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Engineering Infrastructure Needs for Blue Economy Growth in Nigeria's Port and Maritime Sector

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Abstract

Nigeria's ports and maritime sector have great potential to drive blue economy growth and contribute more significantly to national development. However, the sector faces infrastructure gaps that constrain its performance. This paper examines the engineering infrastructure needs of Nigeria's ports and maritime sector to support blue economy growth. Analysis of cargo traffic trends, port performance metrics, and infrastructure quality indices over 15 years reveals significant infrastructure deficits. Key recommendations include deep seaport construction, dry port development, dredging of water channels, rail and road connectivity upgrades, and technology modernization. Targeted infrastructure engineering interventions can strengthen maritime operations, stimulate trade, improve competitiveness, and harness the blue economy prospects in fisheries, shipping, offshore oil and gas, maritime transport, and coastal tourism. A strategic blueprint for infrastructure engineering is proposed to unlock the immense potential of Nigeria's ports and maritime sector.

Key words: Maritime Infrastructural Development; Blue economy; Multimodal Transportation; Ports and Harbour Development; and Maintenance of Maritime Infrastructure.

1 Introduction

As a coastal state on the Gulf of Guinea endowed with an extensive coastline and strategically located within West Africa, Nigeria possesses tremendous maritime potentials which if well harnessed can substantially advance blue economy growth and national development (Ifere & Bassey, 2020). Its 853km coastline, inland waterways spanning over 10,000km, as well as ports and harbors provide opportunities for fishing, aquaculture, maritime transport, shipbuilding, tourism, offshore oil and gas, and other economic activities . Its oceans economy has immense potential to catalyse economic diversification, job creation, food security, and improved socio-economic wellbeing while advancing ocean sustainability. The ports and maritime sector occupy a strategic position as the gateway for Nigeria's international trade and economic links vital for

blue economy advancement (Parambi et al., 2021). However, the country currently harnesses only a fragment of its blue economy potential valued at over $1.2 trillion annually.

Nevertheless, persistent gaps in maritime infrastructure constrain efforts to improve the productivity and competitiveness of the nation's ports and fully utilize the rich marine resources for optimal blue economy progression (Okeke, 2014). Note that the sector accounts for over 95 percent of the country's international trade by volume and about 60 percent by value. However, Okon (2018) highlights that deficient port infrastructure often causes delays, congestion, bottlenecks and increased costs for maritime operations and trade flows. Consequently, engineering infrastructure improvements in Nigeria's ports and maritime domain represents a crucial imperative for stimulating blue economy sectors, facilitating external trade, attracting shipping traffic, easing supply chain costs, and driving wider national growth prospects.

This paper examines the key engineering infrastructure needs of Nigeria's ports and maritime sector that must be addressed to support accelerated blue economy growth and harness inherent potentials within the domains of shipping, fisheries, coastal tourism, offshore oil and gas, and maritime transport. Analysis of major infrastructure gaps is conducted drawing on cargo traffic statistics, performance indicators, and infrastructure quality metrics over a 15-year period. Key recommendations and a strategic blueprint are proposed for vital engineering infrastructure interventions in Nigeria's ports and maritime architecture.

1.1 **The Blue Economy**

The blue economy concept recognizes the ocean as development spaces that must be sustainably tapped for economic prosperity (Mulazzani & Malorgio, 2020). Blue economy covers traditional ocean industries like fisheries, maritime transport, and coastal tourism as well as emerging industries like offshore renewable energy, aquaculture, seabed extractive activities, marine biotechnology, and submarine cables (Schutter & Hicks, 2019). The World Bank (2017) estimates that the global blue economy is worth over US$1.5 trillion per year and anticipates growth to over US$3 trillion by 2030. Hence coastal countries like Nigeria with vast maritime domains stand to gain tremendously by strategically harnessing the potentials of blue economy sectors. However, as noted by Silver et al. (2015) suitable infrastructure is imperative for stimulating key maritime industries, facilitating trade flows, easing logistics connectivity, and providing the platform for blue economy enrichment.

2 Nigeria's Ports and Maritime Sector

This sector serves as a critical backbone for external trade and economic prosperity accounting for over 95 percent of exports and imports (Buhari, 2019). Prior to the 2006 port reforms, the sector was plagued by acute infrastructure decay, monumental port congestion, chaotic administrative bottlenecks from multiplicity of agencies, and poor service quality that eroded competitiveness (Mfon, 2013). These factors constrained maritime sector contribution to national GDP compared to more strategic roles played by the sector globally in powering blue economy for other coastal states. However, the 2006 concession programme granting port terminal leases to private operators helped transform infrastructure, improve efficiency, and achieve record cargo milestones over recent years as presented in Figure 1 showing cargo throughput over 16 years.

Table . Cargo throughput in metric tonnes at Nigerian ports for 16 years (1995 - 2011)

YEAR	IMPORT	EXPORT	THROUGHPUT	TURN-AROUND (DAYS)
1995	9,289,971	3,983,082	13,273,053	6.17
1996	10,224,300	5,251,001	15,475,301	6.34
1997	11,213,624	5,369,181	16,582,805	6.71
1998	14,286,864	5,038,854	19,325,718	7.31
1999	15,751,331	6,481,605	22,232,936	6.31
2000	19,230,496	9,702,384	28,932,880	7.01
2001	24,668,791	11,271,901	35,940,692	7.91
2002	25,206,380	11,780,861	36,987,241	11.34
2003	27,839,293	11,926,652	39,765,945	7.89
2004	26,907,075	13,909,872	40,816,947	6.44
2005	29,254,766	15,697,312	44,952,078	7.40
2006	29,089,268	17,061,250	46,150,518	5.31
2007	35,544,965	21,928,385	57,473,350	3.75
2008	41,195,616	22,787,133	63,982,749	4.59
2009	45,757,149	20,018,360	65,775,509	6.55
2010	46,928,848	29,815,879	76,744,727	5.38
2011	52,010,440	31,439,592	83,450,032	5.48

Source: Nigerian Ports Authority

The cargo traffic analysis shows rising imports dominating total throughput, indicating the import-dependent nature of the economy. As further depicted in Figure 2, while exports remained under 40 percent, total cargo volumes increased markedly post-concession reaching a peak of 84 million

metric tonnes in 2011. The peak coincided with surging oil prices which expanded government spending and boosted imports for infrastructure projects (Akinwale, 2012).

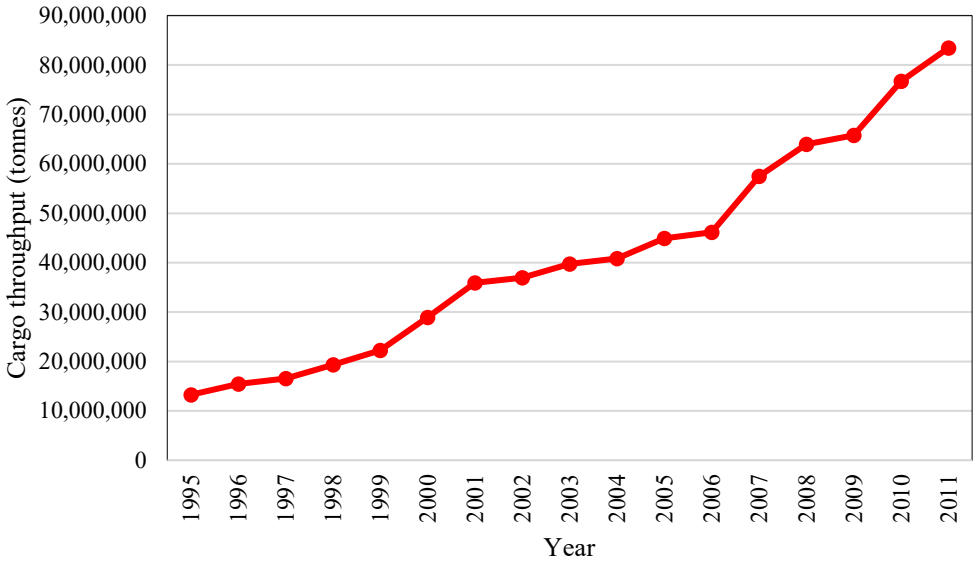

Figure 1: Rise of Cargo Throughput at Nigerian Ports (1995 – 2011)

[Source*: NPA Statistics*]

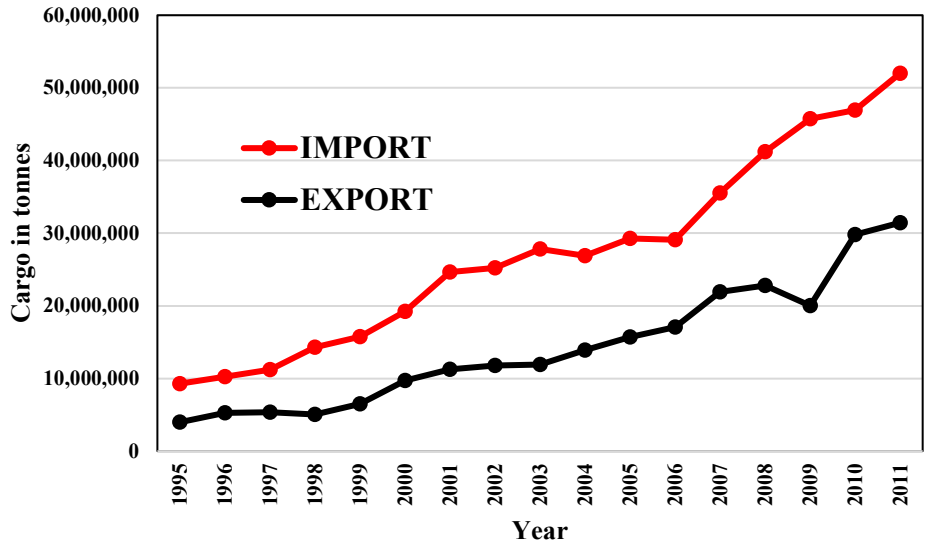

Figure 2: Cargo trade showing import and export for 1995 – 2011

[Source*: NPA Statistics*]

Figure 3 shows the disparity between import and export in percentages. The chart clearly displays the country's over dependency on import. However, several underlying constraints still inhabit

efforts to attain higher efficiency thresholds and fully catalyse the maritime sector for optimal blue economy impact.

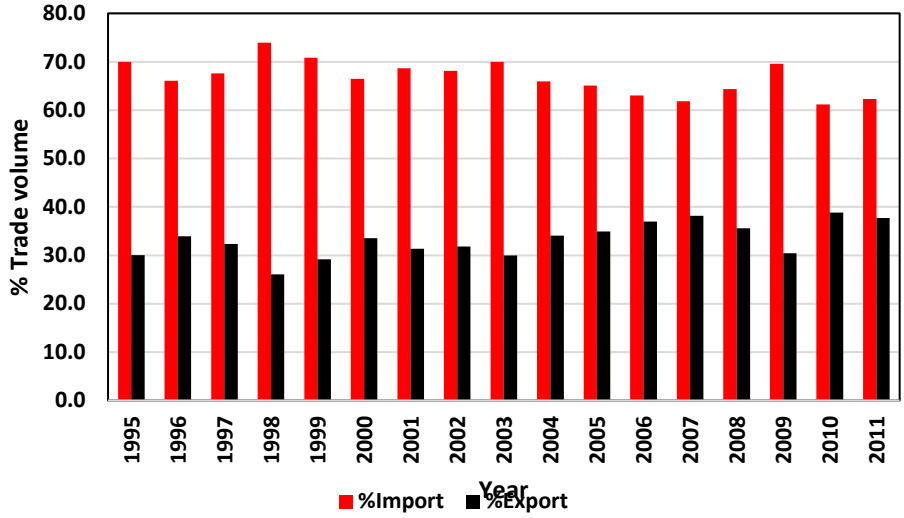

Figure 3: Percentage import and export of cargo through Nigerian ports for 1995 – 2011

The absence of modern cargo handling equipment, the use of obsolete port terminal infrastructure and inefficient cargo clearing process have extended the turnaround time for maximum two days (48hrs) to has high as 12 days as indicated in Figure 4.

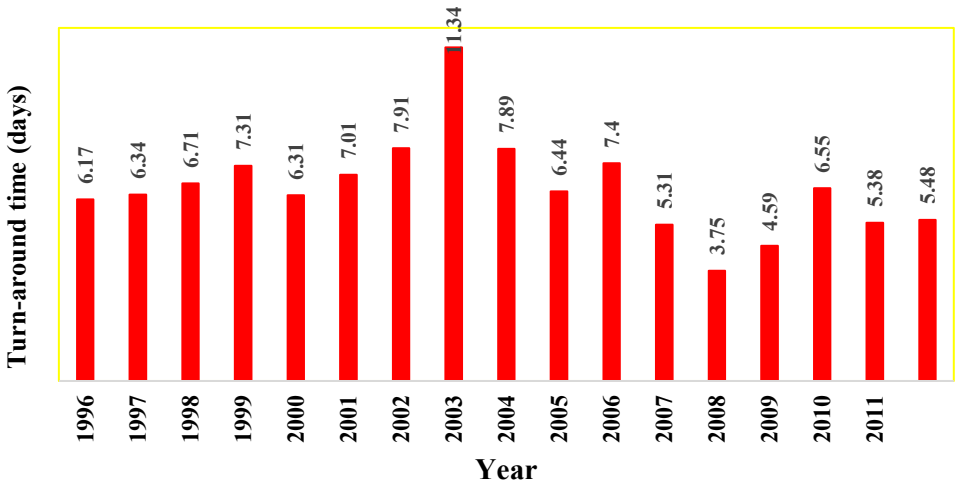

Figure 4: Cargo vessel turnaround time at Nigerian ports for 1995 – 2011

3 Critical Maritime Infrastructure Needs

Nigeria urgently requires significant investments in maritime infrastructure to eliminate current capacity shortages, facilitate trade flows and catalyse blue economic activities across coastal regions. Key engineering infrastructure projects that require priority implementation include:

3.1 Seaport Infrastructure

Nigeria currently lacks deep seaport infrastructure to accommodate Very Large Container Carriers (VLCCs) and Ultra Large Crude Carriers (ULCCs) which now dominate global shipping and oil transportation (Nwanosike & Tipi, 2021). Figure 5 displays this category of ships requiring a large draught. With just three meters depth, Nigeria's premier Lagos ports remain shallow, unable to allow large capacity new generation vessels. Larger container vessels also divert to neighbouring countries. The impacts constrain shipping, undermine transshipment hub prospects, increase costs, and impede wider maritime productivity essential for blue economy optimization as identified by (Okeke, 2014).

(a) (b)

Figure 5: Cargo ships requiring a large draught: (a) VLCC and (b) ULCC

Though Nigeria recently completed the Lekki Deep Seaport to support 90,000 tonnes DWT ships, other ports need similar engineering interventions. Proposed Badagry Deep Seaport is also underway but further deep seaport projects are vital at Onne, Calabar, Warri, and Port Harcourt to expand capacity. Deep seaports allow efficient consolidation of export cargo from agricultural, solid mineral and oil sectors into VLCC loads attracting more shipping traffic and revenues. Hence engineering deep seaport projects remains an urgent maritime infrastructure priority.

3.2 **Dry Port Infrastructure**

Nigeria's dry port infrastructure is also grossly inadequate. The few inland container depots (ICDs) including Isiala Ngwa, Jos and Funtua are small facilities unable to alleviate landside bottlenecks and seaport congestion. Dry ports when fully developed promote intermodal transport, provide platforms for cargo consolidation, shipment of imports to inland areas, and exports from production zones to seaports. Hence engineering more dry ports close to major cities using PPP models is crucial for shipping cost reduction, inventory savings, decongestion and toll-revenue generation, as dry port usage expands in consonance with cargo throughput growth.

Figure 6: Dry cargo port solution to decongesting port terminals

3.3 **Channel Dredging**

Expanding dredging and maintaining adequate depths along vital shipping channels on Nigeria's coastal shelf, rivers, estuaries, and port locations will allow safer passage for bigger vessels and prevent ship groundings. This will facilitate movement of containers through inland waterways, spurring maritime connectivity with inland locations.

Figure 7: Dredging and widening of water channels for navigation

Currently, heavy siltation of channels frequently hampers navigation. Attaining over 13 meters depth and 200 meters width dimensions for the channels ensures they align suitably with engineered deep seaport requirements. The dredging and channel engineering must also capture inland water channels, especially along Rivers Niger and Benue, to support IVTM catalysed by more dry ports.

3.4 Inefficient Seaport Infrastructure and Systems

Current cargo volumes already exceed handling capacity at major ports often resulting in long vessel queuing, waiting times and gridlocks as shown in Figure 8 (Mfon et al, 2018). It underscores the urgent need for expanding port infrastructure to keep pace with Nigeria's growing maritime trade and support emerging sectors. Key aspects include:

(i) **Electronic Call-up System:** Adoption of digital truck call-up platforms with RFID technology integration can optimize cargo evacuation, decongest port access roads, and enhance supply chain visibility.

Figure 8: Nigerian seaport congestion due to inefficient seaport facilities and systems

(ii) **Rail & Road Networks:** Interconnecting seaports to key inland trade hubs through modern rail and road linkages will ease congestion, facilitate inland container transports, and support multi-modal cargo distribution.

(iii) **Truck Transit Parks:** Establishing trailer parks and holding bays fitted with required amenities will address haphazard truck parking and congestion around ports arising from delays.

(iv) **Inland Container Depots:** Building dry ports and container freight stations linked with seaports by rail will ease congestion through port decentralization and extend inland access to maritime trade.

3.5 Multimodal Transportation and Roads Network

As (Adekanbi, 2021) highpoints, developing intermodal transport infrastructure is pivotal for efficient freight distribution from ports inland. Nonetheless, Nigeria's ports have remained seaside enclaves with huge landside disconnect partly accounting for bottlenecks and rising haulage costs. Rail infrastructure is a key imperative allowing bulk freight transfers over long distances complementing trucks for intra-city distribution. Hence a coordinated port-rail interconnection engineering agenda involving channelization of dedicated freight rail-lines into key seaports is profoundly important to support dry port operations as shown in Figure 9.

Figure 9: Multimodal transport solution for enhanced maritime operation.

Furthermore, specialized engineering works to expand and upgrade maritime access roads into seaports, strengthen pavement capacity and construct functional truck parks for articulated vehicles used in haulage operations is vital for seamless freight flows. (Ogunsanwo, 2021) stresses investing about N80 billion in roads upgrades serves as key infrastructure priority for boosting port productivity. Hence integrative rail and road engineering interventions remain utmost imperatives.

3.6 Cargo Handling Infrastructure

As earlier highlighted, gaps in handling equipment and terminal infrastructure often undermine operational efficiency, service quality and overall productivity. Hence engineering aspects must

prioritize procuring large capacity quay cranes, extending berth space, constructing stacking areas along with installing automated cargo handling systems essential for fast turnaround of vessels, as indicated in Figure 10. Nigeria can adapt leading global ports operational efficiency by deploying engineering innovations in automated guided vehicles, smart logistic technologies, truck call up apps and AI powered analytics for cargo forecasting and traffic scheduling as (Kumar & Haq, 2021) propose.

Figure 10: Cargo handling equipment at port

3.7 **Ship Building & Repair Yards**

New shipyards provisioned with modern slipways, fabrication workshops and equipment will foster domestic vessel construction and maintenance capacity to tap into demands for offshore oil/gas, fishing trawlers etc. as shown in Figure 11.

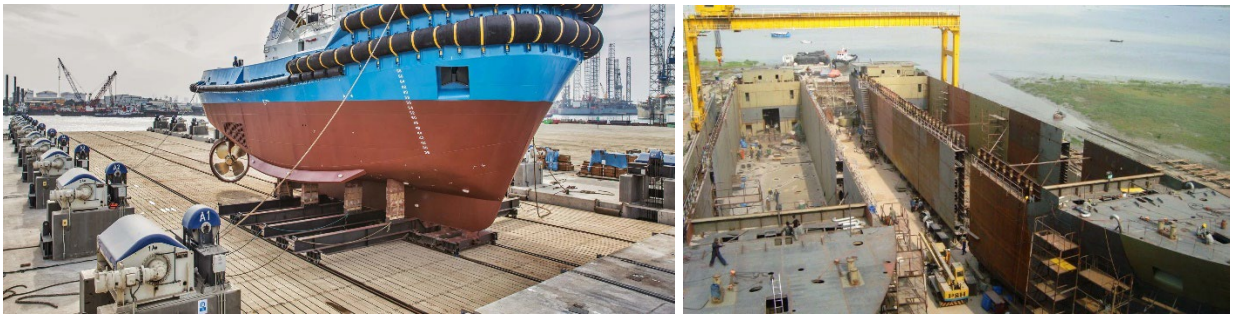

Figure 11: Shipyard for ship building and repairs

Engineering designs, technical studies, environmental impact assessments and commercial feasibility analysis need to be urgently undertaken on these infrastructure initiatives to determine costs, site locations and project timelines for successful implementation and profitability.

3.8 Infrastructure for Ships and Ports Security and Safety

As indicated in Figure 12, maritime security remains indispensable for business continuity, vessels, and cargo safety. Hence engineering aspects must encompass perimeter fencing, CCTV systems, sensors, scanners, patrol boats, channel marking and vessel traffic systems (Adewumi, 2015). Robust engineering interventions in security infrastructure foster confidence, attracts more shipping traffic and stimulates spin-off for ancillary maritime services.

Figure 12: Ships and ports security and safety

4 Recommendations for Advancing Port and Maritime Infrastructure

A concerted strategy encompassing planning, engineering, financing, reforms, and capacity building is essential:

4.1 Infrastructure Masterplans

Detailed infrastructure development plans focused on augmenting port capacity synchronised with maritime connectivity expansion needs to be formulated considering forecasted blue economy growth across sectors.

4.2 Public-Private Partnerships

The immense costs needed make private sector participation critical through PPP models for accelerated infrastructure delivery across greenfield deep seaports, terminals, dredging, digital systems, and intermodal links. Viability gap funding can potentially offset initial risks.

4.3 Customs, Regulations and Policy Reform

Streamlining excessive red tape, taxes, and paperwork to expedite clearances while reforming tariff structures through greater regional harmonization. Fiscal incentives also need to promote sustainability focused engineering infrastructure adoption.

4.4 Local Content Requirements and Capacity Building

Mandating joint ventures and local sourcing stipulations in projects can enable skills development in areas like port engineering design, construction, mechanization, equipment fabrication, digital technologies, and environmental management. Table 2 summarizes the major engineering infrastructure needs highlighted based on gaps analysis that must be urgently bridged to boost productivity.

Table 2: Summary of Key Engineering Infrastructure Needs

Infrastructure	Key Engineering Requirements
Seaports	Constructing deep seaports; Channel dredging and engineering works; Quay walls expansion; Berth construction; Land reclamation.
Dry Ports	Greenfield and brownfield dry port projects; Intermodal yards and gates; Warehouses; Administrative buildings; Ancillary facilities
Ship Channels	Capital and maintenance dredging; Channel markers; Widening and curve improvements; Slope protection; Navigation aids
Rail Network	Port rail sidings and freight track construction; Bridges and crossings; Signalling equipment; Rolling stock fleet upgrade
Roads	Access roads rehabilitation; Pavement engineering and capacity expansion; Truck terminal and parking facilities
Cargo Handling	Quay cranes; Reach stackers; Forklifts; Conveyor systems; Transit sheds; Equipment maintenance workshops
Security	Perimeter fencing; CCTV and sensors; Scanners; Vessel traffic systems; Navigation aids; Security boats; Firefighting equipment
Institutional	Concession frameworks; Infrastructure funding mechanisms; PPP models; Skills development organisation

5 Proposed Strategic Blueprint for Maritime Infrastructure Engineering

A comprehensive strategic blueprint encompassing a holistic program of critical maritime infrastructure engineering interventions is imperative for stimulating blue economy prospects based on the foregoing analysis. The proposed blueprint which can be jointly developed by the Federal Ministry of Marine and Blue Economy; and Ministry of Transportation alongside key maritime agencies such as Nigerian Ports Authority and Nigerian Maritime Administration and Safety Agency for critical input, review, and implementation. The strategic infrastructure engineering blueprint would guide maritime infrastructure budgeting, finance allocation, and development.

(i) Hence outlined in the blueprint will be concrete deliverables around timelines, budgets, funding, requisite legislation, and concessions' frameworks for executing proposed dry ports, deep seaports, maritime access roads rehabilitation, rail freight modernization, dredging programs, cargo handling equipment modernization and channel re-engineering projects.

(ii) Others are monitoring and evaluation frameworks focused on a composite of performance improvement metrics that must be tracked after infrastructure interventions to validate effectiveness. Metrics like ship turnaround times, dwell times, multi-modal freight haulage costs, marine transit insurance premiums, port labour and equipment productivity data and customs clearance times will indicate progress.

(iii) Institutional strengthening around maritime skills, research, innovation, regulatory benchmarks, and emerging technologies adoption are also covered as vital complementary aspects within the blueprint recognizing their strategic relevance for sustaining infrastructure operability.

By cumulatively outlining the roadmap, technical interventions and enabling frameworks for bridging Nigeria's maritime infrastructure deficits, the proposed strategic infrastructure engineering blueprint serves to catalyse increased investments, partnerships and participation required in executing projects that enhance productivity necessary for optimizing blue economy impact.

6 Conclusion

As coastal countries globally prioritize marine resources more consciously for economic diversification, Nigeria must equally harness inherent maritime potentials optimally towards expanding the frontiers of domestic blue economy agenda for sustainable growth. However, substantial engineering interventions focused on bridging infrastructure gaps represent a critical success factor. Thus, implementing the proposed strategic blueprint for maritime infrastructure upgrading serves as a vital avenue for supporting the engineering revamp considered indispensable towards bolstering the productivity, efficiency, global competitiveness and blue economy prospects of Nigeria's ports and maritime sector.

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