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Assessing the Role of Maritime Engineering in Sustainable Blue Economy Development in Nigeria

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Abstract

The blue economy presents significant opportunities for sustainable growth in Nigeria given the country's extensive maritime resources. However, harnessing the full potential of the blue economy requires building local capacity in key areas like maritime engineering. This paper examines the status of maritime engineering in Nigeria and assesses priority areas to develop capabilities to grow the blue economy sector. After analysing gaps in skills, infrastructure, technology and policies, the study proposes recommendations focused on investments in technical training, research and development, adoption of emerging technologies, infrastructure upgrades and strategic partnerships. Finally, it concludes that developing homegrown expertise in maritime engineering is fundamental to Nigeria's quest for responsible and sustainable blue economy.

Key words: Maritime Engineering; Blue Economy; Maritime Development; Ocean resources

1. Introduction

The "blue economy" concept recognizes the ocean's vast potential for sustainable economic development through diverse activities like offshore energy production, seabed mining, marine biotechnology, tourism, transportation, and fisheries (Silver et al, 2015). With a coastline spanning over 850 km and maritime area encompassing over 200 nautical miles, Nigeria is endowed with substantial ocean resources that can drive blue economic growth. The country has prioritized developing its blue economy as part of long-term development plans to harness the potential of its marine and maritime sectors, as indicated in Figure 1 (Chidi, 2022).

Figure 1: Oil and gas platforms in the Gulf of Guinea

Engineering capabilities play a pivotal role in unlocking the promise of ocean-based economies by enabling utilization of marine resources and development of offshore infrastructure and technologies. Maritime engineering, which focuses on the ocean environment, is particularly critical for blue economy activities ranging from offshore oil and gas to marine renewable energy and deep-sea mining (Bazari & Longva, 2022). As Nigeria aims to transition towards a sustainable blue economy model, building local expertise in maritime engineering should be an urgent strategic priority.

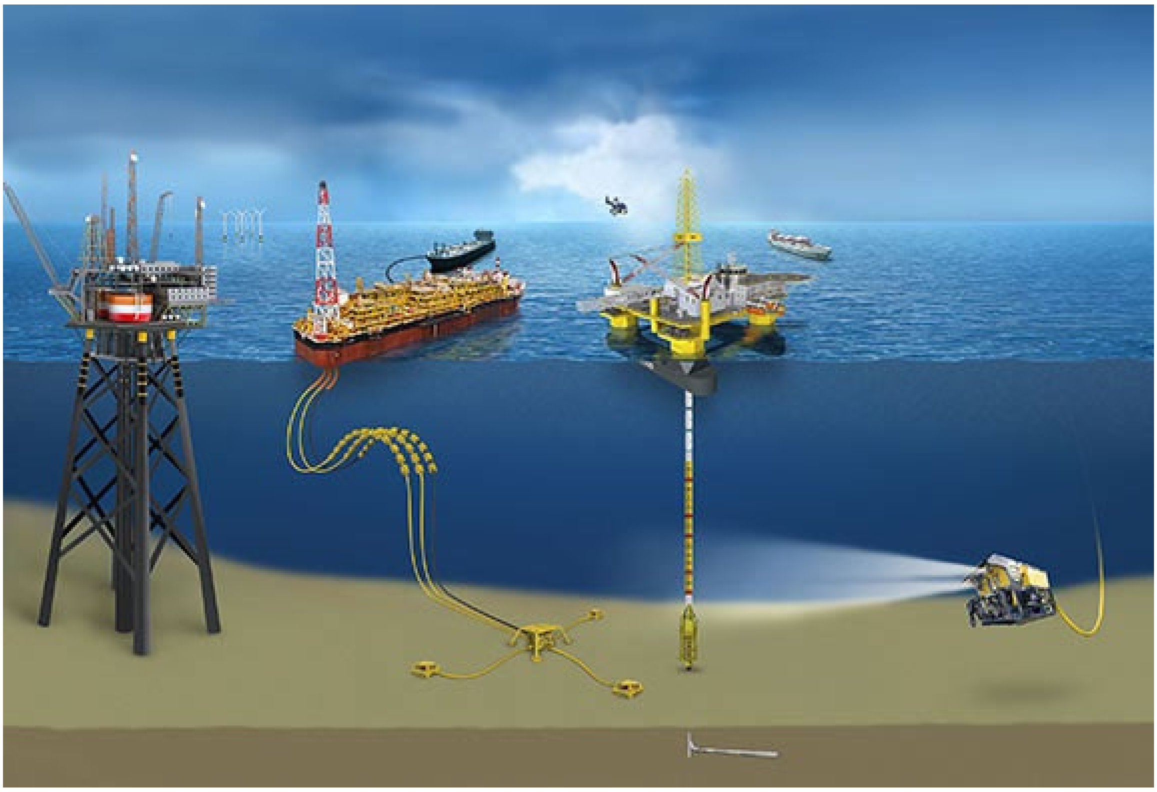

Figure 2: Subsea development of Nigeria offshore oil and gas

1.1 Objective and Scope

This paper investigates Nigeria's maritime engineering landscape and examines priority areas that require strengthening to support diverse blue economy industries. The analysis focuses on identifying critical gaps in skills, infrastructure, technologies and national policies related to maritime engineering. Key sectors that require engineering innovations to foster productivity, efficiency, safety and sustainability are highlighted. Finally, recommendations are proposed for developing a vibrant maritime engineering ecosystem in Nigeria through education, research, investments, technological capabilities and enabling policies.

1.2 Scope of Research

The paper presents an overview of maritime engineering as a field. It considers prospects of expanding Nigeria's maritime engineering capacity citing the country's blue growth potential. Priority engineering focus areas for different blue economy sectors are critically analysed. At the end, it proposes policy recommendations to build maritime engineering expertise and innovation in Nigeria against all the prevalent debilitating factors.

2 An Overview of Maritime Engineering

Maritime engineering is a field that deals with the design, construction, installation and operation of technological systems and infrastructure in the marine environment (Sharma, 2022). It encompasses various aspects like ocean structures, maritime vehicles and transportation, resource extraction, coastal and offshore construction, marine environmental management, and ocean energy systems. Maritime engineering integrates knowledge across disciplines like naval architecture, nautical science, ocean engineering, marine engineering, offshore and subsea engineering and marine surveying. It requires an understanding of the mechanical, electronic, electrical, and civil engineering aspects tailored to maritime transport, infrastructure, and its allied activities. It also intersects with marine science covering oceanography, marine biology, and environmental studies to ensure minimal environmental impacts.

2.1 Major Areas of Interest

Some major focus areas of maritime engineering include:

(i) **Port and Harbour Infrastructure**: Maritime engineers handle activities like planning, design and construction of docks, wharfs, jetties, terminals, and harbours. This also includes dredging to create and maintain navigational channels.

(ii) **Offshore Platforms and Structures**: Designing, building, and installing offshore drilling rigs and platforms for oil and gas, wind turbines and ocean energy systems. Ensuring structural integrity under challenging ocean conditions.

(iii) **Marine Vehicles and Transportation**: Ship and boat design including hull forms, powering, control systems, stability, and manoeuvrability. Modifying and maintaining vessels. Developing marine propulsion technology.

(iv) **Ocean Resource Extraction**: Designing equipment for activities like offshore oil and gas production, fishing, seabed mining, marine biotechnology, and desalination.

(v) **Coastal Engineering**: Beach nourishment, erosion control, designing ports, harbours, jetties, and other coastal infrastructure. Environmental impact assessment.

(vi) **Underwater Technology**: Technologies for underwater exploration, deep-sea mining, underwater detection, and communication systems. Remotely operated underwater vehicles.

(vii) **Marine Pollution Control**: Developing solutions for prevention, mitigation, and control of marine pollution like oil spills, marine debris, industrial effluence, etc. The establishment of proper waste management systems.

(viii) **Maritime Logistics, Operations, and Security**: Improving efficiency, safety and security of maritime operations and logistics using technology. This includes ships and ports safety and security.

2.2 Maritime Engineering Landscape in Nigeria

Nigeria has over 35 registered maritime engineering consulting firms and shipyards for ship repairs (NIMASA, 2022). Maritime education is offered at 8 major universities and polytechnics. Nigeria also has merchant navy institutes and training schools for seafaring careers. However, there remains a shortage of highly skilled maritime engineers and operators within the country while local shipbuilding and maintenance capabilities are limited. Most large marine vessels and platforms operating in Nigerian waters are imported with minimal local contents. The gaps in maritime engineering capacity act as a barrier for Nigeria in harnessing its blue economy potential which the next section examines.

3 Developing Maritime Engineering Capacity in Nigeria

Maritime engineering capacity enhancement requires both human capacity building and infrastructural development. It involves training and retraining of personnel in contemporary technologies, use of expert system, and their working relationships. Figure3 shows engineers on oil rig.

Figure 3: Maritime engineers at work on oil/gas rig

3.1 Nigeria's Blue Economy Potential

Nigeria's blue economy has significant room for growth across diverse sectors:

(i) Offshore oil and gas: Nigeria has around 200 offshore platforms accounting for 70% of total production, which is projected to rise further with more deepwater developments (Okonuju et al, 2019).

(ii) Shipping and ports: Nigeria has seaports in Lagos, Port Harcourt, Calabar and Delta states and these ports either need upgrades, maintenance and additional manpower to improve efficiency and capacity. Coastal shipping provides over 70% of freight cargo volumes (Mfon et al, 2018). However, Nigerian seaports are inefficient and ineffective because of high port costs, archaic clearing process, and lack of automation. These factors have made Nigerian Ports unattractive to importers who divert their cargoes to more efficient seaports in neighbouring countries. These goods are later smuggled through the country's porous borders, thereby making Nigeria lose several billions of naira in revenue yearly.

Figure 4: displays containers at Lagos seaport.

(iii) Fisheries and aquaculture: With waters containing over 200 fish species, Nigeria aims to increase its 2.2 million tons of fish production to 5 million tons by 2025 (Federal Ministry of Agriculture & Rural Development, 2022). Figure 5 presents both the inefficient local fishing technique and the efficient mechanised method.

(a) (b)

Figure 5: Fishing in the Gulf of Guinea: (a) Local fishing gear and (b) Motorised trawler

(iv) Shipbuilding and ship repair: Nigeria has a goal to reduce reliance on imported vessels by building in-country capacity for construction, maintenance and retrofitting of ships. What is lacking is the presence of a competitive repair yard.

Figure 6: Nigerian Navy Dockyard in Lagos

(v) Offshore renewable energy: Nigeria has set a target for renewable energy to reach 30% of its energy mix by 2030, with prospects for offshore wind and ocean energies (Federal Ministry of Power, 2022).

Figure 7: Nigerian wind energy project in the Gulf of Guinea

(vi) Hydrocarbon industry: In addition to offshore oil and gas, Nigeria has untapped potential for seabed and methane gas extraction. The hydrocarbon industry is yet to leverage on the opportunities maritime engineering provides to grow Nigeria's local economy.

(vii) Marine biotechnology: Nigeria's biodiverse ocean ecosystems are a rich source for pharmaceutical, biofuel and chemical development.

Figure 8: Offshore hydrocarbon refinery in the Gulf of Guinea

3.2 Maritime Engineering Challenges

However, Nigeria faces considerable hurdles in maritime engineering capability, infrastructure and enabling policies which have slowed blue economy progress. Some key challenges include:

(i) **Talent Gap**: Acute shortage of trained maritime engineers, naval architects, surveyors, captains, and technical specialists for both private sector and public agencies. Heavy reliance on expatriates.

(ii) **Weak Shipbuilding Industry**: Lack of local capacity for marine and offshore vessel construction, maintenance, conversion, and retrofitting.

(iii) **Port Infrastructure Deficit**: Nigerian ports suffer from aged facilities, productivity and efficiency issues, poor cargo handling capacity and frequent congestion.

(iv) **Technology Gap**: Most marine technologies and engineering systems used in sectors like offshore oil and gas, dredging, and Naval operations are imported. There are limited domestic manufacturing and R&D capabilities.

(v) **Policy and Regulation**: Outdated policies, excessive red tape and weak enforcement hamper development of new marine industries and adoption of modern engineering systems.

(vi) **Access to Financing**: Limited access to investment capital and high borrowing costs impede maritime infrastructure projects and adoption of advanced marine technologies.

(vii) **Maritime Safety**: None adherence to safety rules and failure of maritime administrations to enforce safety regulations.

(viii) **Security**: There are incessant attacks from sea pirates, terrorists, and armed robbers. Also, the sea routes are heavily silted, clogged, and non-navigable.

3.3 Benefits of Expanding Local Maritime Engineering Expertise

Developing Nigerian expertise in maritime engineering is crucial to address the gaps hindering the progress of the country's blue economy. Some key benefits include:

(i) **Efficient Utilization of Marine Resources**: Advanced engineering enhances productivity, safety, and cost-effectiveness of offshore oil/gas, fishing, ocean renewable energy, mining etc.

(ii) **Technology Indigenization and Self-reliance**: Localizing marine engineering, construction and maintenance reduces dependence on foreign firms and creates jobs.

(iii) **Sustainable Use of Ocean Resources**: Marine engineering innovations can ensure minimal impacts on fragile ocean ecosystems.

(iv) **Operational Resilience**: Indigenous engineering skills ensure optimal uptime, maintenance and performance of maritime infrastructure and assets.

(v) **Reduced Capital Flight**: Lower reliance on imported vessels and technologies improves balance of payments.

(vi) **National Security**: Capacity for marine defense technologies reduces risks for offshore oil, ports, and maritime activities.

(vii) **Competitiveness**: Strong engineering foundation positions Nigeria as an attractive location for global marine companies.

4 Essential Areas for Maritime Engineering Development

Based on the gaps and opportunities, here are some priority maritime engineering areas for Nigeria:

4.1 Port Infrastructure and Dredging

(i) Extending ports and building additional deep seaports to enhance cargo handling capacity.

(ii) Port engineering systems like piers, breakwaters, quay walls, lighthouses, terminal infrastructure.

(iii) Channel dredging and land reclamation technologies to create draught for larger vessels.

(iv) Automating port operations using robotics, internet of things, maritime cloud solutions.

4.2 Offshore Oil/Gas Platform and Drilling Engineering

(i) Designing fixed and floating offshore oil/gas platforms suited for Nigeria's coastal conditions.

(ii) Localizing fabrication and integration of topside production modules and jackets.

(iii) Advanced drilling equipment tailored for offshore deepwater reserves.

(iv) Subsea engineering systems, underwater equipment installations and control.

4.3 Marine Vessel Design, Construction and Maintenance

(i) Indigenous design skills for offshore support vessels, cargo ships, fishing boats, ferries, and navy vessels.

(ii) Infrastructure and systems for in-country vessel construction, maintenance, and retrofitting.

(iii) Dry-docking facilities for ship and rig repair, conversion and scraping.

(iv) Technology and infrastructure for vessel fuel conversion, emission control and automation.

4.4 Fishing and Aquaculture Technology

(i) Advanced offshore aquaculture systems, fish cages and hatcheries.
(ii) Fishing vessel, gear, and equipment innovations to boost efficiency and sustainability.
(iii) Onboard handling, processing, packaging, and cold storage technologies.
(iv) Fish finding and fish behaviour analysis systems.

4.5 Ocean Renewable Energy

(i) Evaluating feasibility and design of offshore wind, wave, and tidal energy systems.
(ii) Floating offshore wind turbine foundation engineering tailored for Nigeria's coast.
(iii) Power electronics, subsea cables, and offshore grid integration for ocean renewables.
(iv) Developing hybrid platforms integrating offshore wind, oil/gas, and ocean energy systems.

4.6 Marine Pollution Control and Biotechnology

(i) Modelling software, sensors, and aerial systems to monitor oil spills, wastes and pollution.
(ii) Engineering bioremediation solutions using microbes, biosurfactants, biopolymers etc.
(iii) Marine biotech R&D for pharmaceuticals, biofuels, industrial enzymes, and chemicals.
(iv) Engineering processing systems for marine biotechnology applications.

4.7 Ocean Mining and Seabed Mineral Extraction

(i) Technology for mapping, accessing, and extracting Nigeria's deep sea mineral reserves.
(ii) Vertical underwater mining shaft systems, seafloor crawlers, pumps and lifting systems.
(iii) Support vessels, platforms, and onshore infrastructure to transport and process seabed ores.
(iv) Environmental impact assessment and developing sustainable mining practices.

4.8 Coastal Protection and Port Infrastructure Resilience

(i) Solutions to mitigate rising sea levels, coastal erosion, floods, and storms.
(ii) Protecting coastal settlements, ports, and maritime infrastructure from climate risks.
(iii) Engineering climate resilient marine structures and buildings.

4.9 Maritime ICT, Automation and Digitalization

(i) Automated cargo handling systems, cranes, and robotics at ports and on vessels.

(ii) Maritime cloud platforms, sensors, IoT, big data analytics, AI, and digital twin simulations.
(iii) Remote monitoring, predictive maintenance, logistic optimization, using digitalization.
(iv) Electronic navigation, dynamic positioning, enhanced communications, and automation systems for vessels.

4.10 4.11 R&D, Manufacturing and Strategic Partnerships

(i) Joint R&D projects between industry, government agencies and universities.
(ii) Aerospace and defence partnerships to adapt maritime applications.
(iii) Partnerships with universities abroad to exchange maritime engineering knowledge.
(iv) Building local manufacturing capabilities through joint ventures.
(v) Collaboration platforms and clusters linking stakeholders.

4.11 Ocean Resource Mapping and Planning

(i) Advanced surveys and technologies like sonar, LIDAR, GIS, radars to map ocean topography, resources, habitats, and infrastructure.
(ii) Spatial data analysis using geospatial information systems (GIS) and geospatial marine cloud platforms.
(iii) Maritime spatial planning models balancing conservation, sustainability, and economic/industrial demands.

5 Recommendations for Strengthening Maritime Engineering in Nigeria

5.1 Increase Public and Private Investments

Substantially higher investments are vital for developing maritime infrastructure, education and R&D. Government funds should support universities, vocational institutes, and R&D centers focused on marine engineering. Tax breaks and low interest loans can incentivize private companies to invest in infrastructure, technologies and skills training. Diaspora remittance funds could also be utilised to advance sustainable blue economy.

5.2 Incentives for Adopting Advanced Marine Technologies

Providing tax breaks, subsidies, and preferential loans for adopting cutting-edge marine technologies related to construction vessels, port infrastructure, renewable energy, aquaculture, biotech etc. can accelerate technology indigenization. Fiscal incentives for joint R&D between industry and academia should also be introduced.

5.3 Partnerships with Leading Maritime Firms

Strategic partnerships with leading international maritime companies can enable knowledge transfer to Nigerian firms through training programs, onsite assignments, and joint projects. Partnerships in areas like offshore platforms, marine biotech, ocean mining, marine surveying and port infrastructure development must be prioritized.

5.4 Technical and Vocational Education

(i) Scholarships for students to pursue maritime engineering and naval architecture degrees abroad.

(ii) Curriculum reforms at polytechnics and technical institutes to meet industry demands.

(iii) Workforce training programs in partnership with maritime companies.

(iv) Sponsoring student competitions for designing ships, ROVs, AUVs, and ocean technologies.

5.5 Building Multidisciplinary Ocean Research and Engineering Centres

Establishing state-of-the-art research centres at universities for translational research across ocean engineering, marine sciences, data analytics and environmental management. They can serve as hubs linking academia, industry and government.

5.6 Supporting Maritime Startups and Innovation Ecosystems

Providing business incubation, grants and mentorship to Nigerian startups working on maritime technologies through dedicated programs. Collaboration with international accelerators and innovation hubs should be facilitated. Access to risk capital needs to be improved substantially.

5.7 Localization of Marine Manufacturing Capabilities

Policy initiatives and joint ventures with foreign firms are required for phased indigenous manufacturing of vessels, port equipment, cranes, offshore platforms, and other marine technology components. This will build vital self-reliance.

5.8 Attracting Maritime Talent from Nigeria's Diaspora

Leveraging networks of prominent Nigerian engineers and technicians working with leading international maritime firms by providing incentives for them to return and contribute their expertise. Their global experience can catalyze capability development.

6 New Inventions by Our Local Maritime Engineers

6.1 Design, Development and Production of AirBoat

Inventors – Engr. Dr. Tamunodukobipi Daniel, Engr. Prof. (Comr.) E.A. Ogbonnaya, Engr. F. Keribo

Airboat is propelled by aerial propeller and steered by a pair of vertical aerial rudders which direct a stream of forced air towards starboard or portside as required for manoeuvring. Both propeller and rudders are mounted in a protective cage to prevent damage resulting from flying objects or overhanging tree branches. Airboat carriage capacity depends on buoyancy, mission, and nature of route. Some airboats have buoyancy sufficient for carrying more than 10 passengers, and may be unsinkable because of built-in floaters. In the absence of floaters, a flooded airboat sinks very quickly (8-15seconds). On some, passengers are sheltered from the harsh environment using a fixed or retractable canopy. Airboat can readily climb in and out of water having a bank inclined as much as 45°. Typically, airboats do not have brakes and reverse motion. Stopping and reversing are dependent on the operator's maneuvering competence. Their characteristic Teflon-coated flat-bottom in conjunction with the absence of protrusions below the waterline enables them to safely glide over delicate vegetation, marauding animals, craggy river canals, grassland, and frozen lakes.

Figure 9: Airboat prototype

Source: (Tamunodukobipi et al, 2017)

6.2 The Real-Time Floating Surveillance Unit (RFSU)

Inventors – Engr. Azubuike John Chuku

The Real-time Floating Surveillance Unit (RFSU) concept consists of a floating structure that can be anchored in strategic locations in the gulf of Guinea and equipped with Radar and Auto Identification System in order to scan the surrounding area. The data recorded by the Radar and the AIS will be transmitted live, through a satellite antenna to a control station. The data from all the RFSUs when processed will be applied to keep a constant surveillance over the gulf. The power required for the operation of the Radar will be supplied by Solar panels, installed on the RFSU, through batteries to support the operation all the time (Chuku et al, 2017).

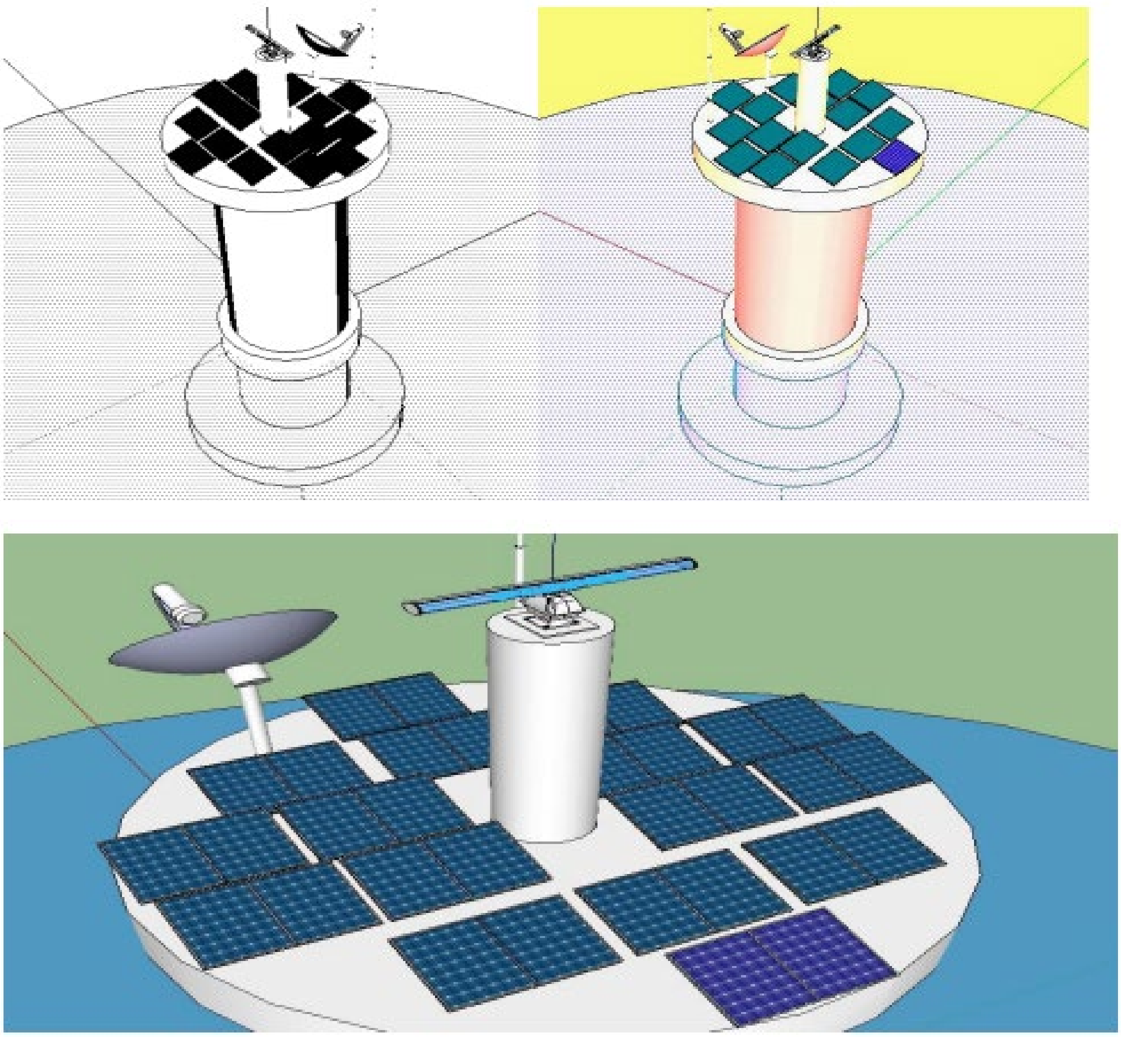

Figure 10: The RSFU and Equipment mounted on the top.

Source: (Chuku et al, 2017)

6 Conclusion

In conclusion, maritime engineering serves as a lynchpin for unlocking Nigeria's immense blue economy potential across sectors like offshore oil and gas, fisheries, transportation, and renewable energy. Developing local expertise and knowledge in this arena through targeted investments, training programs, research centers, strategic partnerships, infrastructure development and progressive policies is therefore of vital economic and strategic importance for the country's future. Sustained commitment and collaboration between government, industry and academia is essential to build a vibrant maritime engineering ecosystem over the next decade. This can significantly advance Nigeria's journey towards becoming a globally competitive blue economy.

References

Bazari, Z., & Longva, T. (2022). The Blue Economy and Maritime Affairs. Geopolitics of Natural Resources, EnerPol, 129-156.

Chidi, O.P. (2022). Nigeria's Blue Economy: prospects, challenges and the way forward. Maritime Logistics Professional. Jan/Feb 2022.

Chuku, A.J., Morrison, I., & Mkpa, A., (2017). Design analysis of Offshore Antipiracy Real-Time Floating Surveillance Unit (RFSU); A Case Study of the Gulf Of Guinea. World Journal of Engineering Research and Technology. WJERT, 2018, Vol. 4, Issue 1, 139-154. ISSN 2454-695X. www.wjert.org

Mfon, E. E., Ezekannagha, G. N., & Udosen, I. (2018). The potentials of inland water transportation in Nigeria: Resource for sustainable development. Journal of Transportation Technologies, 08(04), 327-340.

Federal Ministry of Agriculture & Rural Development (2022). National Fisheries Development Plan (NFDP) 2022-2026.

Federal Ministry of Power (2022). Nigeria Energy Transition Plan.

NIMASA (2022). Indigenous Capacity Statistics Bulletin, Vol 2, Issue 1. Nigerian Maritime Administration and Safety Agency, November 2022.

Okonkwo, C., Kumar, L., & Taylor, S. (2018). The Niger Delta wetland ecosystem: What threatens it and why should we protect it?. African Journal of Environmental Science and Technology, 12(5), 173-190.

Sharma, R. (2022). Role of Emerging Maritime Engineering for Blue Economy. Marine and Offshore Engineering, Springer, Singapore.

Silver, J.J., Gray, N.J., Campbell, L.M., Fairbanks, L.W., & Gruby, R.L. (2015). Blue economy and competing discourses in international oceans governance. The Journal of Environment & Development, 24(2), 135-160.

Thien, P. Q., Hieu, N. K., and Vuong, P. M. (2015). "Numerical simulation of floating airboat: Estimation of hydrodynamic forces", Int'l J. of Mech. Engg and Applications, doi: 10.11648/j.ijmea.s.2015030103.17.