of the nation yet meet at the confluence of Lokoja and later flow into the Gulf of Guinea via a vast network of

distributaries and creeks that make up the Niger Delta emphasises the significance of these rivers for IWT.

Adams (1999) found that Nigeria now has navigable canals with a capacity of around 10,000 kms and a long coastline of roughly 852 kms. On the basis of this, he observed that the nation had a considerable potential for moving cargo and people by water from the coast to the inland. Anyam (2003) lamented the fact that potential investors have not yet taken advantage of the enormous business opportunities that IWT offers, which may enable it to compete with both road and air travel. Adams (2004) supported this by lamenting that the FGN had not yet given IWT the attention it deserved, notably in terms of finance and the building of infrastructure. The lack of channelisation and dredging of navigable rivers, the poor construction and rehabilitation of river ports, the scarcity of infrastructure for water transportation and safety and security issues along the navigable waterways were some of the barriers identified to a sustainable IWT.

In contrast to Bangladesh, where water transport accounts for 32% of the transport sector (Rahman, 1994), the Philippines, where it accounts for 20% of the sector (Fellinda, 2006), Sierra Leone, where it accounts for 3% of the sector (Kimba, 2008), India, where it accounts for 0.15% of the sector (Raphuram, 2004) and Nigeria, where it accounts for only 0.08%, Ezenwaji (2010) focused on the underutilisation of Inland Waterways in Nigeria (NIWA). Like earlier scholars Aderamo and Mogaji (2010), he found that a number of natural elements have a negative impact on Nigeria's use of inland rivers as transportation routes.

Ndikom (2013) found that IWT gave investors opportunities such as facility management, jetty operations and boat building. He noted that issues of security concerns discouraged potential and foreign investors. River channel dredging and maintenance, a lack of private sector participation in the water transport industry, the construction and rehabilitation of river ports, the purchase of passenger ferries, security boats, the construction of channel buoys and other projects were other problems limiting IWT's viability. Conflicts between federal and state agencies overseeing IWT in Nigeria were more concerning, and they have stymied the growth of that industry.

The above review underpins that the state of IWT in Nigeria is still largely under-developed despite efforts by stakeholders. The operation, its major contributions, socio-cultural constraints limiting its operations and policy trusts and targets, etc. remain largely unknown. However, none of them examined the challenges militating against the utilisation of the River Niger nor proffered strategies to mitigate the challenges. It is this gap in the literature that this study seeks to fill by appraising the utilisation of the River Niger Inland Waterways for enhanced economic and national development in Nigeria.

3 Issues on Nigerian Inland Waterways System

The Inland Waterways have been a major source of transport conveying both passenger and freight even before the independence of Nigeria. In particular, IWT has accounted for well over 38% of produce transported in the country. Commodity transportation across the riverine and coastal state of the federation has been increasing from the early 1960s to date. By implication, IWT has made a significant contribution to the economic and national development of the country.

However, the demand for transport is growing in Nigeria, which may require the development of the nation's Inland Waterways for navigation. In particular, environmental changes and pressure from other human activities have resulted in little priority accorded to Inland Waterways and thus reduce the viability of the river for IWT. In addition, previous administration has seen the need to improve the viability of the Inland Waterways system, especially the Rivers Niger and Benue. This is due to her prospect of promoting commodity flow along the riverine areas and national development.

According to Table 1, across the years studied, the highest quantity of 7.91 tonnes of agricultural produce was transported through Inland Waterways in 2021, closely followed by 7.48 tonnes in 2020 and in 2019, 7.39 tonnes was transported. Similarly, 32.8 tonnes of cassava was the highest produce transported across 10 years, followed by yam with 25.2 tonnes moved and 8.1 tonnes of palm kernels.

Given Nigeria's highly limited and congested transport environment, one major shortcoming of IWT development in Nigeria is the non-sustainability of IWT services by different levels of governments and the lack of private sector participation in Nigeria which has resulted in the ugly state of IWT irrespective of its glaring importance in the development of the economy. For instance, traders in Aba and Onitsha, which both have robust industries producing shoes, apparel, textiles, plastics, pharmaceuticals, petrochemicals, polyethylene, cosmetics and aluminium products, are big importers and exporters. On a daily basis, the Onitsha market receives more than five million visitors and conducts over twelve million unique transactions. Over \$3 billion in trade is transacted annually at the Onitsha market, with unbanked transactions accounting for about 40% of this total. This translates to Onitsha being one of Nigeria's most economically significant cities and having one of the highest GDPs. Recently the Onitsha inland port is now operational, especially with the dredging of River Niger which makes it navigable in a bid to convey commodities to Onitsha thus decongesting the Lagos seaport for economic and national development of the country.

Table 2 further shows the high demand for the movement of containerised cargoes across the Nigerian Inland Waterways system, with the Lokoja area leading, followed by Onitsha and Makurdi areas. This is very important for informing business decisions by investors. Also, it shows that no significant relationship exists between Warri, Onitsha and Makurdi in terms of TEUs handled, while Lokoja was found 100% different from the three stations. Also, no significant relationship exists between

Table 1 Statistics of generated agricultural produce transported through Inland Waterways 2012–2021

Products	2012 (tonnes)	2013 (tonnes)	2014 (tonnes)	2015 (tonnes)	2016 (tonnes)	2017 (tonnes)	2018 (tonnes)	2019 (tonnes)	2020 (tonnes)	2021 (tonnes)	Mean	Ranking
Beans	1.8	1.8	1.9	2.1	2.1	2.2	2.2	2.2	2.2	2.3	2.1	11
Cassava	31.4	31.4	32.1	32.7	32.7	32	32.1	32.7	32.9	38.2	32.8	1
Groundnuts	1.6	2.3	2.5	2.5	2.9	2.9	2.7	2.7	2.8	2.9	2.6	10
Maize	6.9	5.7	5.3	5.1	5.5	4.1	4.6	4.7	4.8	4.8	5.2	7
Millet	5.6	5.7	5.9	6	6	6.1	5.5	6.1	6.3	6.3	6.0	6
Palm kernel	7.3	7.3	7.8	7.8	8	8.2	8.5	8.5	8.6	8.7	8.1	5
Plantain	1.6	1.7	1.7	1.8	1.9	2	2	2.1	2.1	2.1	1.9	13
Rice	2.9	3.1	3.3	3.3	3.3	3.3	2.8	3.2	3.4	3.5	3.2	8
Sorghum	7	7.1	7.3	7.5	7.5	7.7	7.1	7.7	8	8	7.5	4
Starchy roots	1.2	1.2	1.8	3.8	3.8	3.9	3.9	3.9	4	4	3.2	8
Sugar cane	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.7	14
Sweet potato	1.2	1.5	1.5	1.6	2.5	2.5	2.5	2.5	2.5	2.5	2.1	11
Wheat	–	–	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	15
Yam	22.8	23.2	24	24.8	25.9	26.2	26.2	26.3	26.3	26.6	25.2	2
Mean	7.07	7.12	6.85	7.13	7.35	7.28	7.21	7.39	7.48	7.91		
Ranking	9	8	10	7	4	5	6	3	2	1		

Source NIWA (2022)

Table 2 Data on the Potential of moving containerised cargo from Port Harcourt and Onne Ports by Inland Waterways, 2012–2021

Years	Warri			Onitsha			Lokoja			Makurdi		
	TEUs	Tons	% TEUs	TEUs	Tons	% TEUs	TEUs	Tons	% TEUs	TEUs	Tons	% TEUs
2012	1,600	36,000	1.3	9,800	102,000	2.7	36,500	456,000	2.1	2,400	40,500	1.8
2013	2,800	40,600	2.2	15,500	221,500	4.2	55,100	787,300	3.1	3,200	46,100	2.4
2014	3,330	48,000	2.6	24,000	302,500	6.5	77,600	966,000	4.4	44,500	79,000	33.5
2015	5,400	74,200	4.3	28,300	390,400	7.7	123,900	1,708,700	7.0	6,800	93,500	5.1
2016	60,500	88,000	48.1	31,000	464,500	8.4	166,000	2,001,500	9.4	7,200	122,000	5.4
2017	7,500	100,500	6.0	38,800	520,100	10.5	183,800	2,467,100	10.4	9,800	131,600	7.4
2018	8,800	102,800	7.0	42,000	599,500	11.4	211,000	288,000	11.9	11,200	176,000	8.4
2019	10,100	132,900	8.0	51,600	678,800	14.0	264,300	3,477,200	14.9	13,700	180,100	10.3
2020	12,500	156,400	9.9	60,500	702,300	16.4	288,000	421,500	16.2	15,600	196,600	11.7
2021	13,200	171,800	10.5	67,000	868,500	18.2	368,000	4,772,800	20.7	18,500	240,000	13.9
Mean	12,573	95,120		36,850	485,010		177,420	1,734,610		13,290	130,540	
Ranking	4th			2nd			1st			3rd		

Source NIWA (2022)

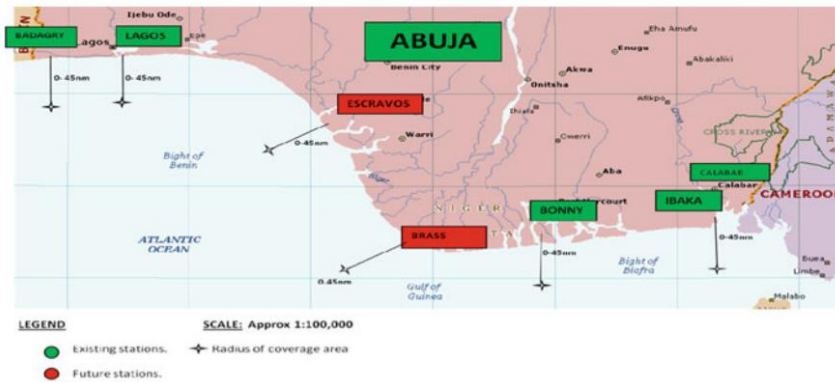


Fig. 1 Map of the study area

Warri, Onitsha and Makurdi in terms of capacity, while Lokoja was found 100% different from the three stations.

4 Research Scope

The scope of this study is delimited by time, space and content boundaries. In terms of time, the study covered the period from 2012 to 2021. In terms of space, the study focused on locations around the Niger and Benue rivers which include States like Kogi, Delta, Anambra and Abia. This is because these states utilise River Niger for IWT. In terms of content, the study is limited to the viability of the River Niger for IWT. This content was chosen because it links one of the most viable commercial cities along the Rivers Niger and Benue (Fig. 1).

5 IWT Development in Nigeria

There have been various attempts to build a practical IWT in Nigeria, as per the information obtained during the course of this study from pertinent literature and interviews. From the colonial to postcolonial era, the nation's marine infrastructure generally was developed in four phases, resulting in a total of 8 seaports with a projected combined transport capacity of 35 to 60 million tonnes of cargo yearly.

Some major events after Nigeria gained her independence in 1960 such as the breakout of the civil war in 1966 reduced the relevance of IWT and thus affected revenue and employment opportunities. The oil boom of the 1970s further reduced the use of IWT in Nigeria as dependence on oil revenue resulted in the massive development of road infrastructure with a drastic reduction in reliance on agriculture

and its produce. This period and afterward witnessed a slump in the export of agricultural products that were carried by inland river vessels. Badejo (2009) outlined the following reasons as responsible for the further decline of IWT in Nigeria: policy reversals, political and legislative aspects, economic dynamism and market size, global conspiracies and gang-ups, the relevance of human capacity and technological advancements, financial accessibility, infrastructure and equipment failure, fierce competition from international shipping operators, a general lack of coordination and integration, multilateral versus unilateral competition and an overreliance on road transportation are all factors.

This trend continued throughout the 1980s and 1990s until the FGN set up NIWA through Decree No. 13 of 1997 in a bid to resuscitate IWT. The NIWA was granted the sole responsibility to manage, regulate and control all Inland Waterways in the country as well as ensure the development of infrastructural facilities for IWT as contained in the extract of NIWA Act 2004. Since its establishment, the IWT did not improve as most of the bottlenecks experienced before its establishment continued. Contemporary challenges such as insufficient funding, inadequate skilled force and worsening climate change coupled with human activities affected the nature of the rivers, as well as growing insecurity problems. Despite the challenges, NIWA achieved some strides through the construction of some facilities such as the inland river port at Akpanya near Lokoja, Kogi State and the construction of a jetty at Yenegoa II, Bayelsa State. A committee was set up in June 2019 and chaired by the Vice President, Prof Yemi Osinbajo, with a task to ease the gridlock experienced in Lagos as a result of trucks and trailers transporting containers from Apapa port to the other parts of the country. One of the decisions taken by the committee was to commence the construction of a port in Warri (Fig. 2).



Fig. 2 Bonny River (not navigable). *Source* Authors' field survey, 2021

6 Efforts Made by Federal Government in Sustaining IWT in Nigeria

1. Establishment of NIWA

After the country gained independence in 1960, IWT began to deteriorate. The Inland Waterways Department (IWD) kept a respectable amount of authority over the Inland Waterways network of the country, but took few management initiatives. The Federal Government of Nigeria established the NIWA through Decree No. 13 of 1997 to follow the disbanded IWD, with a clear mandate to manage Nigeria's extensive Inland Waterway resources. This was done in an effort to revive IWT in Nigeria and make it efficient, competitive and result-oriented. The NIWA Act of 2004 contained the vision statement: to make Nigeria the leader in the development and administration of inland water transportation in Africa, which is still far from being achieved. Its mission was to develop infrastructure facilities for an effective inter-modal transportation system in accordance with international best practises that is safe, seamless and reasonably priced. It also provided regulatory, economic and operational leadership in the country's Inland Waterways system.

NIWA was also saddled with the responsibility to provide the regulatory services range from giving permits and licences for sand dredging, pipeline construction, slot dredging, and approving designs and building of inland river crafts to inspecting and surveying inland watercraft and shipyard operators. Construction of inland river ports and jetties, capital and maintenance dredging, engineering design of river ports, hydrological and hydrographical surveys, river chart creation and cartography, river mapping, aerial survey and underwater survey were some of the additional services offered. In the inland water and its right of way, NIWA is also permitted to conduct an environmental impact assessment of dredging and other navigational activities.

2. Dredging of the River Niger for IWT

Since the days of colonial rule, plans have been made to dredge the lower Niger (Badejo, 2010). It has proven to be too difficult and frustrating to execute on numerous occasions, leading succeeding governments to cancel numerous contracts even after paying the contractors billions of Naira. The first proposal for the dredging of the River Niger was submitted by the then IWD and later the Petroleum Trust Fund (PTF) in 1996 but handed over the Lower Niger Dredging to the NIWA in November 2000. After 9 years of inactivity, the dredging of River Niger was flagged off on 10 September 2009 at a total cost of N38 billion. The project crystallised the then administration's determination to develop the nation's IWT sector. The 572-km-long dredging, according to Arc. Ahmed Yar'Adua, Managing Director of the Nigerian Inland Waterways Authority (NIWA), encompassed Baro in Niger State to Bifurcation in Bayelsa State as,

the dredged river is expected to provide all-year round navigation, employment opportunities, and improved economic activities as well as flood control. Other benefits he says, include improved carrying capacity, cheaper and safer transport system, reduced axle load on roads, boom fishing and preserve the environment.

After the failure of the dredging of the Ikpoba River in Edo State and the Calabar port in Cross River State, he explained that it was the first significant dredging operation ever to take place in the nation. The dredged Lower River Niger covered 152 settlements in the states of Delta, Bayelsa, Rivers and Edo, as well as Imo, Anambra, Kogi and Niger.

Due to the nature of the River Niger which flows through the alluvial bed and like most alluvial river generates sediment that required continuous dredging. Coupled with the paucity of funds, and lack of commitment of successive administrations, the capital dredging could not be maintained. Dogara (2017) while describing how the Olusegun Obasanjo government created the national transport master plan, stated:

I was part of the development of the national transportation master plan, I don't know what has happened to that, how I wish we implemented that plan, by now we would have gone very far because the national transportation master plan vision is a seamless integration of a multi-modal transportation into one hub, and I think at that time Baro in Niger State had been identified as the center for the hub, it is serviced by a railway that is connected to Minna and all you need to do is to construct a road and airport that will ensure connectivity and you will have access to the Atlantic Ocean through the River Niger, so everything was supposed to be put together in one place.

Table 3 shows that across all the stations studied, the highest water level of 7.3 m was recorded in the month of September, followed by 6.8 m in October and 6.0 m observed in August. The lowest water level of 2.5 m was observed in February and April, followed by 2.6 m recorded in January, March and May, respectively (Fig. 3).

All other pairs of waterways in Nigeria apart from the below combinations have approximately the same water levels. These are Baro to Onitsha, Lau and Makurdi; Itu to Onitsha, Lau, Makurdi and Obubra. Furthermore, Shintaku and Onitsha and Makurdi; Onitsha and Yola, Lau and Makurdi, as well as Makurdi and Obubra have approximately the same water levels (Fig. 4).

7 Construction of Infrastructures and Facilities

The FGN with a vision to develop the nation's IW embarked on the construction of ports, jetties and ramps/slipways across waterways in the country. Ports and jetties are important facilities that enhance the functions of the ships. Along the River Niger, the Onitsha port was constructed, commissioned and operational. The channelisation of Oguta Lake in Imo State and Excravos River in Delta State is in progress. Despite the huge amount expended on some of the projects, they are still uncompleted. As a result, there are worries regarding the appalling state of infrastructure services and facilities to enable NIWA to work at its best for improved national development in Nigeria (Fig. 5).

Table 3 Records of monthly average water levels in selected land Waterway Stations, 2021

Month	Baro (m)	Itu (m)	Shintaku (m)	Onitsha (m)	Yola (m)	Lau (m)	Makurdi (m)	Obubra (m)	Mean	Ranking
January	2.7	1.3	1.9	3.3	2.4	3.5	4	2	2.6	10th
February	2.7	1.1	1.7	3.3	2.2	3.6	3.7	2	2.5	12th
March	2.6	1.1	1.8	3.2	2.2	3.9	3.6	2.1	2.6	9th
April	2.3	1.3	1.7	3	2.2	3.7	3.7	2.3	2.5	11th
May	2	1.5	1.8	2.9	2.2	3.5	4.1	3.1	2.6	8th
June	2	2.1	2.6	4.1	2.3	3.6	5.1	4.4	3.3	7th
July	2.9	3.5	3.8	5.6	3.2	5	6.3	5.5	4.5	4th
August	4.4	4.2	5.7	7.9	4.6	6.9	7.6	6.5	6.0	3rd
September	6	5	7.6	10	5.2	7.8	9.3	7.4	7.3	1st
October	5.5	4.8	7.4	10.1	4.4	6.3	9	6.6	6.8	2nd
November	3.4	2.9	4.1	6.4	2.8	4.5	6	4.3	4.3	5th
December	2.7	1.7	2.2	3.9	2.4	3.6	4.6	2.8	3.0	6th
Mean	3.3	2.5	3.5	5.3	3.0	4.7	5.6	4.1		
Ranking	6th	8th	5th	2nd	7th	3rd	1st	4th		

Source NIWA (2022)



Fig. 3 River Niger at Onitsha. *Source* Authors' field survey, 2021



Fig. 4 Completed Onitsha Inland Port. *Source* Authors' field survey, 2021

8 Impact of Inland Water Transportation in Nigeria

8.1 Axle Load Reduction on Roads

The nation's road transportation system has come dangerously close to collapse, especially in Lagos, as a result of our continued reliance on trucks and trailers to deliver cargo from the Lagos Ports. When IWT is improved, Nigeria's highways will see some stability. Axle and destructive loads on the roads would be lowered because to the water's larger carrying capacity, which would lower the expense of road repair



Fig. 5 Baro Inland Port. *Source* Authors' field survey, 2021

nationwide. Additionally, the ferry services in Lagos from Mile 2 to Apapa to CMS reduce traffic gridlock on road as well as excessive loading of the road. Furthermore, an effective IWT system would greatly assist in reducing the carnage and pressure on the nation's roads.

8.2 Revenue Generation

Yakubu (2007) posited that revenue generated from IWT amounting to over N1.890 billion between 1998 and 2006, could be more if the IW sector was fully utilised. He asserted that more revenue could be generated through the improvement in dredging and development of IW river ports and the building of dockyards which in turn could attract more investors. According to the NIWA mission, the Nigerian Ports Authority (NPA) could generate money by charging registration fees for ships, customs duties, port fees and tariffs for the use of its facilities by ships that berth at sea. Revenue generation could be accomplished in accordance with the NIWA mandate through fees for ship registration, customs duties, port charges and tariffs realised by the Nigerian Ports Authority (NPA) for the use of its facilities by the vessels that berth at sea. In 2014 alone, NIWA had an Internally Generated Revenue (IGR) of N2,239,339,686 only.

Despite the low level of the development status of IWT in Nigeria, NIWA experienced a steady increase in IGR over the years which is an indication that more funds could be generated if IWT in Nigeria is well-developed and effectively utilised especially the River Niger, thus improving its contribution to the Gross Domestic Product (GDP) of Nigeria.

8.3 Promotion of Tourism

Tourism attraction equally contributes to revenue generation in Nigeria. The beaches in Lagos, the tourist beach in Port Harcourt and the Ibeano beach in Akwa Ibom attracted about 8.5 million people within and outside Nigeria (NTC, 2016). According to Fidelis (2017), Inland Waterways by 2020 would attract over 12 million tourists and possibly generate about \$12.5 billion annually which could be channelled to developmental projects. Thus, efforts in line with improving tourism centres around the inland ports, especially at Rivers Niger and Benue would generate revenue for enhanced economic and national development.

8.4 Creation of Employment and Job Opportunities

Employment opportunities in IWT range from ship/boat building, and its repairs requiring expertise such as captains; engineers, stewards, etc. Igbokwe (2013) concluded that maintaining the industry in both the private and public sectors would provide about 10% of job opportunities in Nigeria. For instance, indirect employment in the riverine and coastal communities like Lagos and Bayelsa states have a workforce of about 9,000 and 5,500 personnel, respectively. These include boat operators, jetty workers and repairers, among others.

Table 4 and Fig. 4 indicate that the demand for barges and their carriage capacity is increasing from 2012 to 2021, which shows an increasing need for more investment for the provision of more vessels into the Nigerian Inland Waterways' transportation. Vessels that can carry dry bulk cargo are more required, followed by container carrying vessels and barges that carry liquid products.

Thousands of indirect jobs are generated by the various activities in the IW sector which would improve the living standard of the citizenry. This underscores the importance of an all-year-round navigable River Niger for viable IWT from Lagos, Warri, Onitsha and Baro in Niger State which would greatly increase job opportunities.

8.5 Industrial Growth and Development

IWT is significant as it promotes industrial growth and development. Onitsha being a popular market city and positioned along the River Niger's bank witnesses several tonnes of goods transported daily from Lagos by road. This has led to much pressure on the road as earlier highlighted. According to Etuk (2015), to cut down on transportation expenses, business owners choose to construct factories, industries and warehouses close to river ports. Presently, Nigeria's industrial base is very poor making it difficult for IWT to thrive like her counterparts in European countries. A viable IWT would improve the haulage of bulk cargo and raw materials for the

Table 4 Data on the number and capacity of barges required for Inland Waterways Transportation 2012–2021

Year	Container barges			Dry and break bulk barges			Refined oil product barges		
	No	Fleet capacity (tonnes)	% Capacity	No	Fleet capacity (tonnes)	% No	No	Fleet capacity (tonnes)	% Capacity
2012	12	6	26.1	26	18	56.5	8	15	17.4
2013	20	10	20.0	70	50	70.0	10	20	10.0
2014	21	12	23.9	56	61	63.6	11	22	12.5
2015	25	18	29.8	44	70	52.4	15	25	17.9
2016	30	22	31.3	48	72	50.0	18	26	18.8
2017	34	37	31.5	52	79	48.1	22	28	20.4
2018	40	40	33.3	55	80	45.8	25	30	20.8
2019	41	56	35.3	50	85	43.1	25	30	21.6
2020	45	75	42.1	36	95	33.6	26	32	24.3
2021	50	100	45.5	30	100	27.3	30	40	27.3
Mean	31.8	37.6		46.7	71		19.0	26.8	
Ranking	2nd			1st			3rd		

Source NIWA (2022)

Ajaokuta steel plant and the Itakpe iron ore processing plant from the seaports. This would replace the road that could transport 496 million tonnes of raw materials and approximately 2 million tonnes of finished goods.

8.6 Sustainable Development

Water transportation with a far less energy requirement remains the most environmentally friendly mode of transportation thus promoting sustainable transportation. Environmental degradation, lower pollution and depletion of natural resources are least experienced with water transportation. IWT is also cheap requiring lower operating costs as there is no wear and tear on the waterways demanding perennial high maintenance costs. Additionally, bulky and heavier goods are transported over longer distances at the cheapest comparative economic cost.

8.7 Sustainability of Nigerian Inland Waterways System

For thousands of enterprises throughout Nigeria, the Inland Waterways system may provide affordable, dependable and sustainable transportation. By removing major physical, technological or bureaucratic bottlenecks, Inland Waterway transport helps to divert traffic from roads. It will become even more effective by providing freight forwarders with a high-quality service that other land modes find it difficult to compete with in terms of price and dependability. Additionally, due to their efficiency and cleanliness, the usage of Inland Waterways will help the environment. The shipping sector and freight forwarders have the capacity and opportunities to take advantage of and win new business for Inland Waterway transportation.

However, Inland Waterways' substantial capacity alone is insufficient to boost their market share and modal split in comparison to road and rail transportation. The IWT industry must better integrate into seamless door-to-door transport chains, including effective transshipment operations and terminal hauls, in order to capture and maintain market share in growing markets and market niches, such as those for biomass, containers, bulky and heavy goods or waste and recycling materials. In addition, the IWT industry must comply with the increasingly sophisticated needs and requirements of supply chain and distribution managers. It is crucial to strengthen the connection between IWT and maritime shipping in order to accomplish the twin goals of expanding into new markets and improving intermodal transport and logistics chains. Promoting and regulating the usage of river-sea vessels—inland ships operating international runs between river and sea ports of different nations and coastal runs between river and sea ports of the same country—would be one way to accomplish this goal and relieve the congestion in maritime traffic. Getting rid of the wait times for loading/unloading commodities from inland vessels at the seaports is another significant problem in this sector.

To increase the appeal of the profession and deepen staff training, adequate transport and logistics policies are required. To guarantee complete traceability of commodities for their clients, IWT operators regularly modernise and expand their boats, create new transshipment strategies, establish regular container transport lines and increase their usage of information technologies.

Carbon emissions and global warming have emerged as crucial challenges for the future of IWT. First, whenever practicable, a modal shift away from road transportation can help to reduce the carbon emissions of the transportation industry. However, in order to keep this advantage, efforts must be made to guarantee that IWT advancements keep pace with the ongoing decrease in CO₂/t-km (CO₂ intensity) in road transport. There is a chance that significant fluctuations and decreased water depths will have an effect on IWT. There are possibilities where rivers will experience very little impact from climate change. All potential outcomes need to be taken into account when analysing the potential effects on inland navigation. IWT must simultaneously endeavour to retain and grow its competitive edge in environmental friendliness through research and innovation, taking into account, for example, the usage of alternative fuels.

Although no significant changes to the institutional framework of inland navigation in Nigeria are anticipated, governments and other stakeholders must have ongoing, inclusive consultation and coordination mechanisms in order to coordinate their policies and regulations and further harmonise rules and legal frameworks for an effective and long-lasting IWT.

Recent studies of the IWT labour market, for example, revealed that more workers will be needed in all areas covered by inland navigation due to the current technical developments, including investments in larger vessels and vessels with new capacity as well as the likely long-term increase in transport volume. In addition, a sizeable portion of the labour force is anticipated to quit the industry over the next ten to twenty years due to the age composition of the current IWT workforce.

9 Conclusion

This research work appraised Nigeria's inland water transportation system as it affects national development (ND). The research discovered that there are numerous challenges affecting the use of the river for IWT. Prominent among the challenges is the issue of the dredging of the River Niger which an in-depth study revealed that a lack of political will and commitment had deterred a capital dredging of the lower River Niger. An overview of the inland water transportation system from the colonial era to the post-independence era also revealed that IWT was the most viable mode of transportation during the colonial era and produced the revenue that was used to construct the rail and road infrastructures which affected the use of IWT. But the discovery of oil and subsequently the oil boom of the 1970s further affected the utilisation of IWT due to the shift from dependence on agriculture to oil as a mainstay.

The study identified some contributions of IWT to national and sustainable development to include, revenue generation, creation of employment and promotion of industrial growth and development. Others are the provision of safe and cheaper means of transportation, reduction of pressure on the roads as well as promotion of tourism. However, the challenges linked to the use of the River Niger for IWT include an ineffective legal framework, lack of political will and commitment on the part of FGN, inadequate skilled manpower and the impact of climate change. Others include the nature of the River Niger, the poor state of infrastructures, insufficient funding and insecurity among others.

Despite the challenges, there are significant plans to improve IWT using the River Niger by the FGN such as the construction of the Warri Port. This is however in a bid to reduce the traffic gridlock experienced in Lagos due to the congestion at the Apapa port. The study also brought to the fore the yearnings of the traders union in Onitsha and the environment in dire need of the construction of an inland port in Onitsha as well as the dredging of the River Niger to make it navigable all year round.

The execution of capital and periodic dredging of the River Niger and the inclusion of the private sector/foreign investors in infrastructural development will mitigate numerous challenges. While the periodic dredging of the River Niger will make the River navigable all year round. The inclusion of the private sector/foreign investors in infrastructural development will mitigate the challenges of the poor state of infrastructures through rehabilitation of the infrastructures and completion of abandoned projects. This could be achieved by the FGN in partnership with the PPP in repairing dockyards, water channels, barges, jetties, water clearing machines and boats by the end of 2022. Additionally, the establishment of an Inland Water Intervention Fund will mitigate the challenge of insufficient funding which seeks to increase funding to complement budgetary allocation.

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