ARTIFICIAL INTELLIGENCE IN ENHANCING SAFETY ON LAKE VICTORIA: A BIBLIOGRAPHIC ANALYSIS OF PATTERNS AND TRENDS IN THE LITERATURE, DEVELOPMENT, AND FUTURE APPLICABILITY FOR MARITIME SAFETY

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New Welfare Services–Sustainable Service Design as a driver for re gional development

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Abstract

Artificial intelligence (AI) technologies are being widely employed globally to enhance marine safety services and address challenges within the maritime sector. Nevertheless, the provision of these services in East Africa, particularly within the Lake Victoria basin, is deficient and inadequate. Consequently, a study needs to be undertaken to pinpoint certain domains in marine safety that may be enhanced by deploying AI systems on Lake Victoria.

Bibliometric research was undertaken to track the research literature on AI technologies employed for maritime safety (AI) by analysing 278 journal papers published from 2012 to 2024. The study further conducted semi-structured interviews with seven respondents who possess knowledge and experience in economic operations and maritime safety within the Lake Victoria Basin. The interview results supplemented the findings of the bibliographic analysis on the potential application of AI and other related non-technological factors that need to be considered along with AI for maritime safety at Lake Victoria. The results of this study will play a pivotal role in the development of an all-encompassing Lake Victoria maritime strategy aimed at guaranteeing safety, security, and sustainable practices within the Lake Victoria Basin. The study results might also be useful in the implementation of the Zanzibar Blue Economy Policy.

Originality/value

The study will review relevant literature on AI in maritime safety by (1) obtaining and comparing the most influential AI academic literature through bibliographic analyses; (2) identifying five AI research categories/clusters that are most relevant for maritime safety and (3) matching the identified AI categories with the Lake Victoria maritime safety requirements identified through interviews with maritime experts from the region with the view to developing a strategy for the overall improvement of safety and resilience in the Lake Victoria basin.

Keywords

- Artificial intelligence
- Maritime safety
- Systematic literature review
- Bibliometric analysis
- Lake Victoria

1. Introduction

The advent of AI has revolutionised society, exerting a profound influence on businesses and economies, thereby fundamentally altering how value is provided to customers. Significant advancements have been achieved in AI-related technologies, including machine learning, natural language processing, computer vision, and deep learning. These advancements enable computers to acquire knowledge from their surroundings and make informed judgements using the provided data. As a result, AI has completely transformed industries involved in robotics, autonomous vehicles, healthcare, finance, education, and search engines. This transformation is forging a future where AI is deeply integrated into different sectors of society and industry.

The transformative potential of AI has also been recognised in the maritime industry transforming maritime transportation including marine port operations and enhanced marine safety services, Abdelsalam and Elnabawi (2024). Nevertheless, the provision of these services in East Africa, particularly within the Lake Victoria basin, is deficient and inadequate. Therefore, research on AI technologies must be conducted to determine their potential contributions to enhancing maritime services on Lake Victoria in key areas such as navigation, maintenance, emergency response, environmental protection, vessel security, oil spill detection, aerial and underwater surveillance, fisheries management, vessel movements, and environmental factors. The results of this study will play a pivotal role in the development of an all-encompassing strategy aimed at guaranteeing safety, security, and sustainable practices within the Lake Victoria Basin.

2. Literature review

2.1 AI Definition

It's worth noting that the concept of artificial intelligence (AI) has been around for over eight decades, although many people discussing the technology are not aware of this fact. According to Wolfgang Ertel's book "Introduction to Artificial Intelligence" (2017), the origins of AI can be traced back to Austrian scientist Kurt Gödel and his work on first-order predicate logic, which dates back to 1931. The term Artificial Intelligence was, however, coined for the first time in 1956 by an American computer Scientist John McCarthy together with his colleagues Alan Turing, Marvin Minsky, Allen Newell, and Herbert A Simon. MacCarthy and his colleagues are considered the founders of AI ("Wikipedia," n.d.). The purpose of creating AI was to develop machines that could display human-like behaviour and decision-making capabilities. However, defining Artificial Intelligence has proven to be a challenge, as many individuals struggle with questions such as "What is intelligence?" or "How can one measure intelligence?" as they attempt to conceptualize machines emulating human-like behaviour. Ertel ultimately adopted the definition of AI proposed by Elaine Rich (1983), who defined it as "the study of how to make computers perform tasks that, at the moment, humans do better". According to Ertel, the definition that has been in place for the past forty years is not only still relevant but will remain valid until 2050. In my opinion, the World Economic Forum's Empowering AI Leadership: AI C-Suite Toolkit (World Economic Forum 2022) offers a more comprehensive definition of AI, as “systems that act by sensing, interpreting data, learning, reasoning and deciding the best course of action”. While Rich's definition highlights the contrast between AI and human abilities, the World

Economic Forum Leadership Toolkit's definition offers a straightforward and effective means of quantifying investments in these technologies, while simultaneously driving the creation of crucial regulations and protocols for managing associated risks.

2.2 AI Components

Artificial intelligence (AI) is a collection of various components that work together to enable machines to perform tasks that typically require human intelligence. The components include (i) Machine Learning, which is a subset of AI that enables machines to learn from data and improve their performance without being explicitly programmed; (ii) Neural Networks: These are algorithms that are inspired by the structure of the human brain and are used in machine learning to recognize patterns in data; (iii) Natural Language Processing (NLP) which is a branch of AI that focuses on enabling machines to understand, interpret, and generate human language. It includes tasks such as language translation, sentiment analysis, and speech recognition; (iv) Computer Vision focuses on enabling machines to interpret and understand visual information from the real world. It includes tasks such as image recognition, object detection, and facial recognition; (v) Robotics combines AI, machine learning, and mechanical engineering to build machines (robots) that can perform tasks autonomously or with minimal human intervention; (vi) Expert Systems are AI programs that mimic the decision-making abilities of a human expert in a specific domain. They use rules and logic to make decisions based on the information provided to them. It is worth noting that the aforementioned AI functionalities encompass a wide range of capabilities, including sensing, data interpretation, learning, reasoning, and decision-making, as defined by the World Economic Forum. Furthermore, it is crucial to acknowledge that AI is a dynamic and rapidly expanding field, with novel technologies and methodologies emerging regularly.

2.3 AI categorisation

When researching the applicability of AI in various industries, it is helpful to categorise AI in various ways based on its capabilities, functionalities, and technologies. These categories help us better understand the different types of AI and their potential applications. Some of the ways to categorize AI include: (i) Based on capabilities: Narrow or Weak AI, General or Strong AI, and Super intelligent AI. This categorization helps us distinguish between AI systems that are designed to perform specific tasks and those that can perform a wide range of tasks; (ii) Based on functionalities: Reactive Machines, Limited Memory AI, Theory of Mind AI, and Self-aware AI. This categorization helps us understand the different levels of AI sophistication and how they can be used to solve complex problems; (iii) Based on technologies: Machine Learning (ML), Deep Learning, Natural Language Processing (NLP), Robotics, Computer Vision, and Expert Systems. This categorization helps to identify the different AI technologies that are available and how they can be used to develop intelligent systems. Understanding these different categories of AI can help us to better utilize AI in various fields, such as healthcare, finance, and education, to improve efficiency and productivity.

2.4 Artificial intelligence as a service (AIaaS)

Duan et al. (2015) published their analytical work on ‘Everything as a Service (XaaS) on the Cloud: Origins, Current and Future Trends’ exploring XaaS the concept that refers to the delivery of a wide range of services and resources over the Internet, typically via a

subscription model. "Everything as a Service" (XaaS) is a concept that refers to the delivery of a wide range of services and resources over the Internet, typically via a subscription model. The "X" in XaaS can refer to several types of services such as Software; Platform; Infrastructure; or Artificial Intelligence. This approach enables firms and individual service providers to access and use a wide range of services and resources without having to acquire and maintain physical infrastructure or software applications.

Expanding upon the foundational framework established by Duan et al., Hiter (2023) introduced the concept of "Artificial Intelligence as a Service" (AIaaS) which refers to the provision of AI technologies and business operations by AI companies to customers via the cloud. This eliminates the need for customers to invest in their own AI infrastructure. In contrast, (Lins et al., 2021) offer a more comprehensive definition, describing AIaaS as cloud-based systems that enable organizations and individuals to deploy, develop, train, and manage AI models. This aspect of training and management is not as explicitly addressed in Hiter's definition. It would, therefore, be safe to say that AIaaS facilitates value co-creation by empowering businesses to harness the potential of AI technology to drive innovation, optimize processes, and deliver enhanced experiences for customers and stakeholders. AIaaS generates value by allowing businesses and organisations to use advanced AI capabilities to improve their products, services, and operations. The value generation aspect is in line with the theoretical framework of Service-Dominant (S-D) Logic, as outlined in the book "Service-Dominant Logic: Foundations and Applications" by Vargo, S.L., Koskela-Huotari, K., and Vink, J. (2020). This framework posits that service is the fundamental foundation for the exchange of value, and it asserts that all businesses and economies are service-based. Applying Service-Dominant Logic to AIaaS highlights the importance of service provision, value co-creation, resource integration, relationship-building, and ecosystem collaboration in leveraging AI technologies to deliver value to clients and stakeholders. By adopting an S-D Logic mindset, AIaaS providers have already made progress in enhancing their service offerings, deepening client engagement, and fostering a promising future in the rapidly evolving AI market. The benefits of AI-as-a-Service (AIaaS) are numerous. These include improved efficiency, enhanced customer experience, accelerated innovation, data-driven decision-making, cost savings, and accessibility to AI technologies. With AIaaS, organizations of all sizes and industries can take advantage of the power of AI without requiring extensive technical expertise. Leading cloud companies now offer a range of AI-powered services such as machine learning, deep learning, analytics, and inference. This trend has given rise to AI-as-a-Service or AIaaS, as noted by Lins et al. (2021). Examples of such services include Amazon Web Services "Amazon SageMaker" and "AWS AI," Microsoft Azure's "Azure Cognitive Services" and "Azure Machine Learning," and Google Cloud Platform's "Google Cloud AI Platform" and "AutoML." Other cloud platforms, such as IBM Cloud, Oracle Cloud, Alibaba Cloud, Tencent Cloud, Baidu Cloud, and Huawei Cloud, also provide similar offerings.

Generative Artificial Intelligence (GenAI) is an interesting field AIaaS field where the collaborative and co-creative nature of value creation is at the core of the GenAI services. In GenAI-based services such as ChatGPT and Google’s Bard AI, users’ decisions are often influenced by the stimuli encountered while using a product or service, and these experiences can be shared with others through social media or blogs (Mondal, et al., 2023). This active engagement aligns with the co-creation concept of S-D Logic.

2.5 AI in business and adaptability in People's lives

Artificial intelligence (AI) is progressively being integrated into people's daily lives in various ways, improving convenience, efficiency, and personalisation. The range of AI-based services in business and people's daily lives is enormous ranging from online shopping to home care devices and from education to financial services, child welfare to employment. Some examples are virtual assistants (Google Assistant), online shopping keeping track of user preferences, purchase history and searching behaviour; social media, healthcare including medical diagnostics, personalised treatment recommendations, health monitoring wearables; smart home devices such as security cameras and energy efficiency device; navigation applications such as google maps, guru maps; entertainment platforms such as Netflix, education in personalised learning and online adaptive tutoring; financial services in fraud detection, credit scoring, personalised financial advice and enhanced customer services.

2.6 Artificial Intelligence's Applicability in Maritime Safety

Extensive literature discusses the utilization of AI technologies to advance marine safety and overcome various challenges within the maritime industry. The application of such technologies has been established to heighten safety, efficiency, and sustainability in the maritime domain. AI tools are implemented to address concerns surrounding navigation, maintenance, emergency response, environmental preservation, vessel security, oil spill detection, aerial and underwater surveillance, and fisheries management. This includes monitoring vessel movements and environmental elements that prevent illegal fishing activities and promote sustainable practices. In **predictive maintenance**, AI use to monitor ship components and machinery conditions is illustrated by Makridis, Kyriazis, and Plitsos (2020), who wrote on how machine learning methods can be utilised along with sensor data from the ship to find outliers in time series data. This lets engineers figure out how certain parts of a ship's main engine will work, predict when they might break down, and plan repair, which lowers the chance that the engine will break down in the middle of the ocean. **Fisheries management** is a crucial process that involves counting fish in fish flocks. In their study, Sirigineedi, Mohan, and Sahu (2023) demonstrate how automated fish counting, monitoring, and surveillance using computer vision and deep-learning AI techniques can help prevent illegal fishing activities and ensure sustainable practices. **Ports** are also utilizing AI to manage shipping traffic, cargo handling, and logistics with greater efficiency. Bakr and Elnabawi (2024) have made a compelling case for the transformative impact of AI on the marine industry, particularly in port operations. Ports are leading the way in this transformation by employing cutting-edge AI and digital capabilities to introduce a new era of operating strategies that offer enhanced efficiency, accuracy, and security (Bakr & Elnabawi, 2024). Meanwhile, Lin, Chang, and Chung (2022) have conducted a study on exploring the importance of different port governances in smart port development. They examine the impact of new technologies such as robotics, big data, and AI on port operations, with a focus on Taiwan's smart port development strategy.

Other AI usages include the **Autonomous Navigation Systems** to analyse data to make real-time decisions on navigation. For example, according to Qu et al. (2023), the robust fusion of Automatic Identification System (AIS) and visual data can enhance maritime traffic surveillance in inland waterways. AI is used in **Collision Avoidance** to keep ships

safe by preventing them from colliding with each other. According to Liu and Shi (2020), Ningbo Zhoushan port in China is one of the world's largest ports, which handled 1.08 billion tonnes of cargo in 2018. More than 1,000 ships come in and out of the port every day, and to detect other ships and obstacles, sensors, cameras, and radar are used. AI algorithms then process the data in real-time and make navigation decisions based on it. **Emergency Response Systems** have been improved by automated emergency procedures, as discussed by Rodger and Guida (2020). Crus et al. (2020) highlighted the use of open data and AI analysis for **vessel monitoring/tracking**, **environmental monitoring, and fisheries management**. Additionally, AI-powered surveillance systems are being used to monitor vessel perimeters and detect unauthorised access or security threats, thereby enhancing overall **maritime security**. In 2023, Li, Jiao, and Yang provided a systematic review and analysis of ship trajectory prediction methods using machine learning and deep learning techniques. Researchers have developed a model using machine learning to investigate **human fatigue** and its influence on maritime accidents. The model, created by Fan and Yang (2024), analyses historical data on accidents and incidents to identify risk influential factors (RIFs) that contribute to human fatigue. By using this method, they hope to reduce the occurrence of maritime accidents. Finally, the literature review focused on maritime areas concerning **weather and route optimisation** planning. As per Wu et al.'s (2023) research, weather and sea conditions play a significant role in ship safety and navigation efficiency. To tackle this challenge, Wu et al. (2023) created a cutting-edge model that leverages historical and real-time weather data. This sophisticated model generates optimised ship routes that are both fuel-efficient and secure, thereby enhancing maritime safety and economy.

Numerous publications on maritime safety research, referenced in the preceding sections concerning AI implementation, highlight multiple facets of artificial intelligence, including machine learning, deep learning, natural language processing, robotics, computer vision, and expert systems, all of which were previously introduced in section 2.2. It is critical to continue exploring the potential of these AI branches to tackle various maritime safety issues.

2.7 Cultural, social, economic and gender considerations

It is globally accepted that the rise of AI has transformed society, influenced businesses and economies and altered how value is delivered to customers. Lazăr, Atanasiu and Mortan (2024) in their paper on Socioeconomic and Cultural Determinants of the Development of Artificial Intelligence acknowledge that AI has seen explosive growth, with economic considerations becoming increasingly prevalent. Their research focuses on the impact of AI on economic growth. The authors argue that AI should be viewed as an outcome rather than a factor of economic growth. They identified four important determinants that influence AI development, namely GDP, growth rate, R&D funding, and urbanisation. Moreover, the study highlights the significance of cultural variables, such as uncertainty avoidance, in shaping AI development in different countries. By understanding these determinants, policymakers can construct effective AI regulatory policies that can stimulate innovation and have a positive impact on economic growth. A study conducted by Lazăr, Atanasiu, and Mortan has shown that AI has a positive impact on economic growth. However, the International Monetary Fund's study titled "AI Adoption and Regulatory Impact" (IMF 2024) suggests that the effect of AI on employment and

productivity is unclear, with a broad range of estimates and no clear direction. The report also highlights two key findings: Policy and Research Are Partly Disconnected, and Regulations Differ Widely and Face Difficult Trade-Offs. To address these issues, the IMF recommends closely monitoring and potentially guiding the direction of AI technology. Furthermore, future research should focus on obtaining more accurate, granular, and up-to-date data on AI applications, with a stronger emphasis on policy interest.

In their 2024 paper, Lazăr, Atanasiu, and Mortan discussed the socioeconomic and cultural factors that influence how AI is perceived in different societies. When considering the East African region specifically, we can gain insights into the national attitudes towards AI and its potential for economic growth. According to the Lloyd's Register Foundation World Risk Poll (2022), East Africa is the most less AI-receptive globally. According to the World Risk Poll data, Eastern Africa has the lowest level of optimism towards AI. More than half of the respondents (51%) believe that AI will mostly have negative impacts on people in their country in the next twenty years. A survey question asked whether people believe that artificial intelligence will "mostly help or mostly harm" individuals in their respective countries in the next two decades. According to the analysis of the World Risk Poll's study, the ratio of individuals who believe that AI will mostly help versus harm in East Africa was 0.4, while the most positive region, East Asia, had a ratio of 4.4 (Lloyd's Register Foundation World Risk Poll 2022). The negative perception of digital technologies from the study was attributed to awareness. The study recommends policymakers and industry leaders to ensure the safe use of digital technologies in their respective countries.

The United Nations Educational, Scientific and Cultural Organisation has thoroughly addressed the challenges of AI adoption and gender in their article titled "Global Dialogue on Artificial Intelligence and Gender Equality" (UNESCO, 2022). The document outlines the significant functions of AI in individuals' lives. Some notable aspects include: (i) The accuracy, universality, and trustworthiness of data sets utilised by AI influence its patterns, forecasts, and recommended actions. (ii) AI's biases and assumptions can exacerbate the stigmatisation and marginalisation of women worldwide. (iii) The impact of AI on gender equality. The UNESCO (2020) paper elaborates on its results regarding gender biases in AI data sets, specifically focusing on training data sets. Artificial intelligence has the ability to disseminate detrimental gender norms, which could result in women being left behind in several aspects of economic, political, and social life.
AI can have a detrimental effect on women's economic empowerment and labour market possibilities by automating jobs. The UNESCO report proposes two proposals as a solution to the causes that contribute to the proliferation of gender imbalance in AI. The first step involves implementing regulations for AI that specifically target potential hazards, societal consequences, responsible advancement, and ethical standards. The second step entails establishing a national or regional policy framework that promotes the growth of human talents through technical education and adaptation.

2.8 Ethical and Legal Issues

Artificial Intelligence like any other disruptive technology will always be a source of uncertainties and risks, and would therefore require regulators to make intricate determinations regarding when and if they should "intervene" and what type of regulatory measures to refer to (Zekos, p.3, 2022). The Cobbe and Singh (2021) paper titled "Artificial

Intelligence as a Service: Legal responsibilities, liabilities, and policy challenges" discuss extensively the legal responsibilities, liabilities, and policy challenges associated with Artificial Intelligence as a Service (AIaaS) and the role of AIaaS providers in data protection and liability for illegal use of AIaaS. Notable challenges that Cobe and Singh identify include responsibility for unlawful actions conducted through their AI services; accountability of intermediaries for the unlawful actions of clients utilising their AI services; acquisition of consent for additional processing, particularly when dealing with sensitive data categories; adherence to existing regulations such as
The General Data Protection Regulation (GDPR) of May 2016 for the European Union, which most East African Community member states follow as a model law. GDPR encompass data protection principles, legal grounds for data processing, technical and organisational safeguards, accountability, and Adherence to enforcement measures imposed by regulatory bodies. The European Union has recently made additional progress in passing the European Union Artificial Intelligence Act (EU AI Act) on 14 December 2023 meant to enforce rules relating to "general-purpose AI systems" such as chatbots and other AI systems designated by the Act as "high risk" such as AI uses in critical infrastructure (European Union Artificial Intelligence Act, 2023).

Bakr Abdelsalam and Elnabawi (2024) contend that "as AI systems make more decisions, the ethical implications become more complex. Issues related to privacy, accountability, transparency, and consent can pose serious challenges if not properly addressed". In the same vein, Zekos cautions that "AI can violate the principle of equal access permitting governments to identify and repress cultural groups and so there is a risk that AI could be used to "criminalize" certain cultures" (Zekos, p.9, 2022). It is in this spirit that the European Union Artificial Intelligence Act, 2023 rules "ban certain AI applications that threaten citizens' rights, including biometric categorisation systems based on sensitive characteristics and untargeted scraping of facial images from the internet or CCTV footage to create facial recognition databases. Emotion recognition and AI that manipulates human behaviour or exploits people's vulnerabilities will also be forbidden".

3. Methodology

The study utilises a bibliometric research approach to track the research literature on AI technologies employed for maritime safety (AI) by analysing 278 journal papers published from 2012 to 2024. It also examines the trend of AI development for maritime safety. The study further conducts semi-structured interviews with eight respondents who possess knowledge and experience in economic operations and maritime safety within the Lake Victoria Basin. These interviews serve to supplement the findings of the bibliographic analysis on the potential application of AI and other related non-technological factors that need to be considered along with AI for maritime safety at Lake Victoria.

4. Bibliographic Results and Analysis

In our bibliometric analysis, we utilise the following approach to examine the relevant literature. The search query employed is "Artificial Intelligence" AND "Maritime safety" on the Lund University Libraries (LUBsearch discoveries). The limiters employed consist of

items published from January 1, 2012, up to the present, as well as publications that are accessible inside the library's collection. The materials that were searched include Academic Journals, iscovery; ePublications; and Databases A-Z. The search results were exported in the Research Information Service (RIS) format for utilisation in the bibliographic analysis application "VOSviewer". There were 225 retrieved publications from the search.

The VOSviewer bibliographic analysis tool offers three distinct modes of display: network visualisation, overlay, and density. Each mode highlights a certain characteristic that might be valuable based on the users' desired observations. The network visualisation mode (Fig. 1) displays the primary clusters of publications. The status line of the view provides information about the number of publications and their connection strength, which represents the cross-referencing of the publications. The Overlay mode (Fig.2) enhances the appearance of the connectivity between clusters, while the density mode (Fig.3) reduces the visibility of linkages and highlights the primary categories of publications. In aggregate, the subsequent is a concise overview of the knowledge we have acquired from the three graphs.

Eight (8) AI clusters of published analytical works seem to show in the analysed data. The 8 clusters and their respective number of items in the cluster some of the main items are mentioned below.

Cluster	Item	Category
No1	52	Artificial Intelligence (AI), computing and processing, marine vehicle, circuit devices, signal processing and analytics, data mining, maritime.
No.2	47	**Maritime safety**, **communicatio**n, **control position**, **shipbuilding**, **navigation instruments**.
No.3	34	**Automatic identification**, **collision avoidance**, data augmentation
No.4	32	**Data and information**, Machine learning
No.5	22	**Autonomous ships/systems**, **traffic engineering**, **maritime safety management**, risk management, **ship crew**
No.6	21	**Climate change**, **environmental disturbances/pollution**, **naval architecture**, **oceanography**, **emission port**
No.7	16	**Environmental effects /sciences**, **maritime security**, **port security strategy/sustainability**, **port governance**, **Smart port**
No.8	1	**Automatic Identification System (AIS)** with the highest link strength of 7515
Total Search Items	225	

Table 1. Categories of Publications

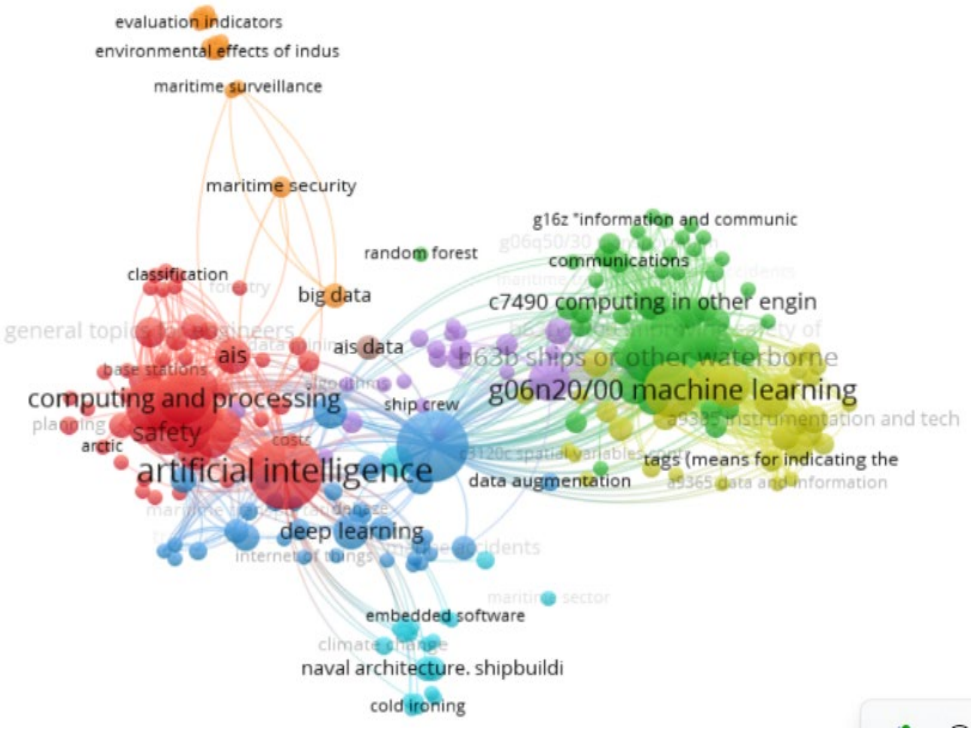

Fig. 1Network Visualisation

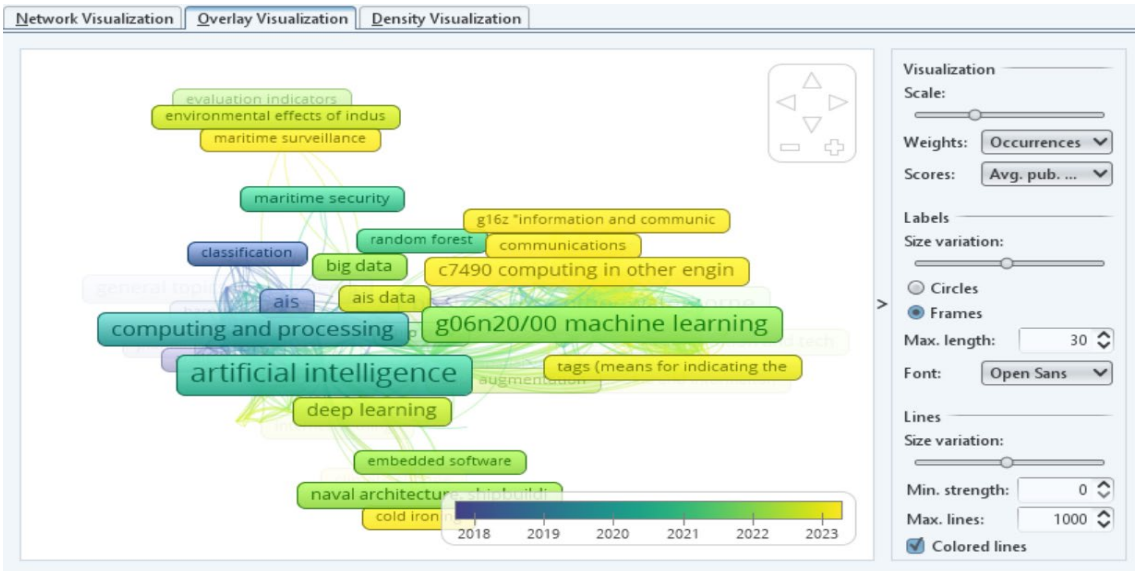

Fig. 2 Overlay Visualisation

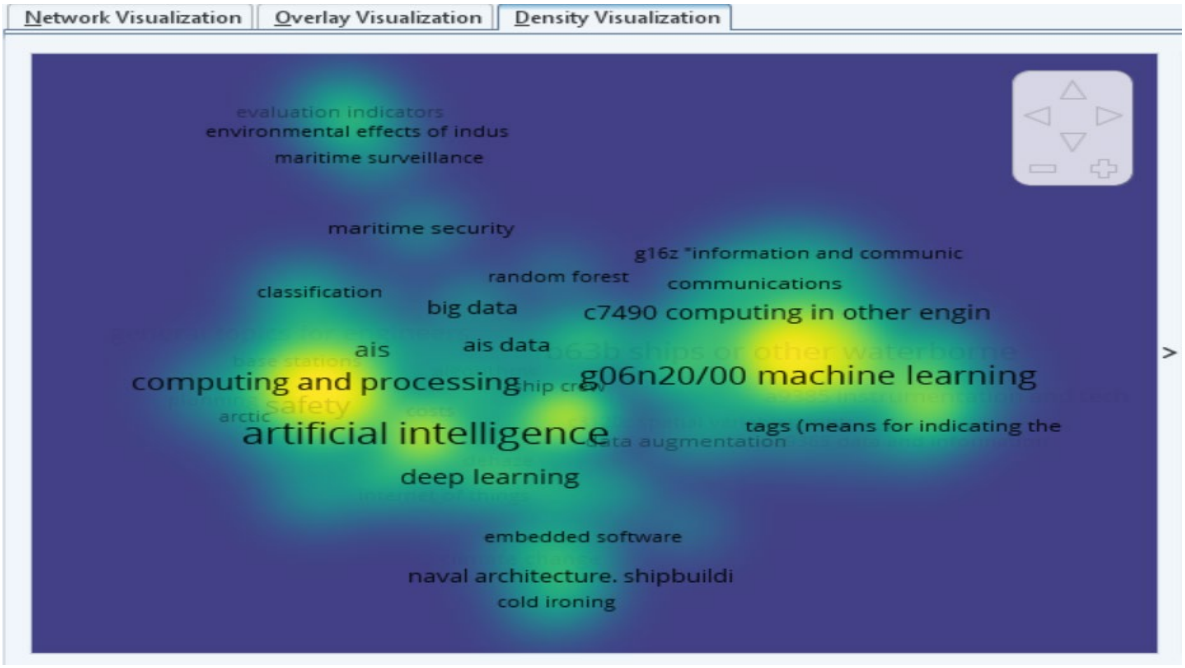

Fig. 3 Density Visualisation

It will be observed that we have 52 numbers from Cluster1 that refer to AI components that work together to enable machines to perform tasks which were mentioned in Section 2.2. What seems to appear here that has been much researched include computing and processing, marine vehicles, circuit devices, signal processing and analytics, data mining, and maritime. There is also a strong link to other clusters such as Cluster 4 which with machine learning. Other clusters provide important information in the categories of maritime safety that have received high scholarly attention in the past twelve years. The identified areas that were also discussed in the literature review include Cluster 2 Maritime safety, communication, control position, shipbuilding, and navigation instruments; Cluster 3 Automatic identification, collision avoidance; Cluster 4 Data and information; Cluster 5 Autonomous ships/systems, traffic engineering, maritime safety management, risk management, ship crew; Cluster 6 Climate change, environmental disturbances/pollution, naval architecture, oceanography, port emission; Cluster 7 Environmental effects /sciences, maritime security, port security strategy/sustainability, port governance. Smart port; Cluster 8 with only one item Automatic Identification System (AIS) with the highest link to the rest of the cluster items.

5. Interviews

Seven experienced maritime safety actors and digital transformation professionals from the East African region will participate in semi-structured interviews. The interviews will consist of seven fundamental questions, and all responses will be transcribed and evaluated. To protect the identities of the respondents, they will be assigned pseudonyms. The interviews took place during the second week of April 2024.

Q1:The first question asked respondents to pick the five critical safety areas for Lake Victoria from a list of ten. The ten mentioned areas were: (i) navigation; (ii) maintenance; (iii) emergency response; (iv) environmental protection; (v) vessel security; (vi) oil spill detection; (vii) aerial and underwater surveillance; (viii) fisheries management; (ix) vessel movements; and (x) environmental factors. The results are shown in Table 2.

Safety Area	**Score**							
	1 Mbwawe	2 Daud	3 Stev	4 Hulk	5 Tintin	7 Malim	8 Yesh*	Total
i Navigation		√	√	√	√	√	√	6
ii. Maintenance		√		√	√	√	√	5
iii. Emergency response	√	√	√	√	√	√		6
iv. Environmental protection		√		√	√	√	√	5
v. Vessel Security	√		√					2
vi. Oil spill detection	√	√						2
vii. Aerial and underwater surveillance			√					1
viii. Fisheries management	√		√		√		√	4
ix. Vessel movements	√			√			√	3
x. Environmental factors						√		1

** Future ports must be "Smart Ports" that are AI-powered. We consequently require AI-enabled aids for navigation; crew management; and safe port and harbour for vessel landing, discharge, and loading.*

Table 2: Five critical safety areas for Lake Victoria

Based on the insights gathered from the seven interviewed respondents, it was determined that Navigation and Emergency response are the top priority safety concerns facing Lake Victoria. This was followed by maintenance and environmental protection, with fisheries management coming in third. One respondent also emphasized the importance of port safety, particularly in terms of vessel navigation and the safety of cargo and passengers during loading and unloading. As such, there is a growing need for "smart ports" that leverage artificial intelligence technologies to enhance safety and efficiency.

Q2: The respondents were further asked in Question 2 to mention safety concerns that they can ascribe to human mistakes or non-technical factors that may arise even if AI-based technological solutions are in place.

The responses received were quite intriguing and covered the following points:

i. **Insufficient staff training or experience**: Accidents can occur due to insufficient staff training or experience, such as untrained responders or seafarers who may not be able to use equipment or charts properly.

ii. **Failure to comply with maritime legislation** and safety procedures, including maintenance schedules, can put the safety of the crew, vessels, and the environment at risk. For example, a respondent provided an instance of non-compliance by the crew of a vessel that sank in Lake Victoria due to their failure to follow the proper procedures

for filling water tanks to steady the vessel based on the amount of luggage on board. In this case, the tanks remained unused as they were hermetically sealed. Another example provided was the failure to address the problem of hull corrosion, which resulted in a decrease in the velocity of the vessel.

iii. **Fatigue by crew staff** due to long working hours may impact their decision and performance.

iv. **Human Erro**r: Errors made by humans, such as problems with communication, judgement, or decision-making, and not following navigation aids like hydrographic charts, have been identified as contributing factors in accidents. One respondent gave an example of a recent accident where a plane was supposed to land at an airport that had poor navigation lights. Small fishing boats were near the airstrip, and the pilot mistakenly took the fishing boats' lights to be the airport runway and landed on the water. There is no proof of the accuracy of this account. Still, if it is true, it is a good illustration of human error in marine safety. Poor port and fisheries management can lead to frequent accidents due to the high volume of vessel movements in a confined area.

v. **Environmental factors**. Lake Victoria is known for its unpredictable and sudden severe weather changes, which can impair visibility and make navigation unsafe. The HIGHWAY project was consequently initiated to mitigate any potential risks by providing early and accurate weather forecasts.

vi. **Risk Management culture**. Two facets were discussed concerning the risk management culture. The first one is the absence of a culture of upkeep in the region, particularly with the vessels that operate on Lake Victoria. The majority of the watercraft on the lake are locally crafted tiny boats and function without any upkeep. The second one is that even when safety requirements are adhered to, they are merely being met to satisfy the obligatory criteria, without necessarily improving safety. A case was presented where safety life jackets were securely stored on board vessels to prevent theft by being locked under strict supervision, occasionally, situated in a vessel's corner, where it is arduous to reach or perceive distinctly.

vii. When it comes to vessel security and piracy, technology such as AI can help prevent or minimize security breaches. However, it's important to note that even if no physical harm occurs during a security breach, the **psychological effects** on both crew and passengers can be significant. Respondents emphasized the need for deliberate efforts, such as training, to address trauma, fear, and other psychological implications for crew, passengers, and their families in the event of such incidents.

Q.3 To evaluate the familiarity of digital technology initiatives, a question was asked to identify any efforts introduced by member states or stakeholders to enhance safety standards, improve operational efficiency, and secure maritime operations on Lake Victoria. All seven respondents agreed that they are aware of digital solutions introduced in the region to tackle maritime safety challenges on Lake Victoria. The following digital initiatives have been implemented to enhance safety on Lake Victoria: (i) an Electronics

Chart Display and Information System (ECDIS) provides seafarers with digital charts and navigational information to help them plan their routes and monitor their progress; (ii) Automatic Radar Plotting Aids (ARPA) to improve collision avoidance standards at sea; (iii) Radio Detection and Ranging (RADAR) that uses microwave segments or ultra-high frequencies of the radio spectrum to identify obstacles and control the range of objects in the area; (iv) Image recognition by satellite; (v) *remote monitoring systems using weather buoys; (vi)* Port security; (vii) Echo Sounders, a type of sonar, used to measure bottom depth and detect underwater objects; (v) the implementation of the HIGH impact Weather Lake project (HIGHWAY). The HIGHWAY project is an ongoing regional project supported by the World Meteorological Organisation (WMO) intended to improve early warning systems in the Lake Victoria region. The HIGHWAY project uses advanced numerical weather prediction combined believed to be AI-enabled with mobile phone technology to disseminate weather forecasts to fishermen in Kenya, Rwanda, Uganda and Tanzania. Uganda's Mobile Weather Alert initiative was established as early as 2011 through a collaborative effort of five organizations. These include the Uganda National Meteorological Authority (UNMA), Ericsson, the MTN Group, the National Lake Rescue Institute, and the WMO. Together, they piloted the Short Message Service (SMS)-based Mobile Weather Alert system. The initiative that was mentioned by six respondents was the Multinational Lake Victoria Maritime Communication and Transport (MLVMCT) project. This project was intended to be a regional project involving three countries. However, Kenya decided to execute the crucial elements of the project at the national level. At the same time, the other two partners, the Republic of Uganda and the United Republic of Tanzania, proceeded with its implementation as a regional project. Upon visiting the African Development Bank website AFDB (2020) more details about the project revealed that the MLVMCT project started in 2018 intending to establish a Maritime Communications System to improve safety on Lake Victoria. The system includes a Maritime Safety Coordination Centre, Search and Rescue centres, and a maritime transport strategy for the East African Community. It also involves implementation studies for Lake Victoria Maritime transport. The Maritime Communications System consists of a Maritime Communication Network, an emergency response infrastructure (Search and Rescue Centres), and a weather data dissemination mechanism. The system is centred around a functional communication network that can receive any distress signal in International Morse code, specifically the SOS signal. Upon receiving such a signal, the system promptly sends out a rescue boat from a coordinating centre. According to the respondents, the system is expected to employ artificial intelligence (AI) technologies to perform various tasks. These tasks include sending and receiving distress messages through radio, mobile, or satellite communication, determining the source of the signal, and transmitting the location to a Search and Rescue site. This information is then used to dispatch rescue boats to the accident location. Artificial intelligence (AI) can be utilised in radio equipment installed at telecom towers to enhance coverage over the lake. In addition, it has been observed that the weather buoys are equipped with sophisticated artificial intelligence modules.

Q.4 Question No.4 was designed to specifically inquire into the respondents' recognition of the capability of artificial intelligence in tackling the difficulties related to maritime safety and security. Illustrative challenges were provided to stimulate their recollection of domains where AI can be advantageous. The mentioned areas include ship tracking systems such as GPS and Automatic Identification System (AIS), predictive maintenance

using Internet of Things or data analytics to prevent breakdowns in vessels or machines, autonomous ships, remote monitoring systems, virtual reality (VR) training, advanced weather forecasting, and cybersecurity measures to protect onboard systems.

All respondents unanimously recognised that Artificial Intelligence (AI) significantly improves marine safety, as long as humans are properly trained to utilise its potential. The indicated categories pertain to the prompt scheduling of maintenance for ships by vessel owners and operators, including the implementation of predictive maintenance. This leads to enhanced overall operations and ensures that the vessels are fit for seaworthiness. Moreover, artificial intelligence can aid ships in choosing the most favourable routes for their voyages, hence improving marine safety. AI has the potential to enhance various areas, such as ship tracking, virtual reality training for seafarers, automatic identification systems on the route, and determining the most fuel-efficient route, weather forecasting, and early warning systems. These improvements would cover aspects like wind speed, wind strength, wind direction, and wave height. One respondent, however, stressed that ethical considerations and long-term environmental mitigating strategies must accompany the implementation of AI in maritime safety.

Q.5: AI is currently and will continue to substantially influence people's lives. **Question five** asked respondents to provide their ideas on factors that should be considered, in addition to technological applications, to achieve the best possible outcomes. The provided examples accompanying the questions included factors such as gender, nationality, boundaries, ethical considerations, and impact on the environment. The factors identified by the respondents had some similarities but were mostly characterised by their diversity and intriguing nature and have been synthesised as follows:

i. The first key factor As AI is a creation of computer science, it is crucial to address ethical considerations to prevent its misuse or abuse. This includes avoiding the exploitation of weaknesses in other systems to gain unauthorised access, which can lead to privacy invasion, financial breaches, identity theft, or the misuse of AI itself.

ii. One of the key concerns expressed was related to border issues. Different countries utilise diverse AI methodologies and are strict in the way that these technologies are utilised. In contrast, the other bordering countries have permissive rules regarding the utilisation of AI within their borders. The Lake Victoria riparian countries must synchronise their AI policies and regulations to optimise the advantages of this revolutionary technology for the safety and security of marine transportation. The territorial challenge was also brought up by another respondent about the jurisdiction of weather forecasting information. Information sharing of numeric prediction model products with sister organisations across borders needs to be strengthened and harmonised. Given that Lake Victoria spans multiple countries, all respondents emphasised that the Esat African countries must consider boundaries and nationalities when conceptualising and executing AI initiatives on the lake.

iii. Social and economic factors: AI might potentially have significant social and economic implications for the marine industry, particularly in terms of addressing the challenges related to worker displacement and the need for reskilling.

iv. Considering gender is crucial while deploying AI to accomplish UN SDG 5. However, in the context of Lake Victoria, gender may not be a significant determinant as most individuals working and operating on the lake are male.

v. Ensuring the fairness and openness of contradictory AI choices made on a boat vs established protocols on shore.

vi. Building trust in AI, especially in the context of maritime safety, is crucial for ensuring its acceptance and adoption. Human oversight and monitoring.

vii. Technical and operational challenges: AI in the marine industry may encounter difficulties in ensuring the durability and dependability of AI systems in harsh and constantly changing conditions. Ensuring the robustness and reliability of AI systems in harsh weather or dynamic environments is important to win crew and operators' confidence in them.

viii. For AI applications and services to have a significant and wide-reaching effect, it is crucial to overcome the language barrier that exists between different nations and local communities.

ix. Additional factors briefly mentioned include the importance of being cautious of any embedded or inserted bias in AI modules that could result in discriminatory results, ensuring the quality of data or information being inputted into AI modules, evaluating the long-term environmental effects of AI technologies concerning electronic waste, and considering the presence of legal and regulatory frameworks at the national or regional level for AI usage.

Q.6: **Question 6** aimed to assess the respondents' assessment of the region's preparedness to adopt Artificial Intelligence as a Service (AIaaS) and its ability to develop innovative solutions for local maritime safety challenges, similar to how it was done with mobile technology in financial services and other digital sectors. Considering the cloud-based nature of AIaaS, which enables individuals or organisations to utilise technology without substantial investment, the respondents were asked whether the region is likely to bypass certain stages of AI development and create bespoke AIaaSs to address safety concerns in Lake Victoria.

All respondents except one were positive that the region will embrace AIaaS to address safety concerns in Lake Victoria. The individual who opposed the concept of early adoption was equally convinced that it would not occur, given that the governments in the nations where Lake Victoria is located do not prioritise the safety of the lake as a top concern. Consequently, the early implementation of AI to solve safety problems in Lake Victoria is unlikely. Nevertheless, given the ongoing technological progress and growing adoption of

AI in the nation, it is plausible that AI will eventually be integrated. Rapid application of AI can only be accomplished if governments receive cooperation from development partners.

The proponents of AIaaS viewed it as a chance for the East African region to rapidly advance its innovation and utilisation. They focused on the potential benefits for private sector operators and entrepreneurs in the transport sector who seek to enhance operational efficiency and ensure vessel safety. Moreover, they contended that the region has made significant investments in its young population, who possess advanced skills in information and communication technology (ICT) and digital literacy. Additionally, a considerable number of the youth have the opportunity to utilise well-established centres for innovation. Additionally, it was observed that the region has a historical tendency to not engage in the process of reinventing the wheel. Given the information presented, it is extremely probable that the East African Region would quickly adopt AIaaS (Artificial Intelligence as a Service) to tackle marine safety issues in Lake Victoria, other inland waters, and the Indian Ocean. These bodies of water have a substantial economic impact on both the countries bordering the sea and the landlocked ones.

An illustration was provided of how truck operators utilised mobile and satellite applications to oversee the movement of vehicles and the consumption of fuel along the route connecting the Indian Ocean with landlocked countries like Uganda, Rwanda, and the Democratic Republic of Congo. If these entrepreneurs have access to AIaaS from local innovators that provide boat or ship tracking capabilities, there will be a significant demand for such services. Concerning the involvement of governments in this process, it was contended that their primary responsibility will be to formulate pertinent rules and regulations and ensure their implementation. Indeed, in nearly all instances of emerging technological advancements, such as the digital realm, governments have consistently lagged in their adoption and establishment of corresponding rules and regulations.

One participant expressed certainty that the implementation of a collaborative search and rescue safety programme on Lake Victoria by two states will likely procure AI-enabled equipment for coordination centres and search and rescue sites involve the use of artificial intelligence (AI) in tracking vessels, conducting surveillance of water users, and monitoring unseaworthy vessels. If executed correctly, as stated by the respondent, this would enhance water transport safety by a factor of 10.

Specific areas of use for AI-enabled services are likely to attract accelerated innovations for safety use due to the high demand of the Lake including the Smart Monitoring Systems using AI-powered sensors and cameras that can be deployed across the lake to monitor vessel movements, detect illegal fishing activities, and identify environmental risks such as pollution and algae blooms. Other areas are in Search and Rescue Operations where AI-driven drones and autonomous underwater vehicles (AUVs) are equipped with computer vision and machine learning algorithms that can assist in search and rescue operations during maritime emergencies. Lastly, the Communication and Navigation area was mentioned. AI-powered communication systems and navigation aids can improve coordination among boats and provide accurate location information to prevent collisions and ensure safe navigation.

Notable applications of AI-enabled services will likely experience rapid advancements in safety-related use cases owing to the significant demand in the Lake. These include the implementation of Smart Monitoring Systems that utilise AI-powered sensors and cameras to oversee vessel movements, identify instances of illegal fishing, and detect environmental hazards such as pollution and water hyacinth that are common in Lake Victoria. AI-driven drones and autonomous underwater vehicles (AUVs) integrated with computer vision and machine learning algorithms are utilised in Search and Rescue Operations to aid in maritime situations. Finally, the Communication and Navigation sector was referenced. Artificial intelligence AI-enabled communication systems and navigation aids have the potential to enhance coordination amongst boats and offer precise location data to minimise collisions and ensure secure passage.

However, it was stated that the aforementioned prospects can only be realised if suitable AI policies and regulations are implemented, together with the necessary skills development and infrastructure, to facilitate the creation and adoption of this technology. This approach would guarantee the efficient utilisation of the advantages of AI while simultaneously minimising any potential hazards or adverse consequences.

Q.7: **Question 7** was designed to gather the respondents' views on three key aspects of AI usage: ethical considerations, legal implications, and unforeseen consequences, also known as the "portability trap." These issues may arise when general AI applications or services have been customised to the specific needs of the Lake Victoria basin. Regarding ethical concerns, the primary issue raised was the potential for AI technology to be misused, such as in the violation of data privacy or the perpetration of identity theft. Ensuring trust in the integrity of the data acquired and processed by AI is a crucial factor to consider. An example was provided to demonstrate the level of confidence that maritime stakeholders have in weather predictions generated using AIaaS modules. The portability trap case is likely to occur when individuals become too reliant on AI. This might result in culpability for judgements made by AI systems that rely on predefined modules that are fed with biased data, leading to biased results.

The legal problems presented relate to the distribution of responsibilities in the case of any disasters, namely in the context of marine incidents, while using cloud-based AIaaS modules. Which legal framework mandates cloud-based module customers to disclose their usage of the provided services? Who would be accountable for the actions and outcomes of an autonomous vessel? The responders unanimously agreed that the introduction of new technology into people's lives will undoubtedly lead to legal complexities. Implementing a legal and regulatory framework is a vital consideration when developing strategies. Furthermore, the efficient use of AI in the local setting necessitates extensive training. Failure to do so would result in its limited effectiveness due to the high illiteracy rate among the populations living around Lake Victoria.

Q.8: **Question 8** focused on the cultural, social, and economic obstacles that indigenous people in the Lake Victoria region may have when endeavouring to implement AI-driven safety solutions. A total of nine criteria were mentioned. The following items are covered below.

i. Indigenous Cultural Beliefs: Indigenous cultures may possess customary ideas and cultural practices that shape their perspectives on contemporary technologies. Reluctance or apprehension towards new technology may impede their inclination to embrace AI solutions. For instance, introducing AI technology such as autonomous vehicles or robots may be seen as upsetting the inherent balance or disrespecting conventional ecological wisdom.

ii. Language and Communication: Indigenous groups and technology developers may face difficulties in successfully conveying the advantages and functionalities of AI systems due to language issues.

iii. Lack of the necessary underlying infrastructure: The indigenous tribes living near Lake Victoria may encounter inadequate energy supply, unstable internet access, and insufficient essential infrastructure to support the implementation of AI technology. Limited access to necessary infrastructure can exacerbate pre-existing disparities and hinder the use of artificial intelligence for safety purposes.

iv. Livelihood Dependency: Numerous indigenous tribes residing near Lake Victoria depend on traditional means of subsistence, such as fishing, to sustain their economic well-being. Failure to take into account the socio-economic implications of introducing AI technology may lead to the disruption of current livelihoods and a subsequent rise in poverty levels.

v. The most apparent consequence is the reduction of employment opportunities, nevertheless, the advantageous outcome is the significant enhancement of water safety, as previously said. This will compel operators, seafarers, and other individuals involved to enhance their skills and keep up with advancements.

vi. From a cultural standpoint, there exists a significant degree of disparity. There is a belief that women should primarily be responsible for managing household affairs while men should focus on their careers. Consequently, the use of AI in indigenous societies may be restricted to only one gender.

vii. The implementation of contemporary technology requires a substantial culture shift. To successfully deploy these technologies, it is necessary to have a thorough comprehension of the basic steps and systems involved. Developing a culture that fosters creativity and adaptability is crucial for creating an environment that is open to change.

viii. Education and Awareness: Lack of education and understanding regarding AI technology and its potential advantages may hinder efforts to implement it. Community members may lack a comprehensive understanding of AI systems' functioning and potential applications in enhancing lake safety.

ix. Acts of vandalism targeting high-value AI-enabled devices: Certain local community members near the lake participate in disruptive actions that damage

costly electronics driven by artificial intelligence. For example, participating in the act of vandalising weather buoys that have already been constructed on the lake.

6. Discussion of the Findings

As mentioned in section 2.2, AI is a combination of many elements that collaborate to empower machines to carry out jobs with comparable intellect to that of a human. The VOSview bibliographic analysis tool generates findings by combining several components of artificial intelligence (AI) with AI technologies that are employed to categorise AI. Upon examining the Overlay visualisation of the VOSview (Fig.1), it becomes evident that there are eight clusters. These clusters encompass both the technologies and the maritime safety areas that they are employed to tackle unique safety concerns. By reducing the connections between these items and categories, the Density visualisation(Fig.3) reveals a greater emphasis on AI technologies and a small number of distinct categories that are associated with the ten marine areas identified in the literature assessment. The study identified the top five areas that maritime safety practitioners should prioritise by correlating these ten categories with the opinions of respondents who possess substantial knowledge of the Lake Victoria region. Table 3. displays the compilation of AI in maritime safety, both on a worldwide scale and specifically for Lake Victoria.

	AI in Maritime safety: Bibliographic Analysis (Global) (225 publications)	**AI in Maritime safety Literature Review (Global) (10 areas/categories)**	**Interviews (Top 5 for Lake Victoria)**
1.	Navigation instruments/ Traffic engineering/ control position/	Navigation	Navigation
2.	Communication/ Data and information/ Maritime safety	Emergency response	Emergency response
3.	Shipbuilding/ naval architecture,	Maintenance	Maintenance
4.	Environmental effects /sciences; environmental disturbances/pollution/ port emission/ oceanography	Environmental protection	Environmental protection
5.	Maritime surveillance	Fisheries management	Fisheries management
6.	Autonomous ships/systems	Oil spill detection	
7.	Smart Port/ Port governance	Aerial and underwater surveillance	
8.	ship crew, maritime security/port security	Vessel Security	
9.	collision avoidance/ Automatic identification/ Automatic Identification System (AIS)	Vessel movements	
10	maritime safety management/ strategy/sustainability/, risk management	Environmental factors	

Table 3. Identified AI-enabled Maritime Safety Areas

Four safety categories have been consistently confirmed in all three rounds of the investigation. The focus areas are **Navigation**, **Emergency response**, **Maintenance**, and **Environmental protection** in the maritime and port sectors. The analytical study on marine safety did not appear to include coverage of **Fisheries Management** as a category. However, according to the stakeholders on the ground, it was one of the top five crucial safety zones in the Lake Victoria basin.

The study suggests that while AI can help tackle safety issues on Lake Victoria, non-technological factors like inadequate staff training, maritime legislation failure, crew fatigue, poor communication, risk management culture, and lack of maintenance are also crucial. Addressing psychological impacts is also critical.

The survey verified that survey respondents trust digital technology to enhance safety protocols, operational effectiveness, and marine activities on Lake Victoria. All seven mentioned at least one past or ongoing digital solution initiative introduced in the region to tackle maritime safety challenges on Lake Victoria and unanimously acknowledged that Artificial Intelligence (AI) greatly enhances marine safety, provided that humans are well taught to harness its potential.

Utilising AI in the marine industry presents a multifaceted challenge. To optimise AI usage results, the study reveals that implementing AI for maritime safety necessitates careful examination of ethical concerns, cross-border issues, social and economic factors, fairness, trust, technical and operational obstacles, language barriers, and legal and regulatory frameworks. Ensuring the alignment of AI policy is essential for maintaining safety in sea transportation, addressing the issue of worker displacement, facilitating the process of reskilling, and overcoming language obstacles. Additionally, when considering services to improve safety on Lake Victoria, it is more logical to prioritise gender equity and diversity management. Although women may not be the primary participants in fishing activities, they play crucial roles in the fishing value chain. They can encourage men to take safety measures, such as using digital services for weather forecasting, navigation assistance, and search and rescue operations. Ethical concerns presented by the study's respondents regarding AI technology include potential misuse, data privacy violations, and identity theft. The portability trap case may occur when individuals become too reliant on AI, leading to biased results. Legal issues raised include the assignment of responsibilities in disasters and accountability for autonomous vessels. Implementing a legal and regulatory framework is essential for effective AI use. Extensive training is necessary for efficient local use.

It is anticipated that the East African region will embrace Artificial Intelligence as a Service (AIaaS) in order to mitigate safety concerns in Lake Victoria. However, early adoption of AIaaS is deemed improbable by certain respondents, who contend that governments have not accorded sufficient importance to lake safety. This perspective aligns with the findings of the Lloyd's Register Foundation World Risk Poll (2022), which indicate that East Africa has the lowest level of receptiveness towards artificial intelligence on a worldwide scale. Nevertheless, this idea seems to be invalidated by recent advancements in other East African nations, including Kenya and Zanzibar (a constituent of Tanzania). These countries have prioritised the blue economy and acknowledged AI as an important tool for improving maritime security and fisheries management. As evidenced by its swift adoption of mobile money applications, the region's past reluctance to "reinvent the wheel" suggests that it is likely that it will adopt AIaaS as a means of addressing maritime safety concerns.

7. Conclusion and Recommendations

The study on the use of artificial intelligence for maritime safety on Lake Victoria highlights five domains in marine safety that may be enhanced by deploying AI systems on Lake Victoria. These are (i) Navigation; (ii) Emergency response (iii) Maintenance, (iv)Environmental protection and (v) Fisheries management. The study suggests that while AI can help tackle safety issues, non-technological factors like inadequate staff training, maritime legislation failure, crew fatigue, poor communication, risk management culture, and lack of maintenance are also crucial. The survey confirms that participants of the study trust digital technology to enhance safety protocols and operational effectiveness. However, implementing AI for maritime safety presents a multifaceted challenge, including ethical concerns, cross-border issues, social and economic factors, fairness, trust, technical and operational obstacles, language barriers, and legal and regulatory frameworks. Furthermore, prioritising gender equity and diversity management in Lake Victoria fishing services is crucial, as women play a vital role in the value chain and can encourage men to take safety measures.

The East African region is expected to adopt Artificial Intelligence as a Service (AIaaS) to address safety concerns, despite opposition from some respondents who believe early adoption is unlikely due to the government's lack of priority. It was learned from the study that to address the issue of trust in AI technologies, the region needs to implement AI regulations targeting potential hazards, societal consequences, responsible advancement, and ethical standards, and also endeavour to establish national and regional policy frameworks for public awareness and AI skills development in East Africa.

The study recommends that the results of this study be utilised as a contribution to the execution of the 4th Lake Victoria Basin Commission Strategic Plan (2021-2026), specifically in the areas of improving safety and security in maritime transport on Lake Victoria, as well as promoting economic investment and maximising the potential of the Blue Economy in the Lake Victoria Basin. The findings could have broad applicability to other lakes in the region, as well as in the execution of the Zanzibar Blue Economy initiative. Further investigations are recommended to explore the potential of new and emerging AIaaS for maritime safety and security in East Africa.

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