Journal of Engineering Research and Reports

Volume 25, Issue 12, Page 128-149, 2023; Article no.JERR.109960
ISSN: 2582-2926

The Construction Challenges of Uhuru II Wagon Vessel by Local Engineers under Expatriate Training and Supervision in the Lake Victoria Basin Kisumu, Kenya

Jared K. Makone [a*]

[a] *Department of Civil and Modular in Maritime Industry, Kenya Shipyards Limited, P.O. Box 95359 – 80104, Kenya.*

Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/JERR/2023/v25i121047

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/109960

Original Research Article

Received: 17/10/2023
Accepted: 21/12/2023
Published: 23/12/2023

ABSTRACT

The MV Uhuru II is a cargo ship designed to transport cargo within Lake Victoria. It is a powerful and reliable vessel, equipped with a range of sophisticated systems that are essential for its safe and efficient operation. MV Uhuru I and her sister ship MV Umoja were built in 1965 by Yarrow Shipbuilders in Scotstoun, Glasgow, Scotland, and entered service in 1967. At over 300 ft (91 m), they were the longest vessels on any of the East African lakes. The two vessels were owned and operated by the East African Railways and Harbors Corporation (EARH) until 1977, when EARH was divided between Kenya, Tanzania and Uganda. This research paper aims to explore the challenges encountered during the construction of the first vessel in the Lake Victoria Basin by local Engineers. The study provides insights into the various obstacles faced by researchers, engineers,

**Corresponding author: Email: jakambaga@gmail.com;*

and stakeholders involved in the project by identifying and analyzing these challenges. This paper seeks to contribute to future vessel construction efforts in the region. Local shipbuilding industry seeks to harness the potential of the oceans, lakes and coastal areas while ensuring their long-term health and productivity for future generations. It is estimated that the blue economy, if used properly, has the potential to inject up to 4.8 billion US dollars to Kenya's economy and create over 52,000 jobs in the next 10 years. This, combined with a sustainable approach, should make a difference in the protection of maritime ecosystems. The Lake Victoria Basin is a significant water body in East Africa, providing a vital transportation route and supporting various economic activities; ensuring the long-term viability of fish stocks by implementing effective management practices, combating illegal fishing, and promoting sustainable fishing methods, expanding and promoting responsible aquaculture practices to meet the growing demand for seafood while minimizing environmental impacts. Enhancing port infrastructure, improving maritime connectivity, and optimizing logistics to facilitate trade and economic growth within East Africa region. Constructing a vessel in this region poses unique challenges due to the geographical, environmental, and logistical factors. Hence there is a need to focus on the difficulties encountered during the First-time local Construction of MV Uhuru II wagon Vessel by local engineers under expatriate supervision in the Lake Victoria Basin Kisumu. Kenya needs to formulate a clear and detailed strategy outlining the vision, goals, and steps required to become a pioneer in shipbuilding. This strategy should consider market demand, infrastructure development, skills training, and regulatory frameworks and should invest in the necessary infrastructure to support shipbuilding activities. The MV Uhuru II is a cargo ship designed to transport cargo within Lake Victoria. It is a powerful and reliable vessel, equipped with a range of sophisticated systems that are essential for its safe and efficient operation. One of the most important systems on the MV Uhuru II is its hull structure. MV Uhuru II is the first-class ship built in Kenya from scratch, the ship project costed Kshs 2.4billion until it's completion at period of 24 months and marked Kenya the pioneer of shipbuilding in Africa. The vessel has been constructed and assembled locally saving Kenya tax payer Kshs 1.3billion an amount that could have been spent on importation MV Uhuru II with capacity of 1063 tons was built at the Kenya Shipyards by Kenya agencies including Kenya Defense Forces, the Technical skilled civilian and including partnership with a Dutch firm, Damen Shipyards. These was the part of the Government plan to revive maritime trade and promote blue economy activities in Lake Victoria basin. The vessel built were comfortably carry 22 wagons of capacity of two million liters of crude oil per trip across the lake and can sail to the neighboring Uganda and Tanzania within 10 hours at speed of 14 Knots as compared to MV Uhuru I which sail 17hours at the same distance, The vessel undergone modular approach in shipbuilding industry, this involved the construction of sections or modules of a ship in different locations, which were then assembled to form the complete vessel. While this approach had several advantages such as increased efficiency, cost-effectiveness, and flexibility, it also presented a number of challenges. Securing adequate funding for this sector for vessel construction projects in the Lake Victoria Basin is often difficult due to economic constraints. The biggest challenges facing shipbuilding in Africa is lack of adequate capital investment. Investors are still skeptical about investing in the African shipbuilding industry, and government often doesn't prioritize it in their budgets at the moment, because it's a new local technology exploration. This is one of major challenges Kenya Shipyards Limited will face in future if this technology is not tapped and introduced to our local universities. Unforeseen challenges and delays during construction can lead to cost overruns, impacting the financial viability of the project. The African shipbuilding industry may be limited by the lack of market opportunities and competition from well-established shipbuilding nations in the developed world.

Keywords: Challenges; first time construction; local engineers; Lake Victoria Basin; Uhuru II wagon.

1. INTRODUCTION

Shipbuilding industry in East Africa remains the major challenge because of lack of steel manufacturing industry, skilled manpower, and operational technology. In this project collaboration and partnership with well-established shipbuilding companies were engaged for technology transfer to local engineers. These partnerships facilitated the exchange of knowledge and expertise, driving innovation, improving efficiency and enhancing competitiveness. It allowed shipbuilder to access and implement advanced technologies, ultimately leading to the development of more advanced and sustainable MV uhuru II ship.

1.1 Ship Construction Industry Technology Revolution

Through mid-1960s two major technological developments in the shipping business have played a major role in the shipping market. These have been the unitization and bulk shipping, which have opened up a more global market for manufactured and raw materials. As previously stated, the unitization and bulk shipping were major technological revolutions where the unitization of the liner shipping business during the 1960s since the “break bulk” liner shipping had become unable to manage the increasing volumes of world trade. This made everyone realize that the old methods had reached its end. In order to overcome this problem of increasing volume, palletization and containerization were introduced to speed up the flow of cargo. Before the introduction of these new technologies a goods shipped from Europe to United States could take a couple of months to arrive, however with technological improvements these routes have been cut down to a few days after leaving the factory. So, the shipping industry “used organization to solve its own fundamental problems and, in doing so, opened floodgates for the development of the global economy”. The bulk shipping revolution was just as huge of an improvement as the unitization, where the first bulk transport of raw materials by sea could be viewed as a part of the integrated materials handling operation, in which investments could improve productivity. Just by investing in bulk transport, costs could be reduced to such an extent that it became cheaper for the industries to import raw materials by sea from suppliers located thousands of miles away, comparing with land suppliers located only a few hundred miles away from the industries. As technology progressed, more fuel-efficient diesel engines could be made, with an increase in 25 percent of fuel efficiency during the 1980s. Shipbuilders became more innovative and could adapt fine tuning hull designs, which resulted in cutting down the usage of steel on ships by 30 percent, the improved hull paints gave a better smoothness and submerged hull and made ships more durable and long lived. With the development of hulls and engines, steel ships and the steam engines, and later on the internal combustion engines, the shipping industry increased dramatically. This fast-growing evolution in technology led to major opportunities within the shipping market, and new shipping players to emerge, and also establishment of larger vessels. Not only has the shipping industry been growing with more efficient ships, but also the size of the ships has increased. As Stopford (1997) brings up how Adam Smith (1776) spoke enthusiastically about the efficiency of the ship that “carries and brings back 200 tons weight of goods”, already in 1876, the shipping had evolved into making vessels that carried 3000 gross tons. Today a handy bulk carrier is 45000dwt. Argues that the most outstanding example of increase in size of vessels has been in the oil industry, since during the twentieth century, the average size of tankers increased from 4000 tons to 95 000tons [1].

1.2 Earlier Construction of Vessels in East Africa

Since the 1900s, Lake Victoria ferries have been an important means of transport between Uganda, Tanzania, and Kenya. The main ports on the lake are Kisumu, Mwanza, Bukoba, Entebbe, Port Bell, and Jinja. Until 1963, the fastest and newest ferry, MV Victoria, was designated a Royal Mail Ship. In 1966, train ferry services between Kenya and Tanzania were established with the introduction of MV Uhuru I and MV Umoja. The ferry MV Bukoba sank in the lake on 21 May 1996 with a loss of between 800 and 1,000 lives, making it one of Africa's worst maritime disasters. Another tragedy occurred on 20 September 2018 that involved the passage ferry MV Nyerere from Tanzania that caused the deaths of over 200 people. On 6 November 2022, Lake Victoria was the site of a commercial passenger aircraft crash. Precision Air Flight 494 an ATR 42–500 carrying 39 passengers and four crew, crashed while approaching Bukoba Airport, resulting in 19 fatalities. MV Uhuru I is Now in operational at Lake Victoria ferry in East Africa. She is a Kenya Railways Corporation train ferry that operated between Jinja, Mwanza, Musoma and Kisumu. Uhuru means "freedom" in Swahili.

MV Uhuru I and her sister ship MV Umoja were built in 1965 by Yarrow Shipbuilders in Scotstoun, Glasgow, Scotland, and entered service in 1967. At over 300 ft (91 m), they were the longest vessels on any of the East African lakes. The two vessels were owned and operated

MV Uhuru I anchored at Kisumu Docks

History	
Name	**MV *Uhuru***
Port of registry	Kisumu
Route	On Lake Victoria between Jinja, Mwanza, Musoma& Kisumu
Builder	Yarrow Shipbuilders
Yard number	2243
Launched	1965
In service	1966
General characteristics	
Type	Train ferry
Tonnage	1,180
Length	over 300 ft (91 m)
Draught	8 ft 8 in (2.64 m)
Installed power	800 hp (600 kW) V-8 diesel
Propulsion	screw

Fig. 1. General data for MV Uhuru I

Fig. 2. Dry dock during Construction period in 1905

by the East African Railways and Harbors Corporation (EARH) until 1977, when EARH was divided between Kenya, Tanzania and Uganda. MV Uhuru I was transferred to the new Kenya

Railways Corporation and Umoja was transferred to the new Tanzania Railways Corporation, little a while MV Uhuru I was suspended from service in 2007. It was later revived in late 2019, MV Uhuru I was constructed at the FlenderWerft Shipyard in Lubeck Germany, after its construction the vessel was disassembled into sections, transported by road to the Kenya port city of Kisumu, and then reassembled on the shores of Lake Victoria. The reassembly process took several months and required the expertise of both German and Kenyan Engineers. Once reassembled, MV Uhuru I was launched into Lake Victoria in 1967.

1.3 Dry Dock Construction at Kisumu Port

The Dry dock started Construction earlier as 1905 by Sir William MacKinnon and he was a Scottish ship-owner and businessman who built up substantial commercial interests in India and East Africa. The yard built three "knock down" ferries for Lake Victoria in East Africa. RMS Victoria was built in Scotstoun in 1960 and reassembled at the Kenyan port of Kisumu (Kenya shipyards limited Yard) on the lake in 1961. The train ferries MV Umoja and MV Uhuru I was built in Scotstoun in 1965 and reassembled at Kisumu in 1965 and 1966. Since then, this dry dock had been idle, clogged with silt for a decade up to recently the dock was revived and dredged prior for the operation of constructing MV uhuru II vessel.

The Dry dock where MV Uhuru II undergo construction process was constructed to handle a vessel up to 96m long, its sizes are 106m long by 18m wide and its depth from Lower water level is about 5.4m deep.

1.4 Renovation and repair of dry dock structure prior for Construction of MV Uhuru II

In 2018 the operation of reviving the construction of vessels opened up as blue economy for the manufacturing, repair and refit of large and small vessel to contribute to the blue economy of the country. [2] The proposal for Construction of MV Uhuru II wagon ferry was to resemble MV Uhuru I Wagon but with modernized navigation systems as compared with most of Vessels in Lake Victoria. Kisumu dry dock structure was used to undergo ship construction process after fully rehabilitation and repair completion. During this period the dry dock front gate was closed and the water was pumped out to give room for the construction of the MV Uhuru II wagon vessel, in that regard sand bags filled with sand materials were installed at the front of the gate to protect water seeping out to the dry dock hence caused the height of the exit channel to raise up making it impossible for the vessel to sail out. And with time the entire passage had been filled in by siltation, and the depth reduced when structures around were renovated i.e., Finger pier since then, it has not been maintained. Due to that reason, dredging at the front of the gate was necessary to increase the channel depth for the vessel to sail out without a problem. [3] The channel had been dredged to a depth of average of 4m.

1.5 Construction of MV Uhuru II wagon ferry 10018

The MV Uhuru II is a cargo ship designed to transport cargo within Lake Victoria. It is a powerful and reliable vessel, equipped with a range of sophisticated systems that are essential for its safe and efficient operation. One of the most important systems on the MV Uhuru II is its hull structure. The ship’s hull is designed to be strong and durable, capable of withstanding the stresses and strains of heavy cargo and rough waters.

The hull is constructed from high-quality steel and carefully welded together to form a watertight enclosure that will protect the cargo and crew from the elements.MV uhuru II is the first-class ship built in Kenya from scratch, the ship project costed Kshs 2.4billion until it’s completion and marked Kenya the pioneer of shipbuilding in Africa. The vessel has been constructed and assembled locally saving Kenya tax payer Kshs 1.3billion an amount that could have been spent on importation. MV Uhuru II with capacity of 1063 tons was built at the Kenya Shipyards by Kenya agencies including Kenya Defense Forces, the Technical skilled civilian and including partnership with a Dutch firm, Damen Shipyards. These was the part of the Government plan to revive maritime trade and promote blue economy activities in Lake Victoria. The vessel built were comfortably carry 22 wagons of capacity of two million liters of crude oil per trip across the lake and can sail to the neighboring Uganda and Tanzania within 10 hours at speed of 14 Knots as compared to MV Uhuru I which sail 17hours at the same distance, (Managing Director. Maj Gen. Paul Otieno statement, 2022).

Fig. 3. Dredging work at dry dock frontage

MV *Uhuru* II anchored at Kisumu Docks

History	
Name	**MV *Uhuru***
Port of registry	Kisumu
Route	On Lake Victoria between Jinja, Mwanza, Musoma&Kisumu
Builder	Kenya shipyards limited, Kisumu under license of Damen Shipyards Gorinchem
Yard number	523302
Launched	2023
In service	2024
General characteristics	
Type	Wagon ferry 10018 (WAFE10018)
Tonnage	1,350t
IMO Reg. Number	9933298
Length	99.52 m
Draught	2.60 m
Installed power (Main Engine)	PB=1250 bkW
Installed power (Bow thruster)	PB=447 kW, PS=404 kW,
Propulsion	Fixed Pitch, conifer, CU3/CuAINi

Fig. 4. General Data For MV Uhuru II

Fig. 5. MV Uhuru I & II at Kisumu linkspan

1.6 The Local Economic Structure in Maritime Industry

The economic structure of the Republic of Kenya depends strongly on foreign trade, and a major of its freight distribution is a marine transportation. [4] Through the blue economy has great potential to contribute to higher and faster GDP growth in Kenya, innovation and growth in the coastal, marine and maritime sector could deliver food, energy, transport and mining that serve as foundation for sustainable development in the country. [5] On the Agenda of Vision2030 the blue economy aims to balance economic growth with environmental sustainability, social inclusivity, and resilience. It seeks to harness the potential of the oceans, lakes and coastal areas while ensuring their long-term health and productivity for future generations. It is estimated that the blue economy, if used properly, has the potential to inject up to 4.8 billion US dollars to Kenya's economy and create over 52,000 jobs in the next 10 years. This, combined with a sustainable approach, should make a difference in the protection of maritime ecosystems [6].

1.7 East Africa Inland Ports Towards Implementation of Blue Economy Structure

Kisumu Port which is an inland port is small harbor that serves eastern Africa trade in four countries and is directly exposed to the full energy of the Lake Victoria basin. Because of this natural condition, there is a limit on the capacity of freight handling, especially for containers. [7] There was no enough facility in the port which could manage the increasing of lake borne traffic and an international trend of containerizing freight transportation. The Lake Victoria Basin is a significant water body in East Africa, providing a vital transportation route and supporting various economic activities; ensuring the long-term viability of fish stocks by implementing effective management practices, combating illegal fishing, and promoting sustainable fishing methods, expanding and promoting responsible aquaculture practices to meet the growing demand for seafood while minimizing environmental impacts. [8] Enhancing port infrastructure, improving maritime connectivity, and optimizing logistics to facilitate trade and economic growth. Promoting the development and utilization of renewable energy sources such as offshore wind, tidal, and wave energy to reduce reliance on fossil fuels and mitigate climate change. Supporting sustainable tourism initiatives that protect coastal ecosystems, preserve cultural heritage, and provide economic opportunities for local communities. [9] Strengthening marine protected areas, promoting biodiversity conservation, and addressing pollution and marine debris to safeguard marine ecosystems and their services. Investing in scientific research, technological innovation, and capacity building to support sustainable blue economy practices and develop new solutions for challenges in the maritime sector [10].

1.8 Pioneer Hub for Shipbuilding Industry in Africa

Constructing a vessel in this region poses unique challenges due to the geographical, environmental, and logistical factors. Hence there is a need to focus on the difficulties encountered during the First-time local Construction of MV Uhuru II wagon Vessel by local engineers under expatriate supervision in the Lake Victoria Basin Kisumu. Kenya needs to formulate a clear and detailed strategy outlining the vision, goals, and steps required to become a pioneer in shipbuilding. This strategy should consider market demand, infrastructure development, skills training, and regulatory frameworks and should invest in the necessary infrastructure to support shipbuilding activities. This includes building shipyards, dry docks, and manufacturing facilities. Adequate infrastructure will attract investors and enable efficient shipbuilding operations. Encourage research and development initiatives to enhance shipbuilding technologies, materials, and processes. Collaborate with universities, research institutions, and industry experts to drive innovation and stay ahead of global trends and establish vocational training programs and partnerships with technical institutions to develop a skilled workforce specialized in shipbuilding. This includes training welders, naval architects, marine engineers, electricians, and other relevant professionals [11].

Collaborate with international shipbuilding companies, governments, and industry associations to gain knowledge, expertise, and technology transfer. Joint ventures and partnerships can accelerate the learning curve and provide access to global markets and develop policies and regulations that support shipbuilding, such as tax incentives, streamlined permit processes, and supportive legal frameworks. This will attract investors and encourage local shipbuilding enterprises to thrive. Encourage the use of locally sourced materials and components in shipbuilding projects. This will boost the local economy, create jobs, and enhance the country's self-sufficiency in shipbuilding. Actively market Kenya's shipbuilding industry to attract international clients and investors. Participate in international trade shows, exhibitions, and conferences to showcase the country's shipbuilding potential. Establish quality assurance and certification standards: Implement stringent quality assurance processes and obtain internationally recognized certifications to ensure the ships built in Kenya meet global standards. This will enhance the reputation and competitiveness of Kenyan shipbuilding and establish financial mechanisms, such as low-interest loans, grants, and investment funds, to support shipbuilding projects and facilitate access to capital for local shipbuilders.

1.9 Problem of the Study

Transport system within the lake region plays a critical role in the livelihoods of the residents of the lake basin Kisumu, Kenya. However, the sector has been experiencing a problem of underutilization of water resources due to poor network within the lake among other challenges. The contribution of the transport sector to global economy cannot be underestimated [12]. Despite numerous attempts towards improving blue economy, transport utilization within our waters in Africa is still low when compared to other parts of the world. Within the overall blue-based economy of the country, navigating within the lake and oceans in whatever means is crucial for the livelihoods, income generation, security and employment opportunities and food supply through fishing to millions of people worldwide. Transportation within the lake for instance encourages the fish farming thus, helps the poor and directly promotes their living standard. [13] Kenya’s fisheries sector plays a major role in the county’s blue economy, for example; in 2006 the subsector contributed 0.5% to GDP the figure is likely to increase if value additions at various stages of the supply chain and post harvesting losses are taken into consideration. In terms of security, the transport system within our waters will be enhanced since our border lake and oceans are among the porous entries of pirates and Al-Shabaab militia. The objective of this study therefore was to examine the main challenges faced during construction of transport vessel MV Uhuru II wagon ferry, to examine how limited infrastructure and inadequate facilities for shipbuilding can pose challenges during construction. [14] The availability of suitable shipyards, dry docks, and necessary equipment may be limited, requiring additional investments and logistical planning, to know how lack of skilled labor with expertise in shipbuilding techniques, naval architecture, and marine engineering can be a challenge. Training and developing a skilled workforce may be necessary to meet the specific requirements of ship construction, to determine chain supply and logistics in East Africa may face challenges in terms of the availability and timely delivery of raw materials, components, and equipment required for shipbuilding [15]. Establishing a robust supply chain and efficient logistics network is crucial to ensure smooth construction operations, to know if local policies and regulations are adhering to international maritime regulations and standards can be challenging, especially if the local regulatory framework is not well-developed or lacks specific provisions for shipbuilding. [16] Ensuring compliance with safety, environmental, and quality standards is essential, to know the if securing adequate financing and investment for shipbuilding projects can be challenging, as it requires significant capital investment. Attracting investors and securing long-term funding can be a hurdle, especially if the shipbuilding industry is not well-established in the region, to know how technology transferring advanced shipbuilding technologies and expertise to East Africa can be a challenge. [17] Collaboration with international shipbuilding companies, partnerships, and knowledge-sharing initiatives can help bridge the technology gap and enhance local capabilities and finally, to monitor and assessing market demand and identifying potential customers for the ships being constructed is crucial. Understanding the competitive landscape and positioning the shipyard to compete effectively in the global market can be challenging [18].

2. MATERIALS AND METHODS

2.1 Ship Design Phase

This is the initial phase where the design of the ship wagon ferry started from conceptual stage. It involved a lot of calculations and simulations to ensure the design is safe and efficient. The design included the overall structure, the machinery, and the systems that were installed.

The ultimate project review tool allows users to walk through the 3D model or point clouds, combine several models into one or compare them with each other, check collisions, easily locate and check details about any object, get dimensions and make markups for project coordination and change management.

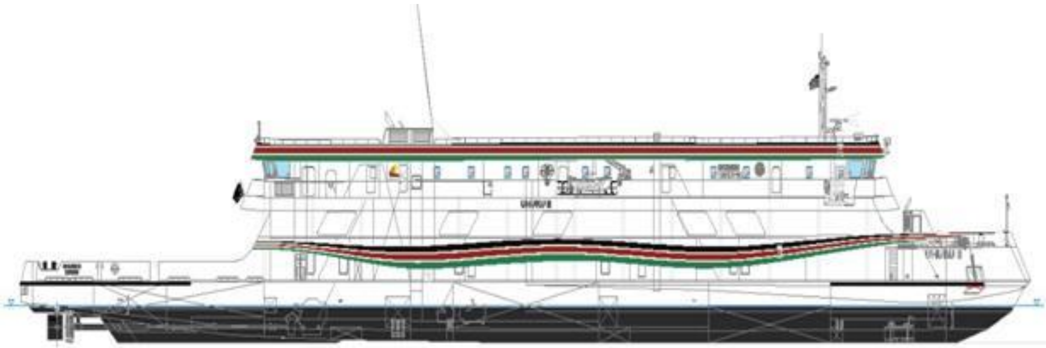

Fig. 6. General outlook of MV Uhuru II

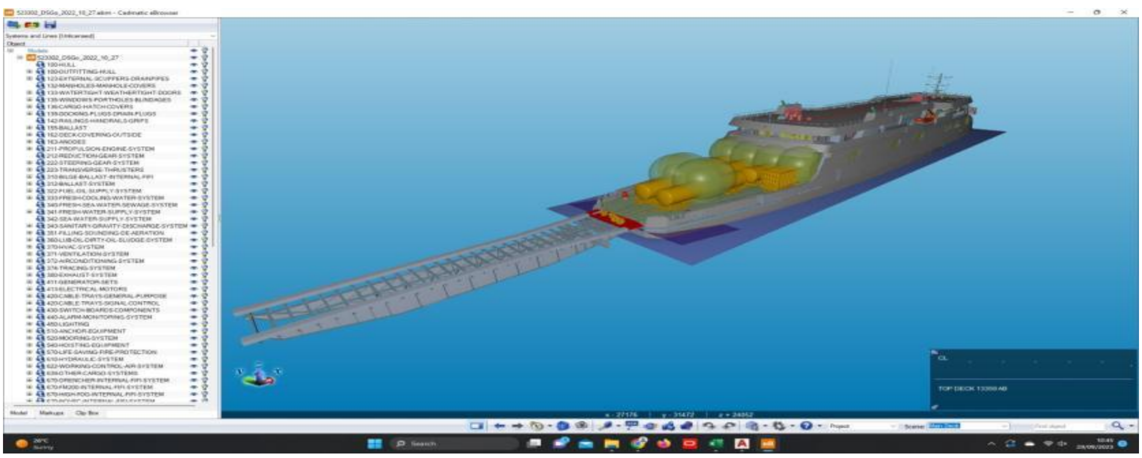

Fig. 7. Cadmatic eBrowser applications installed with MV Uhuru II 3D drawings

This software is integrated with other ship design and engineering software, such as structural analysis tools and production planning systems [19]. This integration enabled a smooth transfer of data between different software platforms, ensuring consistency and accuracy throughout the design and production processes. Excel files are a very popular and easy way to store and exchange all kinds of information within projects. [20] Often, purchasing or production departments use such files extensively. Using the out-of-the-box Excel adapter, the user can merge data stored in these files with other project-related data in CADMATIC e-Browser with a simple setup, an Excel file can be linked to project and data displayed for a 3D object or used for hierarchies or in color coding [21].

2.2 Shipbuilding material Acquisition

Once the design is finalized, the necessary materials were acquired. This often included steel, aluminum, and other materials like wood were commonly used for wagons. Materials were internationally and locally sourced; big metal plates cut was suit and sourced from China; some few metals were locally purchased for the hulling work. Outfitting machines were sourced from Europe including Caterpillar Engines, Gear box, Propeller Generators and Motors and other systems for outfitting.

2.3 Yard and Dry Dock Preparation

The dry dock existed since 1960’s before the construction of the vessel began rehabilitation and renovation of the yard started including repair of existing linkspan, the office facilities and workshops were constructed to facilitate the departmental coordination for the MV Uhuru II construction.

2.4 Ship fabrication Phase

This is where the physical construction begins. The materials are cut and shaped according to the design. For ships and ferries, this often starts with the keel laying, which is the first step in constructing the hull. For wagons, the frame is usually built first.

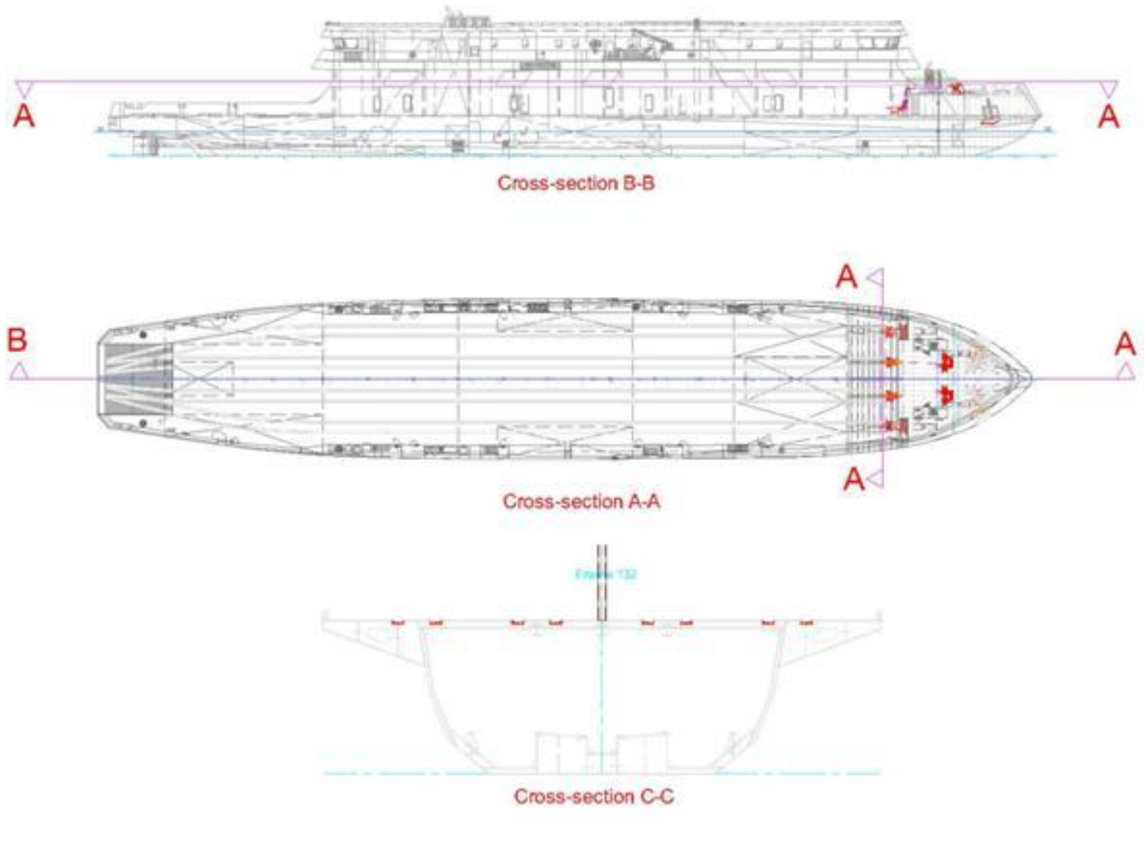

Fig. 8. General layout plan for MV Uhuru II wagon ferry

Chart 1. Specification for MV Uhuru II materials

Material type	Specification for MV Uhuru II
Steel	S235JR
Aluminum	A1200P, H112
Engines	Cat 3512C HD, power 1250kW, speed 1600rpm
Gear box	Reintjes WAF 763L, Ratio I = S.136
Propeller	FPP-5blades, 311.5rpm, nickel AL bronze (Cu3), D-1700mm
Shaft	S355N,250mm diameter
Genset 1	Cat C9.3 DITA power 270kw 1500rpm output 313kva 50Hz
Genset 2	Cat C4.4 Acert DITA power 108.6kw 1500rpm output 123kva 50Hz

Fig. 9. Preparation of dry Dock prior for MV Uhuru II Construction

Fig. 10. Fabrication of first hull section for MV Uhuru II wagon

2.5 Ship Assembly Phase

The cut and shaped parts are assembled to form the structure of the ship, wagon, or ferry. This is a complex process that requires precision and skill.

2.6 Ship Outfitting Phase

After the basic structure is assembled, the ship, wagon, or ferry is outfitted with necessary equipment and systems. This includes installing engines, electrical systems, and other necessary machinery. In addition to its hull structure, the MV Uhuru II is also equipped with an advanced piping system. The piping systems are used to transport oil from the ship’s cargo tanks to its engines, where it is used to power the ship’s propulsion system. The piping system is carefully designed to ensure that the oil is delivered to the engines at the correct pressure and temperature, which helps to maximize the engines' efficiency and performance. The ship's engines are the heart of its propulsion system, providing the power and reliability needed to move the ship through the water. They are equipped with Caterpillar 3500 series four-stroke, V-type, turbocharged marine diesel engines that are well suited for the demands of commercial shipping. These engines are designed to be rugged and reliable, with a proven track record in the marine industry. They can deliver high power output and are known for their fuel efficiency, which helps the ship to conserve fuel and reduce its carbon footprint.

The engines are connected to the ship's propulsion system through a complex network of pipes and valves that carefully regulate the flow of oil from the tanks to the engines. The piping system is carefully designed to ensure that the oil is delivered to the engines at the correct pressure and temperature, which helps to maximize the engines' efficiency and performance. The engines are also equipped with advanced control systems that enable the crew to monitor their performance in real-time. This helps the crew to adjust the engines' settings, if necessary, to optimize their performance and ensure that they are operating at their peak efficiency.

In addition to the engines themselves, the ship is also equipped with a variety of ancillary systems that are essential for operation. These systems include fuel pumps, filters, and separators that ensure that the engines receive clean and properly filtered fuel. The engines are also equipped with advanced cooling systems that help to regulate temperature and prevent them from overheating. The cooling system is designed to draw water from the lake and circulate it through the engines, where it absorbs heat and is discharged back into the lake. Another important system of MV Uhuru II is its electrical equipment. The ship is equipped with a variety of generators and electrical cables that produce the electricity needed to power the ship's navigation system, communication systems, lighting, and other essential equipment. The electrical system is designed to be reliable and robust, capable of operating even under the most demanding conditions.

Finally, the MV Uhuru II is equipped with a firefighting system, which is essential in case of a fire emergency on board. The firefighting system is designed to quickly detect and extinguish fires to protect the crew, cargo, and the ship itself. The firefighting system consists of several components, including fire alarms, fire suppression equipment, and fire extinguishers. The fire alarms are strategically placed throughout the ship, and they are designed to quickly detect any signs of a fire. Once a fire is detected, the alarms automatically trigger the suppression equipment, which floods the affected area with water or foam to extinguish the fire

Fig. 11. Installation of Keel blocks and pipe stand

Fig. 12. Fabrication of the sections

Fig. 13. Transportation of sections from fabrication yards

Fig. 14. Installation of first section

Fig. 15. Installation of upper deck section

Fig. 16. Construction of bridge deck

Fig. 17. MV Uhuru II during painting work

Fig. 18. Piping system

Fig. 19. Main engines

Fig. 20. Ballast motors

The fire extinguishers are also strategically placed throughout the ship, and the crew is trained to use them in case of a fire emergency. Fire extinguishers come in diverse types, depending on the type of fire they are designed to extinguish. For example, a CO2 fire extinguisher is used for electrical fires, while a water-based extinguisher is used for ordinary combustible fires. The firefighting system also includes a dedicated fire pump, which is capable of supplying water to the fire suppression equipment at high pressure. This ensures that the fire is extinguished quickly and that the crew and ship remain safe. In addition to the firefighting system, the MV Uhuru II is also equipped with a fire prevention system. This includes regular maintenance and inspections of the ship's electrical equipment, piping systems, and engines, to ensure that they are in good working condition and free from any potential fire hazards. The crew also receives regular fire safety training to ensure that they are prepared in case of a fire emergency.

Overall, MV Uhuru II is a state-of-the-art cargo ship, equipped with a range of advanced systems that are essential for its safe and efficient operation. From its hull structure and piping systems to its engines, electrical equipment, and firefighting system, every aspect of the ship has been carefully designed and constructed to ensure that it is able to meet the demanding needs of commercial shipping. When it finally sets sail on Lake Victoria in October-2023, MV Uhuru II will be a testament to the ingenuity and skill of the engineers and builders who worked tirelessly to bring it to life. And for the crew who call it home, it will be a source of pride and a symbol of their commitment to excellence and safety.

2.7 Ship Commissioning and Testing Phase

Once the ship, wagon, or ferry is fully assembled and outfitted, it undergoes rigorous testing to ensure everything works as it should and that it is safe for use.

2.8 Ship Delivery Phase

After successful testing, the ship, wagon, or ferry is delivered to the customer. For ships and ferries, this often involves a maiden voyage to its new home port.

2.9 Analysis and Interpretation of the Challenges Faced During Construction

Modular approach in shipbuilding industry involves the construction of sections or modules of a ship in different locations, which are then assembled to form the complete vessel. While this approach has several advantages such as increased efficiency, cost-effectiveness, and flexibility, [22] it also presents a number of challenges:

a. **Coordination and Communication:** With different modules being built in different locations, often by different teams, effective coordination and communication is crucial. Any miscommunication can lead to delays, increased costs, and even errors in the final product.
b. **Quality Control:** Ensuring consistent quality across all modules can be challenging. If one module is substandard, it can affect the entire ship. Therefore, rigorous quality control measures need to be in place across all locations.
c. **Integration:** The integration of different modules can be complex and time-consuming. Each module needs to fit perfectly with the others, and any misalignment can lead to serious problems.
d. **Logistics:** Transporting large modules from different locations to the assembly site can be logistically challenging and expensive. It requires careful planning and coordination [23].
e. **Design Constraints:** The need to design ships in a modular fashion can impose constraints on the overall design of the ship. Some designs may not be feasible or efficient when built in a modular way
f. **Technical Skills:** The modular approach requires a high level of technical skills and expertise. There may be a shortage of such skills in the industry, especially in certain locations.
g. **Risk Management:** If a problem arises in one module, it can delay the entire project. Therefore, risk management is crucial in the modular approach to shipbuilding.

Fig. 21. MV Uhuru II during testing and trials

Fig. 22. MV Uhuru II during commissioning

2.10 Specific challenges encountered during Construction of MV Uhuru II wagon ferry

2.10.1 Geographical and environmental challenges

a. **Shallow Waters:** Lake Victoria has several shallow areas, making it challenging to navigate and construct vessels.

b. **Invasive Aquatic Plants and lake flies:** The presence of invasive aquatic plants, such as water hyacinth, poses challenges to vessel construction and maintenance.

c. **Stick of lake flies to wet paint:** During the painting stage of MV Uhuru II, there were various mosquitoes and insects that used to stick in the paint at night and sometime in the day since the dry dock where painting used to take place is very

close to the lake. This insect attack was a major challenge since they used to stick in the paint and therefore this meant the painting had to be redone. This led to wastage of paint than the initial budget of the paint.
This challenge was solved through frequent fumigation of the insects.

d. **Weather Conditions:** Unpredictable weather patterns, including strong winds and storms, heavy rains increase the complexity of construction activities.

Heavy rains especially in the months of March and September, too much sun also affected and made it difficult to work. They improvised shades for shelter due to these harsh weather conditions. There were also seasons with heavy rains and during such times many activities had to stop since it was almost impossible to work with the heavy rains. The improvision of shades played a big role here as well.

2.11 Logistical Challenges

a. **Limited Infrastructure:** Insufficient infrastructure, including ports, shipyards, and skilled labor, hampers the vessel construction process.

There was much power needed during various stages of the vessel construction like when a lot of welding activities were taking place. The fact that there were many machines on the site at times made it become difficult to maintain the power flow. This was a challenge at times like in those days when there was no power supply at all or during blackouts. The yard needed a reliable power supply and therefore they introduced heavy generators which helped in sorting this out. The lack of good infrastructure, such as reliable power supply, good transportation networks, and communication, hamper the growth of shipbuilding.

b. **Material Sourcing:** Difficulties in sourcing adequate and quality materials for construction within the region.
c. **Transportation/ inadequate supply chain:** Lack of proper transportation infrastructure for moving heavy equipment and materials to the construction site.

Shipbuilding requires well-developed supply chain, something that is lacking in many African countries. This is essential in terms of sourcing materials, parts and equipment. KSL had to ship most of the materials and consumables from Damen. Some of these took up to two months before getting them delivered to the yard. This led to delay of the vessel since most activities had to stop during such times to wait for the delivery.

2.12 Technical Challenges

a. Design and Engineering / Limited availability of skilled labor: Developing vessel designs suitable for the unique conditions of Lake Victoria presents technical complexities.

Shipbuilding requires specialized skills and expertise, and there may be a shortage of skilled labor in Africa, further compounded by the brain drain of skilled workers seeking greener pastures abroad. Various workers that joined the yard had up to zero experience in the shipbuilding field in various areas like welding, boiler making, scaffolding, electrical, pipe fitting, Insulation and carpentry. There were modern machines that most people had no idea on how they were used and Therefore training had to be done from the beginning to make the work easier. A lot of resources and time were invested in training these employees and after all this the yard was not in a position to retain all the employees due to financial strains and therefore most of the trained employees had to leave at some point. This resulted in a waste of both time and resources that is impossible to recover.

b. Construction Techniques: Lack of expertise in constructing vessels in the region leads to challenges in adopting appropriate construction techniques.

c. Equipment and scarcity of Machinery: Limited availability of specialized equipment and machinery required for vessel construction.

A significant challenge for the African shipbuilding industry is the lack of technological innovation in the sector. This poses challenges in terms of competitiveness in the global market. During the construction of the vessel, there were few cranes and they were operating in KPA and at the same time in shipyard yet there were several activities that needed to be done on time. This led to more time consumption due to waiting

2.13 Economic and Financial Challenges

a. **Funding/ Limited capital Investment:** Securing adequate funding for vessel construction projects in the Lake Victoria Basin is often difficult due to economic constraints. The biggest challenges facing shipbuilding in Africa is lack of adequate capital investment. Investors are still skeptical about investing in the African shipbuilding industry, and government often doesn't prioritize it in their budgets. This one of major challenges Kenya Shipyards Limited was and is still facing during the construction of MV Uhuru II. In the beginning of the vessel construction there was quite a big number of employees who later had to be forced to stop working since the company could not retain the big number due to limited budget, this also made it impossible to have many employees on contract and therefore most worked as casual employees who later had to leave because the company could not retain them.
b. **Cost Overruns:** Unforeseen challenges and delays during construction can lead to cost overruns, impacting the financial viability of the project.
c. **Limited market opportunities:** The African shipbuilding industry may be limited by the lack of market opportunities and competition from well-established shipbuilding nations in the developed world.

2.14 Stakeholder Engagement Challenges

a. **Collaboration:** Coordinating efforts between various stakeholders, including government agencies, researchers, and local communities, can be challenging.
b. **Environmental and Regulatory Compliance:** Navigating complex regulatory frameworks and obtaining necessary permits and approvals for vessel construction [24].
c. **Long working hours for the employees:** There was a very limited time for the delivery of MV Uhuru II. This meant that some employees had to work for long hours and others had to work on a night shift meaning the yard was in operation for 24hours so as to deliver the vessel on time.

3. CONCLUSION

The construction of the MV Uhuru II vessel in the Lake Victoria Basin faced numerous challenges, including geographical, environmental, logistical, technical, economic, and stakeholder engagement issues. Understanding and addressing these challenges is crucial for future vessel construction projects in the region. By overcoming these obstacles, the potential benefits of improved transportation and economic development in the Lake Victoria Basin can be realized.

To solve this modular shipbuilding challenges in an area where ship construction has never been experienced by local Engineers before, here are some key steps to consider:

a. **Research and planning:** Conduct thorough research on modular shipping building techniques and best practices. Understand the specific challenges that may arise in the new area and develop a comprehensive plan to address them.
b. **Engage experts:** Seek the expertise of experienced professionals in modular construction and shipbuilding. Collaborate with architects, engineers, and contractors who have knowledge and experience in similar projects to ensure proper guidance and support throughout the construction process.
c. **Site assessment:** Conduct a detailed assessment of the construction site to identify any potential obstacles or limitations. Consider factors such as soil conditions, accessibility, infrastructure requirements, and environmental considerations. This assessment will help in designing appropriate solutions for the specific location.
d. **Adaptation and customization:** Modify the modular construction techniques to suit the unique requirements of shipbuilding in the new area. This may involve incorporating local materials, adjusting construction methods, or developing new modular systems that can withstand the local climate and conditions.
e. **Training and skill development:** Provide training and skill development programs for the local workforce to ensure they have the necessary knowledge and expertise to work on modular ship construction. This may involve partnering with educational institutions or conducting specialized training programs.

f. **Quality control and testing:** Establish stringent quality control measures to ensure the integrity and safety of the modular ship construction. Regular inspections, testing, and adherence to international standards are essential to guarantee the reliability of the final product.
g. **Collaboration and stakeholder Engagement:** Foster collaboration and open communication with local authorities, communities, and other stakeholders. Engage in dialogue to address any concerns, obtain necessary permits, and ensure compliance with local regulations.
h. **Continuous improvement:** Monitor the construction process closely and learn from any challenges or issues that arise. Implement feedback loops to continuously improve the modular construction techniques and address any unforeseen challenges.

4. RECOMMENDATION

The maritime industry in East Africa has immense potential due to its strategic location, vast coastline, and increasing trade activities. However, it is crucial to adopt efficient, sustainable, and safe practices for ship construction to ensure long-term success.

a. **Understanding the local context:** Understanding the local context is vital. This includes a comprehensive study of the local weather conditions, sea currents, and other environmental factors that can affect ship construction and operation. It is also essential to understand the local regulations, labor conditions, and available infrastructure.
b. **Infrastructure development:** Investing in infrastructure is a prerequisite for ship construction. This includes shipyards, dry docks, and repair facilities. It is recommended to collaborate with local governments and international investors for infrastructure development.
c. **Technology adoption:** Embracing advanced technology can significantly improve ship construction efficiency and quality. This includes CAD/CAM systems, automated machinery, and digital twin technology. Training local workforce to use these technologies is also crucial [25].
d. **Sustainable practices:** Adopting sustainable practices is not only environmentally responsible but can also lead to cost savings in the long run. This includes using eco-friendly materials, reducing waste, and implementing energy-efficient processes.
e. **Safety measures:** Ensuring safety during ship construction is paramount. This includes implementing strict safety protocols, providing safety training to workers, and using safety equipment.
f. **Skilled workforce:** Developing a skilled workforce is crucial for the success of ship construction. This includes providing technical training, promoting apprenticeships, and creating attractive career paths in the shipbuilding industry.
g. **Collaboration and partnerships:** Collaborating with international shipbuilding companies can provide access to advanced technology, expertise, and global markets. It is recommended to form strategic partnerships and joint ventures with established players in the industry.
h. **Regulatory compliance:** Complying with local and international regulations is crucial. This includes environmental regulations, safety standards, and labor laws.
i. **Conclusion:** With the right approach, East Africa can become a significant player in the global shipbuilding industry.

Modular shipbuilding is a method adapted in this project due to the lack of local steel manufacture to provide steel plate for the ship. Hence this plate was cut to sizes at the factory and imported in sections or modules, which later assembled on site to form the complete vessel. This method was highly beneficed, more especially in this area where ships had never been constructed fully by the Local experts, [26,27].

This helped on:

a. Efficiency and Flexibility: The modular method allowed for parallel construction of different modules, which were significantly reduced the overall construction timeline. It also provided flexibility as modules built in overseas at different locations and then transported to the assembly site.
b. Quality Control: Each module was inspected and tested individually before assembly, ensuring high quality and reduced the risk of defects in the final product.

c. Reduced Costs: The modular method had to lead to cost savings as it allowed for better planning, reduces rework, and minimizes the need for large shipbuilding infrastructure.
d. Workforce Development: Since the construction of modules were done simultaneously, it provided an opportunity for training and developing the local workforce in various aspects of shipbuilding.

To overcome these challenges, it would be recommended to:

a. Invest in Infrastructure: Build the necessary infrastructure and steel factory to support modular shipbuilding. This could include facilities for module construction, assembly, and testing, as well as transportation infrastructure.
b. Develop a Skilled Workforce: Invest in training programs to develop the local workforce. This could include partnerships with local educational institutions or on-the-job training programs.
c. Establish a Reliable Supply Chainwork with local and international suppliers to ensure a reliable supply of materials and components. This could include establishing long-term contracts or developing local suppliers.
d. Collaborate with Experienced Partners: If possible, collaborate with experienced shipbuilders who can provide technical expertise and guidance. This could help to avoid common pitfalls and accelerate the development of the local shipbuilding industry.

ACKNOLEDGEMENT

Author acknowledges Kenya Shipyards Limited management, our able Maj. Gen. Paul Otieno for support and leadership to ensure the project was successful. I really appreciate the Organization for giving me the opportunity to be involved in the project, it has been an enriching experience and I am proud of the successful completion of this project. I also appreciate Damen Shipyards management, Mr. Rudi and his shipbuilding expert team for their unwavering support and training the local staffs throughout the project, I would like to extend my gratitude to local Engineers team in Department of Defense forces for coordination with Civilian Engineers to ensure success of the project: Col. Brian Omito, Maj. Evans Oleche, Capt. Peter Gatigi, Capt. Asunta Mungai, James Gicheru and Jacinta Kiama for their commitment to excellence and dedication to achieving the project goals and have been instrumental in its success.

Additionally, I would like to recognize the hardworking service team men and women, administration, supervisors who tirelessly made this project a success and entire KSL family.

Finally, I recognize Stellah Gakii and Sweebrah Cherotich for assisting me in making this manuscript success, Thank you for your time and consideration. God bless you

COMPETING INTERESTS

Author has declared that they have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES

1. Stopford M. Maritime Economics. Unwin,London; 1997. https://doi.org/10.4324/9780203442661
2. Mulwa R. Assessment of the status of blue economy sectors in Kenya; 2021. [Accessed on August 2021]
3. Authority TP. Environmental and social impact assessment for dredging of the entrance channel and port turning. Retrieved From Dar-Es Salaam Port, Tanzania; 2019.
4. Mlambo C. The impact of port performance on trade: The case of selected African States. Economies. 2021;9(4): 135.
5. Hidalgo DC, Ducruet C. Port systems and regional hierarchies in Africa in the long term. In African Seaports and Maritime Economics in Historical Perspective: Springer. 2020;45-80.
6. Bank W. The World Bank Annual Report: The World Bank; 2018.
7. Clark X, Dollar D, Micco A. Port efficiency, maritime transport costs, and bilateral trade. Journal of development economics. 2004;75(2):417-450.
8. Gamassa PKPo, Chen Y. Comparison of port efficiency between Eastern and Western African ports using DEA Window Analysis. Paper presented at the International Conference on Service Systems and Management; 2017

9. Humphreys M, Stokenberga A, Herrera Dappe M, Hartmann O, Iimi A. Port Development and Competition in East and Southern Africa: Prospects and Challenges: The World Bank; 2019.
10. Auma JH. Determinants of strategies implementation adopted by infrastructure development projects in Kenya: a case of the Lamu Port-South Sudan-Ethiopia-transport Project (LAPSSET); 2018.
11. Kahyarara G. Maritime transport in Africa: challenges, opportunities, and an agenda for future research. In. Katasonov, A. (2019). Shipping and Ports. Retrieved from Ukraine; 2018.
12. Jiaxin P. Lamu Port–South Sudan–Ethiopia Transportation Corridor (Kenya). In Routledge Handbook of the Belt and Road. 2019;544-548. Routledge.
13. Gekara VO, Nguyen XVT. Challenges of implementing container terminal operating system: the case of the port of Mombasa from the Belt and Road Initiative (BRI) perspective; 2020.
14. Nippon K. Japan international Cooperation Agency (JICA). Data Collection survey on blue economy in the republic of Kenya Journal; 2018.
15. Willner O, Powell D, Gerschberger M, Schönsleben P. Exploring the archetypes of engineer-to-order: an empirical analysis Int. J. Oper. Prod. Manag; 2016.
16. Powell PC, Zigelman CI. Formal manufacturing approaches to modem shipbuilding, Journal of Ship Production. 1989;5(3):188-199.
17. Ofori G. Construction in Developing Countries. Construction Management
18. and Economics, Statistics South Africa, Pretoria, 2007;25(1):1–6.
Available:www.statssa.gov.za
19. Omondi MA. The relationship between international trade and infrastructure development in Kenya Maritime Transport. University of Nairobi; 2019.
20. Spicknall MH, Developing and using an expert system for planning the production of structural piece-parts, Journal of Ship Production. 1992;8(3):1613-1 83.
21. Storch RL, Chirillo LD. The effective use of CAD in shipyards, The National Shipbuilding Research Program 1992 Ship Production Symposium. Proceedings. 1992;2B2-1*-2B:2-10.
22. Minemura T. Scheduling model of cim for shipbuilding, Transactions, 8th International Conference on Computer Applications in Shipbuilding. 1994;12:25-12.37:357-364.
[Accessed on June 2018]
23. Chirillo LD. Flexible production scheduling system, National Shipbuilding Research Program, NSRP 0238; 1986.
24. Ma H, Ma H. Marine economic cooperation and challenges of China & South-East African on Maritime Silk Road; 2019.
25. Van Wyk L. A review of the South African Construction industry Part 1: Economic, regulatory and public sector capacity influences on the construction industry. CSIR Boutek, Pretoria, 2003. Available: http://www.csir.co.za/akani
[Accessed on 21, September, 2009]
26. DeVries RL. Computer-aided process planning: A path to just-in-time manufacturing for shipyards, Journal of Ship Production. 1988;4(3):197-215.
27. Storch RL, Hills W. Computer-aided manufacturing in small shipyards: A U.S. and U.K. Comparative Study, Journal of Ship Production. 1995;11(2): PI>. 81-89.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/109960