

## Assessment of Tanzanian inland waterways vessels accidents, causes, impacts, and mitigation options

By

Jones Atulinda Justace<sup>1</sup>, Anael Elibariki Mtui<sup>2</sup>, Dr Juma M. Msabaha<sup>3</sup>, Dr. Wilfred Johson Kileo<sup>4</sup>,

<sup>1</sup>Department of Maritime Transportation, Dar es salaam Maritime Institute, Dsm, 6727 Tanzania

<sup>2</sup> Department of Marine Engineering, Dar es salaam Maritime Institute, Dsm, 6727 Tanzania

<sup>3,4</sup>Department of Science and Management, Dar es Salaam Maritime Institute, Dsm, 6727 Tanzania



### Article History

Received: 05/09/2024

Accepted: 16/09/2024

Published: 18/09/2024

Vol – 3 Issue – 9

PP: - 21-32

### Abstract

Accidents involving inland waterways vessels pose significant risks to crew members, passengers, aquatic ecosystems, and businesses reliant on maritime transportation in Tanzania. This study assesses the causes of these accidents, evaluates their effects, and examines strategies and options to ensure safe operations. Using a descriptive research design and purposive sampling technique both qualitative and quantitative data were collected from 72 respondents through questionnaires, interviews, and documentary reviews, representing various maritime industry stakeholders. Descriptive statistics and content analysis were used to analyze the data. Findings indicate a consensus among participants regarding causes such as human error, vessel conditions, weather conditions, navigational challenges, inadequate safety practices, emergency response capabilities, and regulatory deficiencies. The associated adverse effects include injuries, loss of life, trade disruptions, environmental damage, and financial losses. Strategies for accident prevention include adherence to navigation rules, regular vessel maintenance, monitoring weather conditions, employing experienced crew members, implementing safety policies, and maintaining effective communication. Understanding the causes and effects of inland waterway vessel accidents is crucial for policymakers, regulatory authorities, and industry stakeholders to develop effective risk management strategies and enhance safety measures in Tanzania's inland water transportation system.

**Keywords:** Tanzanian Inland Waterways, Inland water vessels, Accident, mitigation options

### 1.0 Introduction

Tanzanian inland waterways vessel accidents threaten safety and efficiency. This study examines the origins, effects, and prevention of these events to identify relevant elements, analyze their effects, and propose safety solutions. The research analyzes accident information and engages stakeholders to improve Tanzanian inland waterway safety and effectiveness.

Tanzania contains three major lakes, including Lake Victoria, Lake Tanganyika, and Lake Nyasa. Its economy relies on these interior waterways for trade and people movement. However, preventable accidents on these waterways kill thousands of people and harm property and the ecosystem (Stopford, 2019). This research examines the causes, impacts, and mitigation techniques of these incidents.

Historically, accidents on Tanzania's inland waterways have been a recurring issue, though detailed and comprehensive records from the early 20th century are sparse. Available reports highlights that from 2008 to 2018, over 500 people died in various inland waterways accidents in Tanzania. This signifies that on average about 50 people die every year excluding damage or total losses of cargo and vessel, (Mwakyusa,2019).

The notable accident on Tanzania's inland waterways is the sinking of MV Bukoba in Lake Victoria on May 21, 1996 that killed several hundred to over a thousand persons (Guldenmund, 2021). Other major catastrophes include the sinking of MV Kabalega on May 8, 2005, and the grounding of MV Thor at Ghana Island on March 24, 2006, which lost 300,000 gallons of gasoline. On May 21, 2006, MV Nyamageni capsized, killing 28 persons. The ferry MV Nyerere capsized on Lake Victoria on September 20, 2018,

killing approximately 200 people (TPA report, 2018). On July 30, 2023, two boats capsized in Bunda District, Mara area, killing fourteen individuals, including elementary school students (LVBC report, 2023). On December 8, 2023, MV Wankyo collided with her sister MV Kyone in Lake Victoria, and on April 6, 2024, MV Maman Benita crashed in Lake Tanganyika, according to Tanzania Shipping Agencies Corporation (TASAC). According to the Lake Victoria Basin Commission (LVBC) study (2023), nearly 500 individuals died in Tanzanian inland waterways incidents from 2008 to 2018.

Many research focus on incidents involving bigger sea-going vessels, leaving a void in the particular characteristics affecting accidents with smaller interior waterways vessels (James, 2017). To design effective safety measures and tactics, we must understand these events' particular conditions and causes.

The objective of this study is to assess the factors that lead to accidents involving Inland waterways vessels, in Mwanza ports and to evaluate the effects of those accidents. Furthermore, this study examines the strategies and options to prevent accidents for the safe operation of inland waterways vessels in Mwanza ports, Tanzania.

This study was carried out across the selected ports (Mwanza North, Mwanza South Ports, and Kirumba) in Mwanza, Tanzania because these ports have more inland waterways vessels including ferries, fishing boats, passenger and cargo vessels compared to other ports. Within this scope, the researcher was able to extract data and interact with respondents on determining the root cause of accidents in Tanzania, their effects and mitigation options.

The findings of this study provide new perspectives on enhancing the safety and efficiency of Tanzania inland waterways traffic, which is critical for economic growth and connectivity. Not only that, but also the study will help in understanding the root causes and developing effective measures to prevent accidents, save lives, and safeguard the environment.

## 2.0 Literature Review

### 2.1 conceptual definitions

Inland Waterways, in the context of maritime and transportation studies, refers to waters that are situated within the boundaries of a country and are not directly connected to the open sea (United Nations, 2019). These can include rivers, lakes, canals, reservoirs, and other water bodies that are entirely or partially enclosed by the national borders of the country (Jackson et al., 2020). In contrast to coastal or oceanic waters, inland waterways are not directly linked to the open sea.

Coastal waters refer to the regions where a country's landmass meets the ocean or sea. Inland waterways, on the other hand, are further inland and do not have direct access to the open sea without passing through coastal areas (U.S. National Oceanic and Atmospheric Administration, 2021). Inland waterways encompass a variety of water bodies, each with its

own characteristics. This may include rivers, which are flowing bodies of water, lakes, which are large standing bodies of water, and canals, which are artificial waterways created for navigation or irrigation purposes.

Vessel is a broad term that encompasses any type of watercraft designed for navigation on the water, including seas, oceans, rivers, and lakes. These vessels are used for various purposes, such as transportation of goods and passengers, fishing, scientific research, military operations, and recreational activities (Birch, 2018).

Inland waterway vessels are watercraft designed for use on rivers, lakes, and canals, and they play a vital role in the transportation and economic development of regions within navigable inland waterways (Mineth, 2018). Their design and operation are tailored to the specific conditions of inland water bodies, and they are subject to regulatory frameworks to ensure safe and sustainable navigation (Bryan, 2021).

Accident, in this study, refers to incidents or events that occur in inland waterways and involve inland waterways vessels such as ships, boats, and other watercraft (Dyne, 2019). These accidents can encompass a wide range of incidents, including collisions, groundings, fires, oil spills, and capsizing that result in damage, injuries, or environmental harm in coastal regions (James, 2018).

### 2.2 Human Factors Theory

Smith et al. (2017) highlighted misjudgment, inadequate crew training, weariness, and communication breakdowns as primary causes of inland vessel accidents. These inaccuracies can delay answers, cause navigation errors, and impair crew collaboration. Inland vessel operators can reduce human error accidents by training crews, regulating fatigue using rest schedules, and increasing communication (Manenica et al., 2018). Human errors cause most inland vessel accidents due to their complexity and dynamic character, according to this study. Crew members navigate ships, maintain equipment, and follow safety rules. However, many circumstances can cause errors that impair these duties. Communication issues between crew members or shore-based staff might also cause miscommunication and inappropriate actions. Many Tanzanian research focus on incidents involving bigger sea-going vessels, leaving a void in the particular characteristics affecting accidents with smaller interior waterways vessels (James, 2017). To design effective safety measures and tactics, we must understand these events' particular conditions and causes.

### 2.3 Safety Culture and Organizational Theory

According to Guldenmund (2016), safety culture and organizational theory strongly influence employee safety behavior. A good safety culture encourages safety responsibility, which increases safety procedure compliance and risk identification and mitigation. A weak safety culture can create an organizational atmosphere that neglects safety, raising accident risk. Safety culture and organizational characteristics influence maritime organizations' safety practices and behaviors in inland waterways vessel management, according to this study. A positive safety culture

promotes safety procedure compliance, open communication regarding safety issues, and proactive risk assessment (Nicholson, 2020).

#### **2.4 Regulatory Compliance and Enforcement Theory**

Regulatory compliance and enforcement theory is crucial to inland waterway vessel safety. To ensure safety, vessels and operators must follow regulatory frameworks. Insufficient compliance and enforcement can cause safety difficulties and inland waterway vessel accidents (Holloway & Nicholson, 2016). Safety hazards might develop when regulations are not followed or enforcement is poor. Vessels may overlook maintenance and repairs, causing equipment failures and mishaps. Ships may also exceed load limitations or ignore navigational standards, increasing the risk of capsizing, crashes, or groundings (Hahn, 2018). This study found that regulatory compliance and enforcement are essential to inland waterways vessel safety. Regulations set safety, operational, and procedural standards for vessels to avoid accidents. Standards are enforced by regulatory authorities through inspections, audits, and penalties.

#### **2.5 Causes of inland waterways vessels Accidents**

Previous studies have linked maritime accidents to human mistake, mechanical failure, weather, navigation dangers, and poor safety measures. These factors significantly impact inland waterway transport safety (kimaro, 2017). Human mistake causes most inland waterway vessel accidents. Grabowski et al. (2018) found that human variables such judgment errors and operator weariness cause many mishaps in the US. This quantitative technique examined accident reports and data using statistical analysis to determine the proportion of human error in marine accidents. Nearly 70% of inland waterway accidents were caused by human error. This high incidence emphasizes human factors' importance in marine safety.

Inland waterway vessel accidents are sometimes caused by mechanical breakdowns. The quantitative study by Wang and Zhang (2018) in China examined mechanical failures in inland waterway accidents using statistical analysis. Mechanical failures caused 60% of Chinese inland canal accidents, according to the study.

Regulatory flaws increase inland waterway accidents. In the Amazon River basin, Pires and Linares (2020) found that loose regulatory supervision and inadequate infrastructure increase accident frequency. The study found that regulatory inconsistency contributed to inland waterway accidents by preventing safety regulations and standards from being enforced.

Environmental variables also affect inland waterway vessel accidents. Pires and Linares (2020) found that fluctuating water levels, unpredictable weather patterns, and natural hazards like debris flows and riverbank erosion increased accident risk, especially floods and low water levels, which caused navigational problems and groundings. In contrast, Mwamsojo et al. (2018) stress the need for adaptive methods to mitigate environmental hazards and strengthen Tanzanian inland water transportation infrastructure.

Tanzanian inland waterway vessel accidents are exacerbated by infrastructure deficiencies. Kweka et al. (2019) recommend investing in infrastructure development, including waterway upkeep and navigational aids, to improve safety. This study found that poor channel maintenance and navigational aids increase the probability of inland waterway vessel accidents in Tanzania.

#### **2.6 Effects of inland waterways vessels accidents**

International and local research shows that inland waterway vessel accidents affect society, the economy, and the environment. The financial impact is one. Grabowski et al. (2018) and Pires and Linares (2020) found that accidents cost a lot, including vessel damage, cargo loss, and maritime interruptions. Local studies in Tanzania by Ndalul et al. (2020) and Mwamsojo et al. (2019) found that accidents cost income and raise insurance premiums. Community social impacts of inland waterway vessel accidents are important. Accidents can cause injuries, death, and psychological trauma to crew and passengers, according to Yip et al. (2019) and Sahin (2020). Tanzanian studies by Mwangunga (2017) have also highlighted the human toll of accidents, emphasizing the need to improve safety measures for inland water transporters.

After inland waterway vessel accidents, environmental impacts must be considered. Accidental spills of dangerous substances and pollutants hurt the environment, according to Wang and Zhang (2018) and Pires and Linares (2020). Ndoye et al. (2018) found that accidents damage delicate aquatic ecosystems in Tanzania. Globally, inland waterway accident reduction measures have been proposed and implemented. These include regulatory frameworks, technological advancements, community awareness programs, effective navigation rules, regular vessel inspection and maintenance, weather monitoring, experienced crew and regular training, effective safety policy implementation, and proper vessel communication. The effectiveness of these measures in Tanzania is examined (John and Komba, 2017).

### **3.0 Methodology**

#### **3.1 Research design**

According to Braise (2018), a research design is a thorough road map that directs a study's trajectory toward its goal. Design is a thorough strategy for data collection, measurement, and analysis. To get detailed information from various respondents and ascertain their responses to the topic, the researcher adopted a descriptive research design. Data or information gathered utilized a variety of approaches, including questionnaires to respondents and documentation to evaluate the determinants of accidents involving inland waterways vessels in Tanzania.

#### **3.2 Population and sample size of the study**

According to Hamster (2019), the population of the study is a group of people chosen from the population who interact in a similar environment. However, due to knowledgeable inland waterways vessels, the population for this study comprised 72 Inland waterways vessel operators and officers including accident investigators, TPA officials, TASAC officials, ship repairs/engineers, and experienced seafarers. Respondents

were chosen purposively because the researcher used purposive sampling to select respondents who provided the best information based on the objectives of the study.

### 3.3 Sampling techniques

Choosing a small group of people who most closely resembles the total population of the study is the purpose of sampling (Cohen, 2019). Key informant groups, locations, or events that provide information richness to understand the objectives of the study. In this study, the researcher adopted purposive sampling by choosing respondents purposively depending on the objectives of the study to answer all related questions about the study objectives. The researcher chose this technique because it involves selecting participants based on specific criteria relevant to the research question. It allows for an in-depth understanding of specific cases or groups. The study is appropriate because enables the researcher to collect information from the most appropriate respondents and yields findings that are relevant to the objectives of the study.

### 3.4 Data collection methods

Kothari (2018) argues that research is all about data, the study collected data from major sources, primary and secondary sources. The study involved questionnaires, interviews, and documentary reviews as instruments of data collection. The researcher decided to collect primary data due to the absence of adequate and reliable official records about accidents involving inland waterways vessels in Tanzania. The researcher used Google Forms to share questionnaires to easily extract data from respondents.

#### 3.4.1 Questionnaires

The quantitative and qualitative data, the researcher used Google Forms to share the listed questionnaire to all respondents due to quick response and easy of sharing, a structured questionnaire was given to a total of 66 respondents.

#### 3.4.2 Interviewing

The researcher employed a structured interview with the same questions and sequence as the questionnaire, so it mirrored the questionnaire. Interviews with similar questions in the same order allowed data comparison between questionnaires and structured interviews. Interviews helped improve data dependability by maintaining question sequence and context. A convenience strategy was used to select structured interview participants by contacting potential participants. Accident investigator<sup>1</sup>, vessel operator<sup>2</sup>, TPA officer<sup>3</sup>, TASAC officer<sup>4</sup>, ship engineer<sup>5</sup>, and experienced seafarer<sup>6</sup> participated in 6 structured interviews. The questionnaire instrument was saved as the interview guide for structured interviews, but the conversation focused on accident risk factors and their effects.

#### 3.4.3 Documentary Review

Secondary data was obtained from both published and unpublished materials. Published materials included; written literature, articles, documents and extracts from the Internet as well as journals. According to Banadies (2017), secondary data collection is the study of written texts, including books, articles, and magazine articles that are being published. The

study employed a documentary review as among of key data collection methods. This method involved systematically examining various types of relevant documents to gather comprehensive insights into the factors contributing to vessel accidents. Documents analyzed were accident reports, maintenance records, port authority documents, regulatory and policy documents, weather and environmental reports, training records, and stakeholder reports. Each type of document provided unique information that, when combined, offered an understanding of these accidents.

### 3.5 Data processing and analysis

Descriptive statistics and content analysis techniques were used to analyze and present the data. In particular, the researcher used SPSS software package version 20. The data was summarized, analyzed and interpreted as on each research objective.

### 3.6 Data validity and reliability

Validity is defined as the degree to which the researcher has measured what he has set out to measure (Smith, 2017). Validity refers to the extent to which an empirical measure adequately reflects the real meaning of the concept under consideration. To establish valid data in this study all questionnaires were submitted to the research supervisor before being used for data collection. Also, the questionnaires with answers are resubmitted to the supervisor for review and comments before being processed for drawing results. To test the validity of the data, a pre-test was conducted for 10 respondents to see if the questionnaires contained anything difficult to interpret during the analysis of the data. Validity is used to measure whether the study's results are really about what they seem to be about and check the connections between independent and dependent variables (Kothari (2014). To test for reliability the researcher uses the Cronbach alpha principle to test reliability varies from 0.69 to 0.93 indicating satisfaction and consistency the sample of 10 respondents will be tested and when the results are higher than the minimum alpha of 0.69 would be considered reliable (UCLA, 2019).

## 4.0 Results, findings and discussions

### 4.1 Causes of accidents involving inland waterways vessels in Tanzania

The first objective of this study was to identify the risk factors that cause inland waterways vessel accidents in Tanzania. The researchers identified safety culture implementation and training, human errors, adverse weather conditions, navigation hazards, vessel overloading and deficiencies, ineffective regulatory compliance, technical failure or malfunctions, poor maintenance, and inadequate inspection regimes as contained in Table 1.

**Table 1. Shows the causes of Accidents involving inland waterways vessels in Tanzania**

s/n	Variables	Mean	Std. Dev
	Inadequate safety culture implementation and training	4.15	0.96

Vessel overloading and imbalances	4.20	0.87
Ineffective regulatory compliance regarding inland waterways vessels	3.98	0.88
Technical failure or malfunctions of vessels	4.18	0.85
Navigations hazards	4.02	1.01

Source: Field data, 2024.

#### 4.2 Inadequate of safety culture implementation and training

The average score of 4.15 suggests that respondents agree or strongly agree that safety culture and training are not properly implemented. This suggests this problem is widely considered important. The low standard deviation of 0.96 shows that a total of respondents (83.3%) agree that safety culture and training are poorly implemented. Fig. 1 shows 9.1% disagreed and 7.6% neutral.

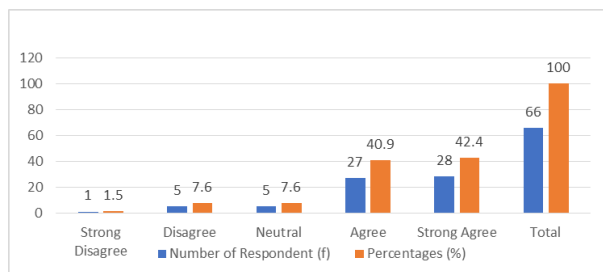


Figure 1 Inadequate of safety culture implementation and training

Source: Field data, 2024.

During the structured interview the following opinions were recorded with Participant4 “without training and regular drills, crews may panic or be unable to perform necessary and required actions during an incident, exacerbating the situation and increasing the likelihood of accidents”.

Participant1 holds that “a strong safety culture extends to passenger education. Inadequately trained crew members may not effectively communicate safety instructions to passengers, leaving them unprepared to respond to emergencies”.

#### 4.3 Vessel overloading and imbalances

The average value of 4.20 shows that respondents agree vessel overloading and imbalances are crucial for safety. The low standard deviation of 0.87 is another evidence of participants’ strong agreement (86.4%) on the overloading and imbalances as shown in Figure 2.

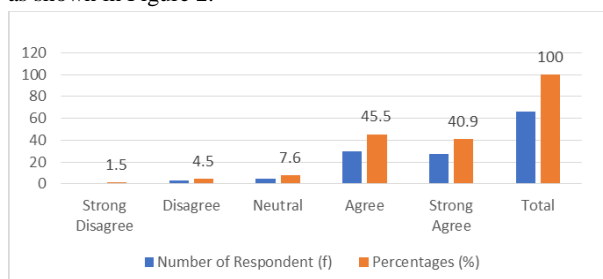


Figure 2 Vessel Overloading and Imbalance

Source: Field data, 2024.

The interviewed Participant 6 further added that “overloading in inland waterways vessels is mostly experienced during the festive/holiday seasons because it is during this period when a larger number of people and the larger quantity of cargo need transported by using the available limited number of the vessel and to meet the deadline. Also, vessels operating in areas with local auctions are more susceptible to overloading”.

#### 4.4 Ineffective regulatory compliance regarding inland waterways vessel operations

Although less strongly than the previous two elements, respondents agree that regulatory compliance for vessels on inland waterways is ineffective. Figure 3 shows that 77.3% of respondents agree and the standard deviation is 0.88, but overall, they think that regulatory compliance for inland waterways vessels is ineffective.

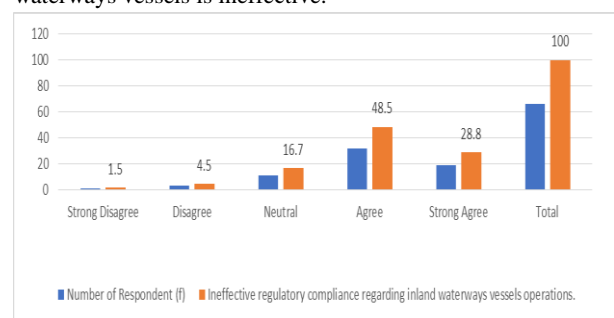


Figure 3: Ineffective regulatory compliance regarding inland waterways vessels operation

Source: Field data, 2024.

From the interview responses, Participant 3 insisted that “there are several crews and other staffs who are employed in marine companies while their education background and certificates are not related to marine”.

Participant 1 holds that “sometimes corruption and lack of proper oversight led to the issuance of licenses and certifications without proper checks. This undermines the regulatory framework and allows unfit vessels and unqualified operators to ply the waters, increasing the risk of accidents”.

#### 4.5 Technical failure or malfunctions of vessels

A high mean of 4.18 indicates that vessel technical faults or malfunctions are safety issues. This means that 87.9% of people agree that these concerns must be addressed as shown in Figure 4. The low standard deviation of 0.85 indicates a high consensus on the matter, emphasizing the necessity to address and minimize technical failures or malfunctions to maintain vessel safety.

In this aspect Participant 5, narrated that “Problems with the steering mechanism can prevent a vessel from navigating properly and this can result in the vessel straying off course, running aground, or colliding with obstacles”. Participant1 commented that “Malfunctions in navigation systems such as GPS, and radar, can lead to navigation errors, also malfunctioning safety equipment,

such as life rafts, fire extinguishers, and bilge pumps, can exacerbate the severity of an incident when an emergency occurs, increasing the risk to lives and property”.

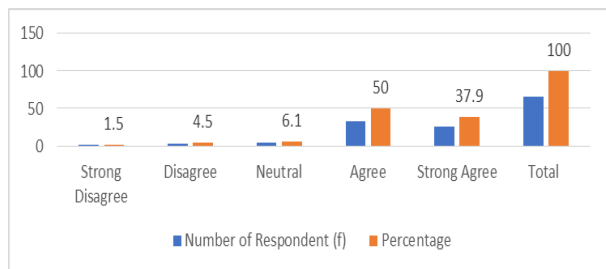


Figure 4 Technical failure/ Malfunctions of vessels (Source: Field data, 2024.)

**4.6 Navigation hazards**

The data shows that 78.8% of the respondents agree that navigation hazards are a concern as shown in Figure 5, although the level of agreement is slightly lower compared to other factors. The higher standard deviation indicates that there are more diverse opinions regarding navigation hazards. Despite the overall agreement on this issue, there is more disagreement among respondents when compared to other factors.

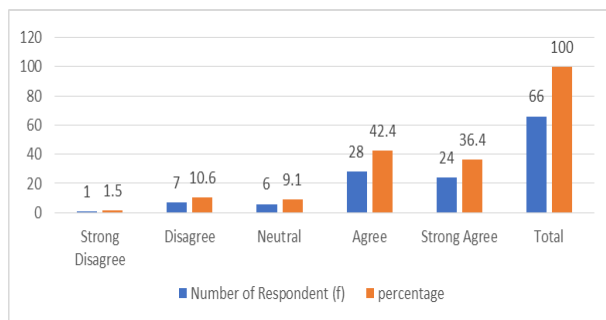


Figure 5: Navigation Hazards (Source: Field data, 2024.)

Regarding the data from the interview, Participant, proposed that “proper buoys, lights, and markers should be installed in most known prone areas as they are essential to guide vessels safely, especially in poor visibility conditions”. Also, Participant6 explained that “Outdated or incomplete hydrographic surveys in most of the inland waterways result in insufficient knowledge about the waterway’s depths, underwater topography, and potential hazards, leading to a navigation error, seasonal changes, such as heavy rains leading to flooding, alters waterway conditions rapidly, introducing new hazards like floating debris or changing currents that can catch vessel operators unprepared”.

**4.7 Effects of accidents involving inland waterways vessels in Tanzania**

After analyzing the data on the effects of inland waterways vessel accidents in Tanzania, respondents agreed that these effects included injuries and loss of life of crew members and passengers, disruption of trade and supply chain, impacts on aquatic organisms and fishing activities, and cargo loss or damage that cost cargo owners and insurers money. Table 2 shows the questionnaire results.

**Table 2. Shows Effects of accidents involving inland waterways vessels in Tanzania**

s/n	Variables	Mean	Std. Dev
1.	Injuries and loss of life of crew members and passengers.	4.20	0.96
2.	Disruption of Trade and supply chain, potentially leading to economic losses for business.	3.53	1.19
3.	Impacts on the livelihood of aquatic organism and fishing activities	3.83	1.04
4.	Loss or damage of cargo leading to financial loss to both cargo owners and insurers.	4.23	0.90

Source: Field data (2024)

**4.8 Injuries and loss of life of crew members and passengers**

According to the mean value of 4.20 and standard deviation of 0.96, from table 2, respondents agree that inland waterways vessels must worry about crew and passenger injuries and deaths. The high mean indicates significant importance, whereas the low standard deviation indicates strong consensus with minimal variation. This indicates a shared understanding of the importance of this safety issue and the need to prioritize comprehensive safety training, strict safety measures, regulatory compliance, and emergency preparedness to mitigate these risks. Figure 6, displays the participants responses regarding the statement that injuries and loss of life of crew members and passengers is among the effects of accidents involving inland waterways vessels in Tanzania.

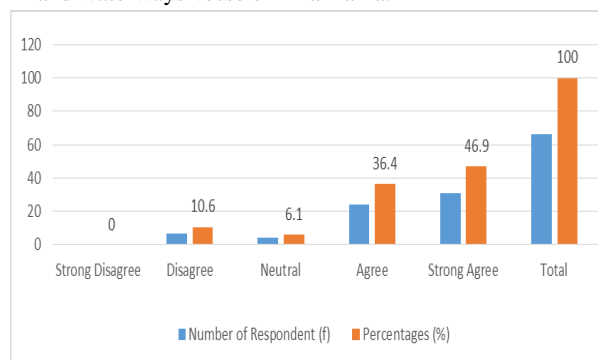


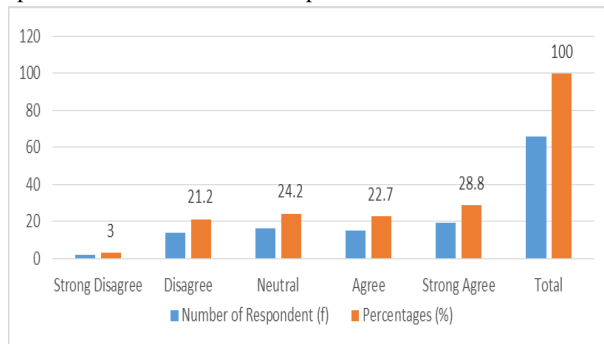
Figure 6; Injuries and loss of life of crew members and passengers (Source: Field data, 2024.)

Participant4 insisted that “ the government is doing its best to ensure safety for inland waterways vessels as in 2017 introduced the TASAC act to ensure inspection and certification”. Participant1 suggested that “despite of these efforts, challenges remain, particularly in the area of enforcement and resources and proposed that continued focus on improving inland waterways infrastructures, enhancing emergency response capabilities, and promoting a culture of safety is essential to prevent future tragedies

and reduce the loss of life and injuries in marine accidents in Tanzania”.

**4.9 Disruption of Trade and supply chain, potentially leading to economic losses for business**

The average of 3.53 and standard deviation of 1.19 indicate that respondents partly agree that trade and supply chain disruptions worry inland waterways vessels. The average suggests that while many consider this problem important, there is less consensus than on other concerns. The higher standard deviation shows a wider range of responses on trade disruption intensity and implications. This shows that the problem is recognized, but opinions on its importance and impact vary, underscoring the need for industry-specific conversations and responses.



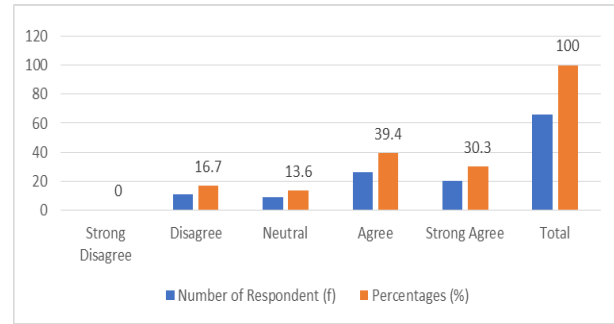
**Figure 7. Disruption of trade and supply chain (Source: Field data, 2024.)**

According to interview Participant3, Tanzania relies on maritime transport for domestic and international trade, so accidents involving inland waterways vessels can disrupt trade and supply chains by causing cargo ship sinkings and financial losses. This is crucial for perishable and time-sensitive commodities. Disruptions raise logistics and transportation expenses. If a key shipping route is blocked, alternative routes may be longer and more expensive, producing supply chain delays and losses that can lead to inventory shortages and an impact on production and sales.

**4.10 Impacts on the livelihood of aquatic organism and fishing activities**

The average value of 3.83 and the standard deviation of 1.04 show that most respondents think that inland waterways vessels worry about aquatic species and fishing. The relatively high average shows most responders value this topic. The moderately low standard deviation shows reasonable agreement, but significant response variability. The necessity of safeguarding aquatic life and fishing activities is widely recognized, although its influence is debated. This emphasizes the need for comprehensive environmental management and tailored initiatives to solve these issues.

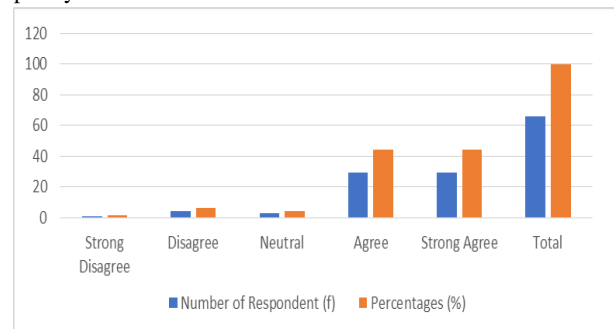
Participant1's statement that "for many coastal communities, fishing is a primary source of protein" caught the researcher's attention. Fish shortages can cause food instability, malnutrition, and reliance on unhealthy foods. Consuming contaminated seafood can cause toxicity and long-term health consequences, straining community health resources.



**Figure 8 : Impacts on the livelihood of aquatic organisms and fishing activities (Source: Field data, 2024.)**

**4.11 Loss or damage of cargo leading to financial loss to both cargo owners and insurers**

The average score of 4.23 and the standard deviation of 0.90 show that respondents agree that inland waterways vessels worry about cargo loss or damage as shown in Figure 9. The high average value and low standard deviation indicate that respondents value this issue highly. This indicates that there is consensus on the importance of addressing cargo loss and damage, emphasizing the need for effective cargo handling practices, improved safety measures, and strict regulatory compliance to reduce financial risks and ensure cargo safety. Participant4 stated that the cargo owner loses the products' worth, which might result in destruction or major damage and significant financial loss in marine accidents. High-value or perishable commodities suffer the most financially. The insurer must compensate the cargo owner for loss or damage per the policy.



**Figure 9: Damage of cargo and financial loss (Source: Field data, 2024.)**

**4.12 Strategies adopted by authority for the safe operations of inland waterways vessels**

This last objective of the study examined Tanzania's current practices for safe inland waterway vessel operation, including encouraging stakeholders to follow navigation rules and regulations, inspect and maintain vessels, monitor weather conditions, and hire experienced crew members.

**Table 3 Strategies adopted by authority for the safe operations of inland waterways vessels**

s/n	Variables	Mean	Std. Dev
1.	Effective adherence to navigation	4.44	0.71

	rules.		
2.	<b>Regular inspection and maintenance of the vessels.</b>	4.47	0.58
3.	Monitoring of weather conditions	4.14	0.80
4.	Employment of experienced crew and regular training programs	4.42	0.72
5.	Effective implementation of safety policies	4.27	0.59
6.	Maintenance of proper communication among inland waterways vessels	4.30	0.67

Source: Field data (2024)

#### 4.13 Effective adherence to navigation rules

The mean score of 4.44 and standard deviation of 0.71 show that respondents strongly agree that inland waterways vessels must follow navigation rules. The high mean shows that navigation regulations are widely accepted for safety and efficiency. The low standard deviation indicates that respondents agreed on most things. This consensus emphasizes the importance of tight navigation standards for inland waterway safety and reliability. The International Maritime Organization (IMO) sets COLREGs (International Regulations for avoiding Collisions at Sea 1972) navigation guidelines that member governments like Tanzania can apply to manage their inland waterways boats. Following navigation rules effectively reduces inland waterway vessel accidents. To increase inland waterway transportation safety and effectiveness, the authority promotes safe navigation, clear communication, risk management, compliance with rules, and a safety-oriented atmosphere.

#### 4.14 Regular inspection and maintenance of the vessels

A majority respondents think that vessel inspection and maintenance are crucial, as shown by the mean value of 4.47 and standard deviation of 0.58. The very high mean shows that most respondents consider this topic significant. Low standard deviation indicates great consensus with few replies. This shows that thorough and consistent maintenance processes are needed to ensure the safety, reliability, and durability of inland waterways boats. Lack of regular inspection and maintenance in inland waterways vessels leads to a lack of life jackets, lifeboats, distress signals, firefighting appliances and equipment, vessels not being dry docked for routine maintenance and repairs, and crews not being licensed to work on the vessel, making accidents more likely.

#### 4.15 Monitoring of weather conditions

The average score of 4.14 and the deviation of 0.80 show that respondents agree that inland waterways vessels should monitor weather conditions. The average suggests weather monitoring is important, but not as much as other safety measures. The moderate discrepancy shows that respondents' views on weather severity and impact on maritime operations vary. This implies that while weather monitoring is vital, opinions may vary on its impact and safeguards. This

underlines the need for extensive weather monitoring techniques and adaptive strategies to reduce hazards and ensure safe navigation in diverse weather situations. Operators can safely travel inland waterways by being informed, practicing caution, and adapting to changing weather (Rasmussen, 2017)

#### 4.16 Employment of experienced crew and regular training programs

Skilled crew and frequent training reduce inland waterway vessel accidents. Maritime operators may improve safety, decrease dangers, and protect people and the environment by using the knowledge of experienced specialists and investing in their growth. The fact that no participants disagreed suggests that these procedures help prevent accidents. The lack of alternative perspectives highlights the importance of trained maritime workers and continual training. The data emphasizes the need for maritime stakeholders to prioritize personnel competence and continual learning in accident prevention and mitigation. International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers (STCW 1978) provides minimum qualifications for shipmasters, officers, and watchkeepers. For Tanzanian interior waterways vessel safety, vessel operators must follow STCW.

#### 4.17 Effective implementation of safety policies

Approximately 95% of the sample agreed. The polled populace agreed that safety rules are essential to preventing inland waterway vessel accidents in Tanzania. Safety measures are crucial to preventing inland waterway vessel accidents in Tanzania. Safety policies promote regulatory compliance, risk assessments, training, safety equipment use, regulation enforcement, and stakeholder collaboration to make the maritime environment safer and more sustainable (Reason, G 2020).

#### 4.18 Maintenance of proper communication among inland waterways vessels

The marine authority advises inland waterways vessel operators to communicate well to improve navigational safety, avoid collisions, respond to emergencies, manage traffic, and comply with rules. Vessels can reduce hazards, and accidents, and make inland waterways safer by communicating openly. The statement was supported by 93.9% of respondents.

### 5.0 Discussion of the findings

This study aimed to assess the Tanzanian inland waterways vessels accidents, focusing on the causes, impacts and mitigation options. The results after data analysis demonstrated a unanimous agreement among respondents regarding several crucial aspects.

Firstly, there was a widespread acknowledgment of the importance of implementing a safety culture and training to prevent accidents. The average score of approximately 4.15 indicates that respondents generally agree or strongly agree that there is a lack of proper implementation of safety culture



and training. This implies that, this issue is widely recognized as significant. The standard deviation of around 0.96, which is relatively low, suggests that there is a consensus among most respondents regarding the inadequate implementation of safety culture and training. This further emphasizes the widespread agreement on this matter. Also, Jackson, et al. (2019), conducted a study examining the role of safety culture and training in reducing maritime accidents. Their findings emphasized the critical importance of regular safety training and a robust safety culture in preventing accidents. The study also highlighted that organizations with comprehensive safety training programs had significantly lower accident rates. In comparison, both studies highlight the significant role of safety culture and training in preventing accidents. The high agreement rate in the current study aligns with Jackson, et al. (2019), findings, underscoring the need for continuous safety education and training programs.

Additionally, respondents overwhelmingly concur that vessel overloading contributed significantly to accidents involving inland waterways vessels. The average value of 4.20 indicates a consensus among respondents on the critical importance of addressing vessel overloading and imbalances for safety. The low standard deviation of around 0.87 further confirms the strong agreement among participants on the significance of these issues. Further studies are recommended to deepen the understanding and develop more effective safety measures. In this part of overloading consider a study by Jones and Smith (2020), that explored the impact of vessel overloading and imbalances on maritime safety. The study revealed that vessel imbalances, due to uneven cargo distribution, are significant contributors to accidents. The study stressed the importance of proper cargo planning and crew training. The current study aligns with Jones and Smith's findings, underscoring the importance of proper cargo planning and training to prevent accidents. Both studies advocate for better cargo management practices to enhance safety.

Furthermore, interviews support the quantitative findings by highlighting specific risks associated with ineffective regulatory compliance, such as lack of essential safety equipment, poor enforcement of loading capacities, and unqualified personnel operating vessels. These insights emphasize the need for robust regulatory frameworks and strict enforcement mechanisms. The average mean score, just under 4, suggests that there is a consensus among respondents that regulatory compliance for vessels on inland waterways is not effective, although not as strongly as with the first two factors. There is a moderate level of agreement indicated by the standard deviation of approximately 0.88, with some variability in responses but overall, a consistent acknowledgment of the ineffectiveness of regulatory compliance for inland waterways vessels as shown in Table 4.4. Refer to a study by Anderson and McDonald (2017), on regulatory Compliance and Maritime Accidents. In their study, they found that weak regulatory compliance is a significant factor in maritime accidents, particularly in regions with limited regulatory oversight. It highlighted issues such as inadequate safety equipment, poor enforcement of safety

regulations, and lack of qualified personnel. The findings are in consistent with the current study, which also emphasizes the critical role of effective regulatory compliance in preventing accidents. Both studies underscore the need for stronger regulatory frameworks and better enforcement.

Technical failures or malfunctions of vessels are considered significant safety issues, as indicated by a high mean of approximately 4.18. This suggests a strong agreement among individuals regarding the importance of addressing these issues. Furthermore, the low standard deviation of approximately 0.85 signifies a strong consensus on the matter, emphasizing the need to address and mitigate technical failures or malfunctions to ensure the safety of vessels through regular maintenance, equipment inspections, and comprehensive crew training to mitigate the risks associated with technical failures. On the other hand, Jones et al. (2018), identified technical failures as a major contributor to maritime accidents, particularly highlighting the role of engine malfunctions, steering issues, and electrical failures. The study stressed the need for regular maintenance and inspections. The current study's findings are consistent with Jones et al (2018), as both studies highlighted the significant impact of technical failures on maritime safety. Both studies emphasize the importance of regular maintenance and technical inspections.

Additionally, the qualitative interviews further support the quantitative findings by providing detailed examples of how navigation hazards such as rocks, submerged logs, debris, varying depths, sandbanks, strong currents, and inadequate navigation aids contribute to increased risks and accidents as same as questionnaire data. The data shows that respondents generally agree that navigation hazards are a concern, although the level of agreement is slightly lower compared to other factors. The higher standard deviation indicates that there are more diverse opinions regarding navigation hazards. Despite the overall agreement on this issue, there is more disagreement among respondents when compared to other factors. Refer to the IMO report (2021), which highlighted global issues with navigation hazards. The report stressed the importance of modernizing navigation aids and improving weather monitoring systems. The report called for international collaboration to enhance maritime safety. The current study's findings are in consistent with the IMO report, emphasizing the need for modernized and reliable navigation aids. Both highlight the importance of international standards and collaboration to address navigation hazards effectively. Moreover, participants share concerns regarding the potential consequences of accidents, including injuries, loss of life, and disruptions to trade and supply chains, thereby emphasizing the far-reaching impacts of such incidents. For instance, the mean value of 4.20 and standard deviation of 0.96 indicate that respondents largely agree that injuries and loss of life of crew members and passengers are significant concerns for inland waterways vessels. The high mean suggests the issue is deemed very important, while the low standard deviation reflects strong consensus with little variability in responses. This implies a shared understanding of the

critical nature of this safety concern, highlighting the need for a priority focus on comprehensive safety training, strict implementation of safety measures, enhanced regulatory compliance, and improved emergency preparedness to mitigate these risks effectively. The findings provide valuable insights for policymakers, regulatory authorities, and stakeholders in the maritime industry to prioritize initiatives aimed at enhancing safety protocols, training programs, and emergency response capabilities.

In this part it is important to refer to a study by Jackson et al. (2018), examining vessel Accidents and Safety Protocols. Their study identified a direct correlation between vessel accidents and the severity of injuries and fatalities. Their study emphasized the need for strict enforcement of safety protocols and regular maintenance of vessels to prevent accidents. Hence the current study aligns with Jackson et al.'s findings, highlighting the critical need for stringent safety measures and proactive enforcement to reduce injuries and loss of life.

Disruption of Trade and supply chain, potentially leading to economic losses for business was also identified as among the effects in which the mean of 3.53 and a standard deviation of 1.19 show that respondents somewhat agree that the disruption of trade and supply chains is a notable worry for inland waterways vessels. The mean implies that although many view this matter as significant, there is not as strong of a consensus compared to other issues. The relatively higher standard deviation indicates a wider range of responses, showcasing differing opinions on the severity and consequences of trade disruptions. This indicates that while the problem is acknowledged, views on its importance and impact vary, highlighting the need for focused discussions and strategies to address specific concerns and viewpoints within the industry such as enhancing navigation infrastructure and implementing effective emergency response protocols. The qualitative data further supports these findings by providing specific examples and highlighting the broader regional impact of such disruptions. Thus, UNCTAD, Report (2021), discussed the global impact of maritime disruptions, pointing out that developing countries are particularly vulnerable due to less resilient supply chains and dependency on maritime trade routes. The report called for international cooperation to improve maritime safety and infrastructure. The findings of the current study are consistent with the UNCTAD report, highlighting the vulnerabilities in Tanzania's maritime infrastructure and the broader regional implications of trade disruptions.

The findings of this study differ from other previous studies for example a study by Li and Chen (2019) explored the impact of adverse weather conditions on inland waterways vessel accidents. The empirical analysis revealed a positive correlation between adverse weather and accident rates. The study highlighted the need for improved weather forecasting systems, effective communication between vessels and authorities, and the development of weather-related safety protocols to minimize accidents during inclement weather

while this study examined different determinants of accidents involving inland waterways vessels in which adverse weather conditions were among them. Other determinants included overloading and imbalance, ineffective regulatory compliance, technical failure or malfunctions, poor maintenance, and inadequate inspection regimes of vessels. Also, Nascimento et al. (2020) conducted a study investigating the influence of navigational aids on Inland vessel accidents. The research utilized vessel tracking data and found that the lack of or malfunctioning navigational aids significantly contributed to accidents. The study underscored the importance of maintaining and updating navigational aids and the need to enhance crew training on their effective utilization. This is again different from my study because the study utilized data from respondents through questionnaires, interviews, and documentary review also navigation aids were not considered in my study.

The findings in this study are strongly supported by authors like Zhang et al. (2023), who examined maritime regulations and enforcement as determinants of accidents in Inland vessel operations. The empirical analysis revealed that weak regulatory frameworks and a lack of enforcement mechanisms contributed to a higher incidence of accidents. The author emphasized the necessity of robust regulatory measures, regular inspections, and stringent penalties to improve safety practices and reduce accidents.

## 6.0 Conclusion

The results of the data analysis offer valuable insights into the risk factors influencing accidents involving inland waterways vessels in Tanzania. Respondents across various aspects, such as safety culture, vessel overloading, regulatory compliance, technical reliability, and navigation hazards, have reached agreements on the major challenges faced within the maritime industry. Inadequate implementation of safety culture and training is highlighted as a critical factor contributing to inland waterways vessel accidents. The majority of respondents strongly agreed or agreed that deficiencies in safety culture and training significantly impact accident occurrence, emphasizing the need to prioritize safety culture development and training initiatives to reduce risks.

Vessel overloading and imbalances are identified as significant causes of accidents involving inland waterways vessels. The high level of agreement among respondents underscores the importance of strict adherence to loading guidelines, proper cargo planning, and continuous monitoring of weight distribution to prevent accidents related to these factors' Ineffective regulatory compliance in inland vessel operations is recognized as a major contributor to accidents. Strengthening regulatory frameworks and fostering a culture of compliance within the maritime industry are considered essential to improving safety standards and preventing accidents.

Moreover, technical failures or malfunctions of vessels are acknowledged as key factors leading to accidents. Proactive measures such as regular maintenance, equipment inspections, and crew training on emergency response procedures are

deemed essential to mitigate the risks associated with technical failures, and navigation hazards like storms, strong tides/currents, sandbars, and fog are identified as significant contributors to accidents involving inland waterways vessels. Addressing these hazards requires proactive measures, including monitoring weather conditions and implementing appropriate safety protocols.

The analysis results offered valuable insights into the effects of accidents involving inland waterways vessels in Tanzania. Respondents agreed on the significant challenges posed by these accidents across various dimensions, such as human safety, economic stability, environmental impact, and financial repercussions.

Injuries and fatalities among crew members and passengers are highlighted as major consequences of inland waterways vessel accidents. Respondents stressed the importance of preventive measures and safety protocols to mitigate these risks.

Disruptions to trade and supply chains, potentially resulting in economic losses for businesses, are recognized as a significant effect of inland vessel accidents as well as adverse effects on aquatic ecosystems and fishing communities are identified as significant consequences of inland vessel accidents. Respondents emphasize the need for environmental protection measures and sustainable practices.

Moreover, the financial losses due to cargo loss or damage for cargo owners and insurers are acknowledged as a significant outcome of inland vessel accidents. Respondents stressed the importance of risk management strategies and comprehensive insurance coverage.

Apart from tangible impacts, accidents involving inland waterways vessels can also have wider implications for regulatory frameworks and policy formulation. International studies, such as those by Grabowski et al. (2018) and Wang and Zhang (2018), have underscored the role of accidents in prompting regulatory changes and the implementation of stricter safety measures. In Tanzania, research by Macha et al. (2017) and Ndalul et al. (2020) has similarly highlighted the significance of accident analysis in guiding policy decisions aimed at enhancing safety in inland water transportation.

In conclusion, several strategies have been adopted by the Tanzania authority for the safe operation of inland waterways vessels among which is strict adherence to navigation rules and regulations, which is considered a fundamental measure in accident prevention. The majority of respondents strongly agree on its effectiveness. Similarly, regular inspection and maintenance of vessels are deemed essential, with unanimous agreement among respondents on the importance of this practice in reducing accidents. Furthermore, monitoring weather conditions, employing experienced crew members, conducting regular training programs, and implementing safety policies are identified as critical strategies in accident prevention. Respondents overwhelmingly support the effectiveness of these strategies. The importance of maintaining proper communication among inland waterways

vessels is also emphasized, with a vast majority of respondents recognizing its role in minimizing accident risks. These findings highlight the need for a comprehensive approach to accident prevention in inland waterway transportation. By prioritizing strategies such as adherence to regulations, vessel maintenance, weather monitoring, crew training, safety policy implementation, and effective communication, the safety of maritime activities can be significantly improved.

## 7.0 Recommendation

Practitioners, researchers, and stakeholders should use this study for reviewing or assessing the safety of inland waterways vessels, to modify the existing situation and practices, and to design new ways for ensuring the safe operation of inland waterways vessels and hence reduce their involvement in accidents. The knowledge gained also stimulates the Tanzania maritime administration to effectively encourage the effective development and implementation of safety policies, navigation rules, and other regulations that aim at ensuring the safe operation of inland waterways vessels. Also, this research has direct implications on the need for education and training, shipping companies and vessel owners should invest in training and career development of their crew to help them take needed actions in challenging maritime operations. Furthermore, the knowledge gained from the findings and methodology used in the study should be used by other researchers to design studies that further will narrow gaps in the existing literature. This knowledge should also be used to design future studies that are more valid, generalizable, transparent, coherent, and credible. Specifically, the knowledge generated by the research should be used to suggest future research topics, and also to help other researchers select variables and measures that may be appropriate for a particular topic area of research study.

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