Safety Audit for Inland Waterways Terminal

A DISSERTATION

Submitted in partial fulfilment of the
requirements for the award of the degree

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by

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CANDIDATE'S DECLARATION

I, Nitin Kumar, Scholar No.17554006 hereby declare that the dissertation titled "Safety Audit for Inland Waterways Terminal", submitted by me in partial fulfillment for the award of Masters in Infrastructure Systems, at Indian Institute of Technology Roorkee, India, is a record of bonafide work carried out by me. The matter/result embodied in this thesis has not been submitted to any other University or Institute for the award of any degree or diploma.

Date:
Place: Roorkee Nitin Kumar

CERTIFICATE

This is to certify that the declaration of Nitin Kumar (17554006) is true to the best of my knowledge and that the student has worked under my guidance for preparing this thesis.

RECOMMENDED

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Prof. Rajat Agrawal

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ABSTRACT

The dissertation is focused to identify the potential and existing safety threats associated with the inland waterways terminals. The research is inspired by increasing numbers of accidents at the inland waterways terminals, for example in August 2015 there were many explosions occurred at Tianjin port in China, these explosions killed more than 160 people and hundreds of people were injured. So to avoid such accidents in the future we tried to develop a safety audit methodology which includes various parameters, these parameters should be inspected and audited at regular intervals to avoid any potential threats to the workers or passengers at the terminal. The method used is standard safety audit method, which includes three stages as pre-audit, audit and post-audit. Main aspects covered in the audit are general safety measures which includes emergency preparedness of the management system, fire safety which include firefighting systems and fire detection, electrical safety which includes fire hazards due to electrical equipment and training given to the workers those who are using that equipment. Indian inland waterways are in the developing stage so this study can be helpful to identify and rectify the potential hazards as soon as possible. For our study we have chosen the inland waterway multi-modal terminal of Varanasi. Findings of the study is mentioned in the result and finding section of the dissertation.

Keywords: Inland Waterways, Safety, Safety Audit, Inland Waterways Terminal

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Chapter 1: Introduction

1.1 General

India is a large country, having navigable waterways of about 14500 Km. Annual cargo movement through the inland waterways is approximately 55 million metric tons. This inland waterways transportation is administered by the inland waterways authority of India (IWAI).

Figure 1: Important waterways in India

The purpose of providing this information here is to set the background for our study which is safety for inland waterways with the help of safety audit tool. Indian waterways system is in its developing stage, it is a huge potential for Indian economic growth if utilized carefully and optimally. For optimization of the waterways system we can classify it as operational optimization and maintenance optimization. Our topic of research which is safety of inland waterways terminal comes mainly under the maintenance optimization. We have classified the waterways system into three sub parts as

a) Inland Terminals
b) Waterways
c) Cargo/Passenger Ships

For our study we will focus mainly on the inland waterways terminal, specifically we have chosen inland waterways multi-modal terminal of Varanasi as it is the first of its kind in the country, successfully conducting the safety audit for Varanasi terminal can help us to frame standard guidelines for other similar inland waterways terminals. Varanasi terminal is a part of Prayagraj to Haldia National Water way 1, which is 1620 Km long, longest waterway of India. Current capacity of Varanasi terminal is 0.54 million metric tons per annum which is projected to become 1.22 million metric tons per annum in 2030.

Figure 2: Location of Varanasi terminal

1.1a Safety related factor

Reason behind choosing the topic of safety of inland waterways terminal is basically accident occurred on 12th of August 2015 at Tianjin port of China. At the port's storage station there were multiple explosions, which leads to more than 160 death and more than 700 non-fatal injuries, cause of explosions was identified as overheating of nitrocellulose (dry) container kept inside the storage station. Basically we can say that some explosive chemicals were stored in the warehouse, like ammonium nitrate, nitrate of potassium etc. So, it is a case of not storing hazardous goods safely, which we can relate with our study as well, the above example is basically storage or warehouse related safety, but we have to consider the safety of entire terminal, i.e. we have to take wider perspective for our study and have to consider multiple factors. The list of factors or parameters considered and their description is given in the method section of the study.

1.1b Economic factor

Another reason for choosing inland waterways system is the economic aspect of the medium of transportation. Transporting goods using inland waterway is cheaper as compared with the roadways or railways, one drawback of using inland waterway is that the medium of transportation is slow and not suitable for long distance transportation of perishable goods like fruits and vegetables. But using cold chain logistics i.e. cold containers we can still transport perishable goods also. As we are focusing our study to India, coal is India's largest bulk commodity, India's annual coal consumption is approximately 1.1 billion metric tons in 2017, and if we compare the transportation economics or logistics cost of transporting coal using different mediums we get minimum cost using inland waterways, using roadways we can move 0.15 tons of coal per horsepower while using railways we can move 0.5 tons of coal per horsepower and using inland waterways we can actually transfer 4 tons of coal per horsepower. If we compare the data in terms of tons moved per liter of fuel then also inland waterway is the most economical as compared to roadways which gives 24 tons on average for one liter of fuel while using railways we can transfer 90 tons of coal per liter of fuel as compared to 110 tons using inland waterways. And if we compare India's logistics cost with developed countries like France, Japan, and Canada even if we compare it with China, India's logistics cost is higher. In most of the developing countries logistics cost is around 6 to 8 percent of the total cost of goods, while in India the logistics cost is about 14 percent of the total value of good and most of the

Indian goods are transported using roadways and railways. Let's first have a graphical look on the economic aspect of IWT in India.

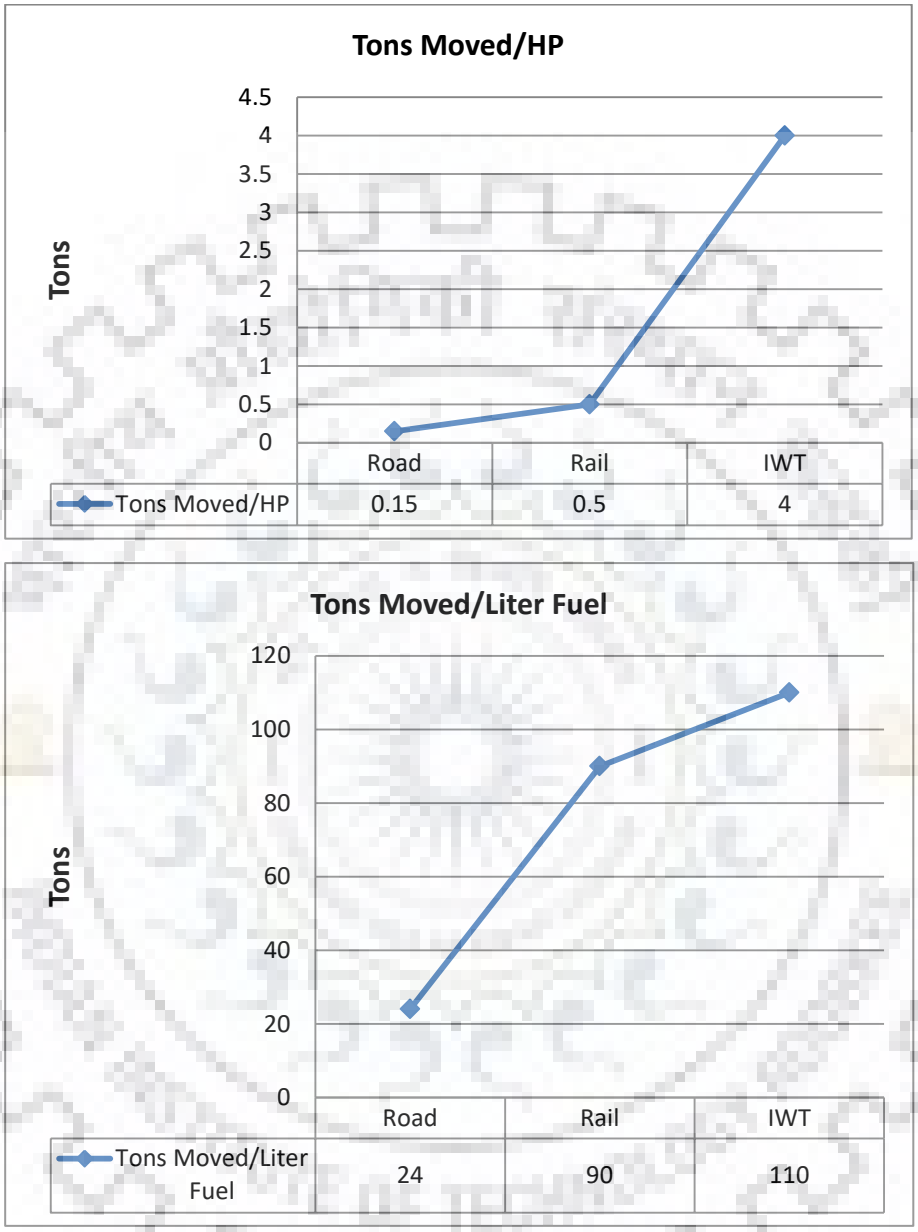


Figure 3: Comparison of IWT with Roadways and Railways

So shifting from road or rail based transportation to inland waterway transportation is economical. One more interesting fact is that 40 percent of India's population lives along existing six waterways. If we consider transporting cost per metric ton kilometer (MT-Km) and compare it with different modes of transportation, we get lowest cost for inland waterway transportation. Minimum saving obtained using IWT compared to other modes of transportation is Rs 0.931 this data can be clearly understood using the tabulated form of representation, table

for the comparison of different modes and cost per metric ton kilometer is given below:

Table 1: Comparative average freight costs for transporting coal in India

Mode	**Cost/MT-Km**
Roadways	₹1.939
Railways	₹1.547
Inland Waterways	₹0.616
Minimum Saving(Railways-IWT)	*₹0.931*

Source: Investment U

Some more important reasons for shifting to inland waterways transportation are; on NW-1 there are 10 thermal power plants(TPS), and 11 more TPS are expected, so coal transportation has large potential, fly ash movement by IWT has been increased, so cement industry has potential, Food Corporation of India (FCI) proposed to transport 30,000 Tons per month from Kolkata to Agartala via Ashuganj, there are 7 fertilizer plants near NW-1 with possibility of transportation of 7.65 lakh Tons per year by IWT.

1.2 Aim

The aim of the study is to identify existing or potential threats to safety at Varanasi inland waterway terminal and recommend suitable measures to counter those threats.

1.3 Objective

- To develop standard safety audit procedure for inland waterway terminal.
- To identify parameters influencing the safety of inland waterway terminal.
- To conduct safety audit for Varanasi inland waterway terminal.

1.4 Scope and Limitations

As only one terminal is audited so the results cannot be generalized for all terminals and the Varanasi terminal is not working at its full capacity which also limits the scope of the study. In general safety for ports is studied in most of the literature and literature for safety of inland waterway terminal is very limited.

Chapter 2: Literature Review

For preparing a good research report first of all we have to understand that how much research is already been done on the corresponding field, and what scope is possible for further research. This is done by reviewing the existing literature available in the corresponding field of research. Mostly I relied on the literature available online, for example google scholar website and websites of Inland waterways authority of India, and various other authentic websites. From google scholar I reviewed more than twenty five research papers related to my topic. Some of those research papers and other related literature are mentioned in this chapter, this literature will help us understand the safety related issues and work done to counter those issues, and further the study will guide us in designing our own study plan and conducting smooth research work. As our topic of interest is safety audit for inland waterways terminal, so I focused on the literature which revolve around this topic, I have noticed that most of the literature available is either of the port related studies or designing related studies and less literature is available on inland waterway terminal, but whatever literature is available I tried my best to extract best possible data related to my study. The method used here for literature review is first the name of the author is provided and the key feature of the study is discussed and the title of the research paper is provided in the reference section.

2.1 Research paper review

D. Roelevena (1995): In 1989 government of Netherlands started a project named "Safety in Inland Waterway Transport" to increase safety levels in the waterway transport and to develop a model which can assess the safety of inland waterway transport, this model is known as "Risk Effect Model," with the help of this model author tries to forecast the probability of accidents. The input of model are attributes of waterway such as radius of curvature, depth, width etc. and weather circumstances such as wind speed, visibility etc. Here Generalized Linear Model(GLM) is used which gives the flexibility of not assuming probability of accident to be normally distributed and binomial approach can be used. After analyzing the data collected in the study one important result obtained is that, weather condition and waterway characteristics are not correlated. For example, poor visibility factor affects the probability of accident in wide waterway same as that in narrow waterway.

Z I Awal (2006): This study is Bangladesh based study and author analyzed total 197 water transport related accidents occurred between 1995 to 2005. Awal classified the factors leading to the accident into four categories, these categories are:

1) Factors related to design of vessel
2) Environmental condition
3) Human factors
4) Administrative or Enforcement related factors

After analyzing all accidents, author concludes that most common type of causes of accidents are inclement weather, overloading and collisions of vessels. Frequency of accidents is highest during monsoon season, i.e. between months of March to July and month of October. One important observation made is that most of the cyclone related accidents occurred during evening hours and before midnight. To avoid such accidents author suggests to make accurate weather forecast and to avoid accidents related to overloading there should be proper mechanism to provide certificates for corresponding loading conditions of the ship and there should be strict regulations regarding inspection of passenger or cargo ships with strict regulation there should be proper implementation also, if required policies can be revised.

M. Fastenbauer et al. (2007): This research basically deals with the River Information Services (RIS) of the European countries. As inland transportation is considered environment friendly mode of transportation, special emphasis is given to develop a reliable river information service with the help of information and communication technology. Basic river information services include information of traffic in respective route, management of traffic and supporting the enforcement of law with the help of instantaneous information exchange. Europe has more than 30000 km of navigable waterways including rivers and canals. The main rivers that contribute the most in inland waterways transportation in Europe are “Rhine and the Danube rivers” remaining canals are mostly tributaries of the above mentioned rivers. These rivers and canals connect almost all countries in the Europe, e.g. France, Germany, Netherlands etc. River information services are basically inland navigation services, provided with the help of electronic devices and internet, as personal computers and mobiles have become standard equipment. The study focuses on interconnecting the installed databases, interconnecting the database of ships or other commercial users with central database and database of ports. With the help of RIS the traffic in waterways can be harmonized

and managed systematically which further leads to safer transportation of goods and avoid any congestion in the waterways reducing delays and confusions which leads to competitive supply chain and reduced economic losses. If we try to understand the architecture of RIS, it is simply based on the principle of electronic recording of all relevant entities in the system like all moving or stationary ships, location of corresponding ports, Size and location of the ship is automatically passed to corresponding controlling station even the data regarding type of material stored in the ship is recorded e.g. dangerous goods. Satellites and radio devices are also used for better positioning and communication. RIS architecture is given in the figure below:

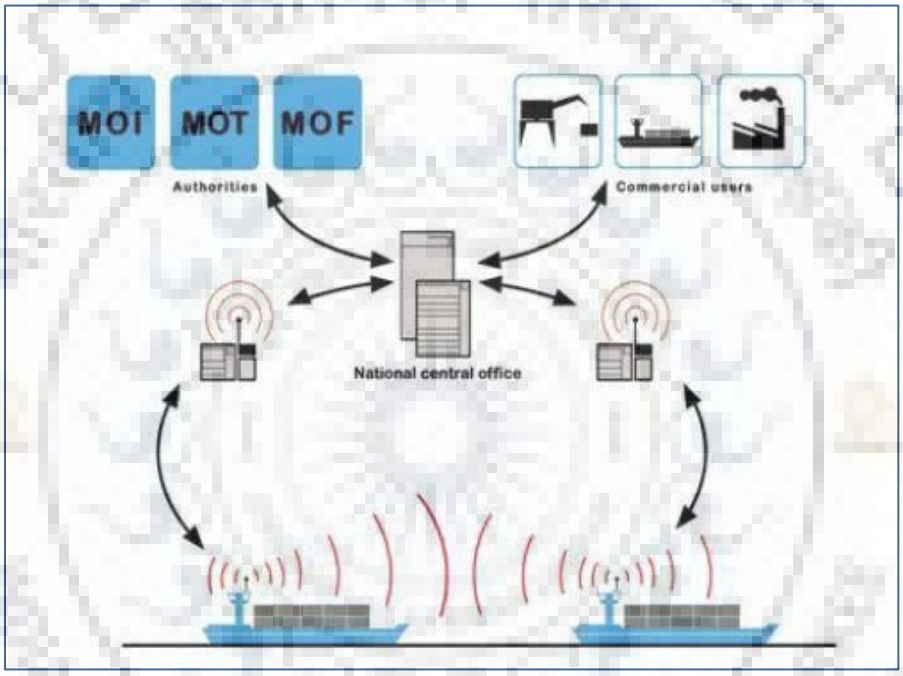


Figure 4: River Information Services (RIS) architecture

Here MOI represents the Ministry of Interior which is an authority for immigration control; MOT represents the Ministry of Transport while MOF represents the Ministry of Finance. So RIS interconnects all such ministries or public authorities as well as private companies which is essential for harmonizing the traffic in inland waterways and managing the transportation related activities. There are specific benefits of using RIS for terminals and ports and theses are:

1) Handling and storage operations can be improved
2) Operating time and operating cost can be reduced
3) Resource management or Terminal planning can be improved
4) Safety related accidents can be reduced

J.M. Bloemhof et al. (2011): As inland navigation is often considered as the green supply chain, here the author is trying to find the competitiveness of the inland navigation with comparison to other mode of transportation like railways and roadways. And by analyzing the competitiveness author tries to make inland navigation as a sustainable navigation, with the help of case study. Author also tries to find the barriers and opportunities for attaining sustainable inland navigation. Different dimensions of sustainability are explored for example, environmental sustainability, economic sustainability, social sustainability, and transportation system sustainability. In conclusion author suggests that inland navigation has competitive advantages over other modes of transportation not because of the sector's innovativeness but because of inherent capabilities like large quantity transfer of goods and low emission of harmful gases making it more environmental friendly. Author suggests that if no innovative action is taken in the inland navigation field like using small size barge etc. then competitiveness gap between road transport and inland transport will become small. It should be noted that innovation should be profitable also.

Di Zhang et al. (2013): In this study, assessment of "congestion risk" in inland waterways is done, Yangtze river of China is choose for case study. As the statistics shows that during the period of 2008 to 2010, total number of accidents was 896 with fatalities of 116 along the Yangtze River. Economic loss was estimated to be 82.21 million (RMB) as 85 ships sunk in the Yangtze River during the period mentioned above. In the study Congestion Risk Index (CRI) was developed by considering the consequences and probability of congestion risk. This CRI is further used to find out the impact of different Safety Critical Factors (SCF), Bayesian network (BN) was used to develop the model. Three most critical safety factors that are obtained in the study that cause maximum congestion risk are grounding, harsh weather condition and confined channel condition.

A. Lisaj and P. Majzner (2014): The author explains the various modes of communication used in the River Information Services (RIS) and also explains about the architecture of information sharing and tries to find the feasibility for implementation of Global Maritime Distress and Safety System (GMDSS) into RIS. Author explains that in European countries Extended Mark-up Language (XML) is used as navigation language for sending and receiving messages. A typical XML contains information related to identification of vessels; information related to traffic condition, information regarding water conditions i.e. water level, least depth, vertical clearance

etc. and ice related information. Very High Frequency(VHF) electromagnetic waves generally ranging between 30 to 300 megahertz with wavelength of about one to 10 meter are used form this communication purpose. Continuous data sharing mechanism helps the skipper to take better decisions and hence increasing the safety of navigation in fairways.

An Caris et al. (2014): As inland waterways are becoming more important day by day, so in this research paper author is trying to find different research efforts, which can be used to integrate inland waterway navigation with other mode of transportation. Author is planning to develop a research approach which deals with the integrated intermodal supply chain. This topic can be related to our research as well because Varanasi inland waterway terminal is also a multimodal terminal. Factors or challenges considered in the study are

1) Effect of climate change on IWT
2) Integration of IWT with urban area
3) Latest technology in the engine development
4) Life cycle assessment of alternative modes

Gemma Dolores Molero et al. (2016): In this study, the objective of the author is to design safer inland terminal with the help of tool known as analytic hierarchy process (AHP), with the help of this tool authors tried to find out the criteria for safer and cost efficient inland terminal design. Special attention is given to the ports where the damage due to accident is more to the society, i.e. where people living in large numbers. Authors tried to identify the dangerous goods with the help of IMDG Code, dangerous goods which can lead to explosions or any other disaster in the vicinity of port or terminal, authors tried to indicate that majority of accidents occur in the storage facility of ports, example of USA is given that 13% of the fire accidents occurred in the storage facilities, so more emphasis is given to make storage facility fault proof. In this study first the criteria that contribute to the safer inland terminal are found and then these criteria are prioritized with the help of multi-criteria decision theory. To prioritize the criteria a panel of experts was constituted, this panel prioritized the criteria with consensus. Delphi method was also used during meetings with experts for knowledge sharing purpose. This study classify the criteria in three level, in first level it identifies five main criteria and these are, environment care, equipment, safety, information and communication technology and business intelligence. These

five criteria are further divided into 21 sub criteria in second level and in third level the criteria number increases to 88 for better results, some important second level criteria are infrastructure, economic, quality, adaptability, usability and management. Result of the study shows that the most important criteria to be considered while designing the inland terminal are:

1) Distance between the terminal and population center of corresponding location, as if any accident occurs or explosion occurs then there should be minimum damage to the society.

2) Land cost of terminal, as for any project to be profitable the economic aspect plays huge role,

3) Industrial Floor area availability.

4) Destruction level of goods stored in the terminal, in handling dangerous goods possibility of vandalism or terrorist attack should be considered.

5) Software used in the implementation of business intelligence (BI) and information communication technology (ICT), in case of BI and ICT, BI software are considered more important by the experts than the ICT software implementation.

6) License cost of ICT software.

7) Functionality of software, like interactive control panel, simulations, data processing and message alerts etc.

8) Maintenance cost of BI and ICT software

In this research paper, various factors are consider for safer design of the terminal some of the factors are not related in our context of study such as license of software, software used for business intelligence. If we consider our topic and then relate it with the above study we are able to find seven factors which are directly related to the safety and security of the port or terminal, these seven factors are listed below according to their importance, most important factor is kept on the first place and so on:

1) Distance between the inland waterway terminal and the nearest population center.
2) Level of damage that the stored material can cause.
3) Time taken or time required to evacuate the terminal.
4) Amount of dangerous goods stored in the terminal.
5) What is the population density of the nearest city or village.
6) What is the reliability of equipment used in the terminal.
7) Climatic factor.

Myo Min Thant (2018): This study has objective to make maritime transport safer by analyzing and improving the policies related to maritime transport sector especially in the Myanmar. Which include legal policies, operational policies, administrative policies and comparative analysis of policies in developed nations like EU and USA. There are about 50,000 ships which are used for the international transportation of goods, known as merchant ships. Movement of such ships should be safe from departure port to the destination port because if any unusual accident occurs it can be deadly one. The study suggests that about 5.4 million twenty foot equivalent units(TEUs) contain dangerous goods which can cause damage to the people or environment if not handled carefully moreover only 4 per 100,000 units are inspected which means safety is at risk. Fire, grounding and inappropriate handling of cargo (shore-side) these three are the main cause of damage to the cargos. For example container cargo named "Maersk Honam" caught fire during its travel in Middle East region similar accident occurred with German ship containing various dangerous goods, name of the ship was "MSC FLAMINIA" it caught fire and there was loss of life and economic loss also. If we consider the storage facility of Myanmar in the recent decade there were many destructive explosions occurred in the storage facility of Myanmar ports resulting in huge economic losses and several causalities. Data obtained by the insurance companies indicates that the claim for insurance is done most commonly for fire related accidents if we talk in percentages then fire related insurance claims amounts for about 28 percent, while grounding claims cost approximately 21 percent and third most common claim is due to inappropriate handling of cargo which amount for about 8 percent cost provided by the insurance companies. So this study tries to find the gaps in the benchmark practices that are followed by developed countries as compared to Myanmar. Firstly the data related to the import and export of dangerous goods has to be obtained, and then the regulations recommended for safe handling of such goods should be critically examined and then find out where is the problem, is the problem is in the policy making or in the policy implementation, this data collection is done using various standard methods. Data collection for the study was done by face-to-face interview and survey questionnaire which is primary data, while secondary data was collected with the help of regulatory agencies. In this study dangerous goods word is used many times so to understand dangerous goods the author provides the table which contains the nine classes of dangerous goods according to the United States classification with examples as given below:

Table 2: Classification of dangerous goods

Class	Description	Example
1	Explosives	Pyrotechnic material, munitions
2	Gases	Propane, dioxygen
3	Flammable liquids	Fuel, ethanol
4.1	Flammable solids	Matches, celluloid
4.2	Self-flammable solids	White phosphor
4.3	Water reactive solids	Calcium carbide
5.1	Oxidizing substances	Fertilizer containing ammonium nitrate
5.2	Organic peroxides	Plastic adhesive
6.1	Toxic substances	Insecticide
6.2	Infectious substances	Hospital waste
7	Radioactive substances	Uranium metal
8	Corrosives	Oil, wax
9	Miscellaneous dangerous goods	

The report suggests that lack of the proper training of shore-based personnel and lack of inspection by responsible authority are two usually neglected factors that affect the safety of the port and cargo vessels. Another important factor responsible for the accidents related to the dangerous goods in poor packaging of the goods, according to the data provided by the cargo incident notification system (CINS), approximately 50 percent of the accidents are due to inappropriate or poor packaging of the dangerous goods, graphically we can show it as shown below:

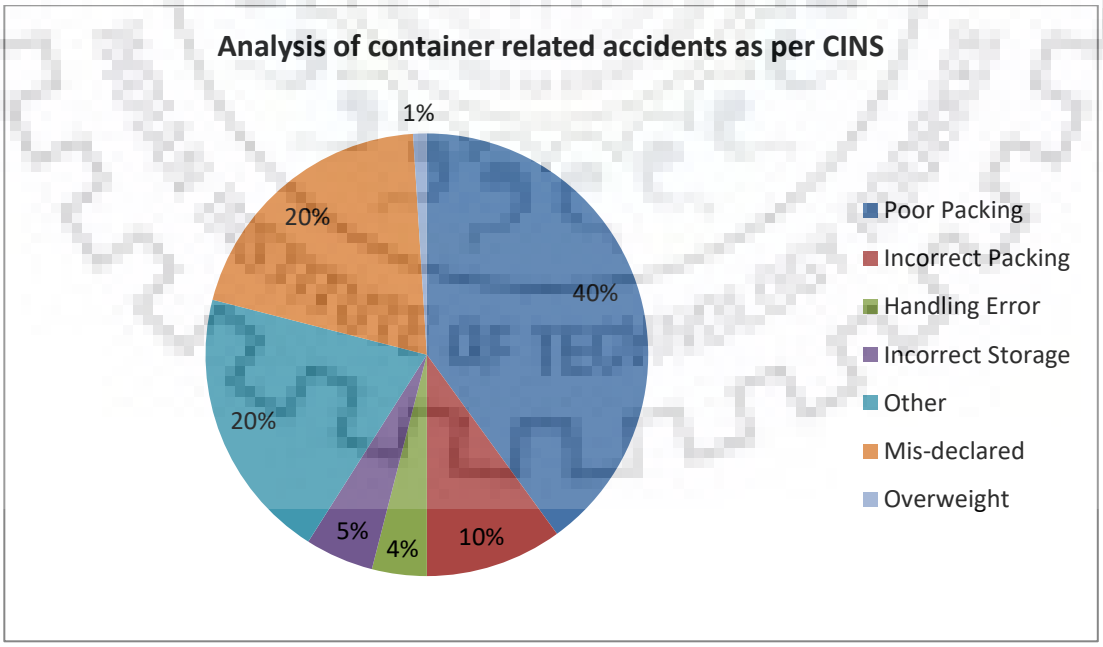


Figure 5: Analysis of container related accident as per CINS

EIA Report, Ministry of Shipping (GoI): This Environmental Impact Assessment report is prepared for Inland Waterways Authority of India (IWAI) by EQMS India Private Limited (Consulting Solution Company) under the project "Capacity Augmentation of National Waterway-1" also named as "Jal Marg Vikas Project". The map of National Waterway-1 is given below:

Figure 6: Location Map of NW-1

From this EIA report we will focus on the data in the context of our area of study which is safety and safety audit. As the report suggests that the level of PM_{10} and $PM_{2.5}$ level are higher than the specified standard level at Varanasi, so special preventive measures to be taken by the terminal authorities like using personal protective equipment e.g. nose mask. Specified limit of PM_{10} is 100 µg/m^3 and that of $PM_{2.5}$ is 60 µg/m^3. As the capacity of the terminal is expected to increase so the existing values of the particulate matter may increase, here is the table given below which gives the projected value of the cargo in million metric ton per annum:

Table 3: Traffic Forecast for Planned Navigational Infrastructural Facilities

Infrastructural Facility	Projected Cargo-2015 (MTPA)	Projected Cargo-2030 (MTPA)
Varanasi Terminal (with current land)	0.54	1.22

2.2 Overview of Indian Waterways

As mentioned earlier that India has 14500km of navigable waterways out of which only 4555km have been declared as National waterways. There are six operational waterways there information is provided below in the tabular form as well as graphical form:

Table 4: Operational waterways of India

Name	Declared In	Total Length(Km)
National Waterway 1	1986	1620
National Waterway 2	1988	891
National Waterway 3	1993	205
National Waterway 4	2008	1095
National Waterway 5	2008	623
National Waterway 16	2012	121

As per "The National Waterways Act, 2016," 105 more inland waterways are considered as national waterways so there are total 111 national waterways in India. Graphical representation of the important operational national waterways is given as follow.

National Waterway-1

Figure 7: Map of National Waterway-1

National Waterway-2

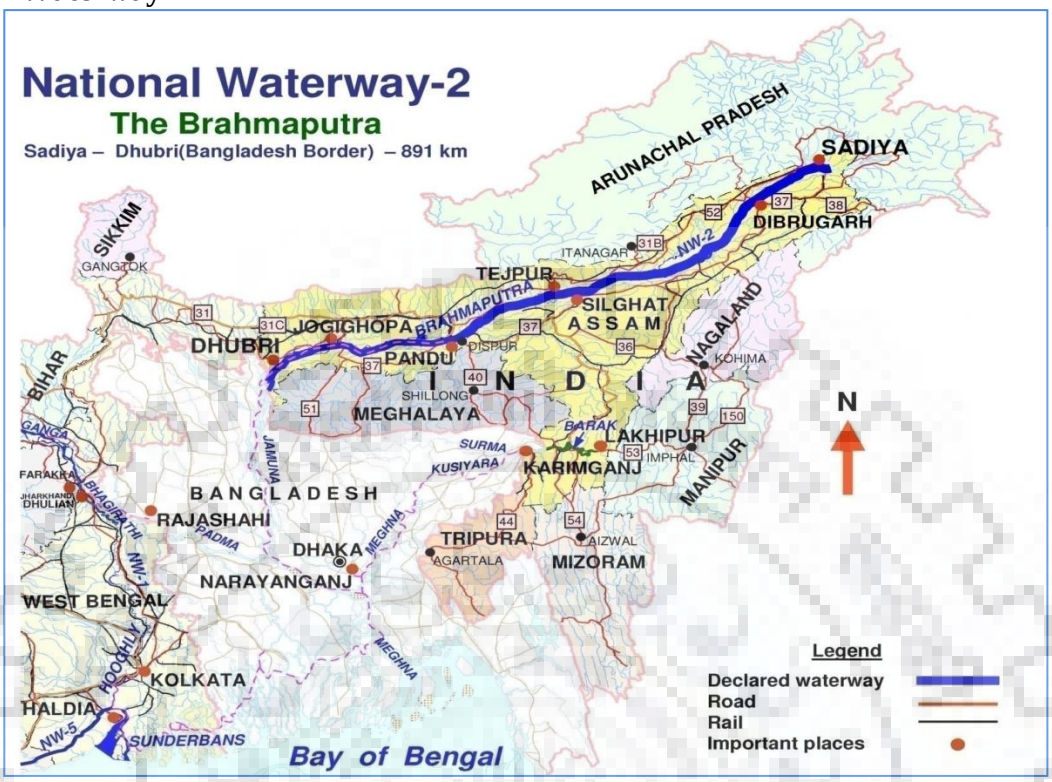


Figure 8: Map of National Waterway-2

National Waterway-3

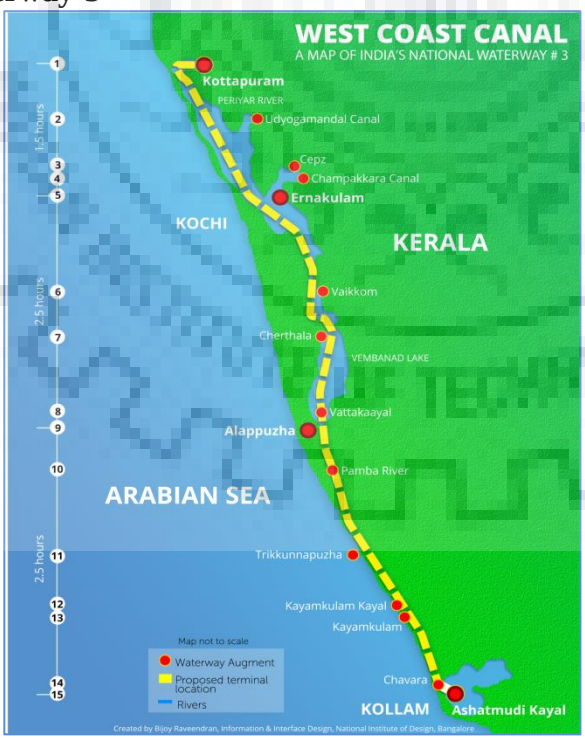


Figure 9: Map of National Waterway-3

West Cost Canal
(Kottapuram to Kollam)

River distance

Kottapuram – Kollam	168 km
Udyogamandal Canal	23 km
Champakkara Canal	14 km
Total Length	**205 km**

National Waterway-4

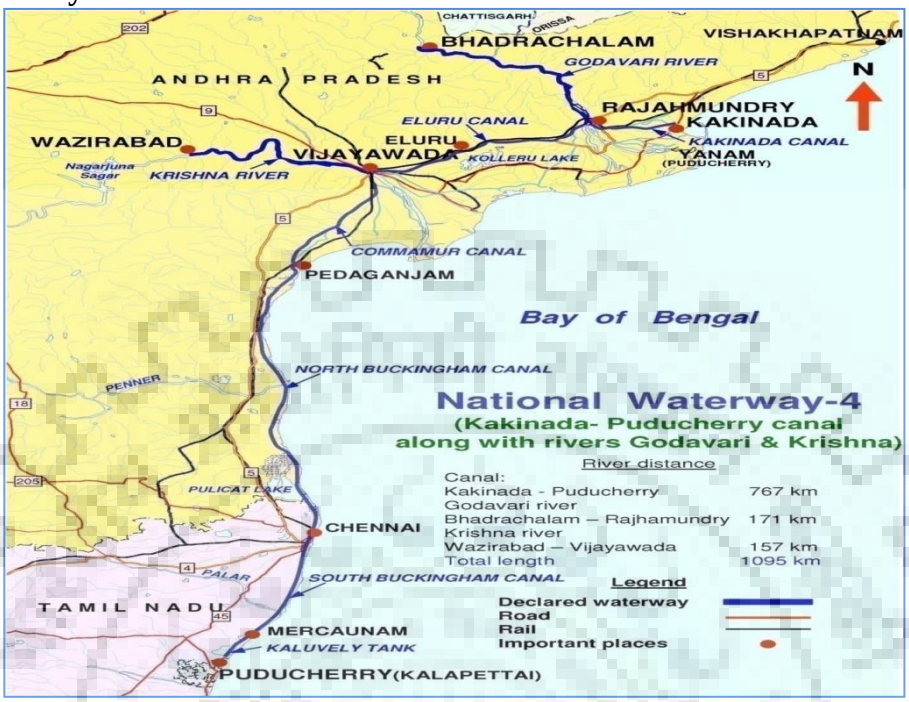


Figure 10: Map of National Waterway-4

National Waterway-5

Figure 11: Map of National Waterway-5

National Waterway-16
Barak River
Lakhipur(Assam) to Bhanga(Assam), 121 km

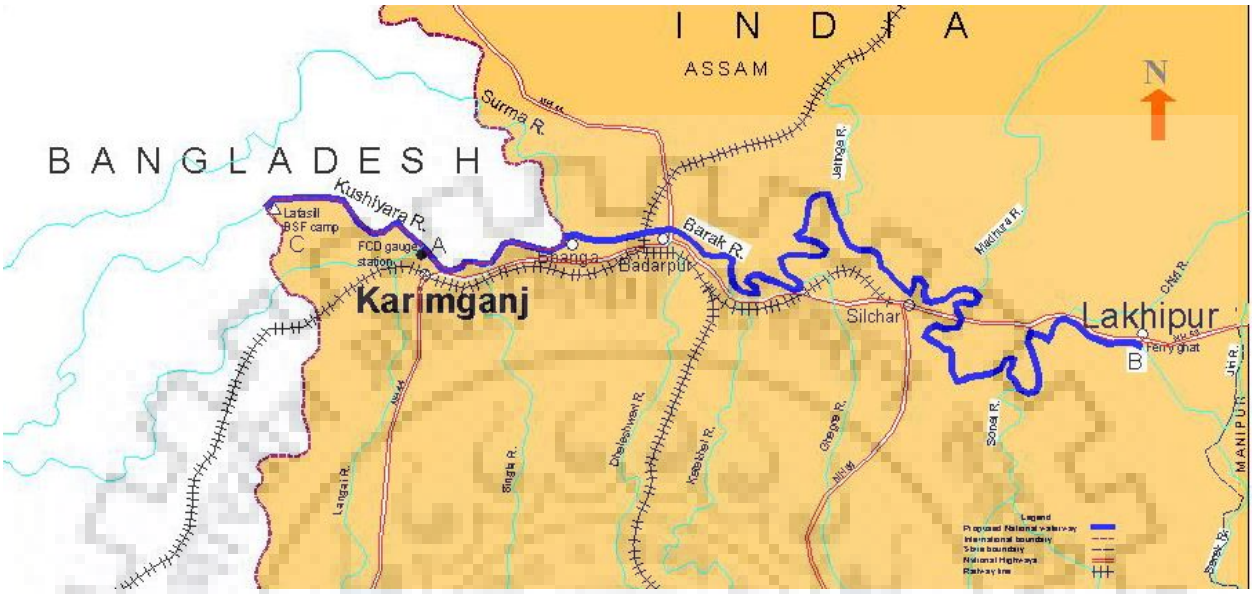


Figure 12: Map of National Waterway-16

Chapter 3: Methodology

As our research area is more descriptive in nature so more qualitative tools are used in the study. One such tool is safety audit tool, another tool is questionnaire. In the data analysis section of the study we used some quantitative measures also to find the level of safety of the terminal. So first we divided our study area(Varanasi inland waterway terminal) into three sub-parts, then for each of those study area we collected data with the help of questionnaire and observation, after that we analyzed the data for drawing conclusions and recommendations. Flow chart of the process discussed above can be represented as given below;

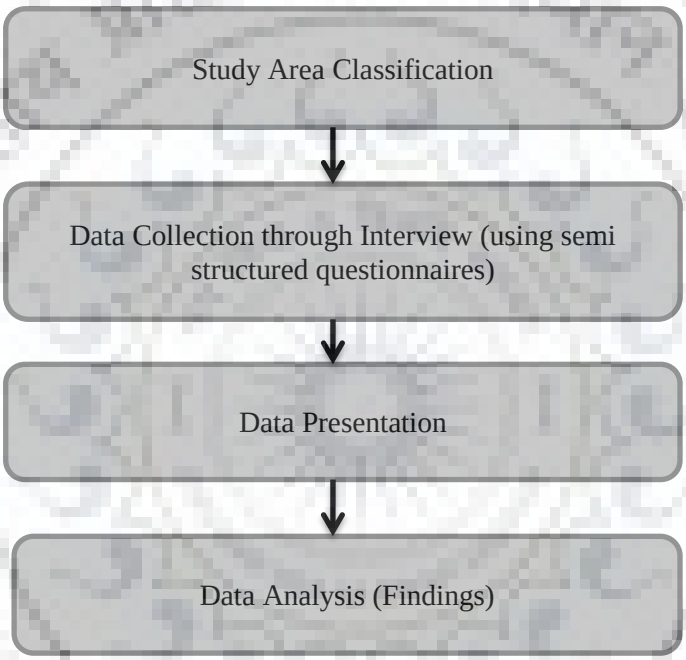


Figure 13: Methodology

Now we will discuss each steps of methodology mentioned above starting with the study area classification.

3.1 Study Area Classification

To conduct auditing process smoothly and efficiently we divided our study area which is inland waterway terminal of Varanasi into three different parts, as by dividing the bigger study area into smaller area will help us to focus on specific issues related with each study area, and detailed analysis is possible.

We divided our study/inspection area in three major classes they are:

1) Building Condition & Housekeeping
2) Electrical and
3) Fire & Emergency Evacuation

We divided our study in the above mentioned three areas because these three areas combined together results into entire terminal, and studying the terminal in small area group is easy. Graphically it is shown as below.

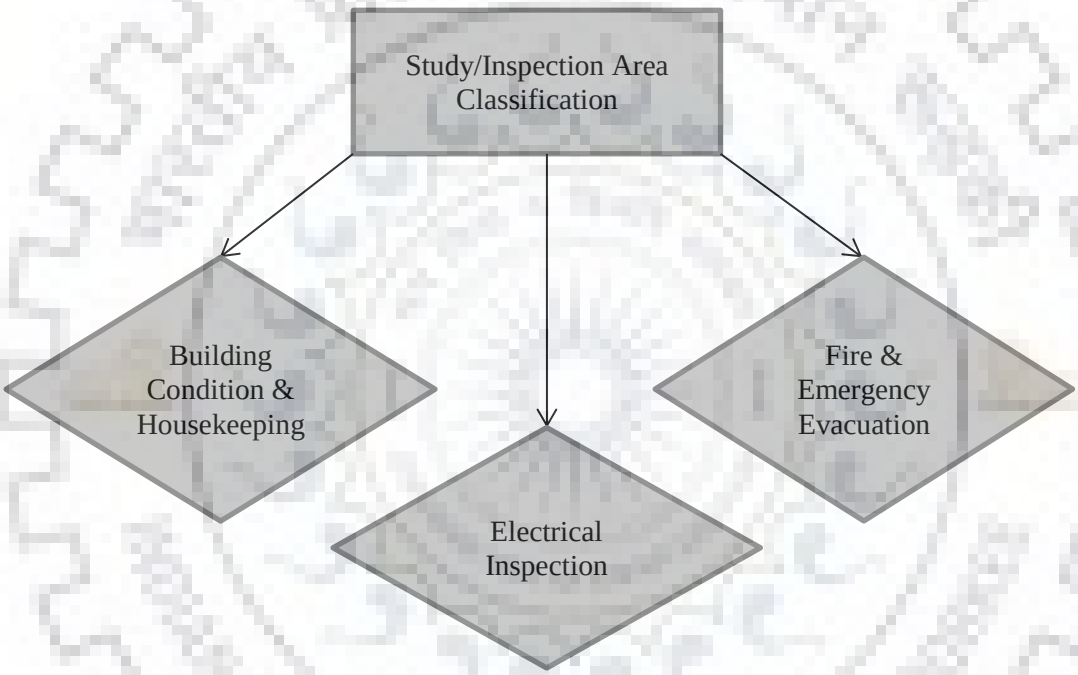


Figure 14: Inspection area classification

3.2 Data collection through interview

After classifying these three study area we tried to find the sub factors or sub classification of these three major areas. We used semi structured questionnaires tool to find out specific factors related to corresponding area of study, for example to find out factors that affect the safety related with electrical equipment we discussed it with the electrical engineers and electricians present on site. Similarly semi structured questionnaires are used for fire related hazards. As the construction work is still going on at the site we gathered information related to construction safety with the help of employees of Afcons infrastructure limited, as Afcons infrastructure limited has contract with IWAI

for constructing the Varanasi inland waterway terminal. After all this study area classification, data collection and understanding the safety audit process we find out various critical factors that governs the safety of inland waterway terminal. These safety parameters are used as base for developing our checklists so in the next chapter we will present in details the data obtained during field survey. Interview conducted for data collection is based on the profile of the employee, so in the table given below we arranged the profile of respondents.

Table 5: Profile of interview respondents

Profile of interviewee	Number of respondents
Operations Management	3
Construction Management	2
Engineer	2
Technician	2
Security Guard	4

According to the profile of the interviewee, corresponding semi structured questionnaires were developed and response of the interviewee is recorded. These responses are used to make our checklist.

3.3 Questionnaires

a) Questionnaire for management employee

S.No.	Questions
1	Do you keep up-to-date system to comply with the occupational health and safety act and its regulations?
2	Do you provide regular training to your employees about health and safety (Induction training, Management training)?
3	Are meetings held regularly regarding health and safety issues?
4	Are structured toolbox talks are regularly held?
5	Do you record accidents and near miss incidents systematically?
6	Do you have team specifically trained for first aid services and first aid facilities are sufficient in your premises?
7	Do you issue personal protective equipment to your employee on regular interval and wearing of PPEs has been enforced?

b) Questionnaire for engineers and technicians

S.No.	Questions
1	Are you aware of you building's emergency evacuation plan
2	Do you have up-to-date training regarding handling emergency situations at work
3	Do you know the location(s) of your building's fire extinguisher(s)
4	Do you know the potential safety hazards in your workplace
5	Are you aware of safety laws and regulations about your area of work
6	Do you reminded regularly to practice safe work habit by your managers
7	Do you feel safe at your workplace

Data presentation and data analysis is done in the next two chapters. To summarize the chapter on methodology we can say that the primary method used for the study is the safety audit tool, which include the three stages of auditing as

1) Pre audit phase
2) Auditing
3) Post audit phase

In pre audit phase we included the planning work like making questionnaires and classifying the study area while the actual auditing phase includes the inspection process according to our checklist and safety parameters mentioned in the upcoming chapters and post audit phase include analysis of the data or information gathered during auditing for making effective suggestions and recommendations.

3.4 Site selection

In this section we will try to explain the reason behind selecting the Varanasi inland waterway terminal for our study. As explained in the introduction chapter of the report, that inland waterway is the cheapest mode of transportation as compared to other modes, so one aspect is the economical aspect for selecting the site and another reason is that Varanasi terminal is the only multi-modal inland terminal in India. Being a multi-modal terminal its importance is increased, as in the future the terminal will be connected to railways so the capacity of the terminal will further increase and hence transportation related safety hazards may also increase, if sufficient preventive measures are not taken. As discussed in earlier chapters that the projected capacity of cargo

transportation from the Varanasi terminal is 1.22 million metric ton by 2030, so to have flawless operation at the terminal we need proper planning and management of all the operational aspects of the terminal including safety.

Source: livemint.com

Source: thehindubusinessline.com

Figure 15: Varanasi multimodal terminal in news

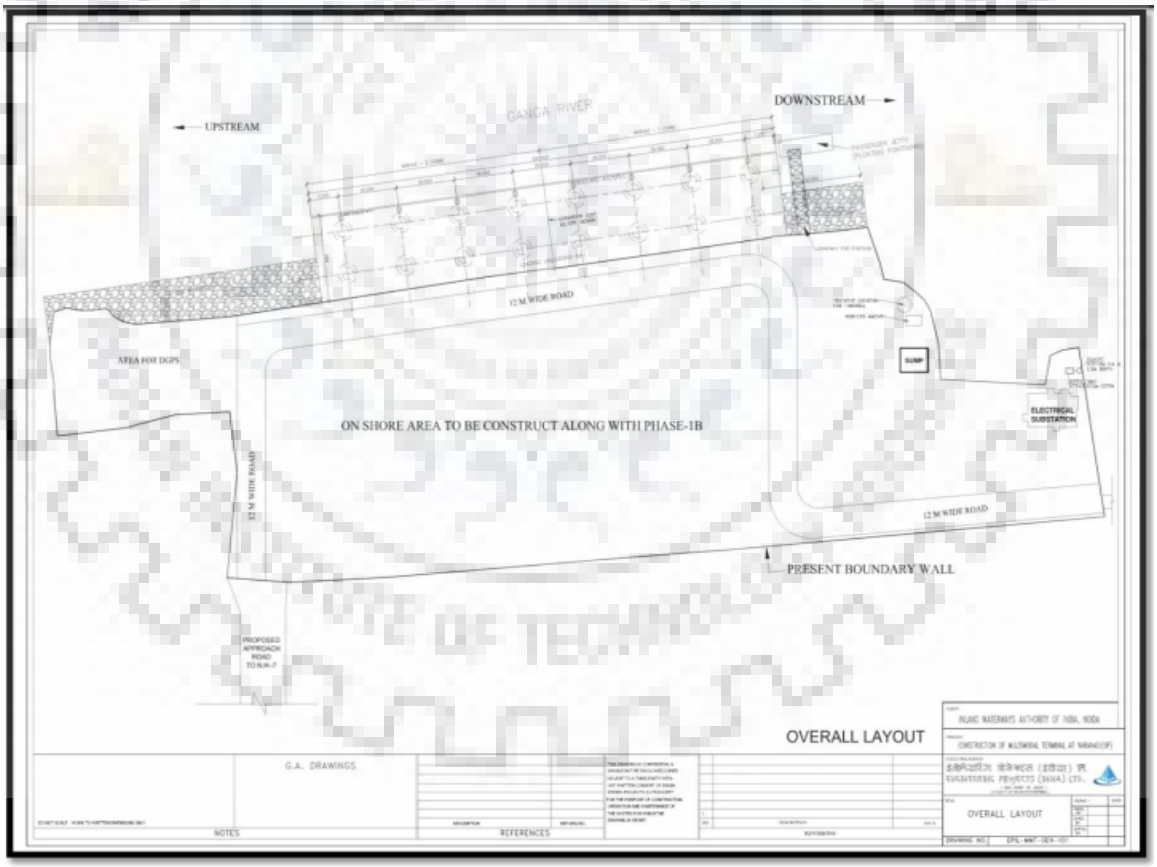
In the future Varanasi terminal will play very important role in connecting national capital region with the eastern states, as government of India is planning a dedicated freight corridor known as Eastern Dedicated Freight Corridor (EDFC) which is a railway corridor specially dedicated for freight movement from Ludhiana (Punjab) to Dankuni (West Bengal), so by developing Varanasi inland waterway terminal movement of goods from north India to eastern states can be complemented. It will function as a link to Nepal, Myanmar, Bangladesh, Thailand, and other south-east Asian countries through the Kolkata Port and Indo-Bangladesh Protocol Route.

Chapter 4: Data Presentation

During our visit to the inland waterway terminal, we observed and recorded some of the important site locations of the terminal that are related directly to our research topic for example location and layout of the terminal, floor condition of the berth used for loading and unloading the goods into the cargo ships, electrical connections and lighting etc. These different locations of the terminal are described in this section. Photos of the terminal are also presented in this section wherever it is required.

4.1 Site Layout

After visiting the inland waterway terminal of Varanasi, we collected primary data mostly in the form of images and secondary data was collected by interviewing engineer at the site as well as technicians present on the site. For better understanding of the site let us have a look of the drawing of the terminal, it shows the schematic diagram of the facility and layout of the site.



Source: HOWE ENGINEERING PROJECTS (INDIA) PVT. LTD. (DESIGN CONSULTANT)

Figure 16: Overall layout of Varanasi inland waterway terminal

4.2 Data of Field Survey

As mentioned in the sections above that the terminal is not operational in its full capacity as only phase-1 is completed till now(as of April 2019), so we are able to analyze only phase-1 of the terminal. Phase-1 of the terminal includes the berth or platform having dimensions as 40m wide and 200m long. Electrical equipment associated with it and a 12m wide road connecting the berth with other parts of the terminal. Terminal buildings like administrative building, electric room etc. is under construction. In the following section we will describe the data collected during visiting the terminal and observing different parts of the terminal.

1. Floor condition:-

Floor condition is found satisfactory; as there is no irregularity in the level, and there are no such obstructions which may lead to tripping hazard also the cleanliness is maintained. Some of the images taken during survey are shown below:

Figure 17: Floor conditions of Varanasi inland waterway terminal

2. Safety Equipment:-

Safety equipment available on site is not satisfactory, there is lack of fire extinguishers and proper plan is not prepared for the firefighting. A few fire extinguishers available are not under proper working conditions and cleanliness is also missing around the areas where those fire extinguishers are placed, we captured some images of such sites which are attached below. Also the first aid kits are not sufficient; there is large scope for improvement in this section.

Figure 18: Safety equipment at Varanasi inland waterway terminal

3. Electrical Cables

Safety related to electrical cables is found satisfactory, as desired cable trays are used only for the transmission of electrical cables and no other supplies like water supply etc. Electrical cables are double insulated types which increases the safety aspect, one issue found regarding electric cables is that the cable trays are not covered.

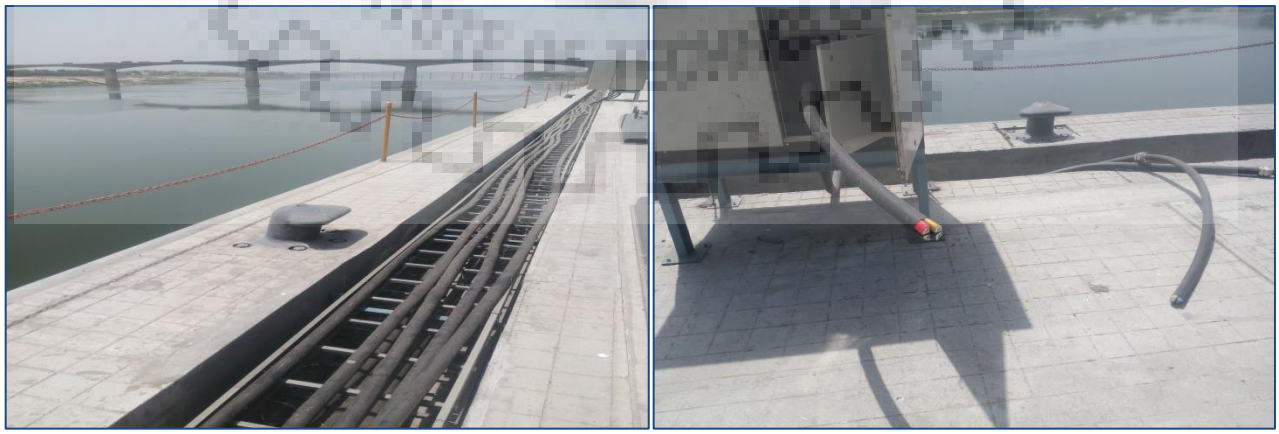


Figure 19: Electrical cables at Varanasi inland waterway terminal

4. Warning signs

As only berth work is completed under phase-1, so we inspected the berth site and found that the warning signs were missing on electrical panels and there should be warning signs placed near the ends of the platform.

Figure 20: Missing warning signs at Varanasi inland waterway terminal

5. Construction work

The administrative building, electrical control room are under construction so their audit is left, it can be done in the upcoming months. Currently the administrative work is done from the IWAI office located in Varanasi trade center near khajuri, Varanasi. This office is approximately fourteen kilometers away from the site, at site there is a temporary office of IWAI and one temporary office of Construction Company Afcons is working on site.

Figure 21: Ongoing construction work at Varanasi inland waterway terminal

Chapter 5: Data Analysis: Findings and Discussion

This chapter is the most important chapter of the study; in this chapter we analyze the data gathered from site qualitatively and quantitatively. As our second objective is to find out the critical safety parameters that affect the safety of inland waterway terminal the most, we discussed about those parameters in this chapter. Checklists are also considered as our in this chapter of findings, with the help of checklists and the data analysis we tried to develop a rating index which is a quantitative index representing the level of safety at the terminal. For developing a quantitative model we first give ratings to the every listed criteria of the checklist, then we found out the which criteria is compiled by the terminal and which criteria is avoided, on the base of this rating we developed individual ratings for our predefined three study areas, after that we multiplied these rating index with the weightage of the corresponding study area to give us a normalized overall rating index. Further on the bases of the value of rating index we classified the terminal site as safe or unsafe this rating index can also be used to analyze other terminals in the country, also in the end of this chapter we tried to develop a standard safety audit procedure, which is explained with the help of flow chart. So let's start describing these topics one-by-one.

5.1 Safety Parameters

After analyzing responses of questionnaire and observing the actual terminal conditions, we are able to identify essential safety parameters, by inspecting these parameters we can assess the safety conditions of the inland waterways terminal. These safety parameters are listed below:

1. Floor condition (level, cleanliness, surface, tripping free etc.)
2. Passageways/Aisle (cleanliness, tripping free, signage)
3. Warehouses/Storage (distance from nearest population center, cleanliness)
4. Safety equipment (PPEs, fire extinguisher, first-aid kit)
5. Lighting
6. Stairways/Ladders (handrails, cages)
7. Electrical cables (grounding, insulation, covers)
8. Warning signs/labels
9. Personnel training
10. Special provisions for person with disabilities

5.2 Checklist

On the basis of above mentioned safety parameters we developed our checklists. Checklist is the most important tool used for auditing purposes or inspections. Checklist is like a guide and tells us which area to inspect and what to inspect. A good inspection can be done if we have pre-defined good checklists. In our study we prepared three checklists covering the three areas mentioned in the above section, viz. Building condition & Housekeeping, Electrical and Fire & Emergency Evacuation.

- **Building condition & Housekeeping checklist**
  - ✓ Are platforms, floors level, smooth and free from loose boards, bumps, holes etc.?
  - ✓ Are storage rooms clean, passageways are clean?
  - ✓ Are permanent passageways and aisle marked and free from tripping hazards?
  - ✓ Is illumination or lighting satisfactory wherever it is required, are protective guards provided around the lights?
  - ✓ Are shelves of storage room confined as heavy objects on lower shelves?
  - ✓ Is there working safety shower and eyewash provided where it is required?
  - ✓ Are bumpers provided where loading and unloading is done to avoid transport related accidents like truck accidents?
  - ✓ Ground inspection for breaks, holes, cracks, falling hazards(including parking area)
  - ✓ Handrails provided for stairs having more than four steps or not?
  - ✓ Cages provided for ladders having length more than 20 feet or not?
- **Electrical Checklist**
  - ✓ Power cables are grounded using grounding conductors or not?
  - ✓ Labels or symbols are used according to BIS or not?
  - ✓ Use of defective wires, fuses and other electrical switches are avoided or not?
  - ✓ Metal ladders are avoided in the areas where there are chances of getting electric shock to the person using it?
  - ✓ Electrical equipment having portable property, is grounding available with them?
  - ✓ Use of adapters having multiple plugs is avoided or not?
  - ✓ Proper signs are applied on the electric panels or not?
  - ✓ Electrically live parts have sufficient distance from working place?

- ✓ Cable trays are used only for cable trays or some other lines are also incorporated?
- ✓ Space around electrical panels is sufficient for maintenance work?

- **Fire & Emergency Evacuation Checklist**
  - ✓ Are firefighting equipment like fire extinguisher, sprinkler in working conditions?
  - ✓ Is firefighting equipment within the range of person working on site, easily assessable and visible to the person working there?
  - ✓ What is the status of firefighting training, is regular training is provided to the workers regarding the use of equipment?
  - ✓ No-smoking signs are provided in the area prone to fire hazard?
  - ✓ What provision are provided for the person with special needs, e.g. children, women, person with disability?
  - ✓ Width of aisles is maintained according to standards or not, for example minimum width of work aisle is 24 inches and for other aisles it is 36 inches?
  - ✓ Exit doors, especially emergency door are able to open without any special effort?
  - ✓ Flammable matter is kept in cold rooms or explosion proof store?
  - ✓ What is the status of emergency escape, are sufficient exit doors are provided in case of emergency situations like fire, flood etc.?
  - ✓ Is there any documentation of site evacuation drill, are drills conducted regularly?
  - ✓ What is the status of first aid kits is there regular inspection and documentation for such safety equipment?

5.3 Quantitative Analysis of Safety Level

For our study site we discussed about checklists, questionnaires and safety audit process, most of these approaches are subjective in nature, so it is difficult to understand and assess the level of safety using only qualitative technique. So in this section we will discuss the quantitative technique used to quantify the level of safety of the overall terminal. We used three step procedure to determine a rating factor which we named as “overall rating index.” This procedure is first we calculated the rating indexes of all three sub-section of the terminal, with the help of our checklist, we analyzed that how many points of the checklist are satisfied by the terminal, then by multiplying this rating index with the corresponding weightage of the sub-section and adding them

together will give overall rating index. Terminology and formula for calculating the overall rating index for the terminal safety is given below:

R_B = Rating index for building and housekeeping sub-section

R_E = Rating index for electrical sub-section

R_F = Rating index for fire & emergency evacuation sub-section

R_O = Overall rating index

W_B = Weightage of building and housekeeping sub-section

W_E = Weightage of electrical sub-section

W_F = Weightage of fire & emergency evacuation sub-section

Assumptions:

1. Every safety related issue mentioned in the checklist is given equal weightage which is 10%
2. Weightage of different sub-section of the study area is different, which is assigned by keeping in mind the importance of that section with respect to safety (W_B,W_E and W_F are respectively 50%, 20% and 30%)

Overall rating index (R_O) is calculated using the formula as mentioned below:

$$\mathbf{R_O = (R_B W_B + R_E W_E + R_F W_F)}$$

We classify the terminals into four categories depending upon the level of safety which itself depends on the overall rating index (R_O), each category has specific range of R_O value, based on the value of R_O categories are named as A, B, C and D where A is considered the safest and D is considered the least safe terminal. According to the value of rating index corresponding safety measures can be taken and further safety measures can be described and implemented, these four categories are mentioned in the table form below:

Table 6: Overall Rating Index category's description

Category	**R_O Range**	**Remarks**
A	80 to 100	Safe
B	60 to 79	Minor improvement required
C	40 to 59	Major improvement required
D	Below 40	Halt the project

For calculating rating index of individual sub-section, we used our checklists and each checklist have ten safety related issues, after analyzing the actual terminal condition we found out that which safety condition is satisfied and which is not, on the basis of that we calculated the rating index for all three sub-section of our study. Detailed approach is given below:

Table 7: Calculation of rating index for building and housekeeping sub-section

No.	Criteria	Criteria review	
		Comply(✔)	Not comply(✘)
1	Are platforms, floors level, smooth and free from loose boards, bumps, holes etc.?		✔
2	Are storage rooms clean, passageways are clean?		✔
3	Are permanent passageways and aisle marked and free from tripping hazards?		✔
4	Is illumination or lighting satisfactory wherever it is required, are protective guards provided around the lights?		✘
5	Are shelves of storage room confined as heavy objects on lower shelves?		✔
6	Is there working safety shower and eyewash provided where it is required?		✘
7	Are bumpers provided where loading and unloading is done to avoid transport related accidents like truck accidents?		✘
8	Ground inspection for breaks, holes, cracks, falling hazards(including parking area)		✔
9	Handrails provided for stairs having more than four steps or not?		✘
10	Cages provided for ladders having length more than 20 feet or not?		✔

So, rating index comes out to be 6÷10, i.e. **0.6**

Table 8: Calculation of rating index for electrical sub-section

No.	Criteria	Criteria review	
		Comply(✔)	Not comply(✘)
1	Power cables are grounded using grounding conductors or not?		✔
2	Labels or symbols are used according to BIS or not?		✘
3	Use of defective wires, fuses and other electrical switches are avoided or not?		✔

4	Metal ladders are avoided in the areas where there are chances of getting electric shock to the person using it?	✔
5	Electrical equipment having portable property, is grounding available with them?	✔
6	Use of adapters having multiple plugs is avoided or not?	✔
7	Proper signs are applied on the electric panels or not?	✘
8	Electrically live parts have sufficient distance from working place?	✘
9	Cable trays are used only for cable trays or some other lines are also incorporated?	✔
10	Space around electrical panels is sufficient for maintenance work?	✔

So, rating index comes out to be 7÷10, i.e. **0.7**

Table 9: Calculation of rating index for fire & emergency evacuation sub-section

No.	Criteria	Criteria review	
		Comply(✔)	Not comply(✘)
1	Are firefighting equipment like fire extinguisher, sprinkler in working conditions?		✘
2	Is firefighting equipment within the range of person working on site, easily assessable and visible to the person working there?	✔	
3	What is the status of firefighting training, is regular training is provided to the workers regarding the use of equipment?		✘
4	No-smoking signs are provided in the area prone to fire hazard?		✘
5	Width of aisles is maintained according to standards or not, for example minimum width of work aisle is 24 inches and for other aisles it is 36 inches?	✔	
6	Exit doors, especially emergency door are able to open without any special effort?		✘
7	Flammable matter is kept in cold rooms or explosion proof store?	✔	
8	What is the status of emergency escape, are sufficient exit doors are provided in case of emergency situations like fire, flood etc.?	✔	
9	Is there any documentation of site evacuation drill, are drills conducted regularly?		✘
10	What is the status of first aid kits, is there regular inspection and documentation for such safety equipment?		✘

So, rating index comes out to be 4÷10, i.e. **0.4**

After calculating individual rating indexes for selected sub-section of the terminal, let's now calculate the overall rating index using the above ratings and multiplying them with the corresponding weightage assigned and then summing it up.

Overall Rating Index (R_O) = (0.6x50 + 0.7x20 + 0.4x30)

So, $\boxed{\mathbf{R_O = 56}}$

As our overall rating index lies between 40 to 59, so our terminal will be classified as category "C" category terminal, one major reason for the lower value of the rating index is that the site is still under construction, so as the construction work will be over then the operation will become more organized and systematic which may increase the rating index above 60 i.e. there is a scope of transforming the terminal into category "B" category terminal with respect to safety factors considered above, but the authorities should not satisfy with the rating below 80. Other major reasons contributing in the lower overall rating index which require improvements are listed below:

a) Firefighting equipment are not in fully functional conditions also there is shortage of such equipment, scheduled regular personnel training is also missing.
b) There is lack of signage and symbols which can result in misjudgement and confusion during emergency situations.
c) Systematic inspection and documentation process related to safety issues is not followed.

5.4 Standard Safety Audit Procedure

As mentioned in our objective section that we have to develop a standard safety audit procedure for inland waterways terminal, in this section we will discuss about it. A standard safety audit in general has five phases these are:

1. Initiation Phase
2. Planning Phase
3. Fieldwork Phase
4. Reporting Phase
5. Implementation Phase

In Initiation phase we select audit plan based on the recommendation of audit committee or council, in planning phase we define the audit assignment and understand the client's requirements, interview management staff and key stakeholders. In planning phase we also make preliminary

survey memo and develop audit plan and budget. While the fieldwork phase include conducting project fieldwork and analysis. In reporting phase a confidential draft report is developed which incorporates management input reviews, then this formal report is sent to audit committee and executive policy committee after that the report becomes public document. Implementation phase includes the implementation done by management as per the audit recommendations, followed by follow up. Conducting an audit can be explained with the help of flow chart, so the flow chart for conducting an audit is given below;

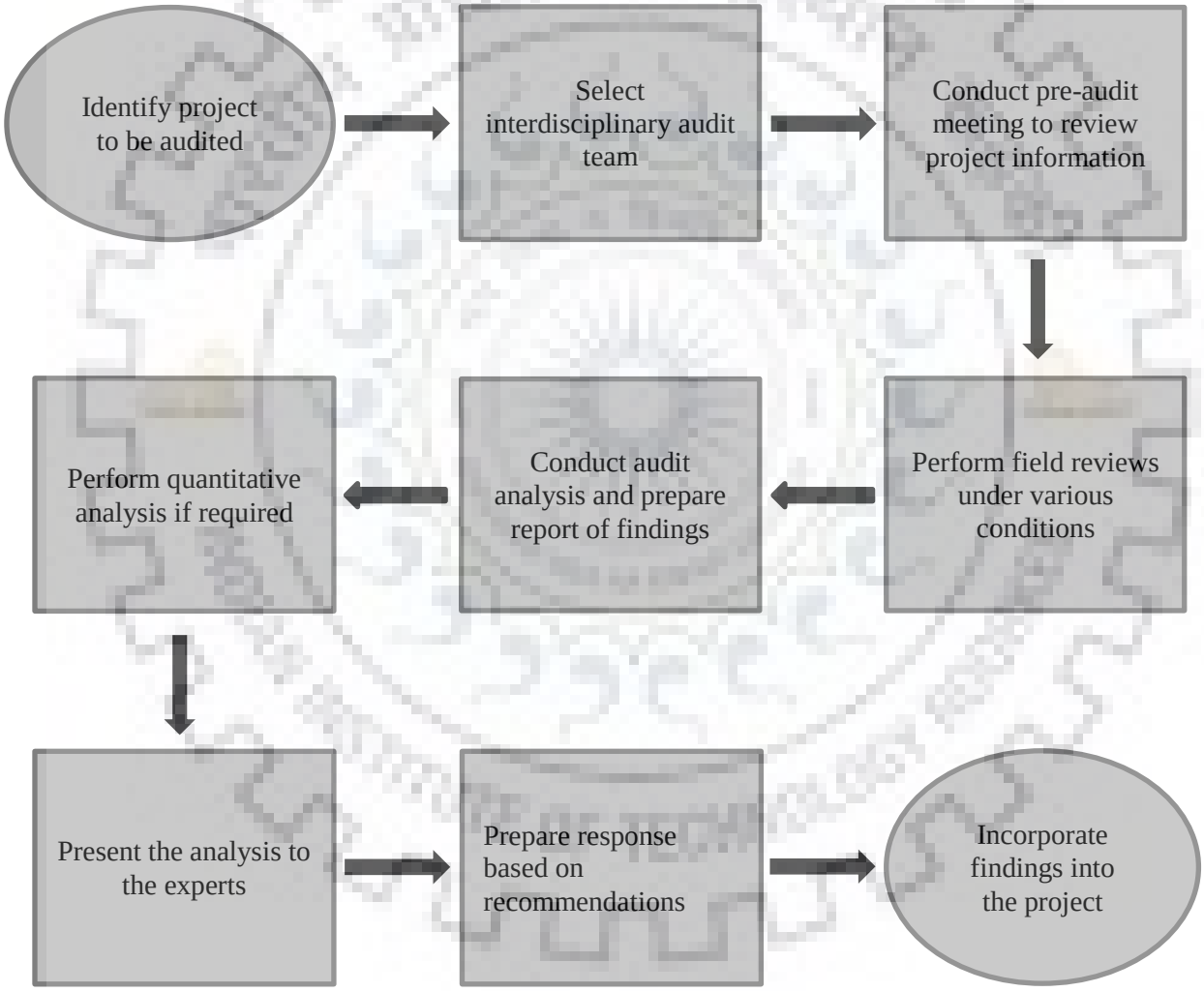


Figure 22: Flow chart for audit process

Chapter 6: Conclusion and Future Scope

6.1 Conclusion

In our study we developed a standard safety audit procedure for inland waterway terminals based on safety audit tool, including checklists and questionnaires. As mentioned in our objectives we have identified critical factors or parameters influencing the safety of inland waterways terminal. We conducted safety audit of Varanasi inland waterway terminal as planned in our objectives so all of our objectives have been accomplished. We also developed a quantitative technique for calculating the overall rating index in context of safety, for any inland waterway terminal. In our case the terminal is inland waterway terminal of Varanasi. We observed that the overall rating index of Varanasi terminal is 56 which cannot be said to be good. So major improvements are needed to enhance the safety of the terminal. Some of the improvement areas are mentioned in the findings and discussion chapter, in nutshell we can say that firefighting equipment, documentation and signage are major area to be improved. A few other shortcomings are, electrical tray is not covered and first aid preparedness is standardized. As per the classification of the terminal in context with the safety, currently Varanasi terminal falls in category C (R_O less than 60) which is not good, but as the construction work will be completed there is scope of improvement in the rating index. In the end we can say that Varanasi inland waterway terminal has huge potential for contributing in the economic growth of India, as it is multimodal terminal and complement other mode of transportation. So safety of the terminal should be given first priority, for better operations management and other logistics related performance.

6.2 Future Scope

As the construction work on the terminal is still going on, it is recommended to visit the Varanasi inland waterways terminal again within next six months or a year and inspect the terminal for any further scope of improvement. In phase-2 construction work of administrative building and storage facility will be completed so there inspection can be done in the future. Besides Varanasi terminal there are two more terminal on National waterway-1 namely, Sahibganj terminal and Haldia terminal, so safety audit for these terminals can also be done in the future.

References

1. A. Lisaj and P. Majzner (2014) “The Architecture of Data Transmission in Inland Navigation”, Journal of Maritime Research Vol XI. No. II (2014) pp 3–7.
2. An Caris et al. (2014) “Integration of inland waterway transport in the intermodal supply chain: a taxonomy of research challenges”, Journal of Transport Geography, 41(2014), pp 126-136.
3. D. Roelevena et al. (1995) “Inland waterway transport: Modelling the probability of accidents” Safety Science 19 (1995), pp 191-202.
4. Di Zhang et al. (2013) “An accident data–based approach for congestion risk assessment of inland waterways: AYangtze River case” Journal of Risk and Reliability 2014, Vol. 228(2) 176–188.
5. Gemma Dolores Molero et al. (2016) “Total safety by design: Increased safety and operability of supply chain of inland terminals for containers with dangerous goods”, International Journal of Science and Research(IJSR), Safety Science, Vol.100, Part B, pp 168-182.
6. Gopinathan Nair Prasanth, “Presentation on Indian Inland Waterways Merseille (France), 13March,2012.” https://www.ccrzkr.org/files/documents/workshops/wwf130312/pres_Nair_Prasanth_en.pdf
7. Inland Waterways Authority Of India “Capacity Augmentation Of National Waterway -1” (Jal Marg Vikas Project), Vol-3: Consolidated Environmental Impact Assessment (EIA). http://iwai.npglobal.in/sites/default/files/6991446056Volume%203%20Consolidated%20EIA%20Main%20Vol.pdf
8. J.M. Bloemhof et al. (2011) “Sustainable Inland Transportation”, International Journal of Business Insights & Transformation Volume 3, Sp Issue 3, pp 26-33.
9. M. Fastenbauer et al. (2007) “River Information Services for commercial users in the Inland Waterway sector”, International Symposium on Logistics and Industrial Informatics, 13–15 September, 2007, Wildau, Germany.
10. Monios, Bergqvist (2015) “Intermodal terminal concessions: lessons from the port sector”, Res. Transp. Bus. Manage., 14 (2015), pp. 90-96.
11. Myo Min Thant (2018) “The legal, administrative and operational framework for the safe maritime transport of dangerous goods: Myanmar as a case study”, The Maritime

Commons: Digital Repository of the World Maritime University, World Maritime University Dissertations.

12. Nogal et al (2016), "A multidisciplinary approach for risk analysis of infrastructure networks in response to extreme weather", Proceedings of 6th Transport Research Arena, April 18–21, 2016, Warsaw, Poland.
13. Peilin et al (2012), "Research on layout evaluation indexes system of dangerous goods logistics port based on AHP. Yanwen Wu (Ed.), Software Engineering and Knowledge Engineering: Theory and Practice", Publisher: Springer-Verlag Berlin Heidelberg, vol. 2. pp. 943–949.
14. Portugal et al (2011), "Location of cargo terminals in metropolitan areas of developing countries: the Brazilian case" J. Transp. Geogr., 19 (4) (2011), pp. 900-910.
15. Roso (2007), "Evaluation of the dry port concept from an environmental perspective: a note", Transp. Res. Part D: Transp. Environ., 12 (7) (2007), pp. 523-527.
16. Saaty (2016), "The analytic hierarchy and analytic network processes for the measurement of intangible criteria and for decision-making". Int. Ser. Oper. Res. Manage. Sci., 233 (2016), pp. 363-419.