

Leveraging Digital Technology on Inland Waterways in Selected Terminals of Lokoja, Gbajibo and Gbajibo-Mundi in North-Central Geo-Political Zone of Nigeria

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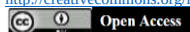
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ABSTRACT

Inland Waterways Transport (IWT) in the North Central Geo-Political Zone of Nigeria has huge potential for movement and trade. The potential is however, limited by its analog systems of operation coupled with poor and inadequate infrastructure. Against this backdrop, this study evaluates the feasibility of leveraging digital technology in three selected terminals namely; Lokoja, Gbajibo and Gbajibo-Mundi in Kogi, Niger and Kwara States respectively in the North Central Geo-Political Zone. Survey design was adopted for the study and data were collected from 384 respondents including 65 Government officials, 106 boat operators and 213 passengers/members of the community. The questionnaire for the survey was drawn on a 4-point Likert Scale plus key informant interviews. Descriptive statistics, mean scores and Chi-square/Anova in SPSS version 26 was used for data entry for the purpose of data analysis. According to the findings, 96.9% of Government officials disagreed that infrastructure is adequate across the three terminals. 87.7% and 82.1% among officials and operators respectively agreed that the terminals are underutilized. 87.7% of officials, 88.7% of operators and 90% of passengers identified analog system as a major limitation. Digital transition was overwhelmingly supported by 92.3% of officials, 88.75 of operators and 92% of passengers while 90.8% key in to automation. The findings revealed that 42.3% have disregard for safety codes and 33.8% pointed to inadequacy of boats as major challenges mitigating against operational efficiency in the study area. 46% of respondents prioritized the introduction of technology and their improvement's expectation. Chi-square results indicates that analog systems affect effectiveness $P < .05$ significantly while Anova showed no difference in support for digitalization across groups $P = .122$. Conclusively, stakeholders are ready for digitalization despite infrastructural shortfalls. The study recommends upgrade of terminals capacity building through staff training, and digital enforcement of safety codes in the selected terminals.

Introduction

Nigeria inland waterways navigation contributes less than 2% to the national GDP and remains underdeveloped and fragmented despite being endowed with more than 3,000km stretch (NIWA, 2021). Globally, inland waterway transport remains a cheaper and safer alternative to road transport. According to World Bank, 2021, digitalization through automated terminals, vessel tracking and e-ticketing has improved efficiency. In Nigeria, with a dominant road transport, IWT still operates manually and informally. The Niger-Benue confluence makes the study area strategic.

Although, a major gap could be the challenge to properly incorporate autonomous vessels into existing waterways, in terms of the compatibility and limitation of autonomous systems, it remains a better option in the current realities. The collaboration between government, academia and the industry known as the Tripple-Helix Model remains a key to the adoption and implementation of automation. This is consistent with the study of Villaruz (2021) who worked on the transformative potential of automation in European Inland Waterway Transport.

However, due to infrastructural deficit, analog modus-operandi and poor supervision, the Lokoja, Gbajibo and Gbajibo-Mundi operate below expected capacity. For these reasons, there is the preponderance of frequent accidents, overloading and loss of substantial revenue. Ahmed *et al* (2024) on autonomous inland waterways vessels emphasizes the need for regulating frameworks, liability and insurance guidelines. As a result of strong advocacy for digital operation and management, leveraging technology in the selected terminals can significantly improve safety, revenue base, utilization and functionality. It is in the light of this that this study examines the perception of the key stakeholders on the adoption and potential digital technology in Lokoja, Gbajibo and Gbajibo-Mundi terminals. Specifically, the study assesses of the adequacy of infrastructure, the effect of analog systems and support for transition to digital technology.

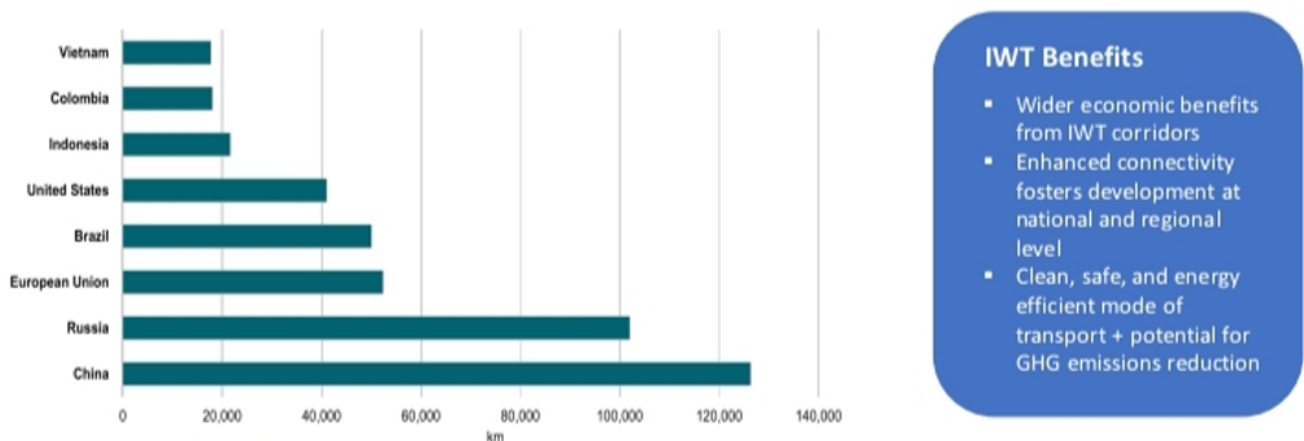


Figure 1: Inland Waterway Transport Globally.

Source: The Geography of Transport Systems from World Bank, Ports, Maritime & Logistics: IWT Development, 2022

The Study Area

The study was conducted in Lokoja, Gbajibo and Gbajibo-Mundi in Kogi, Niger and Kwara States respectively. These selected terminals are hubs for passenger and cargo movement linking the northern and southern parts of Nigeria. The Lokoja terminal is located at the confluence of River Niger and Benue and the busiest terminal. Gbajibo terminal is a riverine terminal on River Niger serving agricultural communities and traders between Niger and Kogi States. Gbajibo-Mundi terminal locates downstream of Gbajibo and connects riverine communities in Kwara State to markets in Niger and Kogi States. This makes them strategic corridors for inland water transport. The climate is tropical with wet season from April to October. The geology is basement complex rocks, sedimentary basin along river valleys. The vegetation is substantially Guinea Savanna with riparian forest vegetation along river banks.



Figure 2: The Terminal Locations in the Study Area

Source: Open Street Google Map

Materials and Methods

Research Design

The study employs descriptive survey and interview.

Population and Sampling

The population comprised Government officials, boat operators, and passengers at Lokoja, Gbajibo, and Gbajibo-Mundi terminals. 384 respondents including 65 government officials, 106 boat operators and 213 passengers/community members were sampled. Purposive and Snowball Sampling was used across the three terminals.

Instrument

Structured questionnaire was drawn for the survey and based on a 4 – point Likert Scale of Strongly Agree, Agree, Strongly Disagree and Disagree. SA = 4, A = 3, D = 2, SD = 1 while the criterion means = 2.50

Objectives of the Study

- (i) To assess the adequacy of infrastructure in Lokoja, Gbajibo and Gbajibo-Mundi terminals.
- (ii) To examine the effect of analog systems on terminal operations and management.
- (iii) To determine stakeholder support for digital technology and automation in the study area.
- (iv) To identify operational challenges and expected improvements for digitalization.

Hypotheses

The hypotheses were formulated in the null form.

Ho1: There is no relationship between analog systems of operation and effectiveness of terminal management.

Ho2: There is no difference in stakeholder support for digitalization across government officials, boat operators and passengers.

Ho3: Infrastructure adequacy does not influence terminal utilization.

Methods of Data Analysis

Data used in the study were subjected to coding and analyzed by the use of SPSS Version 26. The statistics used to summarize the responses include frequencies, percentages and mean scores. Inferential statistics employed Chi-square test to test Ho1 and Ho3 while one-way Anova was used to test Ho2 at 0.05 significant level.

Results and Discussion

Table 1

Descriptive Statistics – Government officials perception n=65

ITEM	SA	A	D	SD	MEAN	OUTCOME
Infrastructure Adequate	1	1	38	25	1.66(96.9%)	Disagreed
Infrastructure good	1	1	27	33	1.54	Disagreed
Terminals underutilized	21	36	7	1	3.18(82.1%)	Agreed
PPP Available	5	15	24	21	2.06	Disagreed
Adequate Funding	3	5	33	24	1.80	Disagreed
Operations effective	7	12	25	21	2.08	Disagreed
Hampered by Analog System	31	26	5	3	3.31	Agreed
Support change to digital	35	25	4	1	3.45	Agreed
Support automation	37	22	5	1	3.46	Agreed

Source: Author's Field Computation, 2025

In table 1, on infrastructure deficit, the mean scores are 1.66 while 1.54 indicated a strong disagreement by government officials that infrastructure is in good condition or adequate. This is in tune with the submission of the Nigerian Inland Waterway Authority (NIWA) that the terminals are dilapidated. The terminals are underutilized with mean 3.18 and 82.1% agreement by operators showed that the terminals are underutilized as a result of poor facilities and analog processes in use.

Table 2

Comparison of Mean on Digitalization across stakeholders

Variable	Officials Mean n=45	Operators Mean n=106	Passengers Mean n=213	Overall Outcome
Hampered by analog system	3.31	3.26	3.32	Agreed
Support Transition to Digital	3.45	3.21	3.26	Agreed
Support Automation	3.46	3.29	3.33	Agreed

Source: Author's Field Computation, 2025

There is a consensus across the 3 groups who are the stakeholders in the 3 terminals for digitalization which is uniform. This is an indication of their desires and readiness to embrace electronic ticketing and digital manifests among others. These findings are in tandem with the United Nations Conference on Trade and Development (UNCTAD) that digitalization has the potential to increase terminal throughput by 30% in developing countries.

Table 3

Operational Challenges and Improvements Expected n=213

Operational Challenges	Frequency	%	Improvements expected	Frequency	%
Disregard for Safety Code	90	42.3	Introduce technology	98	46.0
Inadequate boats	72	33.8	Improve funding	43	20.2
Overloading	41	19.2	PPP involvement	35	16.4
Frequency of the Accidents	10	4.7	Constant collaboration	26	12.2

Source: Author's Field Computation, 2025

Safety disregard was considered a top operational challenge accounting for 42.3% while overloading is 19.2%. This implies that the lack of digital tracking system in operation enables overloading and flagrant disregard for safety code. On the improvement expected, 46% of respondents prioritize introduction of technology which is the high point of this study.



Figure 3: Operating Model/Digital and Technology Solutions

Source: UCLA Digital & Technology Solutions, 2022

Table 4

Test of hypotheses with Chi-Square

Hypothesis	χ^2	Df	P-value	Outcome
Ho1: Analog system against Effectiveness	42.317	9	.000	Rejected
Ho2: Support for Digitalization across groups	3.114	6	.794	Accepted
Ho3: Infrastructure	38.902	9	.000	Rejected

Significant at $P < 0.05$

Source: Author's Field Computation, 2025

The result Ho1: $X^2 = 42.317$ with $P = .000$ implies that analog system reduces effectiveness significantly as 87.92% across groups attest to this. Hence, the null hypothesis was rejected. This means that there is significant relationship between analog system of operation and effectiveness of terminal management was accepted. Ho2: $X^2 = 3.114$ with P-value .794 implies that there is no difference in digital support across groups which ascertained their readiness for transiting to digitalization from analog system. Null hypothesis 2 is hereby accepted. Ho3: $X^2 = 38.902$ with P-value = .000 implies that poor infrastructure reduces terminal utilization significantly. The null hypothesis that infrastructure adequacy does not significantly influence terminal utilization was rejected. In other words, the alternative hypothesis that infrastructure adequacy affect terminal utilization was accepted.

Table 5

Anova-Support for Digitalization across groups

Source	F	Df	P-value	Outcome
Between Groups	2.114	2381	.122	Accepted

Significant at $P < 0.05$

Source: Author's Field Computation, 2025

Ho2: $F = 2.114$ with P-value .122 indicates that there is no difference in support for digitalization across all the 3 groups in all the 3 terminals and as such, accepted. The mean > 3.20 for all groups aligns with the position of UNCTAD that in developing ports, digitalization improves throughput.

Conclusion

Digitalization is giving traction and is considered as one of the key drivers of growth and innovation that will transform the inland waterways terminals in Lokoja, Gbajibo and Gbajibo-Mundi. It enhances efficiency and sustainability of operation enabling real-time data access and improved environmental monitoring. It craft opportunity to auto-sail by autonomous technology and make inland waterway competitive, reduce costs by enhancing navigation and traffic management. Fact remains from the findings that Lokoja, Gbajibo and Gbajibo-Mundi terminals are underperforming as a result of their traditional analog operations and infrastructure deficits. There is a uniform agreement across all the stakeholders to leverage digital technology and automation. It has become a trend in most parts of the developed countries of the world to transit to digitalization and automation of their inland waterways so as to transform the sector. The adoption of advance technology through digital innovation is being imitated by many countries like Tanzania, Ghana, Senegal, Guinea, Kenya, Rwanda and Nigeria in Africa all of which had experienced set-backs in the use of analog modus-operandi on their waterways and are making progress. Digitalization is critical to improve safety, efficiency and accruable revenue in the study area.

Recommendations

Due to the operational and management constraints which are key findings in the study, the following recommendations are suggested as leeway to ensure inland waterways in the study area operate with optional efficiency and tangible outcomes are obtained with evidence-based policy formulation:

- (i) Infrastructure upgrade becomes imperative by rehabilitating jetties, provide and install solar navigational aids in Lokoja, Gbajibo and Gbajibo-Mundi terminals. This also include funding through PPP to fund digital infrastructure.
- (ii) Capacity building through constant training of staff and operators in the study area on digital operations.
- (iii) Digital enforcement through the use of digital manifests to check overloading and to enforce safety codes.

Finally, technology advancement in the inland waterways when applied in the way we move people and goods reduce accidents, provide security and optimize sailing routes to minimize emissions. It creates opportunity to make inland waterway safer, more reliable, more efficient and cleaner.

The use of Artificial Intelligence (AI) in logistics allows for time and money safety because it helps in automating various time-consuming processes and assist in demand forecasting. Its capability in route optimization helps in reducing costs to movement and aid in generating more funds.

References

1. Abdul Malik, M. M. (2022). An appraisal of transport infrastructure for the development of Boro Inland Port in Niger State. *Journal of Science, Technology, Mathematics and Education (JOSTMED)*, 2022.
2. Adewale, A. (2020). Inland waterways development in Nigeria: Challenges and opportunities. *Journal of Transportation Management*, 14(1), 1–12.
3. Akpufu, I. D., et al. (2023). An assessment of inland waterways operations and challenges along coastal communities in the Niger Delta. *Asian Journal of Multidisciplinary Research and Review*, 4(5), 40–57. <https://ajmr.r.org/journal/article/view/158>
4. Ansari, S. A., & Vidyarthi, V. K. (2025). Use of Internet of Things in waterway resources applications: Challenges and future directions: A critical review. *Discover Internet of Things*, 5, Article 96. <https://doi.org/10.1007/s43926-024-00100-w>
5. Balogun, Y. I., et al. (2024). Developing innovative service quality and safety improvement in transportation planning operations and management. *Nigerian Journal of Educational Studies and Research (NJESR)*, 17(1), 120–132.
6. Bernardini, A., Cok, L., Baroni, C., Legittimo, C. M., Marine, A., Mauro, F., Nasso, C., & Bucci, V. (2018). An innovative concept for inland waterway vessels. In *Technology and Science for the Ships of the Future: Proceedings of NAV 2018: 19th International Conference in Ship and Maritime Research*. <https://doi.org/10.3233/978-1-61499-870-9-35>
7. Berrió, L., Cantillo, V., & Arellana, J. (2019). Strategic of passenger transport in waterways: The case of the Magdalena River. *Transport*, 34(2), 215–224. <https://doi.org/10.3846/transport.2019.8943>
8. Boonyainpakvisal. (2024). *Best practices for inland waterway and implications: The Mekong River*. ESCAP Transport Division.
9. Bu, F., & Nachtmann, H. (2021). Literature review and comparative analysis of inland waterways transport: "Container on verge". *Maritime Economics & Logistics*, 23(3), 425–445. <https://doi.org/10.1057/s41278-021-00195-6>
10. Butler, L., Yigitcanlar, T., Paz, A., & Areed, W. (2022). How can smart mobility bridge the first last mile gap? Empirical evidence on public attitudes from Australia. *Journal of Transport Geography*, 104, Article 103452.
11. Calderón-Rivera, N., Bartusevičienė, I., & Ballini, F. (2024). Sustainable development of inland waterways transport: A review of shipping and trade. *Journal of Shipping and Trade*, 9, Article 3. <https://doi.org/10.1186/s41072-023-00162-9>
12. Eberechukwu, A. (2021). *An evaluative study of inland water transport development in Nigeria*. Afribary. <https://afribary.com/works/an-evaluative-study-of-inland-water-transport-development-in-nigeria>
13. Fellinda. (2016). World's water transport needs further dev. *Journal for Transport Development*, 1, 68–72.
14. Havinga, H. (2020). Towards sustainable river management of the Dutch Rhine River. *Water*, 12(6), Article 1827. <https://doi.org/10.3390/w12061827>

15. Justice, J. A., Elibarikimtio, A., Msababa, J. M., & Kileo, W. J. (2024). Assessment of Tanzanian inland waterways vessels accidents, causes, impacts and mitigation options. *Global Scientific and Academic Research Journal of Multidisciplinary Studies*, 3(9), 21–32.
16. Konings, R. (2019). Inland waterway transport: A sustainable solution for freight transport. *Transportation Research Part D: Transport and Environment*, 73, 242–253.
17. Malkus, R., Liububievienė, J., & Jokubynienė, V. (2020). Inland water transport applicability for sustainable seaport hinterland infrastructure development: Klaipėda seaport case. *Transport Problems*, 15(2), 25–31. <https://doi.org/10.21307/TP-2020-017>
18. Miloslavskaya, S., & Plotnikova, E. (2018). Current situation and optimization of inland waterway infrastructure financing. *Transport Problems*, 13(3), 51–63. <https://doi.org/10.20858/tp2018.13.3.5>
19. Naderifar, M., Goli, H., & Ghaljaie, F. (2017). Snowball sampling: A purposeful method of sampling in qualitative research. *Strides in Development of Medical Education*, 14(3), Article e67670. <https://doi.org/10.5812/sdme.67670>
20. National Inland Waterways Authority. (2021). *Masterplan for the development of inland waterways in Nigeria 2021–2030*. NIWA.
21. NIWA. (2019). Harnessing the potentials of inland waterways transport in Nigeria. *NIWA Bulletin*.
22. Nwaogbe, O. R., & Ogorode, P. (2024). Assessment of operational performance and service quality in inland waterway transport: A case study of Warri South-West, Nigeria. *Journal of Sustainable Development of Transport and Logistics*, 9(1), 4. <https://doi.org/10.14254/jsdt.2024.9-1.4>
23. Nze, N. J., et al. (2021). Analysis of operational logistics on inland waterways of Delta State, Nigeria. *Journal of Multidisciplinary Engineering Science and Technology*, 8(11).
24. Ogunleye, O. O., & Ipingbemi, O. (2020). Safety and operational challenges in inland water transportation in Nigeria. *Journal of Transport Geography*, 88, Article 102847.
25. PIA. (2020). *Nigerian Inland Waterways Authority: Dredging and navigation report*.
26. Somuyiwa, A. O., Oyesiku, O. O., & Dosunmu, V. A. (2011). Transport and logistics research and impact of capacity building of local institutions in Nigeria. *American Journal of Scientific and Industrial Research*, 2(4), 559–566.
27. Sulaimon, M. A., et al. (2023). *Assessment of operational performance of inland water transport in Borgu Local Government Area of Niger State*. ResearchGate.
28. Suleiman, M. A. (2024). The role of Boro River Port in the development of inland waterways transport system in colonial Niger province of Northern Nigeria, 1900–1960. *Lapai Journal of Nigerian History*, 16(1).
29. Ukpata, J. O., & Etim, R. S. (2021). Assessment of inland waterway transportation infrastructure in Nigeria. *International Journal of Civil Engineering and Technology*, 12(4), 215–224.
30. United Nations Conference on Trade and Development. (2022). *Review of maritime transport 2022*. UNCTAD.
31. World Bank. (2021). *Digitalization of transport and logistics opportunities for developing countries*. World Bank Group.