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Analysis of the domestic passenger ferry safety in Kenya

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ANALYSIS OF THE DOMESTIC PASSENGER FERRY SAFETY IN KENYA

By

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DECLARATION

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

(Signature): ....

(Date): ......18/09/2017..........

Supervised by: Prof. Jens-Uwe Schröder-Hinrichs

World Maritime University

DEDICATION

Susan and Genna.

May the lord always shine in your lives forever.

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Abstract

Title of Dissertation: **ANALYSIS OF THE DOMESTIC PASSENGER FERRY SAFETY IN KENYA**

Degree: MSc

This dissertation probes in to domestic passenger ferry safety in Kenya. It looks into past accidents that have occurred, their causes, impacts, investigation and if any lessons were learnt from them. Also, it reviews the past and current operational system in the Kenya water transport network by analyzing the passenger vessels, operators, regulators and all stakeholders involved. This analysis further focusses on sampled ferry accidents and incidents in Mombasa, Kenya.

Passenger vessels, especially domestic passenger ferries have been utilized worldwide to connect islands and are considered as an efficient means of transport. They have hugely contributed to reduce time and distance through their operational efficiency by creating shortcuts between islands.

Kenya has access to both the Indian Ocean and inland waters which include lakes, dams and rivers. Passenger vessels in Kenya entail ferries, boats and cruise ships calling at the country's main port. There has been numerous passenger vessel accidents experienced in the country due to various reasons. In most cases, massive losses have been experienced in these accidents.

This research has applied an appropriate accident causation model to study ferry related accidents in Kenya and the effect marine casualty investigation has had thereto. It has also sought to address any gaps that may exist between the operators, the administration and the users.

Human Factor Analysis Classification System – Machinery Spaces on Ships has been used to present the analysis in this study because it has the additional level of outside factors and also expounds on unsafe acts, organizational influences, unsafe supervision and preconditions of unsafe acts which are major areas in relation to the safety of ferries in Kenya. It has provided a better understanding of ferry safety and how the human element contributes to unsafe situations. The closing chapter has outlined recommendations that can help in improving ferry safety in the country.

Key words: Ferries, Accident Analysis, Passenger Safety, Marine Casualty Investigation

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List of abbreviations

CLC	Civil Liability Convention
COMSAR	The Sub-Committee on Radio communications and Search and Rescue
CREAM	Cognitive Reliability and Error Analysis Method
EMCIP	European Maritime Casualty Investigation Platform
EMSA	European Maritime Safety Agency
EU	European Union
EUR-OPA	Major hazards agreement of the council of Europe – Oil Pollution Act
GISIS	Global Integrated Shipping Information System
HFACS	Human Factors Analysis Classification System
HFACS-MSS	Human Factors Analysis Classification System – Machinery Spaces on Ships
ICAO	International Civil Aviation Organization
IMO	International Maritime Organization
ISM	International Safety Management Code
ISPS	International Ship and Port Facility Security
KFS	Kenya Ferry Services
KMA	Kenya Maritime Authority
KPA	Kenya Ports Authority
LL 69	International Load Line Convention
LSA	Life Saving Appliances
MAIB	Maritime Accident Investigation Branch
MARPOL	International Convention on Marine Pollution
MEPC	Marine Environmental Protection Committee

MRO	Mass Rescue Operation
MSC	Maritime Safety Committee
MV	Merchant Vessel
NOAA	National Oceanic and Atmospheric Administration
OPA 1990	Oil Pollution Act of 1990
OPRC	International Convention on Oil Preparedness Response and Cooperation
RMRCC	Regional Maritime Rescue Coordination Centre
SAR	Search and Rescue
SMS	Short Message Service
SOLAS 74	International Convention on Safety of Life at Sea
SRR	Search and Rescue Region
STAMP	Systems Theoretic Accident Modelling and Process
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea
USA	United States of America

ANALYSIS OF THE DOMESTIC PASSENGER FERRY SAFETY IN KENYA.

1 Introduction

This research addresses domestic passenger ferries in Kenya, their operational system, history of accidents and incidents, their causes and preparedness that exists currently and the effect of marine casualty investigations from previous marine casualties. Analysis on passenger ferry safety has been done using the HFACS-MSS taxonomy to probe into accident causations and explore guidance on how to eventually achieve passenger ferry safety in Kenya. Human factor analysis is a multi-disciplinary science that addresses the cognitive and physical behavior of person(s) and how they function in social, technical and environmental situations. It may involve the primary operating personnel, deficiencies in management, policies, supervision, maintenance, and hardware and equipment design (Cushing, 2013). Due to the challenges and constraints of marine casualty and incident investigations in Kenya, the author has proposed countermeasures fixated on endowing an independent investigation body in the country whereby marine causalities and incidents can be efficiently and adequately investigated for the benefit of the nation and IMO objectives on marine casualty investigations.

Marine casualties refer to the operation of a marine vessel that results into a loss of life, injury or loss of persons, damage to vessel or to the marine environment, loss of vessel or its abandonment, grounding or collision. On the other hand, marine incident refers to a series of events related to the safety of a vessel that occurs and may endanger the safety of a vessel, persons and environment if not corrected.

1.1 Problem Statement

Even though water transport is ranked among the safest means of transportation in comparison to road transport, the safety and use of domestic passenger ferries in developing nations still needs more improvement (Galic, Lucik, & Skoko, 2014). Most developing countries face the problem of passenger ferry safety and Kenya is not exceptional as observed from the frequency of recent domestic ferry mishaps.

In every passenger transport operation, passenger safety is an essential element to be observed and maintained. Reports and every data pertaining passenger safety, including past accidents, their full analysis and stipulated recommendations require attention. Sklet (2004) highlighted that major accidents that lead to a higher number of fatalities still exist even though there has been more focus in risk assessment in the maritime industry globally. Further he suggested that if thorough marine casualty investigations could be conducted after every incident, many persons in the industry would learn and this could further help in averting future accidents. The various models of accident investigations applied today should be sustainable in order to ensure that the past mistakes in the ferry industry that have costed lives are not repeated. For a comprehensive investigation, a marine casualty investigation requires a combination of more than one method (Sklet, 2004).

According to Schröder (2003) a solid database for marine casualties is lacking in a majority of developing countries which could help in performing risk assessments for the shipping industry. In developing nations, once a ferry accident occurs, a few unsustainable measures are taken and a plain investigation and recommendation is given. (Fatoumatta, 2015). Seldom will a simple judgement by an expert be utilized if there is no history of marine casualty data. This calls for the need to have knowledge about what can be done to overcome the deficiencies facing marine casualty investigations. In addition, Schröder (2003), and Fatoumatta, (2015) pointed out that it is the mandate of the investigation body that determines the focus of an investigation and as such the model to be used during the investigation.

When ferry accidents occur in developing nations, the poor people are affected most because it is the majority who use the ferries and boats. Limited preventive measures have been put in place to act as measures against these accidents which are recurring. The sector seems to fall into a vicious cycle because of the very many sub-standard vessels operating in the public and private sectors. Improvement of the passenger ferry sector needs to be prioritized in terms of design, construction, survey, investigation, competence, just to mention but a few, in order to make the ferry sector safe in the country. A look at the ever overcrowded vessels at the Likoni Channel sends signals of a looming disaster in waiting. One can ask, what is the maritime administration doing about it? A probe on what policies they have formulated in this regard and the regulations enforced is necessary. According to Lawson et al. (2005), technology, standards and procedures of inspection, certification, Search and Rescue (SAR) services, training, reporting and analysis, and even more important the involvement of both the private and public sectors can contribute towards continuous improvement.

Varying standards, regulations and policies on professional marine casualty investigation, as well as different methods of assessing the investigators proficiency and competence, result in an inconsistent system for safe operations in the marine transport industry (Galic et al., 2014). Therefore with this in mind, the safety of ferries in Kenya cannot be ignored. Although the IMO is not responsible for such kinds of ships, they are of importance for any multi-modal transport system and play a vital role in contributing to a nation's growth within a global economy. Due to these difficulties, this study will hence analyse the impact of passenger vessel safety with view from the ship-owners and the services they provide, the maritime administrations regulation capability and its accident investigation quality.

1.2 Background of the Study

The safety of maritime transportation is an establishment reliant on measures considered to have the capacity to protect human life, materials and non-material property affiliated directly or indirectly to marine transport. Safety at sea is a fundamental component that can be broken down into to the following; institutions bringing legal regulations, those in charge of the implementing and overseeing safety measures and standards, legal instruments related to safety at sea and international maritime conventions, and users at sea (Galic et al., 2014).

Accidents involving passenger ferries are common in coastal and inland navigation especially when necessary maritime safety regulations are not stringently followed and monitored. On the other hand, domestic passenger ferries are deemed to be one of the most successful types of transportation operating today with its commercial demand proving its stakeholders and consumers to be reliant on it in terms of affordable transport of trade and passengers between islands, (Hannah, 2016). According to Hannah, the use of domestic passenger ferries has been utilized worldwide as it has connected islands and its operational efficiency contributed to reducing the distance and operation time by creating shortcuts between these islands. In Kenya, the same case applies, indeed, statistics indicate that many persons use passenger vessels to move from one mainland to the island and back. For instance, in Mombasa, from the island crossing to the Likoni mainland, seven ferries with an approximate carrying capacity of 1500 passengers operate on the channel throughout the year (KFS, 2016). However, while the capacity is about 1500, the ferries usually carry more than the required capacity due to the limited number of ferries and increase in population, thereby ignoring and violating safety the rules and regulations. This is also observed in other water transport areas like Lamu and inland water bodies like Lake Victoria, Turkana and Baringo.

The Kenya Maritime Authority (KMA), is a government parastatal that was set up in June 2004 with a mandate to regulate and oversee maritime affairs in Kenya's maritime industry. Promoting maritime safety is one of the administrations core functions. Being the pacesetter of the industry, the authority has made an effort to strengthen national maritime legislation through enhancing the regulation and institutional capacities for safety and security of the domestic fleet. This has created the effective implementation of international maritime conventions and other necessary instruments on safety and security into the national law for the safety of domestic ships. The maritime administration, among other functions, coordinates search and rescue, promotes the preservation of the marine environment, prevents marine pollution, trade facilitation and maritime investments and supports maritime education and training (KMA, 2008).

1.3 Objectives

Following the background information mentioned above, this dissertation attempts to probe into ferry accidents in Kenya. In addition to having a more specified goal, this dissertation will analyse the causes of ferry accidents and their impacts, and identify the gaps existing in marine casualty investigation as well as the mitigation of these accidents including, but not limited to the following topics:

1. To analyse passenger ferry accidents in Kenya by using an accident analysis taxonomy, Human Factors Analysis Classification System – Machinery Spaces on Ships (HFACS-MSS)
2. To identify and rank causes of accidents and incidents involving ferries.
3. To ascertain the current situation of marine casualty and accident investigation in Kenya.
4. To comprehend the marine casualties involved in passenger ferries, the related challenges and limitations aiming to identify key areas for improvement and provide specific practical recommendations.

1.4 Scope and Research Methodology

This dissertation does not endeavour to showcase all the information and issues involving ferry operations and safety in Kenya. The scope of this dissertation focuses on analysing some selected typical accidents as they have previously occurred in Kenya using the HFACS – MSS framework and taxonomy and probe into the marine casualty and accident investigations in the country. The rationale behind the use of ferries as a category of passenger vessels is due to the potential hazards facing the ferry transport industry in Kenya and to use them as a case in point which can be utilized to learn and to reference future incidents and accidents within Kenyan waters. In addition to the scope, this dissertation will also analyse any existing gaps in marine casualty and incident investigations especially in relation to previous marine casualties for future prevention of similar tragedies.

The main source of information for this dissertation includes the safety regulations for domestic passenger ferries, the Merchant Shipping Bill (MSB), scientific literature, journals, conference proceedings, professional research reports, field studies carried out in various countries, other dissertations, causality reports and articles and where need be, newspaper reports. Put together, this will demonstrate a comparative picture of the strengths, weaknesses, opportunities and threats of the ferry transport industry in Kenya. Besides, lectures from both visiting experts and resident professors contribute to a major extent towards this write up.

1.5 Significance

This study is significant because it focuses on the vital role of transportation which is important for the development of any nation. It cuts across the board in Kenya to address the administration, the seafarers, operators, future researchers and academics, policy makers, stakeholders and the general public. It seeks to highlight any inefficiencies in the ferry sector and suggests measures to bring down the negative implications through marine casualty investigations. It is assumed the research will guide policy makers in decision making concerning the safety of passenger vessels in the country. It will form an empirical and theoretical framework for further research and contribute towards knowledge in the subject area thereby filling some gaps in the maritime literature in Kenya. The public may be enlightened on various causes of marine accidents and the various marine casualties before, while the stakeholders and operators can look at this research as a document to review their roles and mandates. Lastly, but rather important, the recommendations and conclusion will provide new dimensions for safer performance in the ferry sector in Kenya.

1.6 Structure of the study

Based on the problems in the domestic ferry sector in Kenya briefly introduced above the thesis should be structured as follows: -

Chapter I is an introduction to briefly highlight the subject matter, followed by the problem statement, the motivation behind this research, the objectives intended to be achieved and the scope and methodology used. Chapter II highlights the literature review on passenger vessel operations and casualties in Kenya and also looks into the national legal and regulatory framework and what the nation is doing to promote safety in the ferry industry. In Chapter III the methodology to be used is explained while in Chapter IV an analysis of data has been presented followed by a discussion of the analysis in Chapter V. A summary is given and the conclusions are stated in Chapter VI and finally the recommendations are proposed in Chapter VII.

2 Passenger vessel operations in Kenya.

Every country, both developed and developing, struggles to improve its economy. Kenya is a nation where water transport, being an important means of connectivity both internationally and locally, remains to be a very vital means of transport. Various passenger vessels allow for the movement of people within the country and overseas. Internationally, cruise ships and large vessels are used to facilitate movement. The port currently has two dedicated passenger berths for cruise vessels calling at Kenya (WPS, 2015-2016). Cruise ships call at the Port of Mombasa, mostly ferrying tourists to the country, for economic advancement. According to Interferry (2017), a ferry can be defined as any vessel used to transport passengers and/or vehicles on water in a definite route in a frequent and regular basis and can range from small boats to large sea-going ships.

Locally, domestic passenger ferries, speed boats and medium boats are being used. In the inland waters, boats are used to ferry passengers. In the coastal region largely served by the Indian Ocean and rivers, speed boats, boats and domestic ferries are the main passenger vessels. Hannah (2016), notes that domestic passenger ferries contribute towards the nation’s economy through transport more so when the geographical nature of the country dictates for multimodal approach to connectivity for business and services to be carried out in order to move goods and people. Ferries, being the least expensive in the hierarchy of multi-modal transport, make their demand to be high if they are an option in comparison to other transport means. This chapter presents further general information about ferry operations, accidents and a description of their causes and impacts.

Domestic passenger ferries in Mombasa are a huge constituent out of all the water transportation systems. They offer free movement of people between the islands and mainland. They are more favorable considering the distance passengers could use by road to access the Island making them the most efficient means of transport. These ferries are regulated by the state and the legal regulations applying to their operation like construction, registration, operating routes, manning and all equally relevant legal requirements. More precisely, a “domestic passenger ferry” is defined to be a vessel on a scheduled route of regular operations that is entitled to transport passengers in accordance with the schedule (Hannah, 2016). It is a vessel that operates exclusively in national waters of a member state and therefore not governed by international instruments of the IMO. It is therefore up to the national administration in a member state to define the standards of the design, equipment, maintenance and operation of these ships. This has created challenges in a number of IMO states in particular developing countries which are lacking maritime expertise and a shortage of resources in general.

There are several institutions set up in all these places to govern the domestic ferries with the main aim of ensuring that ferry accidents do not occur in order to ensure passenger safety. The Sub-Committee on Radio Communications and Search and Rescue (COMSAR), at its seventh session (13 to 17 January 2003), agreed on guidance for MRO's prepared by the joint ICAO/IMO working group on harmonization of aeronautical and maritime SAR at its ninth session to assist member governments in preparing for, and coordinating aspects of major incidents involving passenger vessel accidents and the rescue of large numbers of persons in distress from vessels and in working with companies that operate large passenger ships and aircraft to ensure that they are prepared to effectively support such rescue efforts (IMO, 2003). However, only moderate progress has been achieved and many accidents on domestic ferries are still reported in many countries.

Similarly, SOLAS 74, Chapter I, Regulation 21 requires all IMO member states that are party to the convention to undertake and conduct investigation into any casualty occurring to its vessels when it judges that the investigation may assist in bringing changes to the present regulations and supply with the pertinent findings of the investigations. As per the IMO MSC-MEPC.3/Circ.4 a report is required so that the final version of the marine safety investigation together with particular marine casualty data is prepared and entered into the Global Integrated Shipping Information System (GISIS) for the marine casualties and incidents module (Fatoumatta, 2015).

The same is stipulated in Article 23 of the Load line convention. The MARPOL 73/78 convention in Articles 8 and 12 also probes into supplying IMO with relevant information if the vessel causes an effect on the marine environment. The STCW 78, as amended, requires reports of any incompetency or act of omission that may cause threat to life or property at sea. However, these requirements only apply to ships covered by the international instruments of the IMO. Domestic ferries as explained above, do not fall into this category. As a result, valuable information on the safety risks involved in the operation of these ships may not be available to an extent as this would be desirable in view of the relatively high accident numbers in many IMO member states. However, with the maritime administration in place, it easier to incorporate into the national law similar regulations for the domestic fleet.

Kenya in performing its flag and port state obligations and as an IMO member state that has ratified these conventions, is required to conduct casualty investigations and supply IMO with the findings on accidents involving its fleet. The Kenya Maritime Authority (KMA), as the maritime administrator since June 2006, needs to incorporate a mass rescue plan into the existing national SAR plan and also develop a passenger ship safety plan as per the IMO requirements. This can be cascaded down to the domestic ferries which are not covered by these requirements.

KMA was established through an act of parliament, KMA Act 2006. This Act gives KMA among other functions undertaking and coordinating research, investigations and survey in the maritime industry in Kenya (Kenya Gazette, 2006). Therefore, the organization is mandated to oversee the safety and security functions in Kenya's Search and Rescue Region (SRR), where among others passenger ferries operate. The Authority has role to coordinate other relevant entities in case of an accident or incident involving passenger vessels. Moreover, the Kenya Ferry Service (KFS) was formed to oversee all ferry operations. They are mandated to ensure passenger safety in the ferries, maintenance of these ferries, and sensitization to passengers on all aspects involved in passenger ferries including accident preparedness and rescue operations. Thus the gap on mass rescue capability in Kenya exists and therefore this research also addresses this problem.

2.1 The Kenya Ferry Services

KFS is a government company that was established through the Kenya law of Companies Act (CAP 486) and operated under the Transport and Infrastructure Ministry for the purpose of operating the state ferries. The company's headquarters operate from Mombasa. According to the history available at KFS, the Likoni channel ferry services in Mombasa began in 1937. To date, the ferries remain operational and create the only link to the southern part of the Kenyan coast. Being situated at the entrance into the Kilindini harbour, their operations remain of utmost importance as a link that serves not only locals heading to the south coast but also commuters traversing to Tanzania and beyond.

Kenya Ports Authority (KPA) was bestowed responsibility by the Government, of running the ferry services with its operations beginning on 1st November 1989. Following that, in 1990 the government bought four new ferries namely MV Kilindini, MV Nyayo, MV Harambee and MV Mtongwe II to supplement the existing fleet (KFS 2016). In 1998 the government formalized the ownership of the Kenya Ferry Services through a National Assembly Sessional Paper No.3 of the same year, by transforming the contributions of both the government and KPA into equity. The company (KFS) is now owned 80% by the government and 20% by KPA (Kenya Gazette 1998).

Currently in the Likoni Channel, there are seven passenger ferries that transport passengers, goods and vehicles between the island and the mainland leading to South Coast. In Lamu where a bigger port is coming up, the only means of commuting to the surrounding islands is by use of passenger ferries and boats most of which are privately owned. The population of passenger vessels in the Lamu area is much higher than any other region in Kenya due to the reason that they are the major means of transport in the vast surrounding number of islands. In Lake Victoria, there is likewise quite a large number of passenger vessels ferrying people from either one island to the mainland or vice versa.

The busiest ferry services in Kenya are offered by KFS which was commissioned by Government of Kenya to specifically ferry people and vehicles across the Likoni channel connecting the mainland and the Mombasa Island due to the capacity of passengers it handles per given day. Data available shows that it ferries over 300,000 pedestrians and more than 6,000 vehicles daily across the channel (KFS 2016). There is a trend of growth especially from passengers which is likely to reach 500,000 by 2019 to 2020 assuming that prevailing trends continue. Although most are older vessels operating in the Likoni channel, the current ferries actively operating the services include MF Jambo, MV Nyayo, MV Harambee, MV Kilindini, MV Likoni, MV Kwale, MV Pwani and MV Mvita.

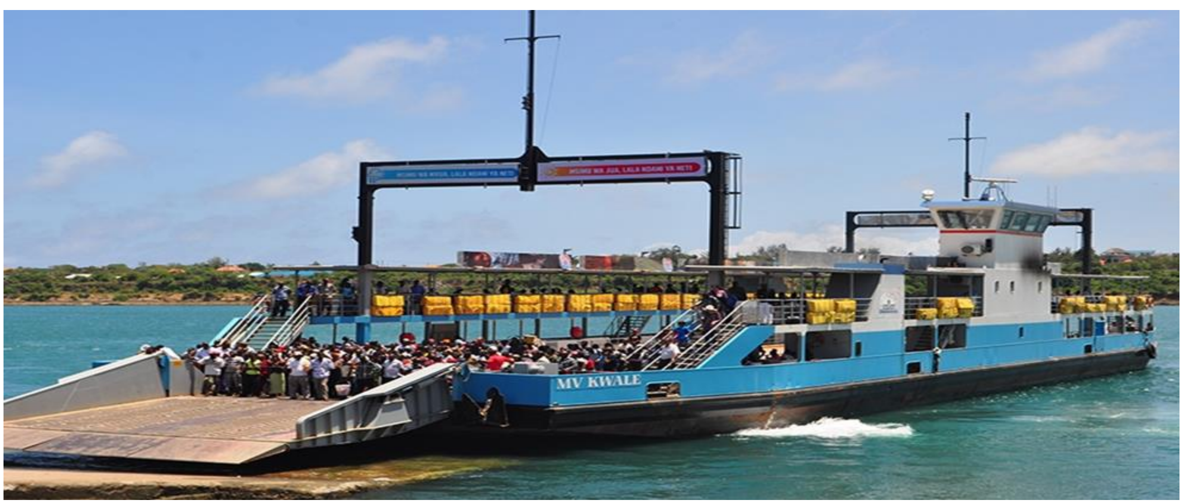

Figure 2-1: Passenger vessel in Likoni channel

Source: Kenya Ferry Services

KFS's facilities are categorised as port facility because it runs within the approach to Kilindini harbour and therefore is expected to be ISPS compliant. KMA as the enforcement agency assesses and certifies the security plan after every four year period as per ISPS Code requirements. There are regular improvements to safety measures at KFS done through the training and upgrading of safety procedures to the public and ferry personnel.

The ferries are equipped with fire-fighting equipment as well as lifesaving appliances. The operation of seven lager capacity flat-bottomed ferries guarantees stability. Major improvements to controls have been put in place at the Likoni passenger ferry terminus; this includes an improved passenger waiting bay, enhanced exits leading to the public bus terminus, enhanced and well-lit staircases to avoid injury and slipping, a lane for persons with disabilities at both the mainland and Island side, an improved passenger walking bay with measured loading control space, uniformed and plain clothes police patrols on board and at the passenger piers to ensure order, control and security (KFS 2016).

2.2 Passenger vessel accidents history

The first major ferry disaster to hit Kenya as a nation occurred on 19th April, 1994 when the ferry MV Mtongwe I, then operating at the Mombasa Island to Mtongwe in the Likoni Channel, capsized and sank with nearly 400 passengers on board (Daily Nation, 1994).

Figure 2-2: MV Mtongwe I - 1994

Source: Daily Nation. Copyright1994

Out of the approximately 400 people on board, at least 270 died. About 70 people aboard survived by swimming ashore or clinging to the few life aids on the ferry. It took a long time for rescuers to arrive at the scene of the accident as SAR services in Kenya regarding marine accidents were not well in place and relied heavily on the rescue by the Kenya Navy. Following the accident, it was reported that the vessel capacity was 300 persons, way below what it was carrying (Daily Nation, 1994). Even after this accident, and considering its magnitude, documented reports on the investigation into the cause of the accident cannot be found apart from newspaper reports.

According to a report in the Herald (1994), MV Mtongwe I was a vessel designed with a carrying capacity of 300 persons but often operated with more on board and had always made it safely across the channel connecting the Mombasa Island and the South coast in Mtongwe Likoni area. On the fateful day there were many more passengers on board that needed to urgently cross over the channel and were taken on board. While only 40 metres away from the Mtongwe shoreline in the South coast, Likoni, the ferry capsized while being steered toward the mainland. A probe into the accident by a commission set up did not apportion the blame but later on the Kenya ferry services and the Kenya Ports Authority accepted liability, where an agreement was reached on the liability of the accident in the sense that the deceased boarded the ferry knowing that it was overloaded. Therefore, they were 30 percent liable and the two authorities accepted 70 percent liability (Daily Nation, 2003)

After the accident, the SAR mission was very difficult. According to the Daily Nation newspaper (1994), the sea disaster was difficult to handle because the sunken vessel, Mtongwe 1, was partly buried in the sand.

Other accidents have also occurred at the coastal waters, especially at the Likoni ferry path. The channel is the main entrance for all vessels entering Kilindini harbour, meanwhile ferries are the main means of transport, connecting the Mombasa Island to the mainland across the Indian Ocean. The high number of ferry associated accidents that are experienced in the channel are attributed to mechanical failure, grounding, man overboard, and rough weather related incidents and rarely there can occur collisions. Other accidents that have occurred in the recent past include vehicle overboard or vehicle losing control while descending the ramps and ended up in the sea or some of the ferries overshooting the ramps. To monitor safety in the channel, a VTS service is offered by the KPA to ensure all vessels are safe.

Figure 2-3: Passenger stranded at sea in Likoni Channel

Source: Daily Nation. Copyright 2008

These was a near disaster at the Likoni Channel when the vessel developed mechanical problems and was pushed by strong winds towards the deep sea. Anxious commuters were waiting to cross the Indian Ocean at Likoni after the ferry was secured by another ferry and supported towards the landing pier after it experienced a mechanical problem with over 1000 passengers in 2008.

Figure 2-4: Passenger vessel MV Nyayo being rescued by tug boat at Likoni - 2015

Source: East Africa Standard Newspaper Copyright 2015

On 17th May 2015 the passenger ferry MV Kwale ran aground on a coral rock and veered off its course while transporting passengers across the Likoni channel. According to records from the KFS, some passengers were hurt due to commotion during the mishap and most panicked forcing them to jump off the ferry so that they could swim to the shore. The ferry at the time of the accident was approximated to be carrying about one thousand passengers. It drifted for about one kilometer from the position it hit the coral rock. Officers drawn from the KMA, KFS, Kenya Navy (KN), Kenya Maritime Police and volunteer organizations helped in the rescue exercise and to secure the vessel (The EAS 2015).

The rescue exercise took about four hours to rescue all the passengers by another ferry MV Kilindini of similar capacity that took in most of the panic stricken passengers. The report further indicated that by the time of rescue the passengers were wearing safety life jackets. Several other vessels from the KN and other rescue boats from rescue partner agencies participated in the rescue as tasked by the Search Mission Coordinator (SMC) at the RMRCC Mombasa.

2.3 Factors contributing to Ferry Accidents

IMO (1997) identified some particular areas of concern that contributes towards ferry accidents. In general, the following factors are common to domestic ferry accidents.

2.3.1 Faulty Design and Construction of Vessels

The root to a safe vessel begins at the design stage. Hull form, superstructure, propulsion system and machinery for stability are all vital elements for a safe vessel. Construction has in most cases been found the cause of an accident. According to Sakalayen, (2006) some professional forward idea of modification in the IMO criteria developed for SOLAS vessels. He however reiterates that this idea seems intended to reduce construction cost but leads to sub-standard vessels. The vessels hull should be divided into several separate and water tight holds to keep the vessel a float longer to allow enough time for evacuation (Hannah, 2016). Water tight hatch covers should be considered as well as automatic steering gears since manual tends to fail quite often in bad weather.

2.3.2 Overloading and overcrowding

Even though the carrying capacity of a ferry is known, overloading is still done by responsible operators despite knowing that they are violating the rules. As long as the regulators continue to fail preventing the operators against carrying passengers and cargo in excess, more accidents will still occur. Currently, various technologies that can count individuals exist. Staff can be informed when the number of individuals who have boarded a vessel has reached the maximum level. The system uses the concept applied in elevators but may not take into account infants and hand-held cargo. This weigh sensing device can overcome overloading hurdle by triggering an alarm when the maximum level is attained and could prevent the vessel from sailing whilst with an extra load (Rahman & Rosli, 2014).

2.3.3 Maintenance

Passenger vessels may have undetected defects obtained either during their construction or wear and tear. In addition, the physical aging of vessels may cause accidents. These factors are very common in the Kenyan passenger vessels. Many of the boats and ferries used in passenger movement are old and have many defects. Ferries that carry passengers across the Likoni channel have experienced numerous mechanical issues in the past. It has been even riskier when they have experienced these problems while ferrying the passengers. The detailed analysis of some of the incidents are as a result of a power failure, passengers concentrating on one side and trucks getting in the ferry losing control and hitting ferry rails among others.

2.3.4 Crew Competence

Knowledge, experience and training by the crew plays a significant role in the vessel safety. Formal training facilities are minimal in developing countries and very expensive for that case. Therefore, to have a competent work force at times requires the employer to initiate and sponsor most of the training required. Employee turnover has also contributed to losing qualified crew to other nations leaving very few trained crew members to man and operate the vessels locally.

2.3.5 Inadequate regulations and enforcement

The failure of regulatory bodies and organizations to continuously monitor the integrity and accuracy of their regulations and policies can lead to an unsafe regime of passenger vessel operations. Continuous monitoring, updating, evaluating and implementation of the amended international regulations into the national regimen will lead to a safety culture and compliance by the vessel operators.

2.3.6 Weather

Unsafe weather conditions, rough seas and storms when travelling by water always pose unavoidable risks. Improving weather information systems and simultaneously making them more affordable even to small passenger vessel owners in the industry could prevent accidents and save thousands of lives (Golden & Weisbrod, 2016). On the other hand a culture of timely caution, safety concern and strong regulation may prevent accidents that can occur due to bad weather.

2.3.7 Stability

According to Sakalayen (2006), overcrowding by passengers on the upper deck tends to reduce the meta-centric height which puts the vessel in a risky situation similarly, cargo that has not been professionally stashed has been observed to create an unstable condition. In bad weather, if a vessel is not stable it is likely to list and eventually capsize.

2.3.8 Low freeboards

Passenger RO-RO vessels are designed in such a way that their cargo access doors are low and close to the waterline in order to make it easy to load and unload vehicles into the ferries. (IMO, 1997). If the vessel stability is affected and lists it is most likely to ingress water due to the access threshold being below the waterline.

In addition, Lawson & Weisbrod (2005) examined a probable way to establish safety concern in ferry operations in developing nations. They looked at the aspect of preventing and responding by concentrating on vessel design, regulatory approach and sufficiency, and also analyzed post event culpabilities for ferry safety.

Table 2-1 Areas of inquiry and prevention function for ferry safety in developing nations.

Function	*Issues/Area of Inquiry*
Prevention	
Regulatory Approach	Are the regulations adequate to the conditions? How does the rule making take place? How are rules communicated? How are regulations enforced? Is there any oversight in the implementation of the regulations?
Vessel Design	Are vessels designed properly for their purpose? What proportion of the fleet of vessels is certified? Are there penalties/obstacles for certification? Are these noncertified vessels long-after, after-market vessels? Are there penalties for noncertification? Is there a difference with respect to accident rates for long-after, after-market vessels? What and how rigorous is the certification process? What is the relationship between ferry fatalities and vessel certification? Are the vessels inappropriate or inadequately maintained and/or improperly operated?
Operational Standard	What is the accident record differential between certified/noncertified vessels with respect to operating standards? What is the accident record differential between vessels that are publicly or privately owned? Are there differences with respect to routes and type of service between public and private operations? How can registration/certification be encouraged by the industry, local government, or citizens groups?
Response	What type of training and drills are available for private or public crews? Is there a relationship between the record of training and drills and ferry fatalities? Is there a formal system in place for search and rescues? Have "safe havens" been identified in event of major storm and/or vessel damage?

Source: (Hannah 2016, Lawson & Weisbrod, 2005)

According to Lawson and Weisbrod (2005), for the economic development of many countries, ferry transport is a significant element because of their principal dependence on them as a means of transportation for their cargo and passengers. They are a catalyst for the nation's economic growth and for job creation. Lawson and Weisbrod (2005) also wrote that ferry transport still remains imperative to those local communities that highly depend on it even if there were high rates of fatalities. Knowing the importance of ferry transport to the communities that use it in Kenya as their basis for economic development it is demoralizing both economically and socially due to their safety. Indications from previous accident experiences point out to various factors that highly contribute to towards their occurrence which include poor maintenance, incompetent crew capacity and outdated technology for on-board emergency response during distress emergencies and therefore contributing to a high number of causalities. In addition, a lack of a mass rescue plan, enough rescue facilities and other shore based emergency response increases the severity of the consequences thus increasing the number of fatalities. According to TAIC (2010), there is a need for significant shore-based influence for overall safety on passenger vessels consequently, safety regulations and the proper maintenance of vessels have been found to contribute highly towards the safety of passenger vessels. Dalziel et al (2012) identified in their research repeated causes in ferry casualties as inadequate maintenance and vessel design, overloading, human error, poor communication, bad weather and unavailable or delayed rescue response. Poor policies have been stipulated thus compromising passenger vessel safety. Also, the manner in which the whole operation is carried out, both by parties involved directly and otherwise, does not guarantee passenger vessel safety.

2.4 External factors

External factors may cause accidents. These factors may either be beyond human control or otherwise. These include: Bad weather, outdated and inaccurate navigational information, heavy traffic in port among others. For vessels operating on short distances and on high traffic routes like the Likoni ferries, ship collision risk seems to be high. Other potential causes are lack of adherence to the IMO requirement that passenger vessels carrying more than twelve persons on international routes to comply with the IMO applicable provisions. A collision of a passenger ferry and other small boats doing fishing within the port area or passenger vessel route is a likely factor in busy channels.

2.5 Regulations derived from Very serious Casualties

Almost all regulations for passenger vessel transport are derived from accidents, incidents and near misses. The Herald of Free Enterprise accident, for example, attributed to the development of the International Safety Management (ISM) Code while the Titanic led to the development of the Safety of Life at Sea (SOLAS) convention. Nurwahyudy (2014) notes that shipping regulations include technical design, the construction, operations, repair, training, manning standards, regular inspections, security and environment impact through the vessels life span. Thorough and adequate inspections should examine in depth the vessels hull condition, performance of the propulsion system, stability information, electrical system onboard and other machinery, fire-fighting and prevention systems, lifesaving appliances and their arrangement, communication and navigation system (Interferry, 2014).

To enhance maritime safety and marine environment protection, many counter-measures have been derived from marine disasters. Investigations into marine disasters have led to major international conventions as illustrated in the table below.

Table 2-2: Regulations derived from very serious casualties

Year	**Ships name**	**Organ**	**Measures**
1912	Titanic	UN, IMO	SOLAS 1929
1965	SS Yarmouth Castle	IMO	SOLAS – Fire and safety amendments (non-combustible material)
1967	Torrey Canyon	IMO	Intervention Convention 1969 MARPOL1973, CLC, 1969
1976	Argo Merchant	IMO	MARPOL 1973 – Protocol of 1978
1977	Tanker Accidents	IMO	SOLAS 1974 – Protocol of 1978
1978	Amoco Cadiz	IMO	SOLAS 1974 – Protocol of 1978 (Introduction of the remote steering gear)
1982	European Gateway	IMO	SOLAS 1988 – SOLAS 90 stability standards
1987	Herald of Free Enterprises	IMO	ISM CODE 1994, SOLAS 1988 amendments, SOLAS 1988 – SOLAS 90 stability standards
1988	Scandinavian Star	IMO	SOLAS 1989 amendments (fire protection)
1990s*	Bulker accidents		SOLAS Chapter XII, adopted 1997
1989	Exxon Valdez	IMO	OPRC 1990, MARPOL 1992 amendments (Double hull)
		USA	OPA 1990
1994	Estonia	IMO	SOLAS 1995 amendments SAR Convention 1998 amendments
1999	Erika	IMO	Follow up in MSC and MEPC
		EU	“Erika” Package
2002	Prestige	EU	EUR – OPA
2012	Costa Concordia	IMO	SOLAS Chapter III – Passenger muster requirement

Source: Author, Li (2006) as adopted.

Typical passenger ships that engage in international voyages must fully comply with the international regulations like SOLAS, MARPOL, STCW and UNCLOS just to mention. This is limited to domestic passenger ferries because they operate as coastal and inter-island vessels, hence are regulated by the State but it does not prevent the owners and operators from applying the national regulations. States are urged to review and update their national regulations in relation to passenger vessels and enforce them to encourage the prevention of loss of life, property and environment damage from ferry related casualties and incidents (IMO, 2015).

2.6 The Legal and Regulatory framework in Kenya

For a competent administration to conduct marine casualty and incident investigations in a compulsory and legal way, there is a need for regulatory and legal framework to be put in place to facilitate the same. Further, there is a need to separate maritime casualty investigation from all the other administrative duties and create an independent body to specifically conduct investigations. The legal framework in Kenya consists of both national legislation and international instruments. The Marine casualty investigation currently as stipulated in the KMA Act, shall be conducted by KMA. This means that the same institution that does the inspections and surveys, ends up conducting the casualty investigations.

The IMO in its Resolution A.884 (21) imposes a duty on flag States to conduct marine casualty investigations. Domestic ferries do not fall under the category referred to in this resolution. A State is therefore supposed to have a national legal framework that may also be similar to the IMO requirements regarding its domestic fleet. Most developing nations are still struggling to do this, and Kenya has taken a step further by adopting the code and enforcing it through the Kenya Maritime Authority as per the provisions in the Merchant Shipping Act, 2009. However, the regulations are yet to be developed on how to conduct casualty investigations on the domestic fleet.

Accordingly, the Kenya Merchant Shipping Act (2012) stipulates that when a casualty occurs, the loss of vessel, life or any damage caused by a vessel a preliminary inquiry into the cause of the casualty shall be conducted by an appointed person with powers as those conferred on an inspector by section 411. Further, a formal investigation shall be held by a board specifically appointed for that inquiry as appointed by the minister and such persons appointed to carry the assessment shall have requisite skills and knowledge in maritime matters.

2.7 Statistical Representation of Ferry Accidents in Kenya

Different sources were able to help in achieving statistics on ferry accidents. KMA was one main source of acquiring the statistics considering its role in surveying, certification, registration, training and inspection. Also, other reports were acquired from the KFS and KPA safety sections. All the reports were consolidated as shown in **Appendix I.**

Ferry transport can be threatened by many unforeseen events that include and not limited to grounding, technical failure or collisions (Łozowicka & Kaup, 2015). Common to the ferries in Kenya is technical failure, followed by groundings and rough weather. Least likely to be included are, sinking and flooding although they are the most catastrophic in their consequences.

According to the reports filed, the main cause of accidents in ferries is mechanical failure followed by overloading then rough weather. Most accidents have occurred during rough weather between the months of April to September and are mostly contributed to by the poor stability of the vessel.

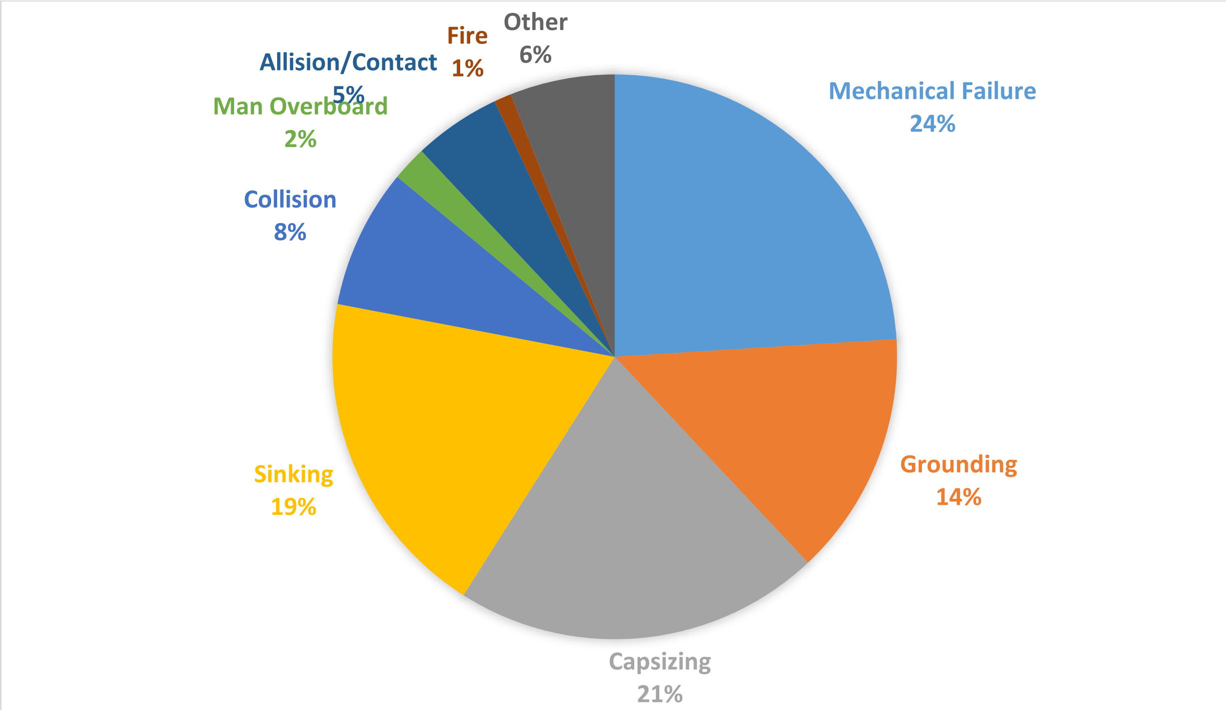

Figure 2-5: Graph showing causes of ferry accidents in Kenya for the period 2006-2016.

Source: Author

3 Methodology

The investigation of everyday accidents and safety related incidents in order to ensure appropriate passenger safety assessment is very important. Water transport being as important to the nation's economy, passenger ferry safety remains vital and should be efficiently and effectively executed. In fact, several studies have recommended efficiency in accident investigations and mitigation analysis. However, the high rate of accidents and fatalities is expected due to the high dependence on passenger ferries in Kenya. This fact is linked by various factors like; purchasing of old, substandard, and/or inappropriate vessels, congestion, insufficient preparation, and abrupt perilous weather changes. Any serious attempt to decrease the number and fatality count of ferry accidents in the developing world must have a complete record of past incidents on which to draw lessons from (Abigail et Al, 2016). In fact, several studies have recommended efficiency in accidents and mitigation analysis.

According to Schröder (2004), if all the day-to-day accident-related data were to be analyzed rather than waiting for an accident to happen, the passenger ferry industry would benefit more, and the operations of safety would be more enhanced. Passenger ferry accident analysis, especially causation, is highly complex and must be understood adequately to improve accident prevention.

It is necessary to assess accidents, their causes and ways to avoid them. In a proactive sense, situational awareness of accident occurrence is beneficial so as to identify the causes and failures associated with them in order to take a timely action. (Heinrich et al, 1980). Reason (1990), introduced the multi-causality of accidents in 1990, whereby according to him, the accident causation mechanism is a reciprocation of active and latent failures. For this reciprocation to be avoided, it is essential for top management to be proactively involved. Failures may be readily noticeable or vice versa. The immediate causes that are observable and quickly distinguished in an accident are the active failures. Contrary, latent failures can exist in the system for quite a long period of time before the active failures can reveal them. Hidden within the organization they are difficult to detect, and examples include poor design, supervision gaps and lack of training.

(Katsakiori et al., 2009). Those quickly noticed can be dealt with sooner than later, whereas the rest can take time and cause more damage.

3.1 Assessment of sources and model

Information in the data set of this research is drawn from the accident investigation reports as provided by the KFS, KPA, and KMA. In addition, where official data was not available, well-represented news sources around the world, were considered. Although most of the reports were available, there were some necessary elements still missing in the entries of some reports. This is a perfect illustration of how incomplete reporting is done not only on passenger vessel accidents, but also other accidents. According to Hannah (2016), this mirrors the incomplete reporting of ferry accidents, complex and multilayered accident causes and lack of careful accident investigation considering that an independent accident investigation body was missing. Furthermore, the missing entries and lack of proper accounts regarding passenger vessel accidents can be considered as the poor record keeping of accident reports. This truncated quality of accident investigation may be indicative of lessons not learnt from previous accidents.

All accidents obtained as data from the above named three organizations were recorded as shown in appendix I, they included those that resulted in no casualties, deaths of one or more passengers and/or crewmembers and those that resulted to no deaths but other impacts were recorded. Each accident entry includes; date, name of vessel(s) involved, flag, location of the accident, where available: number of fatalities compared to total passenger involved, the proximate cause, and any exacerbating factors. Other factors that were available on the reports but not included in the appendix include their operators or owners; weather conditions; captain and crew member response; and the timing and effectiveness of search and rescue efforts, if any was carried out. However, latter factors were inadvertently considered in the selected accident cases whose reports are used for analysis.

In many developing countries for example Kenya, where ferries are a major transport means for many, minor passenger ferry accidents are common as well as major delays and major accidents once in a while. In this case either accident investigations are not carried out or their results are never published. If we get the full-length detailed investigation reports for all, or even most, of the cases described in this dissertation, the analysis of passenger ferry accidents, as illustrated below, would be valuable. With comprehensive reports, we would easily thoroughly outline the interacting technical, organizational, and human factors leading to fatal passenger ferry accidents through various models such as SEMOMAP, as put in practice by Nurwahyudy (2014) to determine the causes and contributing factors of selected ferry accidents.

3.2 Marine Casualty Investigation

To continually improve and maintain safety, assessing maritime accident casualties through investigation is an important requirement as stipulated by several IMO conventions. Maritime casualty investigation is a requirement of SOLAS regulation 1/21, MARPOL Article 8 and UNCLOS Article 94. Furthermore, IMO has adopted reasons (1990) and Rasmussen's Taxonomy of Error (1987) which are part of the HFACS, SHEL and GEMS frameworks to form an integrated human factor framework for use in the investigation of human factors (IMO 2000). This is an indication of the big role that maritime casualty investigation plays for improved and safer water transport.

According to UNCLOS, article 94 on duties of the flag state, paragraph 7, it is the flag states mandate and duty to conduct maritime casualty investigation. It states:-

> *Each state shall cause an inquiry to be held by or before a suitably qualified person or persons into every marine casualty or incident of navigation on the high seas involving a ship flying its flag and causing loss of life or serious injury to nationals of another State or serious damage to ships or installations of another state or to the marine environment. The flag state and the other state shall co-operate in the conduct of any inquiry held by that other state into any such marine casualty or incident of navigation (United Nations, 1982).*

In addition, IMO under SOLAS has adopted IMO Resolution MSc. 255 (84) which is a code that requires every very serious maritime casualty to be investigated. It requires safety investigation to be conducted into casualty involving death, severe environmental damage or total loss of the ship. The code is known as the Casualty Investigation Code, whose aim is to apply international standards and practices that have been recommended for a marine casualty investigation (Hannah, 2016). This however as explicitly explained above, only affects international sea going vessels and not domestic vessels. Therefore, a State is required to draft into their national law, a legislation that will cover an elaborate way of accident investigation and reporting of near misses equivalent to the international conventions above to guide in the domestic fleet accident investigations. This will encourage safety practices in the industry for all domestic vessels.

3.3 Models of accident Causation

Accident investigation is useful in that it helps one to comprehend the entire process, from how the accident happens to what should be done to prevent it. It should be able to make an assumption of how the accident happened and if it was possible to be prevented by considering some measures that can counter the contributing causal factors. Accident investigation has over the past century evolved with early focus on equipment or hardware failures being superseded by more scrutiny on an operator's unsafe acts or human error after which more focus was given to the organizational system in the late 1980's and early 1990's (Salmon, 2011). Moreover, accident models and their scope of investigation are often described together. However, this has changed over time since many accident causation models available often influence the investigation outcome by overlooking some things, unlike others.

According to Hollnagel (2002), accident analysis implies an accident model. Anyanwu, (2014), Psarros et al (2010) further says it is a very important process that provides input for advancement of cost-effective and proactive regulations. An accident model is a representation of conceptual abstract of the development and occurrence of accident by describing thoughts of why and how it occurs and envisions the phenomenon (Hollnagel, 2008). Hollnagel further divided accident models into epidemiological, sequential and systemic and functional giving each a set of hypothesis on how analysis should be performed with their respective reality viewed and their limitations and theoretical foundations.

3.3.1 Traditional Approaches

There are basically two models in the traditional approaches and they include the epidemiological model and the event based model.

3.3.1.1 Event/sequential based model

Heinrich, in 1931, first introduced the Domino Model. It explains that an event occurs in a chronological way following a chain reaction of occurrences. He explains that multiple events occurring each after the other lead to an accident. By eliminating one or more of the links in the chain of events, an accident can be prevented and he further explains that the model is focused on the failure and malfunction of independent causes. It is a linear model determining causes to being independent of every event (Nurwahyudy, 2014).

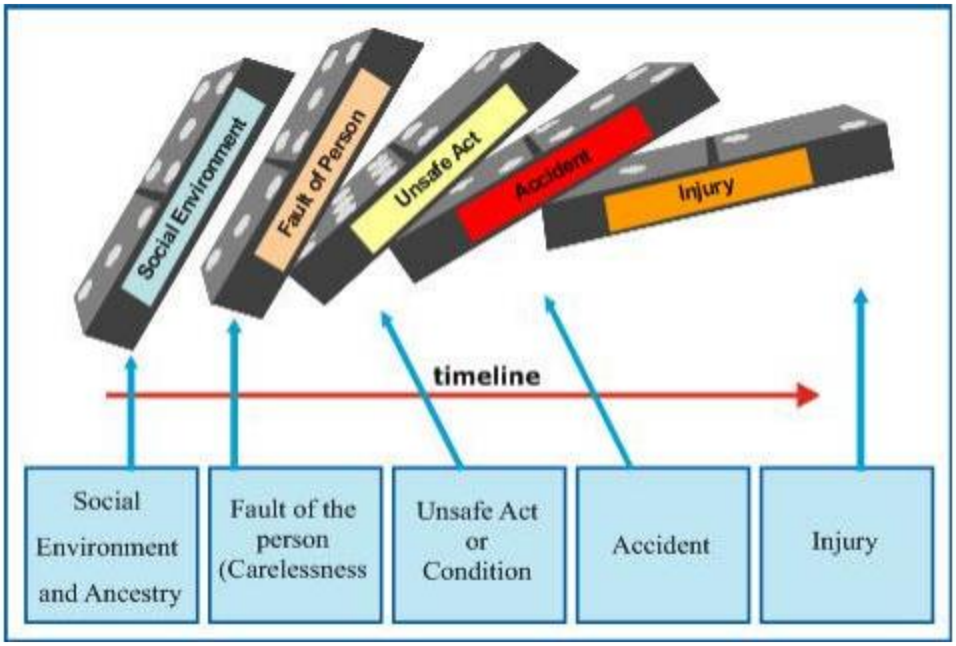

Figure 3-1: Domino-model theory

Source: Heinrich (1931)

3.3.1.2 Epidemiological Model (Complex Linear System Models)

This model was originally used on the biological spread of disease. In 1949, Gordon recommended this model to characterize accident by combining initiating events with environmental factors making the events outcome leading to the accident out of proportion with the resulting accident. The model identified that latent factors contribute to the occurrence of accidents. The Swiss Cheese Model is one example of the epidemiological model as Reason (1997) proposed due to the argumentation that it identified that the safety barrier can prevent latent failures from causing accidents if they are set in place. According to Hollnagel (2002), the epidemiological model for analyzing accidents can be described as the outcome of combined factors that are hardly strong and difficult to specify in depth.

This model avoids bias potential and may lead to an investigation report that describes an accident event completely but it is deficient in two respects; first, it needs an efficient and theoretically supported scheme for classification of accidents and secondly it needs guidance from a theory of accidents (Harvey, 1985).

3.3.2 Modern Approach/Systemic Models

These are models that adopt non-linear model concepts developed due to known insufficiencies in the traditional approach. The models view accidents as emanating development rising because of the complex synergy between active and latent components that could lead to poor performance thereby causing an accident. According to Nurwahyudy (2014). These models include STAMP, CREAM and TRACEr. HFACS is also one of the system based approaches to accident analysis.

3.4 Human Factors Analysis Classification System (HFACS) Framework

This framework for investigating and analyzing human error was a theoretical based mechanism affiliated to incidents and accidents as research indicated it could be certainly dependable in identifying the human factor chain of events associated with accidents (Wiegmann & Shappell, 2007). It investigates active failures by operators including how operator decisions influence the occurrence of accidents in conjunction with the latent conditions in the management level of an organization (Celik & Cebi, 2009).

Within Reasons' Swiss Cheese Model, HFACS emerged from the absence of taxonomies of latent failures and unsafe acts, therefore it was developed and designed to supplement that gap. It is an independent method of establishing the contribution of human error towards an accident and is applied in various kinds of incidents like grounding and collision (Łozowicka & Kaup, 2015). It was initially designed in the United States for the investigation and analysis of operator errors in naval aviation incidents. Drawing from Reason's 1990 concept, it described taxonomies for the failure mode at each of the four levels in the hierarchy (Wiegmann & Shappell, 2007).

Accordingly, Celik & Cebi (2009), reiterated that the HFACS theory motivated accident investigators to seeking latent factors like technological environment, fatigue and physical environment among others increasing consistency of its mechanism for accident investigation practices. It can therefore be said, investigators are able to classify probable causal factors and errors across the taxonomies provided across the four levels. Reason (1997) proposed the "Swiss Cheese" accident causation model and emphasized the organizational dimension of major accidents. Latent conditions and failures are visibly distinguished through the Swiss cheese model. Errors and violations are seen as the consequences of deeper causes.

Undoubtedly, these are unsafe acts known as active failures committed by operators of the system at the "sharp end" that have an immediate and direct impact on the safety of the system. On the other hand, latent conditions can exist in a system for a very long time without causing damaging consequences. Reason (1988), compares them to resident pathogenic agents. In fact, they need to be combined with a local trigger element and active failures to cause an accident. According to Chauvin et al. (2013), latent conditions arise from the strategic and top-level decisions made by governments, manufacturers, regulators, designers, and organizational managers.

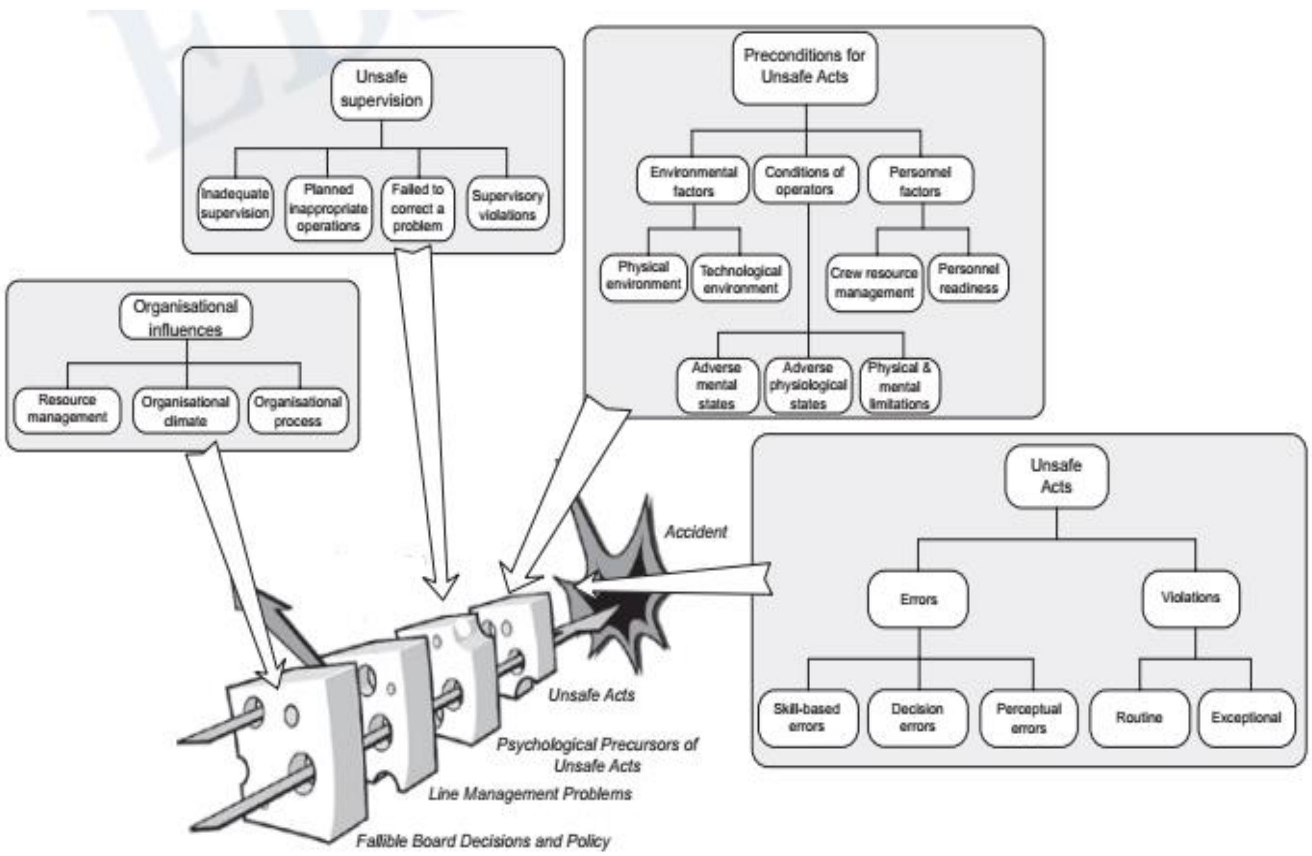

Figure 3-2: Reasons Swiss Cheese model

Source: Salmon, P. (2011)

Made up of four tiers or levels with nineteen causal factors, the structure of HFACS is hierarchical. The four tiers include unsafe acts, preconditions for unsafe acts, unsafe supervision, and organizational influences. In the hierarchy, it is assumed as factors go up by proceeding from active to latent conditions starting from unsafe acts to organizational influences with each level being dependent on the previous one (Springer, 2016). Figure 3.3 below illustrates this.

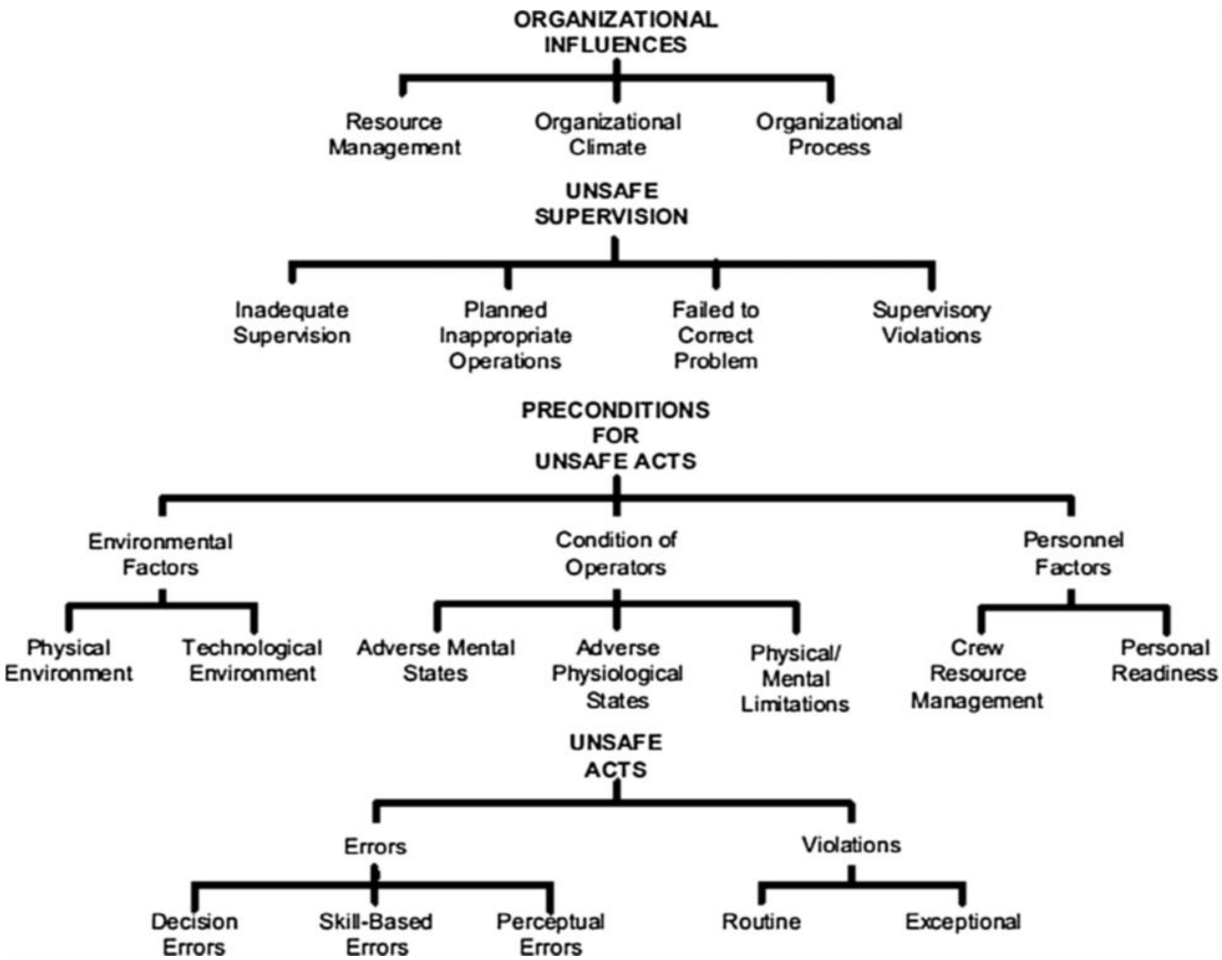

Figure 3-3: HFACS Hierarchy

Source: Adapted from Shappell et al., (2007)

3.5 Human Factor Analysis Classification System – Machinery Spaces on Ships (HFACS-MSS)

For the success of this dissertation, various accident causation models have been observed. However, the model chosen and used that has met the author's preferences and requirements is the HFACS- MSS by considering Ghirxi's adaptation of Weigmann & Shappell's HFACS. The modified HFACS for machinery spaces on ships is illustrated in the table below as adapted by

Schroder-Hinrichs et al (2011) with an additional fifth level to the HFACS called outside factors above the organizational influences with an intention of focusing on the influence of safety regulations in shipping and their enforcement. This model does not intend to change the prior existing framework but comes with minor modification since the HFACS framework was originally designed for use in the aviation industry (Hannah, 2016). The primary aim for this addition is to cater for the effect of safety regulations in shipping and its enforcement. (Schröder-Hinrichs et al., 2011)

Table 3-1: HFACS-MSS Framework

1st Tier	*2nd Tier*	*3rd Tier*
Outside factors	Statutory	• International standards • Flag State implementation
Organizational Influences	Resources	• Human resources • Technological resources • Equipment/facility resources
	Organizational climate	• Structure • Policies • Culture
	Organizational process	• Operations • Procedures • Oversight
Unsafe supervision/ workplace factors	Inadequate supervision	• Shipborne and shore supervision
	Planned inappropriate operations	• Shipborne operations
	Failed to correct known problems	• Shipborne related shortcomings
	Supervisory violations	• Shipborne violations
Preconditions for unsafe acts	Environmental factors	• Physical environment • Technological environment
	Crew condition	• Cognitive factors • Physiological state
	Personnel factors	• Crew interaction • Personal readiness
Unsafe acts	Errors	• Skill-based errors • Decision and judgement errors • Perceptual errors
	Violation	• Routine • Exceptional

Latent conditions ↕ *Active failures*

Remote from the ship ↕ *Within machinery space*

Macro-perspective ⟷ *Micro-perspective*

Source: Schröder-Hinrichs et al. (2011)

3.5.1 Unsafe Acts

These are active actions which lead to an unsafe situation or error. Unsafe acts are classified according to whether they are intentional or unintentional where intentional acts could be mistakes or violations while unintentional acts present themselves as slips due to attention lapses and failures as a result of memory failure (Reason, 1997). According to Reason (1990), unsafe acts should occur in a spatial and temporal proximity of a hazard. Relating to ferry accidents, unsafe acts relate to operator actions and reaction towards an existing situation on board. In this type of industry, it is good to identify unsafe acts from the initial step for the benefit of marine casualty investigation in order to trace back to management level. It's however worth noting that several unsafe acts, by different operators can lead to one accident.

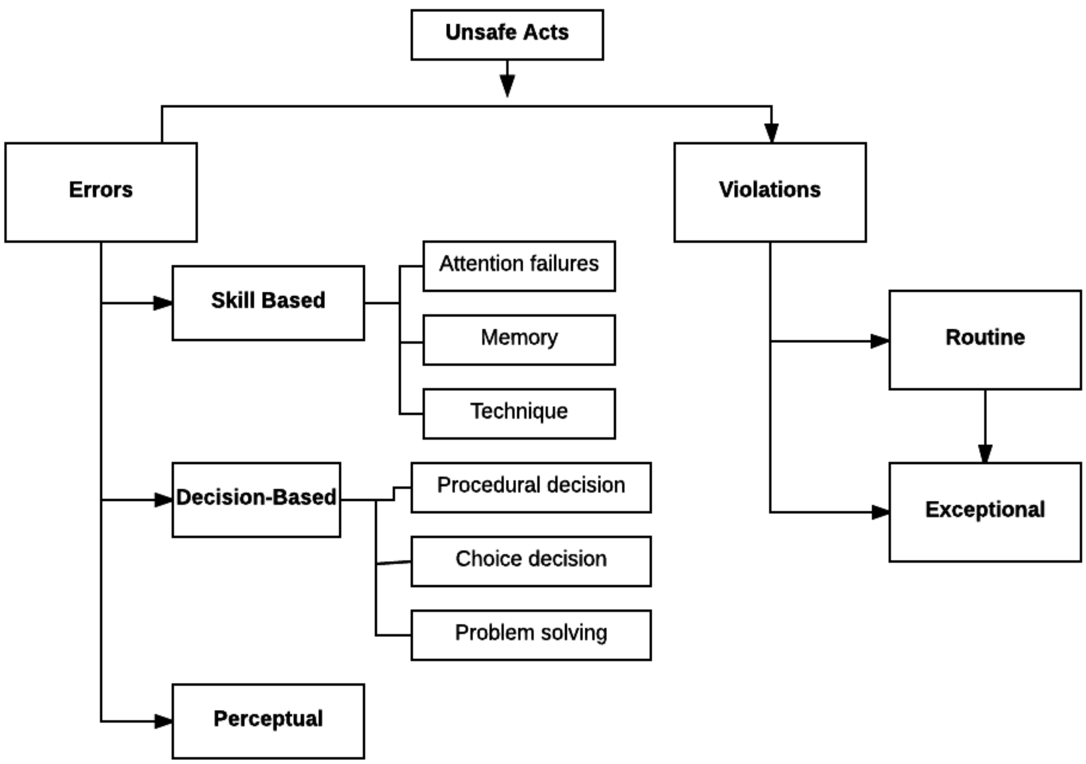

Figure 3-4: Categorization of Unsafe acts

Source: Ghirxi (2008)

3.5.2 Preconditions for Unsafe Acts

Shappell and Wiegman (2000) illustrate preconditions for unsafe acts as factors in a calamity if active or latent preconditions like the condition of the environment, operators, and personnel that affect the individuals' practices to result to an unsafe condition or human error. Both environmental and individual factors are considered with individual factors covering both the physical condition and interaction of the human and the environment that widely touch on physical and technological environment factors (Ren, 2009). In the figure below, the precondition factors are categorized into three groups: crew condition, environmental factors, and personnel factors

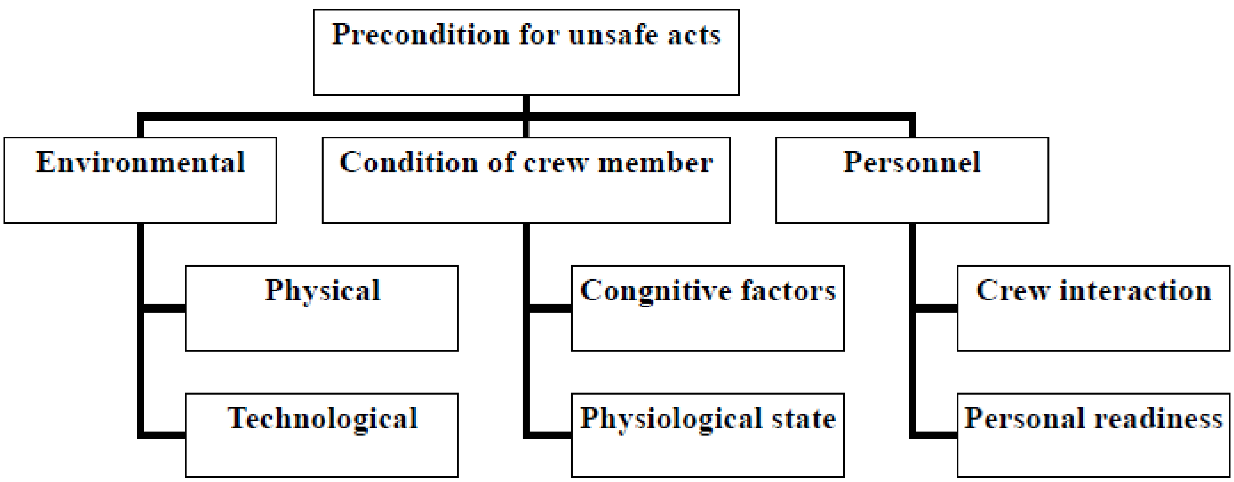

Figure 3-5: Categorization of preconditions for unsafe acts

Source: Ghirxi (2008)

3.5.3 Unsafe Supervision

These are factors in a mishap affected directly by practices, conditions or actions resulting from decisions, methods or policies of the management chain of command from officers at managerial level over technical or support level resulting in human error or unsafe situation. There are four groups under unsafe supervision and they include inadequate supervision, planned inappropriate operations, supervisory violations and failure to correct known problems (Ren, 2009)

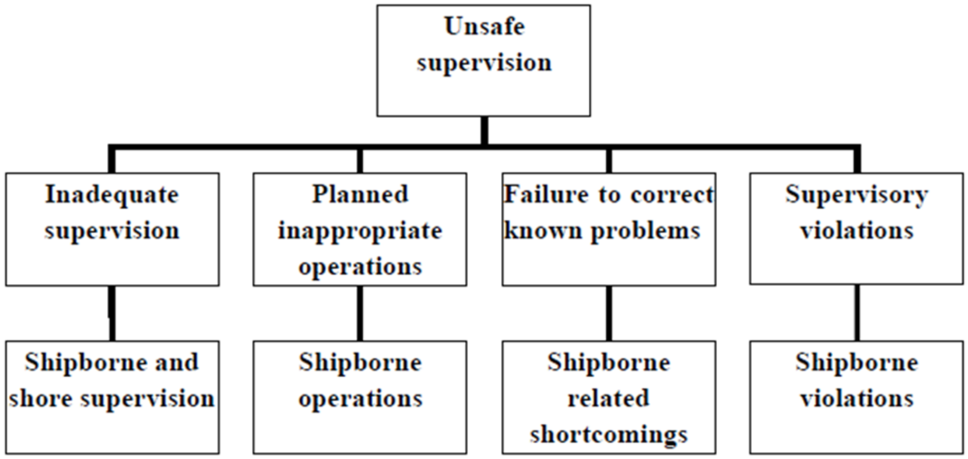

Figure 3-6: Categorization of unsafe supervision.

Source: Ghirxi (2008)

3.5.4 Organisational Influences

These are factors in a mishap if the communications, omissions, policies or actions of high-level management affect conditions, supervisory practices or actions of crew directly or indirectly to result in human error, system failure or an unsafe situation (Shappell & Wiegmann, 2000, Ren 2009). Under this category, four groups including organizational climate, resource management, organizational process and statutory are mentioned. The new category added by Ghirxi has international/national standards and flag state implementation as its subcategories.

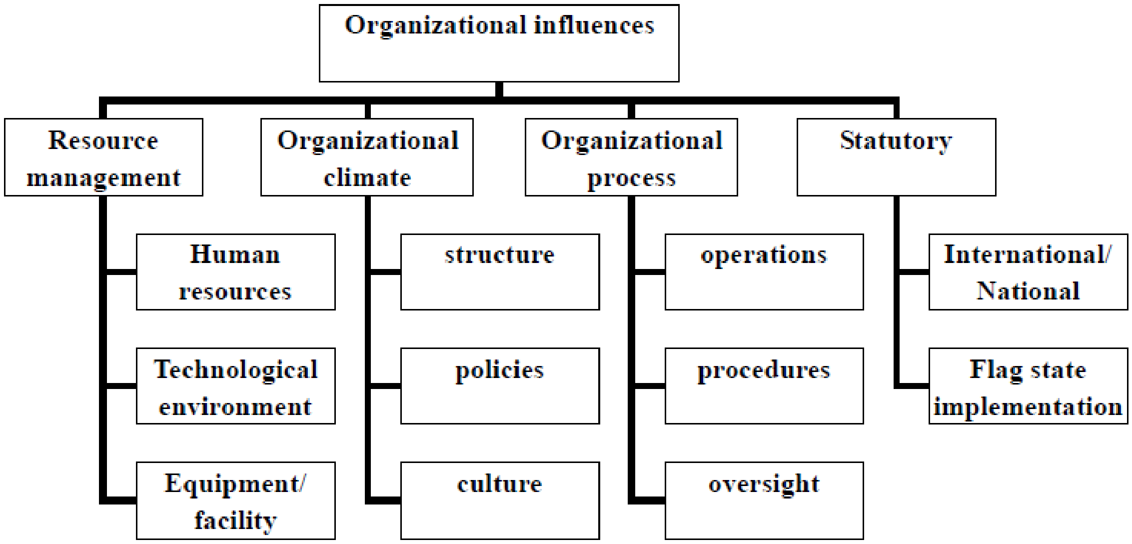

Figure 3-7: Categorization of organizational influence.

Source: Ghirxi (2008)

3.6 Sample selection

All marine casualty reports are supposed to be reported and recorded in the IMO Global Integrated Information System (GISIS) based on the IMO reporting requirements. This study however dwelt on domestic passenger vessels in Kenya only. Domestic ferry incidents and accidents fall under the national jurisdiction, thus their investigation reports were available only locally. For the review it was necessary to take a representative sample which allowed to a certain degree, generalized findings. The reports were complimented by the additional cases of Search and Rescue incidents coordinated at the Regional Maritime Rescue Coordination Centre (RMRCC Mombasa) in order to ascertain the number of casualties and level of severity. The time range of the cases chosen was between 1990 and 2016 and the severity consequences of the cases are highlighted in the next chapter.

For proper identification and classification of the human factors contained in the identified investigation reports proper apprehension of different factors and their relationship was necessary since HFACS-MSS taxonomy does not provide a tool to pinpoint the relationship or failed path (Ren, 2009). Therefore barrier analysis combined with a time-line was chosen to be used as the description tool. According to Reason 2006, the barrier concept gives model interaction opportunity and high risk domain complexity. It is also essential to say that the factors to be analyzed have been obtained from the investigation reports while avoiding re-investigating the accidents that would lead to biased judgement (Ghirxi, 2008).

3.7 Data

Many accidents have been documented in the country and data collected dated back from 1982 to 2016 as shown in Appendix I. Within the overview shown in the appendix, coding was not possible on most of the accidents because of the lack of substantial information on accident investigation reports or no reports at all. However, 10 accidents were obtained that occurred in 2011 to 2017 for the analysis. One more accident involving MV Mtongwe I that occurred in 1994 was included in the analysis because of its magnitude in the nation having been the worst maritime accident to this date.

The seriousness of the reports was categorized according to IMO's MSC-MEPC.3/Circ.1 requirements on revised harmonized reporting procedures. Very serious casualties were classified as those that involved total loss of vessel, severe damage of the environment and loss of life. The serious casualties were classified as those that did not qualify as serious but led to grounding, collision, and vessel damage from bad weather but resulted to the vessel being unfit to proceed. Lastly the less serious were classified as those that did not qualify as a very serious or serious casualties but included hazardous incidents or near misses.

In general 11 marine casualty investigation reports regarding ferries in Kenya have been analyzed as illustrated in the table below: -

Table 3-2: Summary of uncoded passenger vessel accidents

Selected passenger vessel incidents / accidents in Mombasa – Kenya						
NO.	**DATE**	**VESSEL NAME**	**AREA**	**TYPE**	**SEVERITY**	**REMARKS**
1	29/4/1994	Mtongwe 1	Likoni Channel	Capsize	Very Serious	272 died, more than 70 rescued
2	15/9/2011	MV. Kwale/Sea Wind	Kilindini Harbour	Contact	Serious	Damage sustained to both ships
3	1/1/2012	MV. Safina/Al Intsam	Lamu	Collision	Very serious	Damage to both vessels and lives lost
4	20/6/2017	MV. Bassaam	Lamu	Sinking	Very serious	Lives lost
5	11/11/2015	MV. Kwale	Likoni Channel	Grounding	Serious	Passengers evacuated
6	26/9/2011	MV. Yusra	Mukowe	Stranding	Serious	Passengers injured
7	27/7/2013	MV. Hodari	Kiwayu	Mechanical problem	Serious	No injuries
8	9/6/2016	MV. Kilindini	Likoni Channel	Man and vehicle overboard	Less serious	Loss of one passenger
9	25/1/2013	MV. Likoni	Likoni Channel	Vehicle lost control	Serious	Loss of lives
10	17/9/2016	MV. Nyayo	Likoni Channel	Engine failure	Less serious	Passengers evacuated
11	6/6/2016	MV. Harambee	Likoni Channel	Mechanical problem	Less serious	Persons injured

Source: Author

4 Presentation of the findings from accident reports analyses

The essential aim of this study is to present the passenger ferry accident investigation reports and data. This chapter presents data as reviewed and coded using the HFACS-MSS by the author, **(See Appendix II).** The coding has been further reviewed by a qualified person in passenger vessel accident investigation to validate or identify any deviations in the analysis. A total of 11 accidents are analysed. It is important to note that only causal factors that were explicitly mentioned in the reports have been considered and classified according to the HFACS-MSS to avoid subjective interpretations (Chauvin, et al. 2013, Hannah, 2016). With this, no contributing factors have been added.

The choice of HFACS -MSS was attributed due to the IMO's adoption of Reason's (1990) HFACS model and its guidelines on accident investigations (IMO, 1997, Schröder-Hinrichs et al., 2011). According to Li et al. (2008) the model is encouraged for the utilization in the maritime domain. Therefore, being a widely used framework, the author is motivated to apply it since it can easily be used for the kind of data available for this research. Machinery Space Systems as adopted by Schröder-Hinrichs et al., 2011 does not tamper with the original HFACS framework but it includes a 5th level called statutory in order to capture the enforcement and influence of safety regulations in the shipping industry (Schröder-Hinrichs et al., 2011)

For better comprehension, their severity was summarized as shown in table 4.1 below in various seriousness categories according to IMO's proposed process of casualty reports analysis and also the causal factors coded after analyzing the sampled data of ferry accidents around the Mombasa region, Kenya.

Table 4-1: Severity of the passenger ferry accidents and coded factors

Accident Category	**Number**	**Coded causal factors from 11 reports**	**Number**
Less serious accident	3	Unsafe acts	12
Serious	5	Preconditions for unsafe acts	16
Very serious accident	3	Unsafe Supervision	5
		Organizational influence & Statutory	16
Total	**11**	**Total**	**49**

Source: Author

The level of the undertaken analysis was not affected by how severe the ferry accident was or the casualty during the accident investigation.

4.1 Utilization of HFACS-MSS Framework and Taxonomy for Accident Analysis

The human factors captured from the presented reports were coded against Ghirxi's adaptation of Weigmann & Shappell's HFACS framework and taxonomy. From the reports outcome, it can be clearly noted that uncommon accidents do not occur from unique sources but rather a combination of familiar components as a result of unforeseen hazards and unpredictable conditions. Human factors identified from one incident are not likely to vary much from those in a different mishap of the same nature. According to Shappell & Wiegmann (2000), most mishap are due to similar causes and this was proved to be true during the analysis and coding of the reports. The aim of Ghirxi in the adaptation of the HFACS framework was to create a platform for future research and since their adaptation is skewed towards machinery space on ships to capture safety regulations in the ship industry, it can be trusted to be utilized in this analysis.

Upon Coding the 11 accident reports (see appendix II), as presented in table 4-1 above, causal factors on Human Factor Analysis Classification System – Machinery Spaces on Ships were identified. On completing the analyzing and describing of all the accidents the realized human factors were manually coded using the 3rd Tier HFACS-MSS framework indicated in table 4-2 below.

Table 4-2: The identified 49 3rd tier HFACS-MSS causal factors in reviewed accident reports.

Reported HFACS Causal Factors			Figures	
			No.	%
Statutory			**6**	**12.25%**
FS xxx	*Statutory*		*6*	*12.25%*
	FS 000	International standards	2	4.08%
	FS 100	Flag state implementation	4	8.16%
Organizational Influences			**10**	**20.41%**
OR xxx	*Resource management*		*1*	*2.04%*
	OR 000	Human resources	0	0.00%
	OR 100	Technological Resources	1	2.04%
	OR 200	Equipment/facility resources	0	0.00%
OC xxx	*Organizational climate*		*8*	*16.33%*
	OC 000	Structure	0	0.00%
	OC 100	Policies	0	0.00%
	OC 200	Culture	8	16.33%
OP xxx	*Organizational Process*		*1*	*2.04%*
	OP 000	Operations	0	0.00%
	OP 100	Procedures	0	0.00%
	OP 200	Oversight	1	2.04%
Unsafe supervision/work place factors			**5**	**10.20%**
SI xxx	*Inadequate supervision*		*3*	*6.12%*
	SI 000	Shipborne and shore supervision	3	6.12%
SP xxx	*Planned inappropriate operations*		*0*	*0.00%*
	SP 000	Shipborne operations	0	0.00%
SF xxx	*Failed to correct known problems*		*0*	*0.00%*
	SF 000	Shipborne related shortcomings	0	0.00%
SV xxx	*Supervisory violations*		*2*	*4.08%*
	SV 000	Shipborne violations	2	4.08%
Preconditions for unsafe acts			**16**	**32.65%**
PE xxx	*Environmental factors*		*12*	*24.49%*
	PE 000	Physical environment	5	10.20%
	PE 100	Technological environment	7	14.26%
PC xxx	*Crew Condition*		*1*	*2.04%*
	PC 000	Cognitive factors	1	2.04%
	PC 100	Physiological state	0	0.00%
PP xxx	*Personnel factors*		*3*	*6.12%*
	PP 000	Crew interaction	0	0.00%
	Pp 100	Personnel readiness	3	6.12%
Unsafe acts			**12**	**24.49%**
AE xxx	*Errors*		*7*	*14.26%*
	AE 000	Skill-based errors	1	2.04%
	AE 100	Decision and judgement errors	5	10.20%
	AE 200	Perceptual errors	1	2.04%
AV xxx	*Violations*		*5*	*10.20%*

	AV 000	Routine violations	4	8.16%
	AV 100	Exceptional violations	1	2.04%
Total			**49**	**100%**

Source: Author as adopted from Schröder-Hinrichs et al., 2011.

A total of 49 causal factors deduced from the analysis of 11 ferry accidents are shown in table 4-2 above. A clear relation between these factors could not be easily established. Some reports contained more elaborate investigation discussions than others even though they were of a less serious accident magnitude than the very serious accidents. As tabulated in the table above, the data shows that there was no even distribution of all the 3rd tier factors.

The sources of the reports played a significant role as well as how deep the investigation was carried out and the cause of accident analysis in the reports. The most elaborate were the reports from the maritime administrator while those chosen from newspapers were not very elaborate because of the non-follow up of the accidents, and the reporting persons did not have the adequate technical skills to investigate the accidents but highlighted most of the causal factors as much as necessary.

According to IMO requirements, the very serious investigation reports are supposed to be submitted to its secretariat and recorded into the GISIS system while the serious and less serious reports are not a requirement for submission. No report from the state was found in the IMO GISIS database.

4.2 Identification of Contributing Factors.

The reports reviewed led into the 49 3rd tier causal factors as shown in Table 4-2 above. Among the contributing causal factors established, preconditions of unsafe acts were leading with one third of all the factors followed by unsafe acts with a quarter of all the factors, organizational influence (20 %), statutory (12%) and the least causal factors identified were unsafe supervision with 10% in the 1st tier as indicated in Figure 4-1 below.

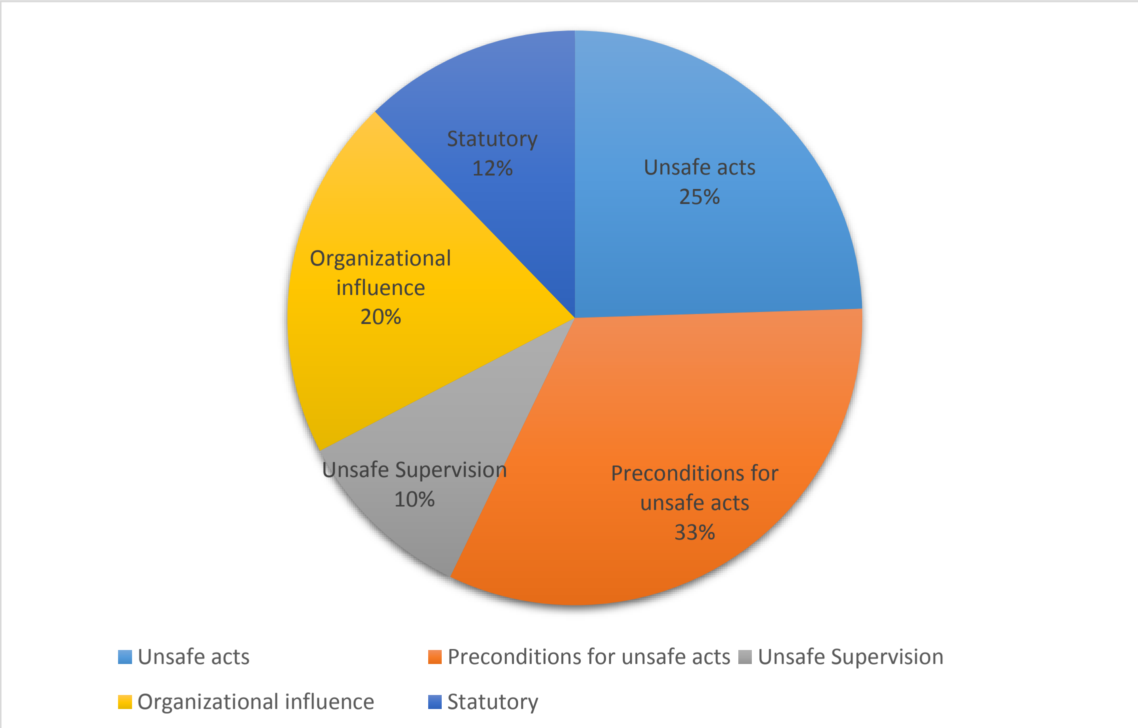

Figure 4-1: Overview of 1st Tier factors

Source: Author

4.2.1 Unsafe acts

There were 12 identified unsafe acts 3rd tier factors from the total causal factors realised. This represented 24.49% of all the identified factors, slightly about one quarter of all the factors as illustrated by figure 4-1. Decision and judgement errors represented 41.67% of all the unsafe acts and were followed by routine violations which was exactly one third of all the unsafe acts identified. Skill-based errors, perpetual errors and exceptional violations together contributed by 25% towards unsafe acts with an equal number of one factor each. The review also revealed that at least all 3rd tier factors of unsafe acts could be identified from most of the reports but were not evenly distributed among the errors and violations.

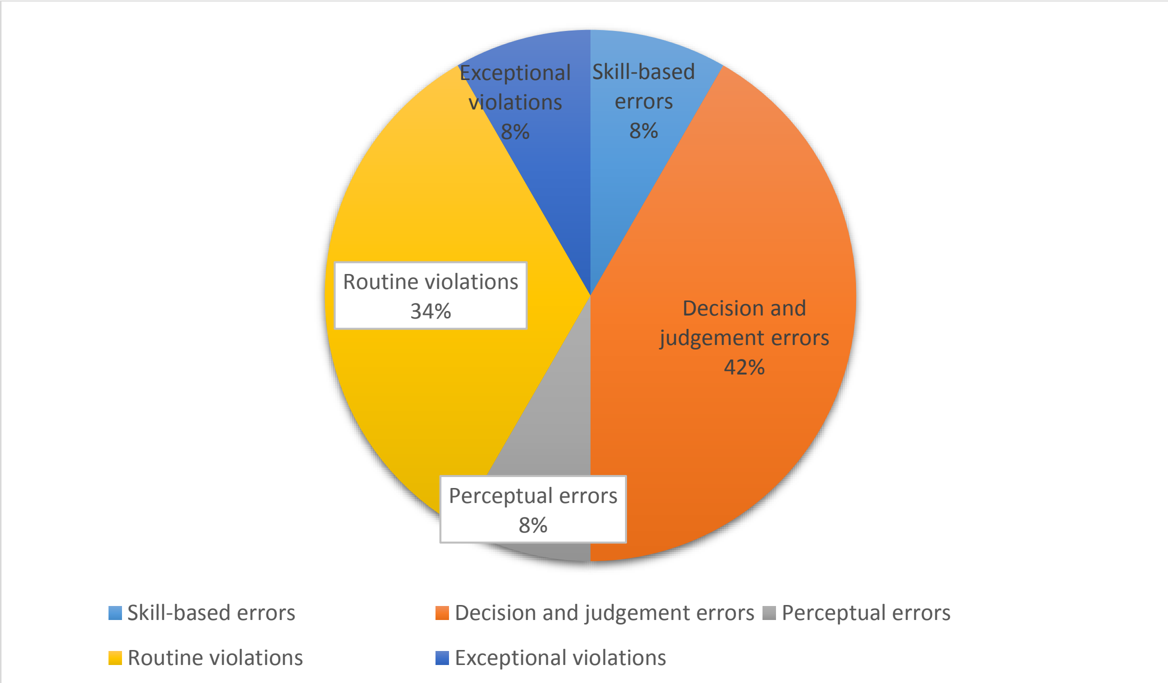

Figure 4-2: Overview of unsafe acts

Source: Author

4.2.2 Preconditions of unsafe acts

Preconditions of unsafe acts led with 16 factors having a representation of one third (32.65%) of the total causal factors identified. These were distributed unevenly whereby environmental factors had two thirds of all the preconditions and were dominated by the technological environment which had the highest number of factors (43.75%) while the physical environment had 31.25% of all the preconditions causal factors as represented in figure 4-3 below. Crew interaction and physiological state in the 3rd tier did not have any factors but all the 2nd tier factors had at least some factors. Not many causal factors were as a result of crew condition and it represented 6% of the preconditions identified under cognitive factors in the 3rd tier. The preconditions identified provided specific indication for deliberating machinery space and engine control room and how it affects human action leading to unsafe situation. This data can tell the maritime administrators and the ferry operators the extent to which technological environment factors matter in the day-to-day ferry operations and also to training institutions on what to improve in maritime education and training.

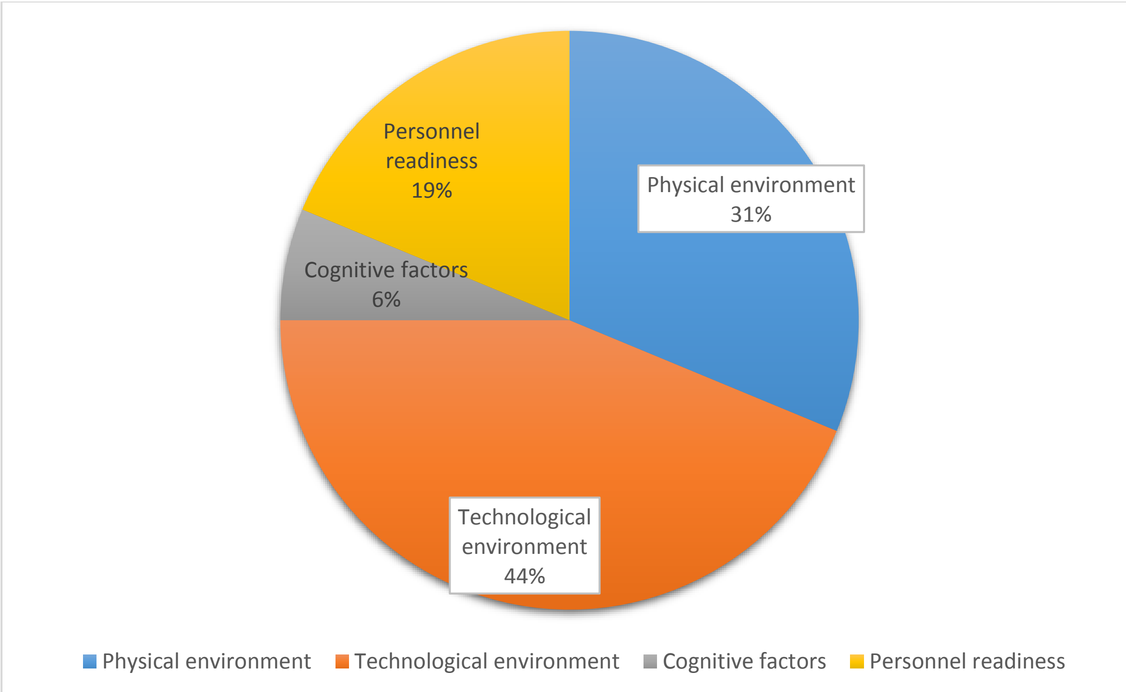

Figure 4-3: Overview of preconditions of unsafe acts.

Source: Author

4.2.3 Unsafe Supervision

This category was the most underrepresented as it was not easy to point out causal factors related to unsafe supervision from the reports. Out of the total number of identified factors, 10% were contributed by unsafe supervision. This was contributed to by shipborne and shore supervision where in a mishap the ships managers' interaction with those officers at management level affected the everyday operation on board the ferry. This were the highest number of contributing human factors in the unsafe supervision category with 60% of all unsafe supervision factors while the remaining percentage was due to shipborne violations. Shipborne operations and shipborne related shortcomings did not contribute to any of the accidents.

4.2.4 Organizational influences and Outside factors

Ten organizational influence factors were identified in seven accident reports representing 20% of the total causal factors while 6 outside factors were identified in six reports. 80% the organizational factors, were due to culture while the remaining attributed to oversight and technological resources with each having 10%. Culture was the leading 3rd tier causal factor whereby it contributed by 16.33% of all the causal factors. This is as a result of how a company's custom, crew attitude and values in the work environment affect their day-to-day decisions and contribute to unsafe acts. In most of the reports, this is attributed to pressure from passengers especially those using the ferries plying the Likoni channel. The ferry schedules according to the ferry operators as indicated in the reports, if not handled well lead to stampedes and overloading rendering the ferries in to further unsafe condition.

Outside factors arise in mishaps if the regulator lacks the necessary depth or leads a sub-standard regime. National standards factors were identified in 2 accident reports representing one third of statutory factors reflecting the drawbacks that could be in national regulations and policy enforcement. The remaining two thirds was identified in port state and flag state implementation. Outside factors contributed by 12.25% of the total identified causal factors because in domestic ferries there is no international control as the conventions do not affect them but rather the national policies and regulations.

5 Discussion of the accident review findings

The results presented in the preceding chapter has been discussed with regards to the 11 accidents analysed in this dissertation. Some of the reports were detailed while some explicitly lacked detail making it impossible to identify more causal factors. However, that by itself can also be considered as an important data source to understand how ferry accidents are handled in Kenya, the record keeping and the kind of investigation carried on. According to Schröder-Hinrichs et al (2011), a look into other studies from the same domain have indicated present consistent causal factor structures. In comparison, by this study focusing on domestic passenger ferries in Kenya, it could relate to the other studies findings and it was thus easier to identify active failures more easily than latent failures, as was discovered in most reports. Human factors contributing directly to the cause of the accident, like collision and overloading, are discussed and also other parameters with broad factors including, but not limited to vessel non-maintenance, sailing in bad weather, failure to provide life-saving appliances among others.

5.1 The unsafe acts involving crew and ferry operators

Crew and ferry owners or operators attributed to many unsafe acts as a result of errors of commission like performing incorrect acts, errors of omission whereby an act is left out like the maintenance of ferries MV Harambee and MV Kilindini. Also, timing whereby ferries were sailing in very rough seas an example of MV Nyayo and Bassaam, without considering their stability. Errors of sequence like, overloading the MV Nyayo, not maintaining it and further letting it sail in very rough seas. If a system is more complex there are likely to be multiple unsafe acts due to errors of sequence or if acts are performed in the wrong order. For instance, the Likoni channel due to the area in which the ferries operate, serves as the approach to Kilindini harbour which has vessels entering and leaving the port. Therefore, considering the high number of passengers and vehicles that need to use ferries across the channel without delays, increases the complexity of the ferry operations. This was observed during the review of the reports when some latent conditions led to active failures whenever there was a small breakdown in one of the ferries or if there was any delay. Errors have different psychological sources, take different forms and happen at various sections of the system requiring diverse ways of solving them. So as to be able to know who is at the sharp end of the accident, prior understanding of each step and section of the system by the investigator is necessary. According to Hollnagel (2008), the function of the system is more important than the structure in order to reduce the number of mishaps.

If the investigation reports were to be utilized properly, the kind of multiple errors of same nature could not be seen recurring in different incidents. To start with, the 1994 Mtongwe I accident could have been used as a learning platform in avoiding the causal factors that led to the accident. The vessel was being overloaded on a routine basis until the accident day. Similar to what was reported in the report of sinking of Mtongwe I, a big percentage of ferries operating in Mombasa are always overloaded especially during the rush hours as discussed in the literature review. Out of the 11 accidents analysed, 8 of them have serious cases of overloading beyond the vessels capacity.

Most unsafe factors account to Errors AE 200 – decision and judgement errors. An example is where MV Mtongwe I's coxswain decided to sail with the vessel even though he noticed that it was overloaded, but due to the fact that he had done several voyages before with the vessel in similar condition, he did not think of any other underlying latent factor that could lead to the failure of the vessel and its further capsizing. Almost 20 years later, this is seen being repeated by MV Nyayo, Harambee, Kwale, Bassaam and many other ferries. Other errors include skill-based errors as seen during the contact between MV. Kwale and Sea Wind. Perceptual errors were also noted in the case of MV. Bassaam whose operator or crew lacked situational awareness on weather condition before voyage.

Violations, more so routine violations, were identified for example in the Mtongwe I accident, which frequently overloaded the vessel especially during rush hours and also on the collision between Safina and Al-intsam, where Safina was overloaded and both vessels were operating at night without navigational lights. The captain of Bassaam who had 30 years' experience, but did not have any formal professional qualifications, was also classified as a routine violation.

5.2 Preconditions for Unsafe Acts

Most factors were identified in this category and environmental factors were the major contributing in most of the accidents because of machinery space, engine control room and technical procedures and how they affected crew performance leading to unsafe situations. Technological environment led among the other factors, especially the vessels operating at the Likoni channel due to vessel maintenance issues and machinery failure, for instance MV Nyayo and MV

Harambee. The lack of navigational lights on Safina and Al-Intsam and MV Hodari operating with a malfunctioning engine was considered technological factors. On its own, technological environment contributed by 14.26% of all the 49 causal factors identified and was the second highest of the contributing factors. Physical environment was the second cause of many mishaps under environmental factors due to the effects of nature like bad weather and rough seas where for example, in the case of MV Kwale contact with the Sea Wind, the Coxswain of Kwale had not taken into consideration the currents and rising tides. The same was experienced with Bassaam and MV Nyayo. Operating during the night limited the physical environment of Safina and Al-Intsam leading to an unsafe situation.

5.3 Unsafe Supervision

Most of the causal factors falling under this category were identified from the Mtongwe I sinking, Kwale and Sea wind contact, MV Nyayo and MV Harambee accidents. In the case of Mtongwe I, shipborne violations were identified because the ferry was overloaded on a regular basis and the management failed to correct the action. For MV Harambee, the management knew the vessel was unfit but due to the fact that two other vessels were undergoing repair, the vessel was allowed to operate. During the Sea wind and Kwale contact, the VTS was not monitoring vessel activities in the busy channel and could have alerted MV. Kwale on time before the contact. Twenty years after the sinking of Mtongwe I ferry, most ferries that operate the Likoni channel still operate under similar circumstances as depicted in the reports.

5.4 Organizational Influences and Outside Factors

The study revealed quite a number of organizational and outside factors. This indicated how the actions and policies of upper level management affect the crew actions leading to unsafe situations. On organisational influence, organisational climate contributed highly through culture on board. This was seen in several mishaps where for example overloading was done and in other cases is still done regularly but the management has failed to correct this known culture instead leaving it to lead to an unsafe situation. The lack of safety culture is seen in a number of vessels including Mtongwe I, Safina and Al-intsam, Bassaam whereby the captain did not have formal training, Hodari, MV Kilindini, MV Nyayo for allowing an unseaworthy vessel to fill in for other ferries and on MV Harambee which, although faulty, was allowed to operate for economic reasons.

Other organisational influences were due to oversight causal factors in the case of Nyayo where two other vessels were already out of order and another was technological resources in the case of MV Harambee that was allowed to operate while faulty because there were no funds to repair the defective vessel.

Under HFACS-MSS, outside factors form their own category and for this study it was used to evaluate the performance of flag and port state control on domestic fleet. In most cases, there are no measures in place to prevent faulty ferries from operating and there is no evidence of regular inspections as identified on the vessel Hodari. The national standards too are compromised and in cases like Safina the police did not have sufficient powers to stop the overloaded vessel from sailing. The causal factor most identified is port and flag state implementation whereby the state's inspections fail to help capture the vessels deficiencies in advance to prevent unsafe situations.

6 Conclusion

The aim of this study was to analyse the factors caused by human error in the domestic ferries in Kenya with an aim of finding a solution on how to reduce the named factors. The study therefore further looked into marine casualty investigations and the status of investigations after ferries have had mishaps that led to casualties.

According to IMO, up to 80% of accidents are caused by human error, however safety of domestic ferries in Kenya depend on a variety of factors not limited to human factors, such as bad weather, navigational, technical, operational and statutory factors. This analysis has found that many types of accidents in the country are caused by human factors. From Appendix 1 it is clear that there have been so many accidents occurring within a short range of time, especially from the most recent years. This is a period whereby it is expected that accidents are supposed to have reduced because the maritime administration has ratified policies and regulations to improve safety, allowed better and more stable vessels to operate, and learnt lessons from previous accidents. With the introduction of maritime education and training in local universities and colleges, it is also expected that the level of training among crews is now improved.

Recurring accidents prompt one to question if the policies and regulations enforced by the maritime administrator were being adhered to. With the right regulations, technical standards, and right resources the chance of bringing down accidents due to human error are very high if the right people with the correct knowledge and skills run the ferry industry. Ship owners are also not left out since some factors pointed out from the reports indicate that they have contributed to some of the causes of the accidents.

During the data collection, it was very difficult to sample reports due to quality of the report reflected either by incomplete accident reporting, lack of reliable accident investigations and in other cases complex forms of accidents or multilayered accidents. There was a very big indication of poor record keeping as well as poor accident investigation reports which for the few available were never published and here this is proposed as another human factor that is contributing to the lack of safety with the domestic ferries in Kenya. However, this should not be seen as a failure of the research project but as another learning point for the ferry sector in Kenya since it reflects the exact picture of the unexplored marine casualty investigation and gives a leeway for further studies in the same in order to improve in the future.

One challenge contributed by the quality of reports was the difficulty in recognizing human error, especially in reports by non-technical personnel and more so in cases where newspaper reports were used. Media personnel are non-technical and may not always have access to the accident scene. To address the issue of quality of the media reports, an analysis had to be done to determine only those accidents with a high percentage of fatalities attributable to human error. In this case human error only included those errors leading directly to the accident. Overloading, collision, sailing in inclement weather after misjudgment, vessel maintenance are all examples of errors that were considered as factors. Due to the insufficiency of the casualty investigations reviewed, not all factors were included but for the reason of not trying to reinvestigate the accidents, only those factors explicitly mentioned in the reports were used for the analysis.

Utilization of the HFACS framework and taxonomy in accident analysis involving domestic passenger ferries in Kenya was successful and the association between the reviewed accident investigation reports and the theoretical model was collaborative even though with limitations from some reports were not being sufficiently investigated. Human factors associated with the ferry owners gave a meaningful trend indicating that they played a role in both latent and active failures during accidents. Therefore, it is paramount for the ferry owners to underpin the causes of previous accidents and the reasons why the regulations in force have not enabled them to achieve maximum safety in the operation of the ferries.

As a result of the lack of an independent accident investigation body in Kenya at the moment, the quality of marine casualty investigation is poor compared to the investigation reports of similar accidents that have been uploaded in the IMO GISIS platform from other nations. The same can also be said on the record keeping of the investigated cases. Incidents involving marine casualty investigation need to be properly documented and this can only be achieved with a proper understanding of the importance of IMO's objective and the role of accident investigation. To achieve these objectives independence is key, not forgetting the incorporating of near misses as part of the investigation.

With maritime education and training now being offered in the country, marine casualty investigation should be considered as an area of interest and be offered as a course locally.

Overall, the marine casualty investigation's main aim is to contribute towards improving maritime safety and preventing similar incidents in future. Investigation reports are supposed to be centrally kept and the more serious cases forwarded to the IMO Secretariat and uploaded in the GISIS system for further reference and learning. The Likoni and Lamu channels should be considered as a hot spot for ferry accidents considering the busy ferry traffic operations thereto.

7 Recommendations

It is not easy for an investigator to get all the facts together that contribute to an accident. The nature of a human being during an accident investigation tends to be protective and therefore what a person reveals about the casualty is limited. In most cases, the major cause of an accident is masked and necessary the evidence destroyed. Commercial vessel owners may also reveal less information to protect their interests and in most cases hide behind classification society certificates and some may never even report a casualty. This has seen non genuine links created between vessel owners and other stakeholders like the administrator, the insurance and the users because they see accident reporting as a reflection of their weaknesses. The crew also does not want to take the responsibility for the accidents for fear of being fired or replaced and therefore not reporting is the easiest way to avoid blame.

Flag states are also seeing accident investigations as an undesired expense and a bad reflection of their image. As a matter of fact, looking from both sides, there are a lot of contradictions that need to be approached carefully in the safety chain and managed properly to achieve maritime safety through proper maritime casualty investigation. Starting with ship design, construction, inspection, maritime administration, maritime education and training institutions, lending institutions, owners, crew, survivors all the way to insurance and P & I clubs, the list, though not exhaustive, indicates quite a number of parties that may be part of a marine casualty investigation. It also shows how complex marine accident investigations can become. From the analysis in this study, the author has suggested the following recommendations to reduce mishaps caused by human errors in the ferry industry in Kenya.

Establishing an Independent investigation body

The public uses the ferries often and has entrusted the maritime administration with their safety. Therefore, in order to have transparency and to avoid conflict of interest, accident investigation in Kenya must be totally separated from the responsible administrative organization that regulates and enforces policies as proposed in IMO's Res. A.884 (21) that was adopted in May, 2008. Legislation should be promulgated and developed in respect to accident investigation to yield credible reports for the regulators, operators and the public. A team of experts should also be established with proper academic qualifications and experience to carry out the duties as required during investigations. The investigation body should be formed with the aim not to blame or fault but to identify the causes of marine casualty and make recommendations to avoid similar accidents and incidents in the future so as to improve water transport (MCIB, 2017).

A legislation to ensure that investigators have access rights to accident scenes and materials like VDR's without intervention should also be put in place. Guidelines should be adopted from the IMO casualty investigation and local guidelines should be developed for the owners/operators of passenger ferries and their crew with respect to investigation.

Creation of a central database and a confidential casualty reporting system

A good example of such a system is the European Maritime Casualty Information Platform (EMCIP) which is a data distribution system and database intended for broadening the analysis of causality information, and providing ready information for the use to enable in identifying risk and documenting casualties. Simply for all those party to the ferry industry in Kenya to contribute towards the reduction of ferry accidents in Kenya, and to reduce the fatality rate involving ferry casualties, there must be a complete record of past incidents to draw lessons, just like the IMO, EMSA Worldwide Ferry Safety Association (WFSA) and the Interferry pledge. To ensure that no incident or accident goes unreported, a confidential casualty reporting system is encouraged with the aim that the reporting person's identity shall not be disclosed but the reported cases will be fully investigated.

A mailing list should also be established in order to ensure all relevant stakeholders receive the accident investigation reports. The database should also serve as reference material during future investigations and the reports should be protected from being amended or deleting some parts.

Audit of the existing passenger ferries

A thorough inspection of the current domestic passenger vessels against the required standards and according to the national regulations as stipulated in the merchant shipping act as this can eliminate unsafe acts of violations based on risk assessment, failing to comply with manuals, operating when unauthorised and violating standing orders and regulations. Audits can also prune out unqualified crews leading to ferries that are equipped with competent crew that can ensure that they are run in a safer manner. Also, if the owners and operators of the ferries could work hand-in-hand with the maritime administrator, take caution and follow the rules and regulations developed for their safety rather than focus too much on making profits, they can improve safety.

Training

Training based on the team approach targeting the reduction of human error related accidents is necessary. This can be achieved through targeting various categories of stakeholders that include the administrative staff, the ferry owners and operators, the crew and the passengers or public in general. A more intensive and incentive based training is recommended for all captains and crew of the ferries in the country that involves low cost technologies and more intuitive items to help them learn the latest trends in the ferry industry and how they can use the latest technology in line with their duties to help reduce accidents. The promotion of such trainings at the Bandari College in Mombasa is necessary so as to encourage as many persons in the ferry sector to train.

The investigators should also be trained, qualified and must be totally objective and uphold the utmost integrity during investigation with skills as outlined in resolution A.996 (25) for investigators. Knowing well that their conclusions and recommendations have far reaching consequences, they should demonstrate patience and understand relevant circumstances during the investigation. They should know what standards to apply in various situations and examine against those standards.

The training institutions should also develop programs using guidelines as laid down in the IMO short courses so that a degree of uniformity is achieved to a global level. Also ensure that officers who return to these institutions for revalidation under the STCW convention undergo courses in accident investigation in the context of accident prevention.

The ship Owner and operators

The accident reporting culture should be the norm. Ship owners must ensure that not only the ship board managers, but all on board their vessels, are aware of their policy with respect to the investigation of events and how such a policy fits into the overall policy of ensuring safety at sea and reducing accidents caused by human error. They should also ensure that the management team on board their vessels are well prepared to contribute towards accident investigation through company education.

Bridge or tunnel for Likoni channel

With the current upsurge of passengers using the Likoni Channel rising above 300,000 people per day, it is evident that unless the ferry operator secures more ferries, there is always going to be more stampedes from passenger scrambling for the minimum ferries available. One long term solution is a bridge or a tunnel from the Island to the Southern coast of Kenya through Likoni. Due to security reasons and the channel being considered an ISPS area because it serves as the approach to the port of Mombasa's Kilindini harbour, a tunnel will be more viable and preferable than a bridge. This will have an impact on the latent failures which later manifest to active failures over a long term leading to ferry accidents in that channel.

Weather reporting system

Even though general weather is usually broadcasted by media houses, special marine weather should be given an up-to-the-minute broadcasting priority specifically to sea-going personnel for adequate planning. Therefore, a system that is capable of broadcasting daily and hourly and developing weather updates at sea is necessary so as to enable the operators and seafarers to prepare adequately. Unsafe weather conditions, strong winds and tides, storms or even tsunamis and cyclones pose safety danger to all vessels at sea. An improved affordable weather information system will help even small business owners in the ferry industry to have situational awareness and in the long run improve safety and prevent loss of life due to weather related human factors. It is preferable to have an SMS system that can push messages from a central source, for example the RMRCC to the seafarers' mobile phones as a complimentary weather broadcasting system. Such a system, by example, is the NOAA's crowdsourcing weather data app for cell broadcasts alias the Meteorological Phenomena Identification near the Ground (MPING).

Control of overcrowding and overloading

The ferries offering services especially at the Likoni Channel are absolutely free whereas the rest are equally very cheap as compared to the other means of transport. This has made transport by water the cheapest and most preferable among many residents accessing the islands and mainland. The disadvantage of this has been an increased number of passengers that has led to overcrowding and overloading of the ferries. Increase in the number of passengers is an underlying risk and with time combined with one active failure can contribute towards an accident. The maritime administrator is needed to play a huge role by having more strict regulations and penalties to the operators against overloading the ferries. Nowadays, there are technologies to count passengers as they pass through to board the vessel such that once the limit has been reached the vessel cannot take extra passengers. There are also weighing systems that are similar to elevator systems that can tell when the vessel's maximum tonnage has been attained. The maritime administrator should ensure these systems are in place and working at all the boarding ramps or piers.

On the other hand, it is easier to educate the public in general by holding campaigns on the ground and through media about their own safety and how they can contribute actively to ensure they are not part of the problem but rather a solution. In 2013 passengers in a Hong Kong vessel prevented it from departing when they noticed cargo blocking the exits. This was triggered by a lesson from a previous accident which occurred and where the loss of lives could have been prevented if the vessels exits were not blocked in the same way (Golden & Weisbrod, 2016). This showed that passengers in a known danger can actively contribute towards minimizing the risk they are aware facing them.

Mass Rescue Operations

Disasters will continue to happen globally and regularly but despite this, the multi-agency approach towards response has remained a poorly researched area (Chen et al. 2008, Salmon et al. 2011, & Salmon et al. 2014). Considering the vast SAR area that Kenya has, and very minimal rescue resources, involvement of other organizations with the help of the SAR coordination by the RMRCC Mombasa will improve the rescue services and minimize the number of fatalities. Mass rescue operations coupled with cooperation among the several state organizations and private agencies is necessary in order to ensure faster and more robust rescue services are availed in case there is a ferry accident

Enforcing the ISM code in national legislation

The MSC-MEPC.7/Circ.7 (2008) section 9 of the ISM code promotes the reporting of near misses as this encourages promotion of a safety culture and also as an integral part of continually improving safety management systems. This will provide the marine casualty investigators a chance to be at bay from deducing blame to the sharp end which always points at the crew on board the vessel but rather gives investigation a holistic approach whereby, the more deep an investigation is carried out, the more factors will be identified, and if recommendations are implemented this can improve the whole system in general. Also, because the ISM code is seen as the ideal instrument to address organizational factors (IMO, 2010).

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Appendix I

Causality Data List.

DATE	VESSEL'S NAME	VESSEL'S FLAG	PLACE/REGION	TYPE OF INCIDENT/ACCIDENT	NO. OF DEATHS
9/5/1982	MV. Eva		Mombasa Port Approach	Grounding	0
18/5/1983	MV. Sanko Cherry		Mombasa Port Approach	Grounding	0
7/10/1983	MV. Bateleur		South East Of Madagascar	Capsizing	3
1/6/1984	MV. Morea		Enroute to Kismayu	Sinking	8
19/6/1984	Kiboko/Alexa	Kenya/	Mombasa Port	Collision	0
25/3/1987	Raudha		Off coast of Lamu	Grounding	0
27/8/1987	F.T. Jonay	Spain	Off coast of Lamu	Man Overboard	1
9/11/1987	MV. Silago Express		Mombasa Port Approach	Grounding	0
6/7/1988	Yatch Emirites	N/A	Mombasa Port	Container Lifting failure	0
6/8/1988	MV. Harrier		South Coast	Capsizing	Unknown
10/12/1988	MV. Atlantic Maru		Mombasa Port Approach	Stranding	0
24/5/1990	MV. Ujuzi		Off Malindi	Grounding	9
8/7/1990	MV. Bernora		Mombasa Port Approach	Grounding	0
5/1/1991	Hana		Off coast of Malindi	Capsizing	Unknown
7/3/1992	Khairat	Zanzibar	Tanga	Capsizing	10
3/9/1992	Atiatularahman		Old port Mombasa	Grounding	0
16/8/1993	M.V Indian Ocean	Somalia	Kilifi	Sinking	0
16/8/1994	MV. Ramora Bay		Off Coast of Somalia	Sinking	1
25/8/1994	M.V. Brats		Kilindini berth #4	Man Overboard	1

29/04/1994	Mtongwe 1	Kenya	Likoni Channel	Capsizing	Apx. 270
25/03/1995	Suzanne Delmas		Mombasa Port	Heavy Contact	0
30/5/1995	M.V. Bonsella	Bahamas	Tanga	Capsizing	0
16/10/1995	M.V. Niyzao	Kenya	Tiwi South coast	Capsizing	0
24/01/1996	MT. Shareen	Kingston	Mombasa Port	Heavy Contact	0
22/9/1996	M.T. Johana			Grounding	0
21/5/1997	MV. Nedlloyd Maine	The Netherlands	Mombasa Port	Jammed Container	0
5/7/1997	Jain Hong 201		Off coast of Mombasa	Sinking	Unknown
19/10/1997	M.V.Fadhil Karim		Old port Mombasa	Sinking	0
21/5/1998	SV. Iqbal		TZ/KN Boarder	Capsizing	6
11/1/2002	Hidaya	N/A	Kisite M. Park	Sinking	0
1/6/2005	Ahlam	Kenya	Lamu	Man Overboard	1
22/5/2005	MV. Ruaha		Mombasa Port	Man Overboard	1
2/7/2005	De La Franqueira/ Sanjeeda		Mombasa Port	Heavy Contact	0
5/23/2006	Fossil	N/A	Mtwapa Creek	Capsizing	1
8/10/2007	Barge Bartun	N/A	SECO repair yard	Man overboard	1
13/12/2007	M.V Asian Trader		Mombasa Port	Stevedores collapsed in cargo hold	0
14/6/2008	M.T. Rhino		Off Mombasa coast	Towing rope accident	1
4/7/2008	M.V. Kairos		AMGECO Dry dock	Fire	Unknown
17/9/2008	Al-Itifaq & Afuwa		Lamu	Collision	1
4/11/2008	Onega I	Panama	Sea	Death of crew	1
11/12/2008	B. Spacial	Kenya	Kisumu Port	Man Overboard	1
8/9/2009	Tusitiri		Mtwapa	Capsizing	1
02/05/10	Elbaron		L Victoria	Capsizing	1
06/06/10	Kirande		L Victoria	Capsizing	2
06/06/10	Mzee Adero		L Victoria	Capsizing	2
06/06/10	Jerusalem		L Victoria	Capsizing	2
12/8/2010	MV.S. Cunene/ Ibi		Mombasa Port	Collision	0
17/8/2010	O. Janabi		Rambira beach	Capsizing	3

19/9/2010	One love		Pirates beach	Sinking	0
4/10/2010	TCG Gokceada	Turkey	Likoni Chanel	Grounding	0
07/10/10	Salome		L Victoria	Capsizing	6
17/10/10	MT FAITH		MOMBASA	Man overboard	1
01/11/10	O. Nyomogi		L Victoria	Capsizing	19
27/08/2011	Lulu	Kenya	Mtwapa Creek	Capsizing	0
15/9/2011	MV. Kwale/ Sea Wind	Kenya/	Mombasa Port	Contact	0
26/09/2011	MV Yusra		Mukowe	Contact	0
24/11/2011	Kaya		Sigir crossing point	Capsizing	17
29/11/2011	MV. Blida/ Kota Nekad	Singapo re	Mombasa Port	Heavy Contact	0
1/1/2012	Safina/ Al-Intisam	Kenya/ Kenya	Lamu	Collision	20
22/01/2012	Shufaa	Kenya	Lamu	Capsizing	5
06/02/2012	Unknown	Kenya	Nyandiwa beach	Capsizing	2
23/02/2012	Patrickmutu a	Kenya	L. Chala	Capsizing	4
09/04/2012	M.V Mara/ Manda	Kenya	Manda jetty	Collision	0
21/08/2012	Millenium	Kenya	Watamu	Capsizing	0
3/11/2012	MV. Chang Tai Hong	Hong Kong	Mombasa Port	Injury to Personnel	1
18/12/2012	Sara Dayo	Kenya	River Nyando	Capsizing	5
21/1/2013	Intl' Medical Corps	Kenya	Off Mfangano Island	Loss of Stability	0
25/01/2013	MV. Likoni		Likoni Channel	Barrier failure	11
14/04/2013	Sifa Ya Bwana	Kenya	L. Turkana – Turkana county	Drowning	9
24/4/2013	MT. Ambrosia		Mombasa Port	Pilot Ladder failure - Drowning	1
11/07/2013	Maverick	Kenya	Diani	Shipwrecked	0
27/07/2013	M.V Hodari	Kenya	Kiwayu	Mechanical problem	0
06/08/2013	Ombembe	Kenya	Lake Jipe	Capsizing	1
30/10/2013	MV. Zella Oldendrff	Malta	Mombasa Port	Heavy Weight Crushing	1
10/01/2014	Kukhu Nang'oma	Kenya	Sumba Channel (L. Victoria)	Capsizing	0
01/05/2014	Mkizi	Kenya	Mld Marine Park	Not stated	0

20/11/2014	KWS boat	Kenya	Msa Marine park	Capsizing	4
2/1/2015	Kitezi	Kenya	Diani	Capsizing	4
10/1/2015	Alsamadi	Kenya	Diani	Flooding	15
14/01/2015	MV. Andrea	Kenya	Lamu	Mechanical Failure	0
19/01/2015	MV. Bilaal	Kenya	Kisite mpunguti	Grounding	12
6/4/2015	Jet Ski-Boat	Kenya	white sands	Capsizing	12
25/05/2015	MV Waamo Star	Kenya	Malindi M. Park	Flooding	0
24/7/2015	MV Alsham	Kenya	Lamu	Capsizing	5
22/9/2015	FV Vega	Kenya	Mambrui Malindi	Grounding	20
19/10/2015	Kahawa	Kenya	Mombasa	Drifting	2
11/11/2015	MV. Kwale	Kenya	Likoni Channel	Grounding	0
20/01/2016	Rangi	Kenya	Shimoni	Sinking	4
28/02/2016	Nuzla	Kenya	Lamu - Manda bay	Capsizing	2
11/3/2016	Kenya Navy	Kenya	Magogoni	Capsizing	Unknown
17/05/2016	Zuhura	Kenya	Shimoni	Mechanical failure	5
6/6/2016	MV Harambee	Kenya	Likoni Channel	Ditched	1
9/6/2016	Al -Ikhlas	Kenya	Mkandani	Capsizing	18
09/06/2016	MV. Kilindini	Kenya	Likoni Channel	Man Overboard	1
13/06/2016	Mombasa 1	Kenya	English point	Capsizing	6
7/7/2016	Likoni 1	Kenya	Diani	Capsizing	4
26/7/2016	Mastakher II	Kenya	Pemba channel	Engine Failure	5
29/7/2016	Tamu	Kenya	Mtwapa	Drowning	4
17/08/2016	Hamza	Kenya	Diani - Tiwi	Capsizing	2
24/08/2016	Bishara	Kenya	Lamu	Capsizing	4
29/08/2016	Zabar	Kenya	Lamu - Kiunga	Capsizing	5
6/9/2016	Mashallah	Kenya	Msambweni	Capsizing	16
17/9/2016	Mv. Nyayo	Kenya	Likoni Channel	Engine Failure	0

Appendix II

Coding Human Factor as retrieved from the reports

Only the human factors to be analyzed have been retrieved from the reports that are within the scope of shipping operators, the crew and the maritime administration. Other factors like the shipping operator's unsafe acts and maintenance will be discussed as indicated in the reports.

1. **Mtongwe 1**

Accident information sheet

Accident no.: 1

Date: 27/04/1994

Accident category: Sinking

Ship involved: MV Mtongwe I

Length:

Breath:

Tonnage:

Build when:

Build where:

Operator: KFS

When the ship was taken over by the operator:

Accident date: 27/04/1994

Accident time:

Injuries: 270 lost lives

Casualties: 400

Total loss: Yes

Source of information about the accident: Newspaper (The Herald)

Summary of the accident: The vessel was designed to carry a maximum of 300 people. On the fateful day the vessel had 400 onboard from Mtongwe to Mombasa. The ferry as reported, always carried in excess during the rush hours and had always crossed the channel safely. On the fateful day it was crammed tight with people. It appeared overloaded and swayed violently. It capsized and sank about 40 meters away from the mainland. A total number of 272 lives were lost in the accident.

Unsafe Acts

Violation - Routine violation (AV 400)

To proceed with an overloaded ship.

Pre-conditions

Cognitive factors – Overconfidence (PC 100)

According to the report – the ferry was always overloaded during rush hours

Personnel factors - Personal readiness (PP 200)

Disregard for rules and instructions combined with poor judgement

Unsafe supervision

Supervisory violations – Shipborne Violations (SV 000)

If the ferry was overloaded on a regular basis and the management failed to correct the action on board, they have acted negligently and enabled the accident to happen.

Organizational influence

Organizational climate – culture (OC 200)

If the ferry was overloaded on a regular basis and the management failed to correct the action on board, they have acted negligently and enabled the accident to happen.

Outside factors/Statutory - Flag State (FS – 100)

If there were there any rules, procedures and authorized personnel in place to notice and stop this development.

2. **MV. Kwale/ Sea Wind**

Accident information sheet

Accident no.: 2

Date: 15/09/2011

Accident category: Contact

Ship involved: MV Kwale/Sea wind

Length: 75/119.014

Breath: 16.05M/18.6

Tonnage: 637/6425

Build when: 2010/1988

Build where:

Operator: KFS

When the ship was taken over by the operator: KFS/Liberia

Accident date: 15/09/2011

Accident time:

Injuries: none

Casualties:

Total loss: No

Source of information about the accident: KMA

Summary of the accident: The vessel Sea Wind was fast and secure on the wharf from September 10th waiting to overload. Kwale was underway crossing the channel from mainland on 15th sept the Ro-Ro Passenger Ferry made contact with the Liberian registered general cargo ship, MV. Sea Wind at the Mbaraki Wharf, along the Kilindini Harbor Channel where according to the report she had been secured by port pilots with a 15m overhang towards the ferry landing for a period of five days. On the 5th day the coxswain had just taken over shift and that was his first voyage. In the report, the Coxswain said he lost control of the vessel due to steering failure. But after the contact he continued with normal operation of the vessel. It was established that the vessel did cause contact as a result of suffering mechanical failure but due to not factoring in the incoming tide.

Unsafe acts

Errors - Decision and judgment errors (AE 200)

(AE 205) - Failed to pay attention to incoming and rising tide and the effects this causes to the vessel

(AE 201) - Failed to realize the importance of the use of navigational equipment in this situation

Pre-conditions

Environmental factors – Physical environment (PE 100)

- Strong flooding and tides
- Movement of the vessel

Outside factors – Statutory

Port State (FS 000) - No supervision of ship movements in the area

3. **MV. Safina/ Al-Intisam**

Accident information sheet

Accident no.: 3

Date: 2/1/2012

Accident category: Collision

Ship involved: MV Safina/Al-Intsam

Length:

Breath:

Tonnage:

Build when:

Build where:

Operator: Private

When the ship was taken over by the operator:

Accident date: 1/1/2012

Accident time: 0030hrs

Injuries: 20 lives lost

Casualties: 82

Total loss: Yes

Source of information about the accident: Newspaper (The Telegraph)

Summary of the accident: This is a commuter passenger vessel which collided with another vessel at night while carrying about 82 passengers on board. 43 passengers were saved while 9 bodies were recovered. The report does not give further account of the missing persons but a total of 20 persons died. The passenger ferry was intentionally overloaded with people and baggage and both vessels had no navigational lights. They were operating in the dark when they collided. According to the report before the boat left a police officer tried to stop it but the operator talked him out. The report blamed boat operators for not observing safety regulations.

Unsafe acts

Violation – Routine (AV 400)

No navigation light on

Violation – Routine (AV 400)

Overloading the vessel

Pre-conditions

Environmental factors – Physical Environment (PE 100)

It was night time

Environmental factors – Technological Environment (PE 200)

Both vessels were missing navigational lights

Organizational Influences

Organizational climate – culture (OC 200)

No safety culture – when police tried to prevent the ferry from leaving, management interfered and told the captain to proceed.

Outside factors

Statutory - Port State (FS 000)

No sufficient enforcement powers to local police – an officer warned the captain, but he was instructed by management to still proceed

4. **MV Bassaam**

Accident information sheet

Accident no.: 4

Date: 20/06/2016

Accident category: Sinking

Ship involved: MV Bassaam

Length: 69m

Breath: **14m**

Tonnage:

Build when:

Build where:

Operator: Private

When the ship was taken over by the operator:

Accident date: 20/06/2016

Accident time:

Injuries: 20 lives lost

Casualties: 128

Total loss: No

Source of information about the accident: KMA

Summary of the accident: On 20th June 2017, the vessel started her journey at Lamu Palace with passenger lifesaving appliances on board safely locked away. Thirty minutes into the journey, a stronger gush of wind hit the vessel and efforts to realign it to a safe speed and position failed as the captain lost control. The vessel took in water from the bow, flooded and sunk. According to the report, the captain did not have any formal training and certification, but had an experience of over thirty years on sailing. From the report, there are indications that the captain did not take into consideration the fact that from June to August season, the region is known for intermittent rains with strong winds and rough seas. From previous records, there are higher number of vessels capsizing in that season. The captain did not consider that and the report further says he was ill prepared, delayed and failed to correct the vessels position to counter the strong wind and control the vessel when she was hit by a sudden gush of wind. The vessel tripped on the fore due to the force of the wind and took in water from the bow, further loading the vessel, gradually exhausting the spare buoyancy and subsequently capsizing the vessel. The high number of fatalities was contributed by lack of floatation devices. 20 lives were lost due to poor judgement on the part of the captain, lack of life saving appliances and trading a passenger vessel in rough seas contrary to laid down safety regulations and guidelines.

Unsafe Acts

Violation – Routine (AV 400)

To operate a ship without proper training.

Violation – Exceptional (AV 500)

Not to provide safety instructions prior to departure.

Errors - Perceptual errors (AE 300)

Lack of situational awareness

Preconditions

Environmental factors – physical environment (PE 100)

Sudden wind forces

Personnel factors - Personal readiness (PP 200)

Lack of training

Organizational influence

Organizational climate – culture

A captain without any formal training has been employed to operate the ship

5. **MV Kwale**

Accident information sheet

Accident no.: 5.

Date: 11/11/2015

Accident category: Grounding

Ship involved: MV Kwale

Length: 75M

Breath: 16.05

Tonnage: 637 RT

Build when:

Build where:

Operator: Kenya Ferry Services

When the ship was taken over by the operator: 14/06/2010

Accident date: 11/11/2015

Accident time:

Injuries: several persons

Casualties: Approx. 1000

Total loss: No

Source of information about the accident: Newspaper (The standard media)

Summary of the accident: The vessel lost power in one of the generators that power the vessels engines and stalled. This led to the vessel drifting for about 1 kilometer from the channel where it hit a coral reef and grounded with approximately 1000 passengers on board. Several passengers in fright jumped overboard to swim to the shore. Several persons sustained injuries from the impact of hitting the rock. The other passengers waited for up to four hours until another ferry MV Kilindini, Kenya Navy vessel and two tug boats were deployed to rescue the vessel and evacuate the passengers. The vessel was refloated after the tide was high later on.

The information given about Kwale was not sufficient to code individual human factors involved in the accident.

6. **MV Yusra**

Accident no.: 6.

Date: 26/09/2011

Accident category: Contact

Ship involved: MV Yusra

Length:

Breath:

Tonnage:

Build when:

Build where:

Operator: Private

When the ship was taken over by the operator:

Accident date: 26/09/2011

Accident time: 1330 hrs

Injuries: none

Casualties:

Total loss: No

Source of information about the accident: (KMA)

Summary of the accident: On 26 September 2011 MV Yusra struck the end of a breakwater while departing from Mukowe for passage to Lamu Island. The ferry's bow was damaged but the vessel returned to its berth without assistance. The impact resulted in several minor injuries to passengers and crew. There was no pollution. The contact with the breakwater resulted from a loss of directional control as Yusra turned towards the harbour's eastern entrance. The ferry's engines were set to 'full astern' and the starboard anchor was let go, but these actions did not prevent the ferry from running into the breakwater at 3.5kts. No announcement was made by the coxswain to warn the passengers and crew. The loss of directional control was due to a change in the mode the steering control system was operating. The change in steering mode was not intentionally initiated and remains unexplained. The response of the bridge team was positive but the action to stop the ferry was taken too late.

Unsafe Acts

Errors - Skill based errors (AE 100)

Unintentional and unnoticed change of steering mode

Errors - Decision and judgement errors (AE 200)

Late recognition that manoeuvres are not carried out as planned

The error is not explained in the accident information. There are some actions to prevent the accident described, but it is unclear how they were carried out. The information is not sufficient to add further coding in respect to Preconditions for unsafe acts or other organizational factors.

7. MV Hodari

Accident no.: 7.

Date: 09/08/2013

Accident category: Contact

Ship involved: MV Hodari

Length:

Breath:

Tonnage:

Build when:

Build where:

Operator: Private

When the ship was taken over by the operator:

Accident date: 25/07/2013

Accident time: 1330 hrs

Injuries: none

Casualties: 70

Total loss: Yes

Source of information about the accident: (KMA)

Summary of the accident: The passenger vessel departed Kiwayu to Lamu at 1330hrs, several minutes into her voyage, there was total blackout on board the vessel due to power failure causing panic to passengers. This was due to loss of power and malfunction in the engine room system that caused a total power failure onboard the vessel. According to the report the captain had had several such incidents and had reported to the owner for the past whole year. The vessel kept drifting for several hours until deployed rescue boats from Marine police unit and the Kenya Navy evacuated the passengers the following day. The incident was reported to the rescue centre 5 hours later by the owner of the vessel. All passengers were safely evacuated but the vessel ran aground on coral rock and sank on the 27/07/2013.
The information is not sufficient to code the unsafe act leading to the accident. However, it is clear that the engine was not fully operational at the time of the accident as several instances with engine problems were reported during the year prior to the accident.

Preconditions for unsafe acts

Environmental factors - Technical environment (PE 200)

Vessel operating with a damaged engine.

Unsafe supervision

Inadequate supervision – Shipborne and shore supervision (SI 000)

Shore based management deficiencies

Organizational influences

Organizational climate – Culture (OC 200)

- Owner did not react to earlier reports of engine problems
- Owner reported the accident only 5 hours after it occurred

Statutory - Flag State (FS 100)

There is no evidence of regular inspections of this vessel

8. **MV. Kilindini**

Accident no.: 8

Date: 09/06/2016

Accident category: Vehicle and Person overboard

Ship involved: MV Kilindini

Length:

Breath:

Tonnage:

Build when:

Build where:

Operator: KFS

When the ship was taken over by the operator:

Accident date: 09/06/2016

Accident time:

Injuries: 1 person died

Casualties: 1

Total loss: No

Source of information about the accident: Newspaper, KMA

Summary of the accident: A private vehicle on board the ferry erroneously engaged its reverse gear with the driver still inside and plunged into the sea. The vehicle slid from the ferry at Likoni Channel. The vehicle took close to 30 minutes to sink as the occupant struggled to break out of it. Unfortunately according to the report, there were no divers onboard and the ferry crew only threw a life ring to the vehicle driver even though still trapped. The vessel proceeded with its journey across the channel. The occupant of the vehicle drowned to death after the vehicle sank. The ferry management defended the crew for only throwing a life ring to the deceased. The ferry operator KFS relies on volunteer divers and SAR services for other organizations like KMA, Maritime police, Kenya navy and KPA. The operator as well does not have any specialized diving equipment for emergency cases.

Pre-conditions

Environmental factors - Technological environment (PE 200)

Inappropriate physical barriers to prevent the car from going overboard

Personnel factors – Personal readiness (PP 200)

Inappropriate response to the accident and no support given to the struggling driver

Organizational influence

Organizational climate – Culture (OC 200)

The response to the accident could be an indicator for a lacking safety culture. There do not seem to be good emergency plans in place or any assessments made of likely accident scenarios and how to react in such a situation.

9. **MV. Likoni**

Accident no.: 9

Date: 25/01/2013

Accident category: Barrier failure

Ship involved: MV Likoni

Length: 75

Breath: 16

Tonnage:

Build when: 2010

Build where:

Operator: KFS

When the ship was taken over by the operator: 2010

Accident date: 25/01/2013

Accident time:

Injuries: 11 persons died

Casualties: 1000

Total loss: No

Source of information about the accident: Newspaper (The daily Nation)

Summary of the accident: While loading the vessel in Likoni Mombasa, a trailer descending the ramp failed its breaks, lost control and caught passengers and cyclists who were already onboard unaware and killed 11 of them and injured 20 others. Vehicles are loaded in to the ferry first before cyclists and passengers come on board. In this case, the loaded trailer was descending the ramp while passengers and cyclists were on board.

The information is not sufficient to code the unsafe act leading to the trailer moving into the passenger area.

Pre-conditions

Environmental Factors - Technological environment (PE 200)

Failed breaks

Technological environment (PE 200)

In appropriate design of the ramp and the terminal to prevent such accidents

Unsafe Supervision

Supervisory violations – Shipborne violations (SV 000)

The system was that normally the trailer should be moved on board first and thereafter passengers and cyclists should be allowed to get on board.

It is unclear from the report if the operator or the authorities can be blamed further for allowing a risky operation. It would require more information to allow for such coding.

10. MV Nyayo

Accident no.: 10

Date: 17/09/2016

Accident category: Engine failure

Ship involved: MV Nyayo

Length: 75m

Breath: 16m

Tonnage:

Build when:

Build where:

Operator: KFS

When the ship was taken over by the operator:

Accident date: 17/09/2016

Accident time: 0615hrs

Injuries: none

Casualties: 1000

Total loss: No

Source of information about the accident: Newspaper (The daily Nation), KMA

Summary of the accident: According to the report MV Nyayo was presumed not to be in a good condition by management when the ferry operator allowed it to continue offering services due to a breakdown of two other ferries. During that early morning, the sea was rough with current swells and heavy rains. The ferry developed mechanical problems with over 1000 persons on board and was swept away by the heavy tides and currents to deep sea. Tug boats from KPA secured the vessel and towed the vessel after several reinforcements. The operator KFS' management warned the passengers about the rough weather after the incident.

Unsafe act

Errors - Decision and judgement error (AE 200)

To allow for the operation of an unsuitable ferry in severe weather conditions.

Pre-conditions

Environmental factors - Technological environment (PE 200)

Unsuitable ferry

Physical environment (PE 100)

Severe weather and sea conditions

Unsafe Supervision

Inadequate supervision - Shipborne and shore supervision (SI 000)

The ship was not in good condition and this was known

Organizational

Organizational process – Oversight (OP 200)

Two ferries were already out of order

Organizational climate – Culture (OC 200)

Lacking safety culture when allowing an unseaworthy ship to fill in for other ferries

Statutory - Port and Flag State (FS 100)

No measures in place to prevent such ferry from operating

11. MV Harambee

Accident no.: 11

Date: 24/11/2015

Accident category: Mechanical failure

Ship involved: MV Harambee

Length: 75

Breath: 16

Tonnage:

Build when:

Build where:

Operator: KFS

When the ship was taken over by the operator:

Accident date: 24/11/2015

Accident time:

Injuries:

Casualties: 1000

Total loss: No

Source of information about the accident: Newspaper (The daily Nation), KMA

Summary of the accident: The ferry developed a mechanical problem and overshot a ramp while trying to land on the mainland in South Coast, Likoni. According to the report the ferry was operating despite being faulty. The report further indicated the ferry had stuck on the rump on Mombasa Island 10 days earlier. And a week before, the management of KFS had said that the ferry needed urgent replacement of two engines but financial constraints had made them to continue using the vessel.

Unsafe act

Errors - Decision and judgement error (AE 200)

To allow for the operation of an unsuitable (damaged) ferry

Pre-conditions

Environmental Factors - Technological environment (PE 200)

The ferry was defective and had known problems with engines etc.

Supervision

Inadequate supervision - Shipborne and shore based (SI 000)

The ship was not in good condition and this was known

Organizational influences

Organizational climate – Culture (OC 200)

Lacking safety culture when allowing an unseaworthy ship to operate for economic reasons

Resource management - Technological resources (OR 100)

No repairs of a defective ship

Statutory - Port and Flag State (FS 100)

No measures in place to prevent such ferry from operating

Appendix III

Ferry incident & accident pictures in Kenya

Figure: Passengers on a ferry in Likoni Mombasa
Source: Business daily(2015

Fig: A passenger vessel capsizes after colliding with a cargo boat. ***Source: world bulletin (2012)***

Fig: Uncontrolled number of passengers boarding ferry
Source: Baraka (2016)

Fig: A vehicle loses control and rams into a ferry
Source: The EAS (2013)

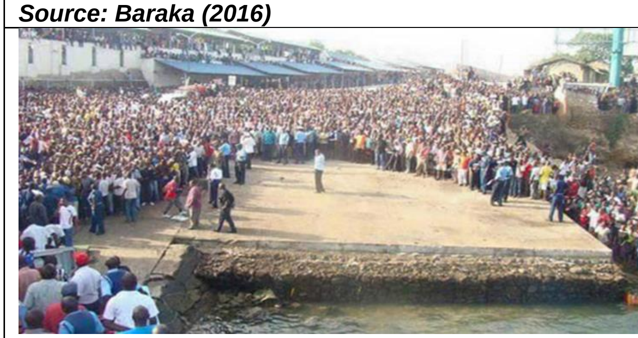

Fig: Passengers cause stampede after two ferries stall.
Source: Capital (2015)

Fig: A ferry is swept away by strong tides in Likoni channel. ***Source: Daily nation (2017)***

Fig: Marine police recover a body after capsize of MV Safina.
Source: The telegraph (2012)

Fig: Passengers disembark MV Kwale from make-shift landing after grounding.
Source: The star (2015)

Fig: Overcrowded passengers on board MV Harambee.
Source: The daily nation (2010)

Fig: Passengers in a crowded ferry in 2015
Source: Baraka (2015)

Fig: A track loading into the ferry tumbled and killed 11 people.
Source: The daily Nation (2013)