OPTIMIZATION OF VESSEL TURNAROUND TIME AT A SEAPORT WITH A SPECIAL REFERENCE TO NEW MANGALORE PORT TRUST

Thesis

Submitted in partial fulfilment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

by

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October 2019

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D E C L A R A T I O N

I hereby declare that the Research Thesis entitled "OPTIMIZATION OF VESSEL TURNAROUND TIME AT A SEAPORT WITH A SPECIAL REFERENCE TO NEW MANGALORE PORT TRUST". Which is being submitted to the National Institute of Technology Karnataka, Surathkal in partial fulfilment of the requirements for the award of the Degree of Doctor of Philosophy in Port Operations and Management (Coastal Engineering) is a bonafide report of the research work carried out by me. The material contained in this Research Thesis is has not been submitted to any University or Institution for the award of any degree.

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C E R T I F I C A T E

This is to certify that the Research Thesis entitled "OPTIMIZATION OF VESSEL TURNAROUND TIME AT A SEAPORT WITH A SPECIAL REFERENCE TO NEW MANGALORE PORT TRUST" submitted by Dayananda Shetty K (Register Number: AM15P01) as the record of the research work carried out by him, is accepted as the Research Thesis submission in partial fulfilment of the requirements for the award of degree of **Doctor of Philosophy.**

Dr.G.S.Dwarakish

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ACKNOWLEDGEMENT

I wish to thank my research Guide **Dr. G.S. Dwarakish**, for having suggested the area of research in the field of port operations and management. I am deeply indebted to him for his patient guidance and encouragement throughout my research work. His motivation and inspiration and above all for his confidence on my ability made me to achieve what is done so far.

I wish to thank **The Chairman** and the Management of New Mangalore Port Trust for giving me an opportunity to carry out research work, by giving official permission to carry out higher studies at NITK Surthkal.

I wish to thank the **Head of Department** and all Professors of Department of Applied mechanics and Hydraulics, NITK, for having extended all the facilities for the successful completion of my research work.

I would like to express my sincere thanks to the RPAC members **Dr. Subba Rao,** Department of Applied Mechanics and Hydraulics, and **Dr. Sitaram Nayak,** Department of Civil Engineering for giving useful inputs throughout my research work.

I thank **Sri. Vijayanand Gurudev**, Mysore and his family for helping me out of many tight corners during my formulation of Computer modelling of the research work.

I also wish to thank my wife and children, who despite the many inconvenience faced, stood by me and encouraged me in every stage of my research work.

Finally, I thank all the non-teaching staff and fellow researchers ofDepartment of Applied Mechanics and Hydraulics, NITK, and all my NMPT friends who helped directly or indirectly in completing my research work at NITK and NMPT.

DAYANANDA SHETTY K.

ABSTRACT

Turnaround time of a vessel in a seaport exhibits the capability and ability of a port in providing efficient and effective services. Ship turnaround time is one of the most significant Port performance indicator. This is the total time, spent by the vessel in port, during a given call. It is the sum of waiting time, berthing time, service time (i.e., ship's time at berth) and sailing delay. Indian ports play a crucial role in trade and economy, as 95% of merchandise trade is handled by ports. However, port turnaround time remains a key problem. It is significantly slower when compared to ports in other developing countries, being several times higher than for ports in China, Singapore and Malaysia. It is estimated that about 40% of ships time is spent in ports. The main contributing factors in high turnaround time of a vessel in a sea port are the port congestion, loading/unloading speed, method of cargo handling, general operational delays, strikes, ship catastrophe, pilotage and mooring time and delay due to weather. To reduce the turnaround time of a vessel in a seaport, the port processes are to be streamlined and capacity augmented. This research is aimed at identifying the factors that are responsible for turnaround time of vessels at New Mangalore Port. As the present day vessels are of very large size to take advantage the economy of scale requires huge investment. The return on investment depends on the earning of vessel during her entire life. The voyage time of a vessel is the only earning period of the vessel, whereas the time spent in seaports is expenditure for the ship owners. Therefore every ship owners expect a very low turnaround time to get maximum benefits. The turnaround time is a function of port operations and port facilities. Currently, it is not possible to determine the significant factor(s) that influence port performance, in terms of turnaround time. The primary data of vessel arrival/departure in New Mangalore Port Trust (NMPT) recorded at Vessel Traffic Management System (VTMS) are used for the present study. This study revealed that more than 120 factors affect the turnaround time of the vessel in a seaport. The factors attributable to high turnaround time at NMPT are mainly due to the pre-commencement and post-commencement documentation/custom formalities and the total time lost during loading unloading process. Non-availability of berths in case of liquid bulk cargo and non-availability of equipment's and lack of mechanization in

the dry bulk cargo handling also contributes to the increased turnaround time of vessels.

The weightage of these factors in contributing high to turnaround time are analysed through the developed optimisation tool and total time consumed by the top 20 critical factors are calculated month on month basis. The sensitivity analysis shows that in the year 2018-2019 on an average of 1350 hours per month is lost which is around 17.50% of the total monthly turnaround time of the all vessels calling on to the port during the year in consideration. The major constrains which contribute to this increased turnaround time are the total time lost during loading and unloading operations, documentation procedures, custom clearance, survey of the cargo and the time lost due to non-port account. The sampling of cargo and lab test for quality assurance before loading and unloading the cargo by the concerned authority also contributes to the delay in turnaround time of the vessel. Weather constraints and some of the port constraints like shifting of vessel from one berth to the other for draft requirements, idle time at berth are some of the factors which also contribute to the increased vessel turnaround time in NMPT. Thus, the outputs of the optimization tool will able to help the port management to verify the problems in an identified area on a real time basis and to come out with better solutions in providing services and improving the port activities, to ensure lower vessel turnaround time and increased port productivity and efficiency. It is possible to tackle all the delay causing factors by the port management in providing efficient and effective services and increased port productivity, with the aim to achieve optimum port performance. The model can also be useful in generating various Management Information System (MIS) outputs and Port Performance Indicators (PPI) with respect to the category of cargo handled, Berth wise, on daily/monthly/yearly basis.

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LIST OF ABBREVIATIONS

AAPA	American Association of Port Authorities
ABP	Association of British Ports
ADB	Asian Development Bank
AQCS	Animal Quarantine and Certification Services
BOT	Build Operate Transfer
BT	Berthing Time
CAGR	Cumulative Annual Growth Rate
CBIC	Central Board of Indirect taxes and Customs
CDRUG	Drug Controller
DFT	Department for Transport
DWT	Dead Weight Tonnage
FDI	Foreign Direct Investment
FSSAI	Food Safety and Standards Authority of India
ICD	Inland Container Depot
IM	Inward Movement
ISO	International Organisation for Standardisation
ISPS	International Ship and Port Security
JNPT	Jawaharlal Nehru Port Trust
KDS	Kolkata Dock System
KPT	Kolkata Port Trust
LOA	Length Over All
LPG	Liquefied Petroleum Gas
MMD	Mercantile Marine Department
MTPA	Million Tons Per Annum
MRPL	Mangalore Refinery and Petrochemical Limited
NH	National Highway

NMDP	National Maritime Development Program
NMPT	New Mangalore Port Trust
NWTB	Non-Working Time at Berth
OM	Outward Movement
OSBD	Output per Ship Berth Day
PBWT	Pre Berthing Waiting Time
PGA	Partner Government Agencies.
PHO	Port Health Officer
POL	Petroleum Oil Liquid
PPI	Port Performance Indicator
PPP	Public Private Partnership
PQIS	Plant Quarantine Information System
SEZ	Special Economic Zone
ST	Service Time
TEU	Twenty foot Equivalent Unit
TRT	Turnaround Time
VAL	Value Added Logistics
VLCC	Very Large Crude Carriers
VTMS	Vessel Traffic Management System
VTRT	Vessel Turnaround Time
VTRTO	Vessel Turnaround Time Optimisation
USD	United States Dollar
UNCTAD	United Nations Conference on Trade and Development
UPCL	Udupi Power Corporation Limited
WCCB	Wild Life Crime Control Bureau

CHAPTER 1
INTRODUCTION

1.1 General

The globalization of trade and removal of trade barriers between the various countries have resulted in tremendous growth in maritime transportation. This growth resulted in a change in both the pattern of trade and the composition of cargo. The huge volumes of cargo are moved from one destination to another by sea transportation because of its cost effectiveness. The change in trade pattern has made the evolution of new generation and sophisticated vessels to enable fast, consistent and cost-efficient transfer of merchandise. With the advent of latest model and size of vessels, there is a demand for more port infrastructure and enhanced quality of service to back up the international trade (Michel and Noble, 2008). Thus, there is high competition among port authorities to attract shippers. To increase the productivity and performance of their terminals, the port management will have to consider the lower turnaround time for the vessels calling on to the port. The turnaround time of a vessel in a seaport depicts the potential ability of the port terminal in providing efficient services. The present research is aimed at identifying the factors responsible for increased vessel turnaround time in the Indian port sector and to provide cost-effective and efficient services with high port productivity. It is also aimed at achieving optimum port performance in major ports of India. The vessel turnaround time is a function of port throughputs and port facilities. At present, there is no universal method to determine the significant factor(s) that influence port performance, in terms of turnaround time.

Ports essentially provide a variety of service activities for the vessels, cargo and inland transport. In the recent past there are rapid changes in sea transportation. The shipping sector has moved towards specialized vessels of larger size and higher speed. These modern ultra large vessels are of high investment and therefore demand increased utilization and decreased idle time of the vessel. Managers and authorities at ports have increasingly been under pressure to improve port performance by ensuring that the port provides services on an internationally competitive basis (Simoes and Marques, 2010).There has been higher stress to decrease the loading and discharging

time at ports. As the demand from the shipping line increased, demands for the rapid service from the ports are also increased. This resulted in development and modernization of many ports throughout the world to achieve improved performance. The level of fulfilment acquired by the shippers shows the degree of port performance accomplished. This means ports are required to improve their planning and operation capacity by engaging modern equipment and high-tech technology to enhance the terminal logistic process. To enhance terminal port resources, it is vital to ensure that port operational flow can operate smoothly. The port performance indicators are simply a measure of the efficiency of various port activities. Such indicators must be easy to calculate and simple to analyse and understand by the port managers. They should provide reliable input to the top management in the key areas of port operations. There exists a strong interrelationship between port productivity and various port performance indicators. The port productivity is thus a function of its performance. Port performance measurement is complex since the port is a group of various trade activities where a large number of organizations offer goods and services and together create diverse port functions (Langen et al.2007). There are no internationally accepted systems to determine the effectiveness of services provided by ports. Any methods used by the port managements are only rough and only give an approximate estimate of the effectiveness of different functions carried out in the port. The main purpose of measurement of port performance is to give a direction to the port authority for scheduling and manage the operations of the port.

There are two groups of factors affecting the performance of ports, namely client service issues and cargo handling issues (Murphy et al.1991). Performance estimation helps the port authority in taking corrective action at the problematic areas of port operation. Port managers depend on performance measures, as an important aspect of scheduling and controlling processes (Neely et al.1997). Port performance is highly connected to factors such as type of the hinterland, local produce, local economic growth, status of the international economy, and policy of government trade support, landside development, people and their culture (Tongzon, 2002).Performance measurement is important for the efficient and effective management of organizations. It reflects an organization's objectives, customer requirements and the external competitive environment (Kennerley and Neely, 2002). It can be used to

assess the success of organizations. Bruijn (2002) discussed how performance measurement could fill several functions, including transparency, learning, sanctioning, appraising and benchmarking between organizations and competitors.

In a supply chain context, measuring performance is a managerial tool that assists in planning and organizing activities, motivating workforce, and controlling events within acceptable parameters (Morgan, 2004). The modern vessels are of high cost, and therefore to increase vessel utilization in the voyage, there has been increasing pressure to reduce loading and unloading period at ports (Kumar et al.2004). Widely accepted performance measurements are unavailable, although there is a wide range of measures and indicators for port efficiency and performance, as ports are very dissimilar (Bichou and Gray, 2004). The port infrastructures offer the physical environment and port amenities for port working effectiveness (Gordon. et al. 2005).The volume of trade, the total value of commodity throughput and port-related employment are all possible indicators to assess port performance. Port productivity, in general, might be comprehended from different points of view and its effect on business promotion (Clark et al. 2004). Port management needs dependable performance estimation framework to quantify the effectiveness and adequacy of their functions. Consequently, the improvement of amenities and tasks is the shared objective in most current estimation frameworks.

1.2 Indian Ports

There are 12 major ports in India. Most of them have to deal with many deficiencies like low connectivity with the hinterland and insufficient port infrastructure. The policy of privatization of these government-owned ports have opened up larger prospects for expansion and improvements. The assessment of productivity and efficiency of the major ports is very much required when the reform process has to be allowed by private participation. The lack of research work in the area of port productivity and efficiency caused in the poor evaluation of the level of performance by the Indian ports. The economic reforms of the Indian government by the industrial policy 1991 gave new direction and status to the port reform process. In India, the economic reforms started late compared to the world economic growth.

But there are many positive features in the financial operation in the post-transformation phase. To assist long duration developments of the economy with fool proof technique, the reform process are essential. Therefore, it is vital to have legal and regulatory systems to back up the privatization process. Even though the reform process was started during early 1991, it needed a long period for the government to implement the same in the various economical segments. The Government of India is aimed to have a robust strategy frame work to extend the reform process to different segments of the economy over some time. The government-owned ports are opened for private participation during 1995-1996(Maritime Agenda-2020, 2011). The selected areas of port activities like terminal operation, berth operation, cargo handling, dredging, stevedoring, providing the tug operation, maintenance of existing yards and sheds, etc., are allowed to private sector participation. The private participation is allowed through a competitive tendering process with Public Private Partnership (PPP) mode and Build Own Operate and Transfer (BOOT) mode contracts for a 15 to 30 years concession agreement. The sole purpose of privatization of operations at major ports of India is to improve the performance efficiency, cost reduction, and capacity augmentation. To achieve this authority of the port management are vested with operational autonomy and made accountable for completive business with sustainable port efficiency. Due to this reform process, many of the port terminals are equipped with sophisticated port equipment, development of new captive berths/jetties and up gradation of existing infrastructures. The implementation of the latest technology in cargo handling, loading, and unloading, improved port infrastructure enabled the major ports with improved ability of cargo handling. Thus, the efficiency and productivity are also increased due to reforms and private participation.

1.2.1 Problems in Indian Major Ports

There are various drawbacks in the performance of major Indian ports compared to most of the high-tech ports at the international level. Indian major ports are greatly hindered by infrastructure and port facilities (India Transport Report 2014). The growth rate of Indian ports in both export and import is high in spite of recession

across the world maritime logistics sector. Therefore it is highly important to review the present constraints in the major ports to ensure a favourable condition in both infrastructure and policy of the government towards long term implications of the Indian port sector. It is expected that there is a steady growth of traffic in Indian ports at 6 % Compound Annual Growth Rate (CAGR) to reach about 3600 MT by the end of 2029-30 from the current level of 690 MT. Hence, there is an urgent need of capacity augmentation at the major ports to meet the projected traffic growth.

Some of the problems faced by Indian Ports are

- Poor maintenance of cargo handling equipment, floating crafts, tugs, etc, leading to frequent break down during operations and also inadequate capacity and out dated design of existing equipments.
- Insufficient facilities with the port and not taking timely action for dredging of berth and approach channels by the port authority.
- Insufficient container cargo storage yards and lack of latest container handling and lifting machinery.
- Improper scheduling and wrong deployment of port equipment to handle different categories of commodities.
- More labour oriented bulk cargo and break bulk cargo handling methods in general cargo terminals
- Lack of exclusive berths/Jetties for different categories of cargo handled
- Lack of systematic communication methods between various stakeholders of the pot like Port Authorities, Customs, Port security, and Shipping agents
- High vessel turnaround time compared to the ports in the neighbouring countries.

1.2.2 Problems Related to Cargo in Indian Major Ports

The major ports of India have to deal with mixed types of commodities based on the economic requirements of the country. Every port has developed some level of capability to deal with particular type of cargo. There is no dedicated berths/infrastructure for an individual type of cargo to be handled. A berth has to cater for multiple cargos handling with certain modifications and adjustments with

cargo handling equipments. But, all of the major ports are constrained by one or the other problems in cargo handling methods when the performance level is considered. To study the bottlenecks in the major ports of India, the Government of India referred the matter to the authorities of Belgium to study the present situation and to recommend a course of action to be taken to overcome the limitations faced by the major ports of India. The study team gave some suggestions in its report indicating the existence of stimulant systems for competition amid the major ports, entrusting of authority and responsibility to port management, freedom in port pricing and investment, quick decision making, operational autonomy, and professionalism.

1.2.3. Reforms in Indian Ports

Port reforms in the Indian port sector were initially started in the year 1995 (Maritime Agenda, 2020), even though the economic reforms are introduced in 1991 by Indian Industrial policy. Indian government allowed private sector players in port operations in a phased manner. Presently up to 100%, Foreign Direct Investments (FDI) is allowed in port-related infrastructure development. Most of the countries in the world are moving towards port sector privatization; the landlord port model is taking over the old traditional service port model. In this model, the port authorities have a hold on the port infrastructure and carry out regulatory duties. All port-related services are rendered by the private operators by developing port infrastructure and providing equipment. The Government of India is also promoting fully privatized ports allowing private players under the landlord port model at major ports. Various developmental port projects are awarded under BOOT and PPP modes for a concession period of 15 to 30 years. The developments in the international maritime sector created both opportunities and threats to the major ports of India. The requirements from the domestic and foreign markets in India have developed intraport competition between them. The Indian government has taken various steps to improve the port sector on par with world class high tech ports. Modernization of existing facilities, augmentation of port infrastructure, logistic networks, single window system, port-related Special Economic Zones

(SEZ), the abolition of trading licenses, make in India, and concession on tax regimes are some of the initiatives taken. The government introduced the National Maritime Development Program (NMDP) to augment the performance of existing ports and modernization of port facilities. Investment by private participation through BOOT and PPP is allowed on profit sharing basis, including the construction of captive terminals, providing warehousing facilities, mechanization of berths/jetties for cargo handling facilities, construction of ship repair facilities and dry docks, etc..., through a global competitive bidding process. Major changes are made in administrative setups to bring about improved organizational behaviour and effectiveness. The existing Indian major ports are changing towards the Landlord Port Model type of service and leaving the role of providing service to the vessels and restricting their role in giving basic infrastructure and maintenance of channels and lagoons and managing the operation of the terminals and handling of cargo to private operators. To keep this height of volume augmentation and cargo handling, the government has set some strategies that include: 1. Introduction of landlord port model in the major ports, 2. New land policy permitting port authorities to lease their vacant land on long-term and short-term basis, 3.Improved road and rail network to the port cities, 4. The policy restricting monopoly among major ports by the common port tariff, 5. Privatization and commercialization of existing major ports.

1.2.4 Profile of Indian Major Ports

Indian major ports have acted as a vital logistic route in the export/import of a variety of cargo and merchandise from India to various countries of the world. At present in India, there are 12 major ports and over 180 minor ports. In the Indian economy, the ports play a special role by handling over 90% of international cargo by volume and 80 percent by value. There are six major ports on the east coast and six are on the west coast of India, spreading across a total 7516 km of coastline starting from the state of Gujarat to state of West Bengal. During the initial stages of port development, each of the ports is established to cater a specific cargo in each of coastal states. At present 11 of major ports are functioning as autonomous port trusts

and the Kamarajar Port Limited (erstwhile Ennore Port Limited) is developed and established as a corporation. Initially, all the major ports of India are administered centrally through the central government. And later at first the six ports were brought under the Major Port Trust (MPT) Act 1963 and functioning as port trusts, These ports include the oldest three major ports Mumbai, Kolkata, and Chennai along with the Cochin port trust, V.O.Chidambaranar (erstwhile Tuticorin port,) and Visakhapatnam port. Later the remaining 5 Ports namely Jawaharlal Nehru Port (JNP), Deena Dayaal port (erstwhile Kandla port), Mormugao port, New Mangalore, port and Paradip port were included to the list of major port trusts. Kamarajar (Ennore) Port Limited is the only major port which is not registered as a trust. All other major ports of India are established under the Major Ports Act, 1963.

At present, all the major port trust are under the control of the ministry of shipping, the Government of India and are governed by the Major Port Trust Act 1963. The present government is started the process of replacing the old Major Port Trust Act 1963 with latest amended New Major Ports Authorities Bill, 2016. To enhance the cargo throughput from all the major ports, a new berthing policy for dry bulk cargo was introduced in the year 2016 and also a new stevedoring and shore handling policy is also implemented in 2016 in anticipation of increased performance and operational efficiency. To bring increased private investment into the port sector, the government of India revised the Model Concession Agreement (MCA) for PPP and BOT projects in major ports. A dispute resolution mechanism of society for Affordable Redressal of Disputes-Ports (ARD) was included in this agreement. With a focus on the substantial enhancement on port capacity and development of infrastructure, the cargo handling capacity of all major ports increased to 1451.19 MTPA in 2017-18 from mere 174.0 MTPA in 1994-95. During 2017-18, the cargo traffic handled at major ports was 679.36 MT. The present government gave a boost to port-led development with the introduction of SAGARMALA project, involving an investment of USD 14.06 billion covering 142 port projects. The allocated Budget amount under the Ministry of Shipping in 2018-19 is USD 289 million. The capacity and the cargo handled at major ports from 1994-95 to 2017-18 is shown in figure. 1.1.

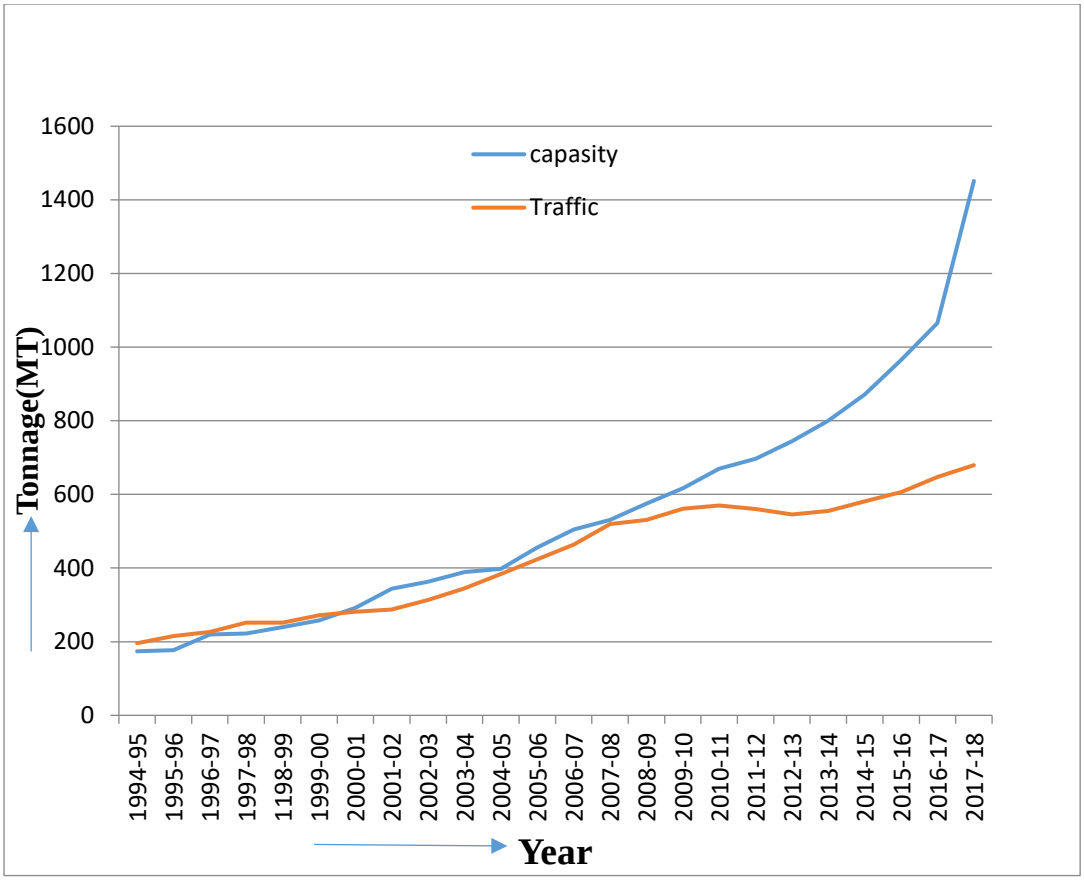
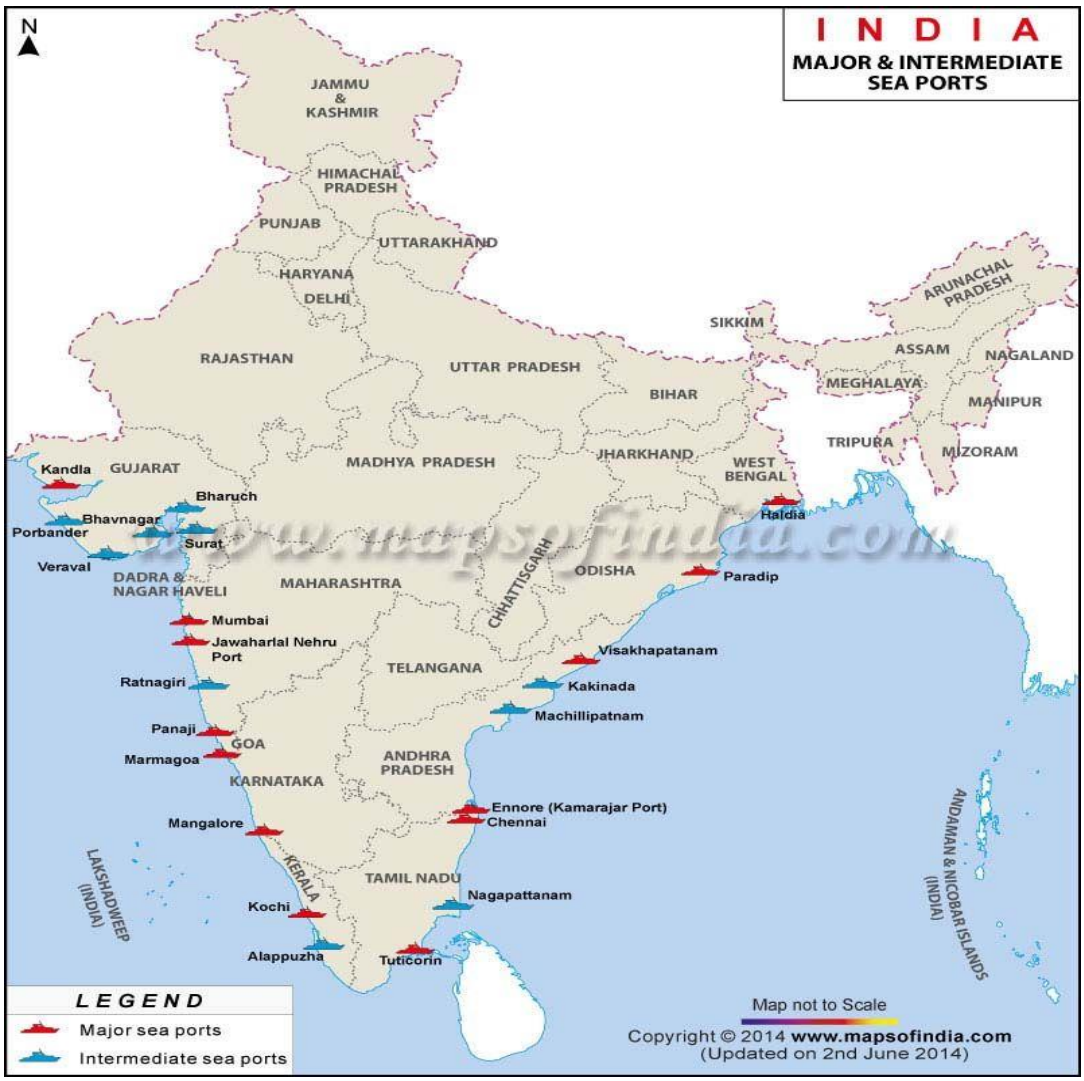


Figure1.1. Major Ports-Capacity and Traffic (Million Tonnes)

[Source: Port statistics –MOS]

1.2.5 Major Ports of India a Detailed Study

India is blessed with a vast coastline of about 7516 Kms, sharing with ten maritime states namely Gujarat, Maharashtra, Goa, Karnataka, Kerala, Tamilnadu, Andhra Pradesh, Telangana, Orissa, and West Bengal. All the twelve Indian major ports falling on these maritime states share the total Indian export and import requirements. All the major Indian ports have their advantages and work under different regional constraints. Some ports are natural ports, some are semi-natural and others are fully artificial ports. There are various constraints in development and working of major ports of India, and hence the performance level of each and every port is not uniform. The figure 1.2 shows the location of major Ports along the Indian coastline.



Source: www.mapsofindia.com

Figure 1.2 Map showing the location of Indian Major Ports

1.2.5.1 Kolkata Port Trust and Haldia Dock complex

One of the oldest major ports in the country is Kolkata Port. It is serving the maritime trade since the regime of the Mughal king from the times of Aurangzeb to East India Company. After the British rule in India, the administrative control of this port is brought under the Government. At present, the port has a long riverine channel of 232 Kms, with berths provided along the Hooghly river for different cargo facilities. There is a well-established rail road connection to the port hinterland. The port is catering the needs of whole eastern India along with the neighbouring countries of Nepal and Bhutan. There is two dock system in Kolkata

port trust namely Kolkata Dock system (KPT) and Haldia Dock System (HDC). The main cargo handled at this port is Iron ore, mica, metallurgical coke, ferro-chrome and coal (thermal and coking).

1.2.5.2 Paradip Port Trust

Paradip Port is a major port situated in the state of Orissa on the east coast of India. It serves the eastern and central part of the country. Paradip port is strategically located to serve a huge hinterland spreading over the states of Orissa, Jharkhand, Chhattisgarh, Madhya Pradesh, Uttar Pradesh, Bihar, and West Bengal. Paradip port enjoys the advantages of delicate submerged soil so that it can be deepened to any depth depending on the draft requirements. The Port is provided with 16 berths, 3 Single Point Moorings (SPM), 1 Ro-Ro Jetty, a well maintained approach channel and entrance channel having 17.1 m draft to cater the needs of wide range of vessels up to greatest Length Over All (LOA) of 260 m. The port is dealing with different freight like crude oil, POL items, iron ore, thermal coal, chrome ore, coking coal, manganese ore, charge chrome, ferro chrome, ferro manganese, limestone, hard coke, ingots and moulds, billets, finished steel, scrap, fertilizer, fertilizer raw material, clinker, gypsum, project cargo and containers.

1.2.5.3 Visakhapatnam Port Trust

Visakhapatnam Port trust is the deepest landlocked and protected port. There are three harbour zones namely, the inner harbour, the outer harbour and the fisheries harbour. The area of inner harbour is 100 hectares, comprising of 18 berths/jetties and outer harbour is constructed with 6 berths/jetties with an area of 200 hectares. The port is having a maximum draft of 17.0 m and can accommodate largest vessels up to 1,50,000 DWT. The Very Large Crude Carriers (VLCC) is handled at Single Point Mooring (SPM). Visakhapatnam is also provided with facilities for ship building and ship repair. The major commodities handled at this port are coal, iron ore, POL, crude, chrome ore, manganese ore, timber and other industrial products.

1.2.5.4 Kamarajar (Ennore) Port Limited

Kamarajar port is located in the east coastline of India in the state of Tamil Nadu and it is about 25 Km north of Chennai port trust. The port is initially developed as a

satellite port to the Chennai port trust to handle the increased demand for coal handling to sate Electricity Board. Later the port is expanded as major port to cater the needs of 1880 MW LNG power plant, naphtha cracker plant and a large petro chemical complex. The port started its operation during the year 2001. It was the only major port established under the Companies Act as Ennore Port Limited. The port is now renamed as the Kamarajar Port Limited (KPL). The port mainly handles coal, cock, iron ore, manganese, bauxite, and other metals.

1.2.5.5 Chennai Port Trust

Chennai port is a fast growing hub port in the east coast of India. It is also one of the largest and the third oldest port among the major ports of India. The port has completed more than 138 years of service to the nation. In Madras (Chennai) maritime trade started very long back during the year 1639 itself. Earlier it was developed as an open road-stead in the year 1815. During the storms in the year 1872, the port got damaged and inoperative. Later during 1881, a new artificial harbour was constructed to cater the increased maritime traffic. The Chennai port is always vulnerable for the effects of cyclone and sand accretion/erosion due to the active sediment movement along its coast. During the year 1920, the port was provided with a dock arm with the group of 4 berths along with the transit sheds and warehouses. A marshalling yard is also developed for the transfer of cargo inside the harbour area. In the year 1964 one more dock arm called Jawahar dock was added with the construction of 6 berths to cater the dry bulk cargo and liquid cargos at the southern side of the harbour basin. In the year 1972 an outer harbour was developed named Bharathi Dock for handling Petroleum, Oil, and Liquid (POL) bulk cargos. The iron ore terminal is equipped with mechanized ore handling facilities with a capacity of handling 8.0 MTPA. The Chennai port has two privatized container terminals. One of these is operated by M/s Chennai International Terminals Private Limited with a capacity to handle 1.5 M TEU's. And the other is operated by M/s. Chennai Container Terminal Private Limited. The major commodities handled at Chennai port trust include coal, coke, iron ore and pellets, manganese ore and bauxite.

1.2.5.6 V.O.Chidambaranar (Tuticorin) Port Trust

This major port is also located in the state of Tamil Nadu on the east coast of India. The port is operating in two main zones. The new major port is developed in zone A and the old port is located in zone B. The main advantage of V.O.Chidambaranar Port Trust is that it is very near to the international sea route among all the Indian major ports It is advantageous to this port to act as a container hub port. The port is well linked with the road network and railway network to all major cities. The main commodities handled at this port trust are thermal coal, timber, petroleum products, various other dry bulk and break bulk cargo and containerized cargo.

1.2.5.7 Cochin Port Trust

Cochin is the only major port located in the state of Kerala on the west coast of India. The port is developed with the construction of berths on the two backwater channels on the Willingdon islands. This port is also very close to the international maritime sea route. The port is planned to become a major transhipment hub to international trade. The port entrance channel is divided into the Ernakulam and Mattancherry channels. The Ernakulum channel is extended up to a length of 4900m and width varies from 250 m to 500 m. The port has a maximum draft of 12.50 m. The Ernakulam wharf is provided with six berths and is used for general cargo and container handling and also a fertilizer berth. The length of the Mattancherry channel is 4008 m and varying width from 180 m to 250 m and a maximum draft of 9.15 m. In Mattancherry channel, there are four general cargo berths and two oil jetties for POL products. The main products handled in Cochin port trust are iron ore, LPG, crude, POL, granite stones, sand, salt, coal, zinc, clay, gypsum, and sulphur.

1.2.5.8 Mormugao Port Trust

The Mormugao Port Trust is on the west coast of India in the state of Goa. It is a natural harbour commissioned in the year 1885. It is one of India’s oldest ports. The harbour lies in the Southern mouth of Zuari river and is protected by a breakwater and a mole. Along the breakwater, three berths were constructed for a length of 350

m during the first stage. Later two more berths were constructed, and breakwater was extended up to a length of 522.40 m. The port is originally catering the export of iron ore as the mining is the major industry in Goa. The port is having iron ore terminal with a dedicated berth provided with Mechanised ore loading plants with a capacity of 1000 tonnes per hour (TPH). The port was declared as a major port of India in 1964. It was the leading iron ore exporting port in India. At present due to the ban on iron ore mining the traffic at the port is drastically reduced. The major cargo handled at this port are iron ore, POL products, export of fish, iron ore castings, metal scrap, liquor, and pharmaceutical products.

1.2.5.9 New Mangalore Port Trust

The New Mangalore Port Trust (NMPT) construction activities were started in the year 1962 and the port was commissioned during May 1974. On 4th May 1974 the New Mangalore Port was declared as a major port in line with the other major ports of India. The port was declared open by Smt. Indira Gandhi then Prime Minister of India on 11th January 1975. On 1st April 1980, the port was given the status of port trust under the Major Port Trusts Act, 1963. Till then the port was under the control of the central government of India.

1.2.5.10 Jawaharlal Nehru Port Trust

The Jawaharlal Nehru Port Trust (JNPT) was a high-tech major port of India commissioned in the year 1989. The port is having highest draft of 15.0 m. This port is exclusively committed facility to deal with container cargo. In a very short period of its commissioning, the JNPT has become the world class international container handling port with sophisticated container handling and storage facilities. The port can handle the largest size vessels that can be having the capacity of 1,20,000 DWT. About 60% of total container traffic handled by major ports of India is handled by the JNPT. It is acting as a container hub port on the west coast of India. JNPT is ranked 24th among the top 100 container ports of the world. This port is well linked with road and railway network to all major cities of India. The main commodities handled at JNPT are containers, POL products, polymers, medicines, frozen meat

and animal products, insecticides, copper, copper alloys, cars, motor cycles, fabrics and non-alloy steel and parts and accessories of motor vehicles.

1.2.5.11 Mumbai Port Trust

The Mumbai port was established in the year 1873, along the west coast of India in the state of Maharashtra. It is known as the gateway of India to the world markets. This port is acting as a catalyst for the development of the country's economic activities, trade and commerce. It gained popularity because it is located in Mumbai, the commercial capital of India. It is a natural deep water port and is surrounded by Konkan main land on the east and Mumbai island on the west. The port operates throughout the year and hence it is all weather port. The Mumbai port has three dock arms, namely Indira Dock, Prince's Dock and Victoria Dock. The port is covering an area of 46.30 hectares of land and a quay length of 750 m in the wet basin and a total length of 850 m along the harbour sea wall. The port is well connected with rail, road and air routes. The Mumbai port trust handles commodities like dry bulk cargo, breakbulk cargo, containers and liquid bulk cargo, POL and industrial products.

1.2.5.12 DeenDayaal (Kandla) Port Trust

Deen Dayaal Port trust (Kandla Port) is located in the state of Gujarat in the west coast of India. This port is situated in the gulf of Kutch and is a natural harbour protected with the natural barriers. The port was commissioned in the year 1950 after the independence of India. The need of developing Kandla as a major port has arisen due to the loss of Karachi port to Pakistan after independence and in order to ease congestion in the Bombay and Calcutta ports, thereby reducing the inconvenience and the cost to the EXIM Trade. Kandla port was declared as a major port on 8th April 1955. On 29th February 1964 the Kandla port was declared as major port trust and brought under the provisions of the Major Port Trusts act. The port has grown gradually in terms of cargo hobbling and it is the No. 1 major port in terms of cargo handling by volume, since it handles more than 100 MTPA export /import cargo yearly. At present, the port is having 12 cargo berths and 6 berths for POL

products. Three numbers of Single Point Mooring (SPM) buoys are provided in the Vadinar offshore oil terminal. All the berths are equipped with mechanised loading and unloading facilities. The port handles cargos like POL products, crude, fertilizer, salt, sulphur, betonies, lead and rock phosphate.

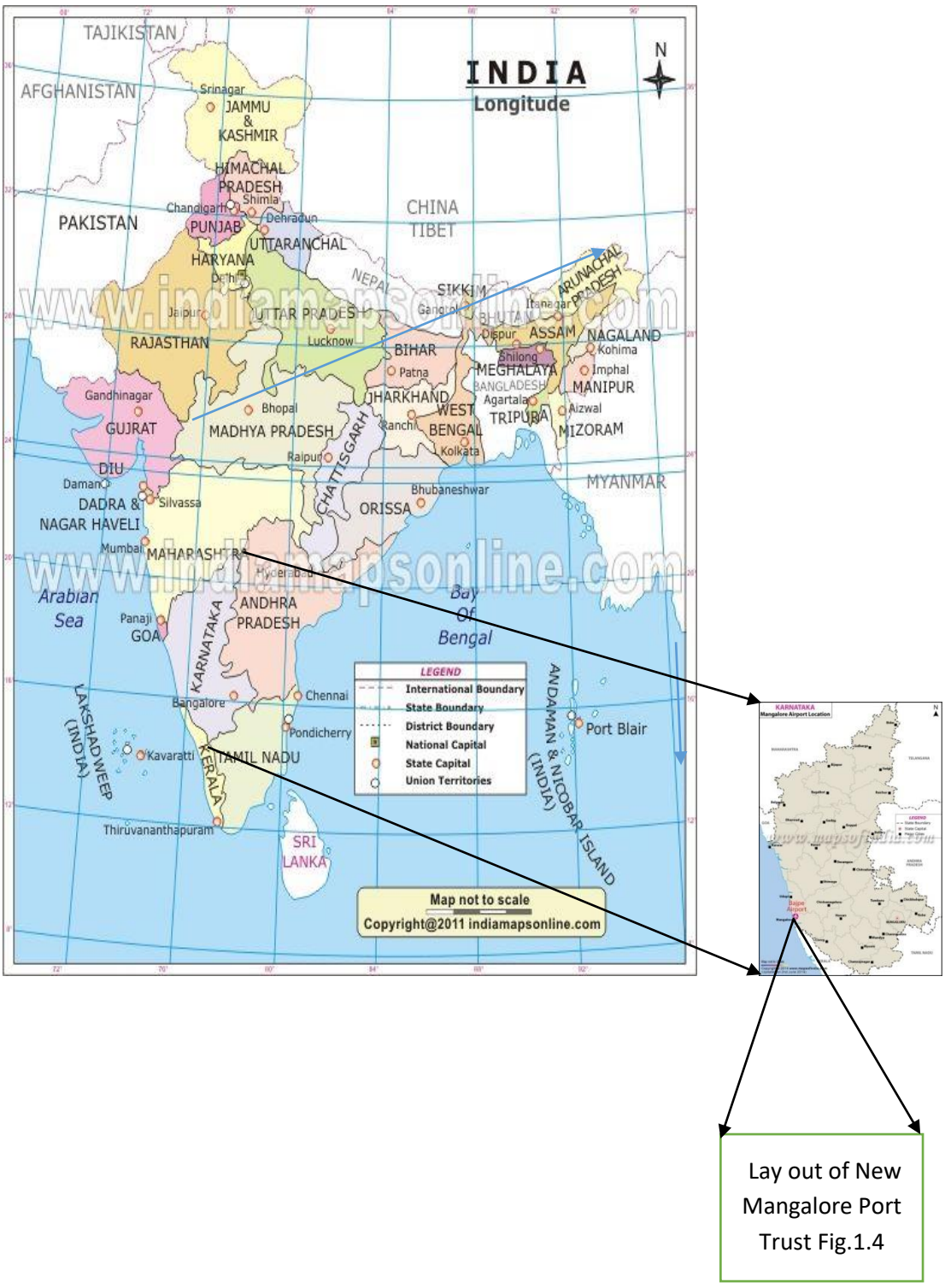
1.2.6. Importance/ Scope of the research work

The port managers are more concerned about the port time and cost, because the port time comprises of not only the cargo handling time but also non-productive time spent by the vessel in her stay in the seaport. The port has to allow the time for waiting for a berth, waiting for tides, manoeuvring and berthing alongside, waiting to start work, waiting at end of work, equipment break down, documentation, waiting for tugs, pilots and so on. It is estimated that the cargo liners spend almost 60% of their time in ports. This considerably adds to the fixed cost of providing shipping services. The time at port costs to the ship owners and their customers. The expenses are high for larger and latest vessels compared to the vessels of the past. This results in grate incentive to reduce the turnaround time in seaports. The port time is dependent on a large number of variables which are interrelated. The port productivity is the main goal of any port. It is observed in the case of NMPT that the number of vessels handled has a very strong positive correlation with the productivity. The larger the number of vessels handled per year, the higher is the port productivity. The turnaround time of vessels calling on to the port is having a negative correlation with the productivity of the port. It may be attributed to an increase in pre-berthing delay, inward movement, outward movement, and delay in service time (loading/unloading time). The smaller the turnaround time the larger the number of vessels handled per year resulting in increased port productivity and port performance. The turnaround time at a seaport will act as a yardstick for the selection of port for the shippers and freight forwarders. The ports having high turnaround time will cost more to the shippers and they will limit their vessels visit such ports. The study on the measuring the port performance and productivity for the NMPT, shows that the pre-berthing delay, turnaround time of the vessel and the idle time at berth are having a strong negative correlation with the port productivity.

It is evident from the study that the port productivity and performance at NMPT is a function of vessel turnaround time. The turnaround time of a vessel comprises of waiting time, inward movement time, berthing time, service time and outward movement time. The return on investment depends on the earning of a vessel during the entire life span. The voyage time of a vessel is the only earning period of the vessel, whereas the times spent in seaports are expenditure for the ship owners. Since, any vessel earns only when it is in the sea, any time in a seaport over and above the minimum time required for loading and unloading leads to a loss in profit along with extra expenditure incurred. Therefore, every ship-owner expects a very low turnaround time to get maximum benefits. Ports are a vital link in the logistic chain. Their efficiency is of vital importance in any effort of minimising the transport cost. Therefore, the shipping lines/shippers are always in search ports having a better turnaround time of vessels for their merchandise in the region or country. Time in ports costs, which are transferred to the shippers by the ship operators. Improvements in vessel turnaround time will be the only means of cost reduction in the maritime transportation system. Therefore it is very essential to identify the factors that are responsible for the high turnaround time of ships in the seaports.

1.3 Study Area

The study area selected is New Mangalore Port Trust (NMPT). It is a deep water all weather port located at Panambur, Mangalore on the west coast of India, in Karnataka state.(Latitude : $12^0$55'N , Longitude :$74^0$48' E). It is the 9^{th} major port out of 12 major ports of India. The map showing the location of New Mangalore Port, Karnataka, west coast of India is shown in figure.1.3 and the layout out of the NMPT is shown in figure 1.4.



Lay out of New Mangalore Port Trust Fig.1.4

Figure 1.3 Location of New Mangalore Port Trust

Figure 1.4 Layout of New Mangalore Port Trust.

1.3.1 New Mangalore Port Trust (NMPT)

The city of Mangalore is on the coastline of the Arabian Sea, and located in between the Gurupur river and river Netravati. It is historically recognised as a centre for ship building. The picturesque coastal city of Mangalore has been mentioned in historic literatures. Mangalore has been described as a port city on the mouth of the river Nitras (Netravati), in the manuscripts of great library of Alexandria. Prominent astrophysicist Ptolemy has also mentioned about this city in his records. The western coast of India, especially Udyavara and Mangalore (described as Mangala) is also referred in Greek drama . A quick trade route for various merchandises of export had been built by the Arab traders between Mangalore and west Asia during the reign of the Vijayanagar Emperor. An army watch tower was built at the banks of Gurupur river by the great king of Mysore, Tipu Sultan, which is now known as Sultan Battery. The history disclosed that the Mangalore port was connected to many important ports at that time, like Persia, Greece and Rome. Due to its geographical factors, Mangalore has been known for its prominence in sea trade. Expeditiously the Mangalore Port has grown into a rich business centre. Due to the growing demands to contemporize the shipping industry, the old port could not cater the needs of growing maritime traffic, after independence. To cope up with the increased demand, the need for a new port was felt and hence New Mangalore Port Trust was established. On 4th May 1974, NMPT was declared as a major port of India. The port was commissioned by formal inauguration by the then Indian Prime Minister, Smt. Indira Gandhi. Till 31st March 1980, both the project and the port were centrally administered by the Government of India. On 01st April 1980, the Port Trust Board was set up under the Major Port Trusts Act, 1963. From then onwards NMPT is serving as the 10th major port trust and has entered the club of other already functioning major port trusts of India.

1.3.2 Details of New Mangalore Port Trust

The port of New Mangalore is located in the Karnataka State on the western coast of India. It is coming in between the major port of Cochin at South and Marmagao port at the North. The port construction was started in the year 1964 and it became operational in the year 1974. There is a steady growth of traffic in NMPT from one lakh tonnes to to 42.16 MTPA during 1974-75 and 2017-18 respectively. The port

infrastructure has been developed in stages and at present, the port is equipped with facilities to face the needs and challenges of major industries and business centres in and around the Mangalore and the port hinterland. The port is well connected with rail and road to the various industrial cities in the states of Karnataka, Maharashtra, Tamil Nadu and Kerala. The implementation of Konkan Railway Project has given a tremendous boost to the traffic growth of NMPT and also established direct connection of Mangalore with Goa and Mumbai. The National Highway (NH) 66 runs from Kanyakumari in South to Panvel near Mumbai in North, connecting important business centres and industrial cities, passes through the port estate. Bangalore, the state capital is connected to the port city by NH 75. National Highway 169 connects Mangalore to Sholapur. The NMPT mainly handles cargos like coal, cock, granite blocks, timber logs, iron ore fines, iron ore pellets, lime stone, gypsum, crude and petroleum products. The port is also specialized in handling fertilizers and various types of chemicals and hazardous liquid cargo. The total area of port estate is 2350 acres including water spread area of 320 acres.

The port has developed and grown since its inception in stages. In the first stage, one shallow berth with a draft of 6.50 m and two general cargo berths with a draft of 9.50 m and one oil jetty with a draft of 10.50 m were constructed. In the second stage, two more general cargo berths with a draft of 9.50 m and an exclusive iron ore berth to cater the needs of Kuduremukh Iron Ore Company Limited (KIOCL) with a draft of 13.0 m were developed. In the third stage two more general cargo berths of draft 10.5m and an oil jetty for M/s Mangalore Refineries and Petro chemical Limited (MRPL) with a draft of 14.0 m were developed. In the fourth stage two more oil jetties were added one with 12.50 m draft for M/s MRPL and another multiuser jetty with a draft of 14.0m were constructed. In fifth stage a general cargo deep draft berth with a draft of 14.20 m along with another multiuser oil jetty with a draft of 12.50 m were added to cater the ever growing demand from the port users. In the year 2014 one captive coal berth for M/s Udupi Power Corporation Limited (UPCL) with a draft of 14.0 m and one Single Point Mooring (SPM) for M/s MRPL with a draft of 21.0 m to cater Very large Crude Carriers (VLCC) on BOOT basis on the policy of private participation in port sector under lease agreement were constructed. At present NMPT

is capable of handling 78.80 MTPA. The table 1.1 shows the Port Performance Indicators (PPI) for the year 1990-91 to 2014-15 of NMPT.

1.3.3. Salient Features of NMPT

- New Mangalore Port is an all-weather port with highest depth inner lagoon on the west coast of India with 15.40 m draft at the entrance channel and turning circle. The port is capable of handling ships throughout the year.
- First among all the major ports of India accredited with the certification of International Ship and Port Security (ISPS) Code and an ISO 9001-2000 Port.
- Equipped with Vessel Traffic Management System (VTMS) for effective handling of vessels during inward movement, berthing operation and outward movements
- The port estate is provided with 24 X 7 CCTV surveillance for the security and safety of the port operations and installations.
- The port is easily accessible to 3 National Highways namely NH 66, NH 75 and NH 169, Konkan Railway, South Western Railway, Southern Railway and Air port.
- Largest LPG handling Port in India among all major ports of India.
- Fully equipped container handling facilities with paved and secured container yard.
- Close to the major international sea route.
- Meeting all standards of Environmental Impact Assessment (EIA) quality as per the statutory requirements.
- Enterprise Resource Planning (ERP) solutions for all business transactions.

Table.1.1 Port Performance Indicators for the Year 1990-91 to 2014- 15 of NMPT.

Particulars	. Traffic Handled (In Million Tonnes)	Number of Vessels Handled	Average Pre-Berthing Delay (In Days)	Average Turn Round Time (In Days)	Average output Per Berth day (In Tonnes)	Idling Time At Berth (In Percentage)	Average output Per Hook Per Shift (In Tonnes)
1990-91	7.62	400	0.79	4.90	4368	46	202
1991-92	8.03	457	1.66	5.31	4776	46	200
1992-93	8.27	492	1.45	6.36	3288	47	204
1993-94	7.09	453	1.92	5.24	5568	48	190
1994-95	8.63	482	2.21	5.72	4560	56	204
1995-96	8.01	514	1.75	5.13	5592	51	224
1996-97	8.88	505	1.50	4.37	7117	48	259
1997-98	12.45	644	1.09	4.10	7258	47	284
1998-99	15.28	729	0.93	3.74	7514	46	341
1999-00	14.21	724	1.07	3.80	9004	40	391
2000-01	17.6	749	0.77	2.89	12190	35	428
2001-02	17.89	734	0.76	2.73	12538	33	481
2002-03	17.50	763	0.65	2.37	15939	24	487
2003-04	21.43	832	0.55	2.35	18048	19	789
2004-05	26.67	876	0.79	2.96	15576	18	1041
2005-06	33.89	1057	0.78	3.00	15048	18	1069
2006-07	34.45	1080	0.78	3.00	15048	18	1069
2007-08	36.02	1144	0.64	3.21	12664	19	1143
2008-09	36.69	1184	0.65	3.00	13644	16	1442
2009-10	35.53	1186	0.81	3.06	13895	19	1433
2010-11	31.55	1097	0.60	2.71	14205	19	1229
2011-12	32.94	1136	0.79	2.95	13960	16	1356
2012-13	37.04	1071	1.05	3.30	15917	16	1495
2013-14	39.36	1062	0.81	3.18	16304	18	1485
2014-15	36.57	1032	0.59	2.46	19414	14	1823

Source: Management Service division, NMPT

1.3.4. Services Provided by NMPT

The New Mangalore Port has been ever responsive to the changing needs of maritime trade. To achieve the success in the world maritime industry, the port is equipped with the adoption of modern technology and infrastructure and providing quality services. Some of the major services provided by NMPT are as follows.

1. Immediate attendance to ships because of simplified procedure for allocation of the berth on arrival of the vessel.
2. Round-the-clock navigation, berthing and unberthing of ships with house trained and harbour pilots of the department.
3. Single window system for various port clearances and payment of port dues through Enterprise Resource Planning (ERP) procedures to avoid the cumbersome practice of moving from one department to other by the port users/agents.
4. Green channel shipping for Star Trading Houses, clearing the goods without routine inspection and examination of goods for some major well-known importer/exporter based on certain well defined criteria.
5. Uninterrupted supply of power to the port users/service providers from the port power grid with reasonable cost.
6. Sufficient covered and open storage area near the berth for storage of import cargo before dispatching to the different destination and also storage of export cargo near the berth well in advance to avoid any delay in loading/unloading the cargo .
7. Ample open storage area inside the Security Compound Wall for storing the large volume of cargo for a longer duration.
8. Separate secured and paved container stack yard for storage of import/export containers.
9. Railway marshalling yard for handling rail bound cargo with link to the national railway net works.
10. Updating daily vessel position and containers in the ports home page so that anyone can have a view of the port operation from anywhere in the world.

11. Arrangements for supply of bunker and fresh water to vessels. Ample supply of water from the ports water supply network to all the vessels and crafts calling on to the port with minimal service charges.
12. Modern Cruise Lounge with all ultra-modern facilities and comforts for the passengers arriving at the port from various parts of the world.
13. Embarkation and dis-embarkation of passengers and services connected with cruise tourism so that they can visit to all the tourist palaces in and around Mangalore and nearby cities.
14. Fire fighting and salvage operations in case of emergency situations by the port fire brigade.
15. Allotment of port land on short term and long term lease basis to the port users for storage of their cargo before export or after the import.
16. Round the clock security coverage in land and water by the Central Industrial Security Force (CISF) personnel.

1.3.5. Important Infrastructures of NMPT

1.3.5.1. Water front facilities

New Mangalore Port is located at Latitude of $12^0$55' 46.6" N and Longitude of 74^0 48' 0" E. Its marine territory stretches from 21 Km offshore to a length of 12 km along the coast. The water spread area and lagoon of port cover an area of 320 acres (129 hectares). The navigational channel provides access to the port basin from the open sea. The channel is about 7.50 Km long, 245.0 m wide and 15.40 m deep and. It is protected by two breakwaters on northern side and southern side each of length 770 m. The distance from the tip of the breakwater to the turning circle is about 1.50 Km. The turning circle has a diameter of 570.0 m and a dredged depth of 15.10 m. The lagoon consists of 16 berths for both dry and liquid cargo vessels. One Single Point Mooring (SPM) buoy is provided at the outer side of the approach channel to cater the Very Large Crude oil carriers (VLCC) and other POL products. The details of berths are provided in Table 1.2.

Table.1.2 Berth Particulars of NMPT.

Sl.No.	Name of Berth	Type of Berth	Draft (In Mts.)	Length (In Mts.)	DWT	Capacity (in MMT)
1	Berth No.1	General Cargo	7.0	125	24000	0.30
2	Berth No.2	General Cargo	10.50	198	30000	2.10
3	Berth No.3	General Cargo	10.30	198	30000	2.40
4	Berth No.4	General Cargo	9.50	198	30000	1.40
5	Berth No.5	General Cargo	9.50	198	45000	1.30
6	Berth No.6	General Cargo	9.50	198	45000	1.20
7	Berth No.7	General Cargo	9.50	198	45000	1.70
8	Berth No.8	Iron ore/General Cargo	13.00	300	60000	4.20
9	Berth No.9	LPG/POL	10.50	280	45000	2.30
10	Berth No.10	POL/Crude Oil	14.00	320	120000	9.30
11	Berth No.11	POL/Crude Oil	14.00	320	120000	8.70
12	Berth No.12	POL/Chemicals	12.50	320	50000	2.30
13	Berth No.13	POL/LPG	12.50	280	45000	2.80
14	Berth No.14	General Cargo/Iron Ore/Coal	14.20	350	85000	5.80
15	Berth No.15	Coal	14.20	350	120000	9.60
16	Berth No.18	General Cargo/Coal	14.20	350	120000	9.90
17	SPM	Crude/POL	23.0	-	320000	13.40

Total capacity of all Berths at NMPT =78.70MMT

1.3.5.2. Land front facilities

The total land area of New Mangalore Port Trust is 2030 acres (822 hectares), excluding the water area of 320 Acres. The total port estate covers 2350 acres (951.04 hectares). The land front facilities include the cargo handling equipments, storage facilities, road networks and railway line facilities inside the port. The details of cargo handling equipments, transit/overflow sheds, covered warehouses, storage tanks are shown in Table 1.3 to 1.6.

Table.1.3 Cargo handling Equipments of NMPT.

Sl.No.	Equipment	Capacity	Total Nos.
1	Wharf Cranes	10Tons	3
2	Mobile cranes		
	i) TIL-Grove RT-880	75 Tons	1
	ii) Escorts model 8100 pick and carry Hydraulic crane	10 Tons	1
	iii) Reach stacker	40 Tons	3
3	Fork Lifts	1 Tons	2
		10 Tons	1

Table.1.4 Transit Sheds / Overflow Sheds of NMPT

Sl.No.	Area	Capacity	Total Nos.
1	5574 SQ.M - Transit Shed	10000 MT	1
2	4380 SQ.M - Transit Shed	8000MT	1
3	4920 SQ.M - Over flow shed	8830 MT	1
4	4380 SQ.M - Over flow shed	8000 MT	2

Table.1.5 Covered Warehouses at NMPT

Sl.No.	Area	Capacity	Total Nos.	Ownership
1	2190 SQ.M	4000 MT	4	NMPT
2	2600 SQ.M	6000 MT	3	NMPT
3	2190 SQ.M	4000 MT	4	CWC
4	2190 SQ.M	4000 MT	1	Consolidated Coffee
5	2190 SQ.M	4000 MT	1	Coffee Board
6	2190 SQ.M	4000 MT	1	Aspinwal& Co.

Table.1.6 Storage Tanks at NMPT

Sl.No.	Liquid stored	Total Capacity	Total Nos.	Ownership
1	Petroleum Products	1,22,452 KL	25	I.O.C
2	Chemicals/POL	52,000 KL	19	IMC
3	Molasses, Edible oil/PO	52,845 KL	8	IPWC
4	Edible oil	12,792 KL	3	Universal Agro Exports
5	Liquid Ammonia	10,000 Tons	1	M.C.F
6	Phosphoric Acid	16,000 Tons	2	M.C.F
7	Edible Oil	17,000 Tons	6	Mangalore Liquid Impex
8	Cement	18,000 Tons	3	Ultra Tech Cement
9	Cement	50,000 Tons	1	Ambuja cements

CHAPTER 2
LITERATURE REVIEW

2.1 General

Seaports are areas where there are amenities for berthing or anchoring of vessels. It has got facilities for the transfer of cargo from ship to shore and shore to ship or ship to ship. It acts as an interface between ship and shore in the maritime intermodal transport system. Present-day ports perform wider range of functions, beyond the cargo operations. They encourage the industrial, economic and social development of a country/region through the combined port services and related activities (Fujita and Mori, 1996).They act as economic multiplier for the nation's prosperity by facilitating the growth of infrastructure like highways, railways and a source of direct and indirect employment. Ports generate trade in the hinterland through logistic providers and other modes of transport, improving the shipping network, performing the function of fundamental part of the logistic intermodal processes in international trade (De Langen and Van der Lugt, 2006).

The ports have a great role in influencing the neighbouring nations and their role extends beyond the geographical boundary of the country. In particular, they significantly affect the various economic activities of landlocked nations. The port performance and efficiency along with the logistic supply chain management will control the cost of various services in the land locked neighbouring nations. High transit costs, which may include economic costs, or costs in time, may ultimately suppress merchandise activities of landlocked countries. This will badly affect their economic development, and progress on the nation as a whole. This is illustrated by the disparity in trade volumes (60% lower) and transportation costs (50% higher) in landlocked countries than in port hosting nations (UNCTAD, 2003). Though, it is possible that the port nations contribute to these high costs through general inefficient port services, the current situation is gradually changing. Allowing the private participation in the maritime sector is creating competition among the neighbouring ports, which inturn make the port authorities and governments to take strategic decisions in order to keep their customers in the landlocked countries.

2.2. Port Operations and Management

The port is a land area with both water side facilities and land side facilities for export and import of goods with a well-connected hinterland that has developed into a business and production centre, playing an important role in international trade and logistics networks (Notteboom and Winkelmans 2001). According to Langen (2003), ports are centre for various commercial activities. The ports are the point of intersection of the waterway with the road and rail network for the cargo collection and evacuation. Sea ports connect the domestic and international markets through worldwide transport network. Ports on looks the flow of cargo and services between the producers and consumers and different nations. They also act as transport centres in the intermodal logistics chain between waterway, railway and airway. Ports are the assets of the national logistic network and acts as a very crucial connection in the logistic chain. Developments of some of the great cities of the world are concentrated near the natural seaports. The cities like Bombay, Hong Kong, Dubai and New York are some of the examples. From the view point of users of the port, it is very important to manage the ports efficiently for the smooth flow of cargo and vessels through port terminals, which inturn determine the prosperity of ports (Robinson, 2006). To attract foreign investment, to create employment and to improve the international trade the ports are to perform very efficiently. The port performance is directly linked with the economy of the hinterland. Ports are the pivotal place for the interface of sea and land transport, where services are provided to vessels and cargo; they act as a nodal point in the maritime network. Ports not only provide value to third party logistic and shippers, they also increase the value themselves (Robinson, 2002). According to Bereford et al.,(2004) the indication that ports are the element of international supply chain comes from the fact that there is improved use of information and communication technology trends in the port. There are three types of container ports: Hub ports, direct call ports and feeder ports (Souza et al. 2003). There are three types of ports landlord, tool and service ports, which differ essentially based on the role of the port authority and the operators of private sector (Trujillo and Nombela,1999). Many of the major ports invested heavily on infrastructure and equipments and hence, port authorities are owners of the port estate land areas

(Bichou and Gray, 2005). The port dues collected and rent from the land are the income to the landlord ports. The port authorities have to create a sustainable economic development of the region and also generate income to cover the cost of investment by running the port in a productive and efficient way. The shareholders have to get a proper return on their investment (Lugt and De Langen 2007).In the service port model the managers of the port are responsible for all the activities of the port by providing infrastructure and recruiting manpower and providing services directly to the port users. The globalisation of industries and liberal economic policies are the main drivers of the change in the maritime sector.

In most of the countries ports are directly managed and operated by the government. The day- to-day port activities are managed by the constituted port boards generally by the national or regional governments (Long 2003). The constituted boards of the port are managing the port land with the responsibility of competitive and sustainable growth of port. The port managers are to deal with the present era port reforms, increased competition among the other ports and hinterlands (Lugt and Langen 2007).The present day logistic experts must be able to cope up with anticipated implications of fastest growing global changes in the maritime industry. One of the most important aspects of modern management tool is the ability to manage the change. Hence, the port management needs to get its forecast right to in the present competitive scenario.

2.2.1 Port Management

The port management is responsible for the regulatory functions and commercial operations. The fact that the ports last longer than the vessels is very significant in the area of port planning and design. Most of the world's ports, docks and terminals, were planned, designed and developed centuries ago, when the size of the ships were small and loading and unloading were done by manual means. It is very difficult to escape from bad decisions in the shipping industry. In any other business one can often escape from the nastiest effects of wrong decisions. In shipping industry the investments are very huge and decisions should be taken on a long term basis, since, the port is dealing with a collection of various merchandise activities within a fairly

random boundary. This makes it more difficult to develop universal concepts concerning the ports. Each port requires different management techniques based on the location and the region in which it is serving the hinterland.

Based on the type of management/service style the ports are classified

- Public service ports
- Tool ports
- Landlord ports.
- Private service ports

Public service ports have a mainly public character. At present, the number of service ports is declining. Many former service ports are in transition toward a landlord port structure. However, some ports in developing countries are still managed according to the service model. Under it, the port authority offers the complete range of services required for the functioning of the seaport system. The port owns, maintains, and operates every available asset (fixed and mobile), and cargo handling activities are executed by labour employed directly by the port authority. Service ports are usually controlled by the central government under the Ministry of Shipping and the day today activities of the port are managed by the chairman, appointed by the ministry and are accountable to the Government. The main functions of a service port are cargo handling activities. In some developing countries the cargo handling activities of the ports are carried out by a separate public department, often referred to as the traffic department. Such departments generally report to the same ministry as the port authority. In the case of the tool port model, the authority of ports creates, owns and maintains all the port infrastructure and port facilities. The operation and management of all the port equipments are done by the port staff. The loading and unloading activity of the cargo is carried out by private cargo handling agents. These cargo agents are outsourced by the port licensed shipping agents. The port authority issues licences to the registered shipping agents to carry out various shipping activities inside the port premises. The Chittagong port in Bangladesh is an example for the tool port model. Some of recent container terminals are managed and operated by the principles of Tool port model. This system creates conflicts among the port authority staff and private terminal operators. This, in turn affects the overall operational efficiency of the port. This bifurcation of various tasks within the tool port system clearly points out the key problems in this type of port management model. As the

operation and ownership of cargo handling equipments lies with the port authority and the cargo handling work is entrusted with private party through contracts through shipping agents or the cargo owner. The cargo handling contractor is unable to fully control all the operations of cargo loading and unloading operations. Some of the port authorities allow the cargo handling firms to use their own handling equipments to avoid the conflict between the port staff and contractor's staff. There are many similarities between a service port and a tool port in the form of its public participation and port financing. The port authorities have made available the land and superstructure to the cargo handling firms in the tool port model. There are opportunities for small and less capital asset firms to carry out business using the ports facilities and equipments, so that any loss or underutilisation of assets is usually bared by the port authority. This will minimise the risk of private cargo handling firms. The absence of investment for the cargo handling equipments and facilities made a significant threat to the large firms form development and function efficiently in the port by competing globally. From the above perspective, a tool port model has its advantages when this model is used as transition means to a landlord port model. This model can be used as a catalyst for the transition from service port to landlord port, the private sector participation not fully established and there if a risk for huge investment. It is the best port management model during the phase of port reforms without transferring the government assets to the private sector. The private sector utilises the port assets and facilities till the port activities are fully privatised through reform process.

The Landlord port is described by its blended open private introduction. Under this model, the port experts goes about as administrative body and as proprietor, while port activities (particularly freight taking care of) are completed by privately owned businesses. Instances of Landlord ports are Rotterdam, Antwerp, New York, and Singapore. Today, the Landlord port is the predominant port model in bigger and medium sized ports. In the Landlord port model, infrastructure is rented to private working organizations or to ventures, for example, treatment facilities, tank terminals, and concoction plants. The rent to be paid to the port expert is generally a fixed aggregate for each square meter every year, normally recorded to some proportion of

swelling. The dimension of the rent sum is identified with the underlying arrangement and development costs (for instance, land recovery and quay divider development). The private port administrators give and keep up their very own superstructure including structures like workplaces, sheds, distribution centres, compartment cargo stations and workshops. They additionally buy and introduce their very own hardware on the terminal grounds as required by their business. In Landlord ports, dock work is utilized by private terminal administrators, despite the fact that in certain ports some portion of the work might be given through a port wide work pool framework. In privatized service ports full privatization is considered by many individuals as an outrageous type of port change. It recommends that the express never again has any significant contribution or open arrangement enthusiasm for the port segment. In completely privatized ports, port land is exclusive, not normal for the circumstance in other port service models. This requires the exchange of responsibility for land from general society to the private segment. Also, alongside the closeout of port land to private interests, a few governments may all the while exchange the administrative capacities to private successor organizations. Without a port controller in the U.K., for instance, privatized ports are basically automatic. The hazard in this kind of plan is that port land can be sold or exchanged for non-port exercises, along these lines making it difficult to recover for its unique sea use. Additionally, there is likewise the likelihood of land hypothesis, particularly when port land is in or almost a noteworthy city. Moreover, closeout of land to private ports may raise a national security issue.

All over the world, there is a move towards full privatization of ports for the following major reasons:

- To modernize infrastructure and establishments, the both of which often dated back to the early long years of the industrial revolutions, to make them progressively receptive to the requirements and wishes of the clients
- To accomplish financial stability and budgetary focuses, with an expanding extent of the financing originating from private sources
- To achieve labour stability and a degree of rationalization, followed by a greater degree of labour participation in the new port enterprises.

2.2.2 Port activities

The commodities that are handled in a seaport are generally grouped into dry bulk cargo, break bulk cargo, liquid bulk cargo and container cargo. The examples of dry bulk cargo are coal, iron ore fines, cement, food grains. fertiliser and food stuffs. The break bulk cargo includes timber, wooden logs, granite blocks, machineries, equipments and uncontainerised cargo consisting of both Lift On Lift Off (LO- LO) and Roll-On Roll Off(RO-RO) cargos like, heavy mortar vehicles (HMV) and light mortar vehicles (LMV) and export/import of vehicles from mortar industries. The liquid bulk cargo consists of crude and POL products. There are two main components in any port system, the vessels and the cargo (Bichou and Gray, 2005).This necessitated two types of logistic services to be provided by the port. One is the service to the vessels and another service to the cargo. The services may be land side services or water side services. The services to the vessels consists of mooring and unmooring of vessels, berthing and unberthing, pilotage, repair and maintenance, supply of drinking water and bunkering. The cargo related services include cargo evacuation, transportation, warehousing and storage, cargo handling, distribution of cargo in the hinterland of the port area. The activities of a port may be within the port or across the regions of supply and the consumers. It may be between two ports or between the hinterland and the port. Langen (2003) stated that the port activities are based on the port related industries. Such port related industries may adopt all port activities that are necessary for the voyage of vessels and their goods and commuters through the port. The various categories of activities of the port related industries are tabulated in the Table 2.1

2.2.3 Port functions

Seaports have been conventionally been interpreted as an anchorage that can house vessels or it is the centre for ships to send out or take cargo. Today the functions of the sea ports have gone beyond their interpretation. They differ from the others on the basis of the service they can provide i.e. container terminals, multipurpose bulk ports etc. Their fundamental task is to transport, loading and unloading, storage and distribution. Some important ports are trying to reduce transport

Table 2. 1 Port-related activities

Category	Activities
Port related	Land and estate management, co-ordination of various stake holders, promotion and marketing, dock safety emergency preparedness and response, approach way and navigational signals and lights, quays berths, jetties, breakwaters, operational buildings, rail/roads and other utilities
Vessel related	Pilotage ,tug boats, Dock labours supply, Shipping agents, mooring/unmooring, bunkering, vessel supplies, vessel repairs and maintenance, container repairs and servicing, stevedores
Ship loading and unloading/discharging related	Private wharves, berths, jetties, container and bulk stevedoring, livestock stevedoring, bulk cargo loading/unloading, passenger terminals
Cargo services related	Customs brokers, freight forwarders, container packing/unpacking, cargo surveyors, wool dumping and fumigation
The land transport and storage related	Road transport, rail transport, transfer between road/rail and storage facilities and storage
Government agencies related	Customs, quarantine, ship safety, port safety, environmental management and port policy service.

cost and to reduce the amount of packaging damage have adopted various concepts of front port, back factory to afford organisation, congregation and classification of cargo with the advantage of their position. According to Harding and Juhel (1997) the functions of the port includes both the international logistic services and value added port services. Seaports emerge from cargo transhipment point to a variety of tasks in a maritime logistic system (Notteboom and Winkelmans, 2001). Due to the growing needs of the maritime trade the port functions have to be expanded and port has to work in a competitive environment. The value added services of the ports includes marketing, freight forwarding, financial activities, estate development, information to

the port customers, research and development, customs and security, insurance and other trade services. According to Bichuo and Gray (2004), the various logistic functions are to be integrated by the ports to become a logistic network than just a link in the maritime transport. Ports are not only an integral part of the transport system but also it is a system of port related production and logistics activities. By expanding the value added services and traditional services ports have opportunities to develop as logistic centre in a logistic chain (Fujita & Mori, 1996). The ports contribute to sustainable development of the country by easing infrastructural developments like roads and railway. This infrastructural development also creates direct and indirect employment to the public. Ports also provide a security boundary for the national safety, as ports are the entry and exit points of a country. Ports also monitor the passage of various commodities, cargo, agricultural goods and tourist transport to ensure safety of the country and its people. The port efficiency and national growth is severely affected by the issues related to port security that includes, smuggling, drug trafficking, human trafficking, theft and damage. Improving the transportation network, developing the relationship with other modes of transport and logistics provider are the functions of the inter model logistic process in the global trade (De Langen and Van der Lugt, 2006).

The following are the functions of various organizations within the port system

- Providing variety of services for the private players within the port logistic System
- Regulating the port operations and economic activities
- Acts as regulator for security, environmental conservation and protection marine safety
- Strategic planning for the future capital investments and operational requirements
- Providing nautical services and facilities to the vessels calling on to the port.
- Marketing and promotion of port services and supports economic development of a region
- Storage, transportation and cargo handling
- Providing value added services for port related activities

Due to the strategic importance of the port land and the properties, it cannot be handed over to the private entities. This affects directly or indirectly on the national and regional economy and welfare of the public. The main functions of the port authorities is the responsibility of managing the real estate within the port area as landlord because of its value and scarcity, as most of the ports are located near to the business centres where land value is very high. The port authority has to use the port land for economic exploitation and development of long-term infrastructures and maintenance of basic port facilities such as berths, approach roads, approach channels and fairways. Broad regulatory powers are entrusted to port authorities for control of both port operation and shipping. They are made responsible for use of laws, rules and regulations for the public safety and port security, protection of natural habitat, port navigation and health care. Port authorities make their own rules and regulations as port bylaws regarding the act of vessels in the port, utilisation of port area and other mandatory regulations. The port authorities have been also entrusted with extensive police powers to maintain law and order within the port boundary. The port has to coordinate with local municipality for their planning and development activities. This is because many of the large ports are located within the city corporation or near the business centres. Therefore the port planners have to give importance for the following points while planning.

- The plans have to be prepared according to the general conditions and bylaws that have been mandated by the local corporation authorities.
- The impacts of the port expansion and future development projects are minimal to the natural environment, railway traffic, roads and other facilities
- The port development projects shall be appropriate with respect to the norms of international and national and regional port competition

The balancing of demand and supply takes place at the level of port authority and the stake holders of the port or the port operators. Therefore, the port should take initiation for the investment in the development of the port infrastructure and port facilities. The port authority has to integrate with the investment plans of the port related industries and commercial port operators or the specific projects for storage,

cargo handling and distribution to arrive at a master plan for the port development. Then these individual master plans are merged into a national level port strategy based on the national economic considerations. These will help avoid replication of port amenities at other ports of the country. In other words the national port policy of any country shall be established by the central government to create a suitable framework for the overall development of the port sector. All the marine operations should be within the control of port authority. These functions are entrusted to the harbour masters of the port and generally comprises of all operations related to safety and security of the vessels within the harbour boundary. The harbour master allocates the various berths to the vessels and will coordinate all the processes needed to take the vessel inside the harbour waters and safely berthed and unberthed. Harbour master is responsible for the vessel traffic management and port related disasters like collision of vessels, explosions, marine pollution and natural disasters. The activities related to the loading and discharging of cargo into or from the vessels comes under cargo handling and storage functions. These also include warehousing, transport and distribution of goods. The terminal operators have to fulfil both the role of cargo handling onboard of the vessel and shore handling.

There are generally two sorts of cargo handling and terminal working firms. The more typical structure for terminal working firms is an organization that claims and keeps up all superstructures at the terminal (for instance, clearing, workplaces, sheds, stockrooms, and hardware). Different firms just utilize the superstructure or hardware that is possessed by the port. Such firms regularly just utilize stevedores or dock specialists and have for all intents and purposes with no physical resources. The port showcasing and advancement work is a legitimate augmentation of the port planning capacity. Port advertising is gone for advancing the benefits of the whole port complex for both the port specialist to pull in new customers and for the port business to for the most part advance its business. This sort of wide promoting is unmistakable from client situated showcasing that is gone for drawing in explicit customers and cargoes for explicit terminals or administrations. An assortment of subordinate capacities, for example, pilotage, towage and ship chandelling, fire insurance administrations, linesmen administrations, port data administrations, and liner and Shipping offices exist inside the port network. Huge port specialists typically don't

give these administrations, with the conceivable exemption of pilotage and towage. In various small ports, in any case, these are a piece of the port expert activities on account of the constrained traffic base.

2.2.4. Role of Ports

The ports are performing different roles based on the nature and scope of business activities. The major roles played by the ports are, they act as economic catalyst, employment creator, integrated logistic system. The various roles played by the ports in the changing business environment are enlisted as below.

2.2.4.1 Economic catalyst

A port acts as an economic multiplier in a region and plays a key role in the regional financial system and provides a connection between the customers and the suppliers. Cullinane et al.,(2003) notes that ports are increasingly linked to the economic competitiveness. Development of ports is beneficial to the regional economy from the economic perspective. Ports increase the economic value by improving the industrial activities and local clusters.(Benito et al. 2003). Bichuo (2006) found that the impact of ports is focused on port financial improvements and traffic efficiency. They act as catalyst to boost the economy of the region where they are located. The services of the ports and port related activities generate improved socio economic benefit in the region through planned development of urbanisation and environmental economy. Ports act as an engine and driving force for the national and local economic development and hence the decision makers consider ports as economic catalyst. The urban planning and development approach creators are keen on incorporating the ports in their local planning in order to have wellbeing, security and natural maintainability. (Gooley 1999; Bichou and Gray 2005). There ports can create expanded monetary profit by the exercises of owning the land, billet, terminals and freight dealing with (Cunningham and Meghan 2000). The goal of any port is to serve the enthusiasm of the country and backing to the provincial and national economies. According to the states arrangement the ports ought to be fit for taking care of oceanic exchange and improvement productively. They likewise advance the exchange and monetary improvement and work at worldwide dimension. Bryan et al. (2006)

assessed the financial significance of different port exercises in South Wales as far as port's commitment to the business age and neighbourhood economy.

2.2.4.2. Employment creator

The development of port acts as an employment creator by enlarging the opportunities for the job seekers. The port mechanization offers lots of opportunities for the new job creation to work with highly sophisticated machineries. The local community and the society is benefitted by getting direct and indirect jobs related to port activities and this will help them to increase their income and change the consumption pattern of the society. There is an increased cash flow through purchases from other industries and act as a multiplier of economic activities.

2.2.4.3. Integrated logistics system

Apart from creating the employment and generating incomes, ports also have indirect impact on the financial competitiveness by attracting investments, tourist attractions, national and international level trading activities and expanding their markets by the companies.(Bryan et. al 2006). Further, ports have an important function of promoting of knowledge and expertise and cultural communications. Robinson (2002) states that ports deliver value added services by creating competitive advantage, so that it can become more enterprising in value-driven logistic system. Grant et al. (2006) notes, ports can demand further dimensions and roles as trade channels and logistics centres in an combined logistics, traffic and supply channel method. In order to reduce the logistic cost the vessel sizes can be increased but it has extreme influence on the port planning and improvements. Firstly, it creates lots of stress on the existing port amenities and infrastructure, as all the ports cannot entertain the call of very large sized vessels due to lack of infrastructure like deep draft berth, backup land, cargo handing equipments, storage and warehousing, availability of tug boats and mooring launches. This also involves huge investments in dredging, expansion of existing wharfs or breakwaters. The larger vessels require better superstructure and high terminal capacities for loading and discharging of cargo with sophisticated cargo handling equipment and storage facilities (UNCTAD 2009).

2.2.4.4. Transport Infrastructure

Ports act as an integral part of national transport network and must be included in the national transport planning. National or local governments like to have some input into the port planning. Ports are also acts as the nation's strategic location for security and safety of the national coastline.

2.3 Measuring Port Productivity and Performance

Ports basically give multiple amenities for the ships, goods and inland transport. In the ongoing past there are fast changes in ocean transportation. The maritime segment has advanced towards sophisticated vessels of bigger size and increased speed. These latest very large carriers are of high cost and insist for better use and reduced inoperative of the ships. The port administration and management has progressively under stress to increase the performance of port by guaranteeing that the port gives services on cost effective basis globally(Simoes and Marques, 2010).There have been expanding strain to reduce the loading and discharging time in ports. As the interest from the transportation line expanded, interest for the quick administration from the ports likewise expanded. This brought about advancement and modernization of many ports all through the world to accomplish improved performance. The level of fulfilment gotten by the shippers will show the dimension of port performance accomplished. This implies ports need to upgrade their arranging and activity capacity by sending inventive gear's and best in class innovation so as to enhance terminal calculated procedure. So as to upgrade port terminal assets, it is extremely indispensable to guarantee that port operational stream can work easily. The port performance indicators are simply a measure of the efficiency of various port activities. Such indicators should be easy to calculate and simple to analyse and understand by the port managers. They should provide reliable input to the top management in the key areas of port operations. There exists a strong interrelationship between port productivity and various port performance indicators. The port productivity is thus a function of its performance. The measurement port performance is very complex, since port is a group of various profitable ventures of very large number of agencies render services and products (Langen et. al.2007).

There are no all-around embraced system to gauge the effectiveness of ports. Any techniques received by the port experts are just rough and just give a surmised value of effectiveness of different activities completed in the port. The fundamental reason for performance measurement is to give a guidance port administration for scheduling and control of port tasks. There are two classes of affecting elements in port performance, in particular client administration issues and cargo taking care of capacities (Murphy et al.1991). Performance estimation helps leaders through catching performance information. Administrators depend on measures as a vital component of arranging and controlling procedures (Neely et al.1997). For the most part, port performance is firmly related to factors, for example, extent of the hinterland, nearby item structure, neighbourhood financial improvement level, status of the world economy, and government arrangement on supporting exchange, landside framework, populace, and culture (Tongzon, 2002). Performance measurement is important for the efficient and effective management of organizations. It reflects on organization's objectives, customer requirements and the external competitive environment (Kennerley and Neely, 2002). It can be used to assess the success of organizations. Bruijn (2002) discussed how performance measurement can fill a number of functions, including transparency, learning, sanctioning, appraising and benchmarking between organisations and competitors. In a supply chain context, measuring performance is managerial tool that assists in planning and organizing activities, motivating workpeople, and controlling events within acceptable parameters (Morgan, 2004). The modern vessels are of high cost and therefore in order to increase vessel utilization for journey, there has been increasing pressure to reduce loading and unloading times at sea ports (Kumar et al.2004). There is no universally accepted port performance measurement system. Many researchers evaluated a wide variety of PPI, but these are dissimilar, as the port facilities and port infrastructure at every port differs (Bichou and Gray, 2004). The operational efficiency depends on the physical condition of port infrastructure and port facilities (Gordon et al.2005).Some of the possible indicators to measure the port performance are port related employment, the port throughput, the total volume of the trade. The ports are prominent node in the logistic network, fast and safe access to facilities at the port from the inland transport route forms a basic factor in measuring

the performance of the port. The Asian Development Bank (ADB) has incorporated port facilities as a very important characteristic of logistic chain. Inland distribution is becoming one of the important aspect of globalisation and maritime transportation model (Notteboom and Rodrigue, 2005). The investment on infrastructure can have both direct and indirect effects on economic development. It also results in high reduction in travel time and transport cost and it also encourages the expansion of business (Taleey 1996). The process of containerization increases the cargo volumes from the hinterlands, which in turn developed pressure on existing facilities at port and connection to the port hinterland and other related logistic networks. This leads to Inland access and port hinterlands relationships in the improvements of the ports (Notteboom and Rodrigue, 2005). In order to create importance to port infrastructure, it is necessary to match port hinterlands. The ports are required to be connected to the broader hinterland to attract increased cargo volume. Improving landside infrastructure helps in relieving port congestion and also helps the port to reach broader hinterlands.

2.3.1 Port Productivity and Efficiency

The Ports acts as a centre for the flow of international goods, distribution and storage. They are like commercial complex, It is also essential to have required sea draft and feeder services. The ports must combine every type of information networks to provide easy and efficient services to the port users. Ports should provide transparent custom service, easy and simple documentation procedures, and quick cargo loading/unloading facilities. The container loading and distribution of cargo must have well organised logistic services. To increase the performance and productivity, ports must adopt latest and sophisticated technology to provide more professional services to the port users with quick port operations, faster custom documentation, and lesser formalities to ease the logistic difficulties. Whether port has reached the level of the integrated supply chain and able to attract more sources of cargo is crucial for productivity and efficiency of the Port. Yeo et al.,(2008) found that the main factor that decides the competitiveness of the port is the condition of the hinterland. Port projects need huge investment for infrastructure and creating port facilities, without government policy and planning this is not possible. Therefore the support of

the government is also one of the factors in deciding the level port performance. The government may formulate maritime policies on the land allotment, tax rebate, public investment and other logistic support. It is the responsibility of the government to invest on creation of new port facilities and development waterway, construction and maintenance of port infrastructure. In addition to above supports the governments must motivate the trade partners and give assistance in the entry and marketing strategies. The financial policies of the government must give monetary support to the investors in port sector on interest of attracting more cargo. According to Grainger, (2007) the authorities of port play a crucial role in developing central expertise and economy by active participation in creating inland freight distribution centre, information systems and intermodality. The development of ports the government has to take major role by incurring huge investment on development of port infrastructure such as container terminals and deep draft berths and jetties to accommodate new generation vessels. There must be proper co-ordination of custom officials and port users for easy and fast custom Clearance formalities. As a whole the efficiency of the port may be assessed from different perspective and their control on merchandise facilitation (Clark et al.2004). Port authorities, planners of the port and managers require a consistent method of assessment of port performance, to estimate the effectiveness and efficiency of service provided to the customers. This envisages the requirements of optimisation of port operations and facilities in the present system of measuring port performance. To enhance the effectiveness of the ports the concerned government agencies have to promote e-governance. It is possible to save financial and human resources in business by implementing automatic operations and paperless transactions, that will also improve efficiency of port operations in logistic system.

2.3.2 Port Performance

In the present era of globalization, where international goods and commodities are to be transhipped from one country to other, it is estimated that about 90% of the international cargo is transported through waterways. Ports are the focal point of the maritime intermodal transport. In this view the performance of ports plays an important role in the international trade and economic growth of the country. In the ongoing past there are fast changes in ocean transportation. Maritime sector has

moved towards high-tech ships of bigger size and increased speed. These high-tech very large carrier vessels are of high investment and in this way necessitate expanded use and reduced idle of the vessel. Directors and experts at ports have progressively been experiencing strain to improve port performance by guaranteeing that the port gives benefits on a globally focused premise (Simoes and Marques, 2010).There have been expanding stress to decrease the loading and discharging duration at ports. As the interest from the transportation line expanded, interest for the fast administration from the ports likewise expanded. This brought about advancement and upgrading of many ports all over the world to accomplish increased performance. Indian government also developed some of the new ports and upgraded some of the existing ports after the Independence. The numbers of Major Ports increased from 5 at the time of independence to 12 in 2015.The performance of Indian ports are still poor compared with other ports in the region, such as ports of Singapore and ports of Colombo and ports of China. The performance of the port is measured based on multiple parameters (UNTCTAD 2000). Such study not only helps in comparing the different ports based on their performance, but also helps to take corrective measures by the port management. Calculating the level of performance of various aspects of any operation and used to compare the performance with a given target value is known as performance appraisal that operation. The port performance indicators are simply a measure of the efficiency of various port activities. Such indicators should be easy to calculate and simple to analyse and understand by the port managers. They should provide reliable input to the top management in the key areas of port operations. They can be used to compare the performance either with respect to time or with the fixed target by the national authority. Port performance measurement is complicated, since port is a cluster of economic activities where a large number of firms provide products and services and together create different port products (Langen et. al., 2007). There are no all-around received methods to quantify the productivity of ocean ports. Any strategies embraced by the port experts are just rough and just give a surmised gauge of productivity of different exercises did in the port. The real motivation behind performance evaluation is to give a manual for port administration for arranging and control of port activities. The history of performance appraisal is quite brief and Taylor’s time and motion study is the earliest efforts on

this concept. But the same cannot be universally adopted in the field of modern human resource management. Performance appraisal may be defined a structured formal interaction between a subordinate and supervisor that usually takes the form of a periodic review in which the work performance of the subordinate is examined and discussed with a view to identify weakness and strengths as well as opportunities for improvement and skill development(Dulewicz, 1989). Also port efficiency as a whole may be understood from various perspectives and its influence on trade facilitation (Clark et. al.,2004).A basic human tendency is to make judgments about subordinates, as well as about oneself appraisal seems both inevitable and universal. In the absence of a carefully structured system of appraisal, people will tend to judge the performance of others, including subordinates, naturally, informally and arbitrarily (Dulewicz, 1989). Apprises seems to have gathered acceptance of the appraisal process and feel more satisfied with it, when the process is directly linked to rewards (Bannister et.al,1990). There are two classes of affecting elements in port performance, to be specific client administration issues and cargo dealing with abilities (Murphy et. al.,1991). Performance estimation helps leaders through catching performance information. Supervisors depend on measures as an indispensable component of arranging and controlling Processes (Neely et. al.,1997). For the most part, port performance is emphatically identified with so many factors as extent of the hinterland, nearby item structure, neighbourhood financial improvement level, status of the world economy, government approach on supporting exchange, landside framework, populace, and culture (Tongzon, 2002).Performance estimation is significant for the proficient and viable administration of associations. It considers association's goals, client necessities and the outside aggressive condition (Kennerley and Neely, 2002). It tends to be utilized to survey the achievement of associations. Bruijn (2002) discussed how performance measurement can fill a number of functions, including transparency, learning, sanctioning, appraising and benchmarking between organisations and competitors. In a supply chain context, measuring performance is a managerial tool that assists in planning and organizing activities, motivating workpeople, and controlling events within acceptable parameters (Morgan, 2004). The modern vessels are of high cost and therefore in order to increase vessel utilization in voyage, there has been increasing pressure to reduce loading and

discharging period at ports (Kumar, et al. 2004).There are no internationally accepted systems to determine the effectiveness of services provided by ports, even though there is are large variety of indicators and measures port performance (Bichou and Gray, 2004).According to Arvis et al.(2010) the competency or incompetency of the services provided to the port customers, cargo carries , shippers and consignees by the ports can be assessed by the time indicators. Managers and authorities at ports have increasingly been under pressure to improve port performance by ensuring that the port provides services on an internationally competitive basis (Simoes and Marques, 2010). Measurement systems are required to assess the current cost, productivity and service levels at ports and to identify deficiencies within these ports. Hence, many studies have been undertaken in relation to port economics, port policy, port management, port terminals and port planning in order to evaluate port performance (Pallis et al., 2011). The other factors that decide the performance level of ports are its geographical location, depth of navigation available, water side facilities, land side facilities, the connectivity of port with the hinterland. The infrastructures at port like number of berths/jetties, buildings, equipments, tug boats, launches and other logistic facilities are also influence on the port performance. Tangzon (1995) noted that only less number of studies are carried out to identify and to explain the different factors that decides the actual performance of a port. He introduced the cargo throughput and operational efficiency as port performance indicators (PPI's). He also identified the location of the port, rate of arrival of vessels to the port, the port rates, economic activity of port city, efficiency of the cargo terminals are the highly influencing factors on the port throughput. He also stated that the size of the vessel, rate of cargo exchange, efficiency and productivity of cargo handling equipments, the work culture and containerisation are also influence the overall efficiency of port functioning. He suggested that for the improvement of the port performance, the crane productivity and terminal efficiency are the vital determinants and their contribution can be quantified.

The demand for the goods and services and the economic activities are closely interrelated and their effect on performance of ports in the region. The quantity and the type of products that has to be imported and exported are based on the level economic development, the structure of the product and the status of word economy.

The larger volume of throughput at port is expected in the local economy in the port hinterland is very good. There is a better international trading, if the world economy is very strong. When the economy of a region is in boom there is high demand for international goods. The scopes of hinterland, the population density, production industries in the hinterland are supporting local economy that decides the performance of the ports. The bigger the population and larger is the demand for consumption, that in turn influence the cargo volume at the ports. The volume of import and export is also depends on the policy of the government. At present the call on protection of environment necessitates the green logistic, which influences the performance of ports. The upcoming rules and regulation on the issues of environmental protection and conservation of water quality in ports are part of green logistic system. The political stability of nation is also influence on the performance of the ports (Peters 1990; Lim et.al., 2003).

2.3.3 Importance of performance measurement

Each and every port is unique in nature and it cannot be compared to other ports. The assets, land area, water spread area, functions, organisational structure, role of ports, policy of management differ from one port to other (Bichuo and Gray 2005). The performance measurement is one of the ways by which ports are compared and distinguished(Drucker 1962).To evaluate the port performance and to decide the corrective action for improvements of port operations, the Key performance indicators (KPIs) are used (Gunashekaran et. al.,2004) .According to Langen et. al. (2007) organisations can get information about the functioning management from the port performance indicators and PPI can be used as a method of evaluation of performance and interaction with the users of the port. To improve the effectiveness of seaport operation, the Performance Indicators of the port can be used as a guide, so that proper resources can be allocated and deployed at problematic operational areas. A set of criteria is evolved for both internal and external measures for various port activities, so as to ensure that the measured indicators are appropriate function of related port activities (Bowersox and Closs 1996). According to Hastings (1996) both the quantitative and qualitative measures of the port performance are to be taken into consideration while calculating PPI. Operational and financial measures are also to be

considered (Gunashekaran et. al., 2004; Kaplan and Norton 1992). Rather than single parameter port performance indicator, multi-parameter performance indicator gives better idea about the overall performance of the port activities (Monaco et al.,2009; Mclntyre et. al.,1998).

2.3.4 Port performance indicators:

Measuring the port performance is complex, because there are multiple activities that are being performed by a very large number of firms so as to provide service to the vessels in the seaport location (Langen et. al. 2007). Even though there are a variety of measures and performance indicators to calculate port efficiency and performance, there is no universally accepted performance measurement system as each and every port is dissimilar (Bichuo and Gray 2004). The World Bank categorised the PPI into two categories, financial performance indicators referring to income, expenditure, operating surplus and rate of return on investment and operational performance indicators referring to port through put, berth occupancy, berth utilisation and idle time). The accomplishment or failure of a business or a service can be ascertained by measuring the performance indicator. According to Robinson (2006), the total time spent, cost of operation and quality of service are three main variables for the satisfaction of the shippers and other stakeholders of the port. Bichou (2006) noted that most down to earth and hypothetical ways to deal with port performance estimation benchmarking are of three general classes: performance measurements and record techniques, financial effect studies and effectiveness outskirts approach. He inferred that the exhibition measures regularly fall into three classes namely measures of input (e.g., time, cost and asset), measures of yield (e.g., creation/throughput, benefit) and mixed measures (profitability, productivity, gainfulness, use, and adequacy). Port effects on the economy are estimated to survey the immediate, roundabout and instigated financial and social effects on their separate hinterlands. Performance of port is portrayed to create ideal yield and monetary riches. Much research is about port profitability or generation capacity to contrast real yield with ideal yield by utilizing wilderness technique, which evaluates port proficiency (Clarke and Gourdin 1991; Bichou 2006). The performance indicators as suggested by United Nations Conference on Trade and Development (UNCTAD, 1976) are shown in table no. 2.2.

. Table 2.2 Performance Indicator Suggested by UNCTAD

Operational Indicators	Financial Indicators
Arrival late	Tonnage Worked
Waiting Time	Berth occupancy
Service Time	Revenue per ton of cargo
Turnaround Time	Cargo handling revenue per ton of cargo
Tonnage per ship	Labour expenditure
Fraction of time berthed ships worked	Capital equipment expenditure per ton cargo
Number of gangs employed per ship per shift	Total contribution
Ton per ship hour at berth	
Tons per gang hours	
Fraction of time gang idle	

Source: UNCTAD (1976)

2.3.5 Performance Measurements in Indian Major Ports

The following are some of the port performance indicators measured in the Indian major ports.

2.3.5.1. Traffic Handled (Port Productivity)

Traffic handled is the cargo or goods transported generally for commercial gain by ship or any other mode of transport. Cargo handled at the port is the key data of the port which reflects the amount of port productivity. As the port has to provide different facilities according to the type of the cargo being handled, it also reflects the utilization of port facilities. Cargo handled during a period is the total of cargo loaded, cargo unloaded and cargo transhipped during that specified period (e.g. Financial Year i.e. from 1st April of a year to 31st March of the next year).

2.3.5.2. Number of Vessels Handled

Vessels handled are the number of ships operated at the ports during the financial year between 1st April of current year and 31st March of next year. Ships in which cargo operations commenced during the financial year and continued in the next financial

year should not be included. It may be noted that the ships which are detailed in the port, after completion of cargo operations, for some reasons and have not left the port during the year, must be included in the estimate of ships handled. It is clarified that the cargo loaded or unloaded partially, must be included in the categories of cargo handled during the year.

2.3.5.3. Average Pre-Berthing Waiting Time (APBWT)

This is the time taken by a ship from its arrival at the anchorage (reporting station) till it starts its movement to the working berth i.e. operational berth. If a vessel is brought into the port and berthed at a non-working berth and vessel is waiting for the availability of working berth, time spent at the waiting berth is to be included in pre-berthing waiting time. The average pre-berthing waiting time can be obtained by dividing the total pre-berthing waiting time of all cargo vessels sailed from the port by the number of cargo vessels berthed. Transit time from reporting station to non-working berth, if any, and transit time from non-working to working berth should not be included.

$$\text{Average Pre} - \text{Berthing Waiting Time} = \frac{\text{Total Pre} - \text{Berthing Time of Vessels sailed}}{\text{Total Number of Vessels sailed}}$$

2.3.5.4. Vessel Turn Round Time (VTRT)

Vessel Turn Round Time (TRT) in the port is the primary indicator to judge the quality of service being given by the port to the ships. VTRT is the total time spent by a vessel at the port from its arrival at reporting station till its departure from the reporting station.

2.3.5.5. Average Output per Berthday

Average Berth day Output is aggregate cargo handled divided by the total number of berth days (both at working and non-working berths) spent by the cargo ships during the year from 1stApril of current year to 31stMarch of next year

$$\text{Average Ship Berth} - \text{Day Output} = \frac{\text{Total Cargo handled by Vessels sailed}}{\text{Total Stay at Working Berth}}$$

2.3.5.6. Average Output per Hook per Shift

It is the total cargo handled / total number of hook shifts deployed.

$$\text{Average Hook} - \text{shift Output} = \frac{\text{Total Tonnage handled}}{\text{Total Number of Hook} - \text{shifts deployed}}$$

2.3.5.7. Idling Time at Berth

It is the total non-working time at working & non-working berths /total number of Vessels sailed. It is expressed as a percentage.

$$\text{Percentage of Non} - \text{working time} = \frac{\text{Non} - \text{working time at Working Berth x 100}}{\text{Total Stay at Working Berth}}$$

2.3.6 Port Delays/Congestion

Port delay/congestion arises when port capacity is insufficient to cope with the traffic arriving at the sea port. It is not a new problem and can occur at any port if there is a sudden surge in the demand or hold-up in the port such as a strike. After the oil price rise in 1980's, many of the OPEC countries spent their increased revenues on extra imports which caused severe congestion in many world ports. And many ports which are most seriously affected by congestion have developed various queue reporting systems. It is very important to identify clearly the cause of the delay, if for instance, the delay was caused by slow customs clearance but this was not recognised and new berths were built, then it would only aggravate the situation. Because of the severe nature of some of this congestion in the early 1980's United Nations Conference on Trade and Development (UNTAD) set up a small working group to analyse the situation. The working group summarised the major causes of congestion in seaports as follows

2.3.6.1. Port Planning

- Investment in new berths without ensuring that back-up areas, port access and operating capabilities such as trained man power, cargo handling equipments and warehousing space are able to service these new berths.

- Inadequacy of inland transport, both in capacity and efficiency, in relation to trucks, wagons, highways and port access routes.
- Late completion of port infrastructure and transport development projects, so that expected capacity is not available on time.
- Failure to keep traffic forecasts updated to reflect changes in the pace of major economic developments.
- Improvements by rebuilding the wharves without considering the expanding traffic volumes during the construction.
- Failure of port management and planning authorities to make adequate plans in time for port development
- Inflexibility in development plans to allow later stage changes in modes of traffic flows.
- Low appeal of port and shipping problems in the public mind, leading to lesser priority being accorded to port investment.
- Political and social interference which bears on the decision making processes.

2.3.6.2. Port Management

- Lack of continuity in the senior port management positions.
- Senior port management is chosen without considering the qualifications required for the job and without adequate provision for upgrading the knowledge.
- Too little training for other staff, particularly of middle management level and operating level.
- Lack of direct authority of management to effect remedial actions.

2.3.6.3. Port Labour

- Poor labour relations, leading to inefficient restrictive practices.
- Problems caused by too much or too less labour, according to circumstances.
- Inefficient deployment of labour.
- Failure to adopt working practices to local circumstances, such as climate.
- Lack of training of dock workers, especially in the use of sophisticated equipments.

2.3.6.4. Co- ordination

- Lack of co-ordination between different private and governmental organisations working in the port area.
- Inadequate consultation between the port authority and users of the port in case of operation and development.

2.3.6.5. Traffic

- Irregular traffic due to erratic import and export policies, especially in case of bulk purchasing and granting of import licences.
- Short term traffic variations due to unrationalised shipping schedules, leading to ship bunching.
- Too many ships operating on certain routes and consequently calling for small tonnages and making inefficient use of berths.
- Inefficient distribution of cargo between hatches thus preventing intensive working of ship.
- Cargo stowed at port of loading without considering the efficiency of discharge.
- Forms of packaging and cargo presentation unsuitable for efficient handling at port.
- Consignees without adequate financial resources or physical facilities to take the cargo.
- Ships spending longer than necessary at berth for reasons such as slack in their schedules.

2.3.6.6. Operations

- Inappropriate policies which lead to transit facilities being used for long-term storage where space is inadequate, thus reducing berth throughput.
- Lack of inland or port warehousing facilities, causing cargo to remain too long in the port transit facilities.
- Necessity of handling bulk cargoes at general cargo berths.
- Lack of reserve capacity to deal with recurring surges of demand placed on ports.
- Pilferage and smuggling resulting in tight controls which impede free and efficient cargo movement.

- Lack of finance for modern handling equipments
- Inefficient mix of handling equipments due to circumstances beyond the control of port management.

2.3.6.7. Maintenance

- Absence of preventive maintenance and running maintenance results in a high proportion of equipments being out of service.
- Lack of qualified maintenance personnel.
- Inadequate stock of spare parts.
- Insufficient standardisation of equipment types.

2.3.6.8. Clearance procedures and documentation

- Late arriving documents and faulty documents.
- Outmoded documentation requirements and processing methods.
- Outmoded clearance facilities for vessel and cargo.
- Importers allowed to order shipments without sufficient funds to take delivery on arrival.

2.3.6.9. Dynamic effects

- Changes in ship types, especially on a experimental basis, with inadequate prior consultation, leading to temporary inefficiency.
- Teething troubles with new cargo-handling methods.
- Emergency diversion and transhipment of cargo destined for another port which lead to temporary peaks in quantities of cargo which a port has to handle.
- Periods of exceptionally bad weather.

Port congestion/delay emerges when port limit is deficient to adapt to the traffic touching base at the ocean port. It's anything but another issue and can happen at any port if there is an unexpected flood in the interest or hold-up in the port, for example, a strike. After the oil cost ascends in 1980's a large number of the OPEC nations spent their expanded incomes on additional imports which caused serious blockage in many world ports. What's more, many ports which are most genuinely influenced by delay have created different line of announcing frameworks. It is critical to distinguish obviously the reason for the deferral, if for example, the postponement was brought about by moderate traditions freedom however this was not perceived and new

compartments were fabricated, at that point it would just bother the circumstance. In view of the serious idea of a portion of this blockage in the mid 1980's United Nations Conference on Trade and Development (UNTAD) set up a little working gathering to break down the circumstance. The following are significant reasons for delay in seaports as pursues.

2.3.7. Vessel Turnaround Time and Port Cost

The port managers are more concerned about the port time and cost, because the port time comprises of not only the cargo handling time but also all non-productive time spent by the vessel in her stay at the seaport. The port has to allow the time for waiting for a berth, waiting for tides, manoeuvring and berthing alongside, waiting to start work, waiting at end of work, equipment break down, documentation, waiting for tugs, pilots and so on. It is estimated that the cargo liners spend almost 60% of their time in ports. This considerably adds to the fixed cost of providing shipping services. The time at ports costs to the ship owners and their customers. The expenses are greater for larger and latest vessels compared to the vessels of the past. This results in greate incentive to reduce the turnaround time in seaports. The port time is dependent on a large number of variables which are interrelated.

The turnaround time issue, which has been examined and contended by many researchers since the rise of containerization throughout the previous three decades have advanced a great deal of improvement. As per UNCTAD, 1976 under operational marker, it states unmistakably turnaround time is urgent to be considered, where it depicts port capacity and capacity to give enormous services high efficiency and performance to port client. Oram and Baker, (1971) characterize vessel turnaround time as the procedure required for loading, releasing and overhauling a vessel from berthing until the vessel's flight. This period begins from genuine entry of a vessel at billet to its real takeoff from the compartment. The strategy for estimating vessel turnaround time has been furnished by Amoyaw, (1999) and Imikata (1978).The most important objective for a sea port should be to increase its throughput or in other words, to reduce the turnaround times of vessels. It is evident that vessel turnaround time is considered as a significant factor when shipping lines make their

port selection decisions. According to Jayaprakash and Gunasekaran (2012), Vessel Turnaround Time (VTT) is widely used as a tool to measure a port's performance. In fact, Mak and Sun (2009) state that vessel turnaround time is the most important parameter out of all the service performance measures. Preston and Kozan (2001) express the vitality of turnaround time for ships, as it becomes their objective to minimize the time spent at the berth. Less VTT not only increase revenues from higher total sailing time per a given time period (higher number of voyages), but also from operational and other cost savings resulting from faster turnarounds, shipping lines could improve their profits. VTT is directly affected by efficiency and productivity of terminals according to Clark, Dollar and Micco (2004). Further Goodchild and Daganzo (2004) state that "Ship turnaround time is dominated by the time necessary to unload and load containers". In their study to identify the persuasive factors for hub port choice of main lines in East Asia, Cherng-chwan and Hui-huang (2005) revealed that 'handling efficiency' is the most influential factor above all other internal factors they considered. Tongzon (2002) explains that "port authorities should give priority to efficiency enhancements" so that they will result in providing faster and better services for the vessels, enabling them to be turnaround quicker. Vis and Koster (2003) consider taking a similar view by suggesting that terminals should enhance their planning and operation capabilities by installing innovative equipment and state-of-the-art technology in order to optimize the turnaround process. However, according to Kasypi and Shah (2010) it is pointless in mere investments in state-of-the-art facilities without having world class productivity. Kasypi and Shah (2006) developed a regression model that relates turnaround time and port facilities. A key finding was that turnaround time is highly correlated with crane allocation giving terminal operators opportunity to determine optimum crane allocation to achieve the desired turnaround time. Authors highlight that port operators around the world invest highly on infrastructure, information and communication technology, multi skilled manpower, and equipment to achieve better turnaround time for vessel at berth. The most important objective for a Port is to increase its throughput or in other word is to decrease the turnaround times of vessels. The high incident of ship cost incurred in a seaport is the reflection of high port dues, pilotage, towage charges and cargo handling charges are of relatively greater importance, may be the deleterious effect of

high vessel turnaround time (UNCTAD, 1964). The managers and authorities at ports are under pressure to improve port performance by ensuring that the port provides services on an internationally competitive basis (Simoes and Marques, 2010). The turnaround time of a vessel is depends on the effectiveness of allocating and scheduling key resources such as, quay cranes, yard cranes, berths and trucks. The issue of turnaround time for vessel is related with berthing cost for shippers and increment voyage for vessel itself. Hence the objective is to minimize the time vessels spend at berth. Port users are looking into berthing side as it is actually can determine the whole aspects such as cost, voyage, marketing, planning and scheduling. The deciding factor here is turnaround time for vessel, because it is able to solve a lot of things for shipping industry. Consequently, taken into consideration supply chain process. High turnaround time means the process from raw material to user is able to reduce, therefore economic of scale is able to be achieved.. It is not easy to coordinate all those port activities which make for efficient service, those that have done so find that there are benefits, even though they have to be shared between the interests of port authority and the ship owners. It is often possible to pass the costs on further down the transport chain, especially where there is little or no competition. The turnaround time is one of the factors that should be included when measuring port performance; the other factors are material handling or labour productivity and berth occupancy (Oram and Baker, 1971). Port performance indicators are useful in getting distinction between port efficiency and effectiveness as well as in measuring port performance (Tongzon, 1995).Port efficiency as a whole may be understood from various perspectives and its influence on trade facilitation (Clark et al. 2004). For this reason, optimization of facilities and operations is the common goal in current measurement systems. In a supply chain context, measuring performance is a managerial tool that assists in planning and organizing activities, motivating workpeople, and controlling events within acceptable parameters (Morgan, 2004). Broadly acknowledged performance estimations are inaccessible, in spite of the fact that there is a wide scope of measures and markers for port productivity and performance, as ports are different (Bichou and Gray, 2004). This implies that ports need to upgrade their planning and activity ability by conveying inventive gear's and best in class innovation so as to streamline terminal strategic procedure. So as to

enhance port terminal assets, it is extremely fundamental to guarantee that port operational stream can work easily. Singapore, (Gordan et. al.,2005) notice, even a little country can outperform its common requirement by clearly effectively applying data innovation in basic regions with the motivation to build the island's ability to deal with colossal throughput in port compartment terminal. Apart from that, Singapore is additionally giving steady government arrangements to Shipping line, sufficient venture from government and private, just as tasks, area, and profound water draft for vessel, and at the same time supports Singapore's port among port clients. In fact, empirical estimation of port efficiency differs across many factors, including the method used for measuring efficiency, the type of data and the region or country in which ports are located (Odeck and Brathen,2012). Based on efficiency scores for ports, previous studies had dissimilar results and conclusions; some shoed high scores and others showed low efficiency scores. This raises the question of whether there is something wrong with the techniques used or simply whether something is not captured by the existing studies (Bichou 2012).Jayaprakash and Gunasekaran (2012) state that ports of developing countries face unwarranted delays with variations, resulting from crew working behaviour, lengthy port procedures and other unexpected natural disturbances. According to these authors with reference to the Indian ports highest percentage out of total turnaround time was consumed by delays with a percentage of 55 %, followed by 43 % of service time and a 2 % of pilot time. This highlights the importance of non-cargo transferring time and delays towards VTT. Henesey et al.(2004) point out that, Government authorities such as customs and health and their procedure could also cause delays. The current outlook and increasing globalization of economies call for higher efficiency from all actors in the transport sector, especially ports, where there is massive public input in their production processes (Berqantino, et al.2013).Efficiency plays a key role in container port completion (Yuen et al.2013). It is time to think about long – term plan for upgrading infrastructure facilities in the major ports (Rajashekar, et al. 2014). Reforms initiated at major ports have given boost to their performance and enhanced market expectations on their efficiency levels. Therefore, it is essential to check the actual competence levels at these ports so that appropriate future plans can be envisaged for their sustainable growth. The study found better efficiency levels at a majority of

these major ports (BhanuPrakash, et al. 2016).Modernization of Indian infrastructure and optimum capacity utilization of resources in sea ports are the need of the hour to cope up with the world standards. Hence, the ports and shipping industry is bound to undergo substantial changes in their maritime web (Padmasani and Tamilselvi, 2016).

2.3.8. Problem Formulation

The first generation ports are merely the cargo interface location between land and sea transport and can be usually recognised by the following features

- It is usually isolated from the transport and trade activities and sees its function in terms of cargo transfer from ship to shore.
- It considers itself as an independent kingdom with little or no co-operation with local authorities.
- The different port activities are isolated from each other.
- It is usually either a break bulk or bulk port.

The present generation ports are developed as transport, industrial and commercial service centres. The port is seen as the hub of the international production and distribution network. The port management is proactive rather than reactive. The main motive behind the port management is the quest for greater efficiency. Efficiency is defined as the optimum use of resources within an acceptable context of safety. Minimisation of the cost and maximisation of the benefits are port management's objectives. The cost can be minimised by minimising payments by users in the port including ship's time at a seaport. The reduced ship's time at a port minimise users total through transport cost and port cost and maximise the benefits to port authority, port town, region and country. The efficient ports attract more customers and more cargo and thus ports within the same country, region, zone and coastline are into serious competition with each other. In other words, they strive to get more ship and cargo patronage than the others. Improvement in port performance is a pre-requisite for further patronage by shippers and ship owners. Port performance variables include volume of vessel traffic, volume of cargo traffic, container traffic and most importantly the turnaround time of vessels in the port.

Port turnaround time has become an increasing important factor in deciding port of call all over the world. It is estimated that the cargo liners spend almost 60% of their time in ports. This considerably adds to the fixed cost of providing shipping services. The time at ports costs to the ship owners and their customers. The expenses are greater for larger and latest vessels compared to the vessels of the past. Whereas the interest of port management is to increase the productivity by attracting more number of vessels in a given period of time. It is clear that the number of vessels handled has a very strong positive correlation with the productivity. The larger the number of vessels handled per year, the higher is the port productivity. The turnaround time of vessels calling on to the port is having a negative correlation with the productivity of the port. It may be attributed to the increase in the pre-berthing delay, inward movement, outward movement, delay in service time (loading/unloading time).The smaller the turnaround time the larger the number of vessels can be handled per year and which in turn increases the port productivity and the port performance. Most ports are marginalized by ship operators due to the ports inability to render friendly services to the ships called. Vessels will limit patronage to ports whose time is high. Shippers, ship owners as well as freight forwarders use the turnaround time of vessels at port as a yardstick for port selection.

The study of port performance indicators at New Mangalore Port Trust, shows that the pre-berthing delay, turnaround time of the vessel and the idle time at berth are have strong negative correlation with the port productivity. It is evident from the study that the port productivity and performance at New Mangalore Port Trust is a function of Vessel Turnaround time. The Turnaround time of a vessel comprises of waiting time, inward movement time, berthing time, service time and outward movement time. The provision of more berths of the quays relative to the number of calling ships at the port through the application of queuing technique has reduced waiting time for most global ports to the barest minimum. Optimal number of berths for any ports could be calculated with precision. However, the advent of larger or bigger vessels at the quays, as ship operators try to enjoy the benefits of economy of scale in the shipping industry means that Vessel Turnaround time problem. The return on investment depends on the earning of vessel during her entire life. The voyage time of a vessel is the only earning period of the vessel, whereas the time spent in seaports is

expenditure for the ship owners. Since any vessel earns only when it is in sea, any time in a seaport over and above the minimum time required for loading and unloading leads to loss in profit along with extra expenditure incurred

Therefore every ship owners expect a very low turnaround time to get maximum benefits. Ports are vital link in logistic chain, their efficiency is of vital importance in any effort in minimising the transportation cost. And thus the search for a better turnaround time of vessels in port cannot be over emphasized. Time in ports costs which are transferred to the shippers by the ship operators. Improvements in this will be the only means of cost reduction in the maritime transportation system. Therefore the research questions can be stated as: What are the factors responsible for the turnaround time of ships in the port, which among the delay factors are critical hence, need to be tackled first under a constraint budget.

2.3.9. Research Gaps and Objectives

Growing competitive forces affecting ports emphasize the need for greater performance levels that extend beyond criteria such as the optimization of operations, cost reduction, time efficiency and trade promotion. More and more ports are expected to improve performance in other areas like security, safety, resource conservation, environmental protection and social inclusion etc. These factors are relevant to the global sustainability agenda and achievement of the Sustainable Development Goals. Productivity gains and improved efficiency and operational performance are becoming even more important, given recent developments affecting the liner shipping market. Adapting to the new paradigm means that ports will need to upgrade their performance, including in terms of turnaround time (time in port of ships), dwell time (time in port of cargo), gate operations, hinterland connections and intermodal connectivity.

There are a wide range of studies on port efficiency but curiously enough, these studies have never focused on turnaround time in ports, despite this being considered as a key performance indicator. More often we see studies in operation research about queuing models of vessels in relation to port planning and berth allocation and port productivity, but there is a drastic lack of systematic recording and analysis of ship turnaround times. While recognizing the inherent limitations of such a measure, ship

time in port or turnaround time could, nevertheless, provide a proxy for overall port performance, as it measures the average time that ships spend in a port before departing to another destination. The average time in port corresponds to the difference between the time a ship enters a port's limits, and the time it leaves those limits. Regardless of whether a ship's visit is related to cargo operations or other operations, such as bunkering, repair, maintenance, storage and idling, time in port includes the time prior to berthing, time spent at berth (dwell and working times) and time spent undocking and transiting beyond port limits. While the average time does not measure the precise efficiency of time in port since it does not distinguish between waiting time, berth time, and working and idle time, the data provide an estimation of overall time in port.

Indian ports play a crucial role in trade and economy, as 95 % of merchandise trade is handled by ports. However, port turnaround time remains a key problem. It is significantly slower than across peer ports in other developing countries, being several times higher than for ports in China, Singapore and Malaysia. Port authorities have fixed timelines for the loading and unloading of goods. Bonuses were announced for those that ran efficiently, penalties imposed on those that exceeded deadlines. Significantly, this scheme was implemented only after the government increased cargo handling capacities at all ports. However, the problem of the Indian shipping industry has always been the turnaround time at port. The Japanese port of Yokohama is the world's fastest, having average turnaround time of 15 hours. Indian ports, on the other hand, recorded an average turnaround time of 68 hours, nearly four times the global average. The longer a ship stays in port, the more expensive it is; one estimate pegs the cost of a single hour's delay at $1,200 for a cargo ship in Indian Ports. The port processes are to be streamlined and capacity augmented to reduce the turnaround time. The port performance requires a set of measures related to vessels stay at port, rate of loading/unloading the cargo and quality storage/inland transport. There exists a strong interrelationship between vessel turnaround time and port productivity. The term port productivity is defined as the total traffic/cargo handled per annum expressed in million tons (MTPA), both import and export in the maritime industry. The port productivity is thus a function of its performance. This means ports need to enhance their planning and operation capability by deploying innovative equipments

and state-of-the-art technology in order to optimize terminal logistic process. Table 2.3 shows the average vessel turnaround time of New Mangalore Port Trust for a period of 1990-91 to 2017-18. And Table 2.4 shows the average vessel turnaround time of major Ports of India for a period of 1999-00 to 2017-18.

Table.-2.3. Average turnaround time for New Mangalore Port Trust

Sl.No.	Period	Average Turnaround Time (in Days)	Sl.No.	Period	Average Turnaround Time (in Days)
1	1990-91	4.90	15	2004-05	2.96
2	1991-92	5.31	16	2005-06	3.00
3	1992-93	6.36	17	2006-07	3.00
4	1993-94	5.24	18	2007-08	3.21
5	1994-95	5.72	19	2008-09	3.00
6	1995-96	5.13	20	2009-10	3.06
7	1996-97	4.37	21	2010-11	2.71
8	1997-98	4.10	22	2011-12	2.95
9	1998-99	3.74	23	2012-13	3.30
10	1999-00	3.80	24	2013-14	3.18
11	2000-01	2.89	25	2014-15	2.46
12	2001-02	2.73	26	2015-16	2.82
13	2002-03	2.37	27	2016-17	2.43
14	2003-04	2.35	28	2017-18	3.34

Source: NMPT Port statistics

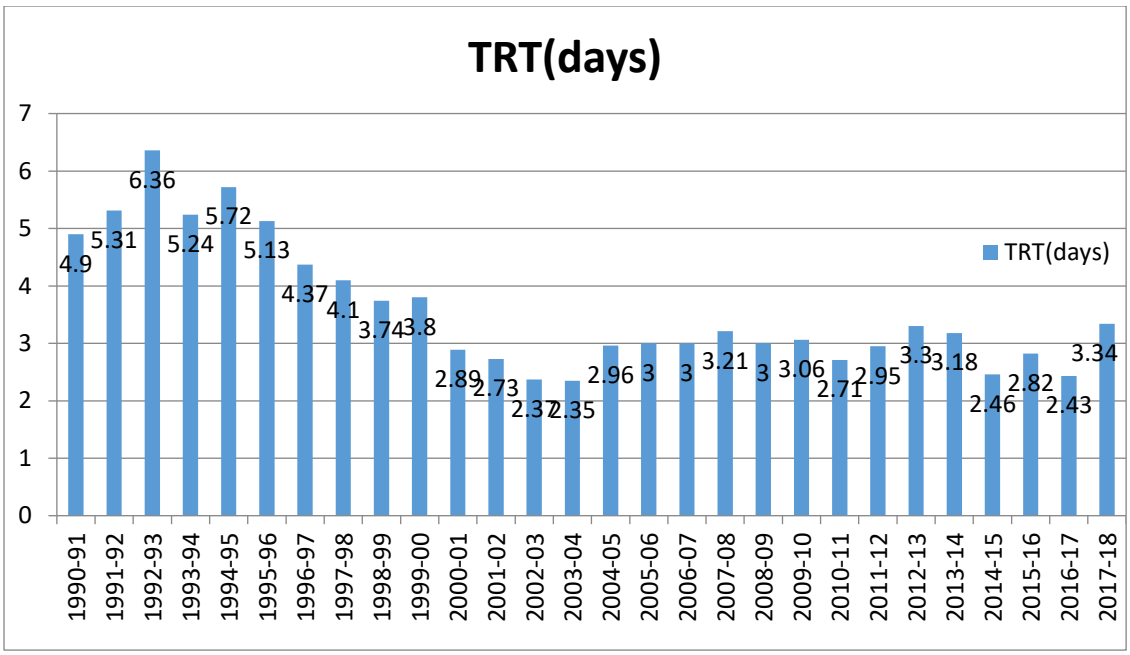


Figure 2.1.Average turnaround time for New Mangalore Port Trust (in days)

Table.-2.4 Average turnaround time for all Major Ports of India (in days)

Sl.No.	Period	Average Turnaround Time (in Days)	Sl.No.	Period	Average Turnaround Time (in Days)
1	1999-00	5.10	11	2009-10	4.63
2	2000-01	4.24	12	2010-11	5.29
3	2001-02	4.44	13	2011-12	4.56
4	2002-03	3.81	14	2012-13	4.29
5	2003-04	3.93	15	2013-14	3.84
6	2004-05	3.54	16	2014-15	4.01
7	2005-06	3.63	17	2015-16	2.82
8	2006-07	3.8	18	2016-17	2.43
9	2007-08	4.0	19	2017-18	3.35
10	2008-09	4.2			

Source: Port statistics –MOS

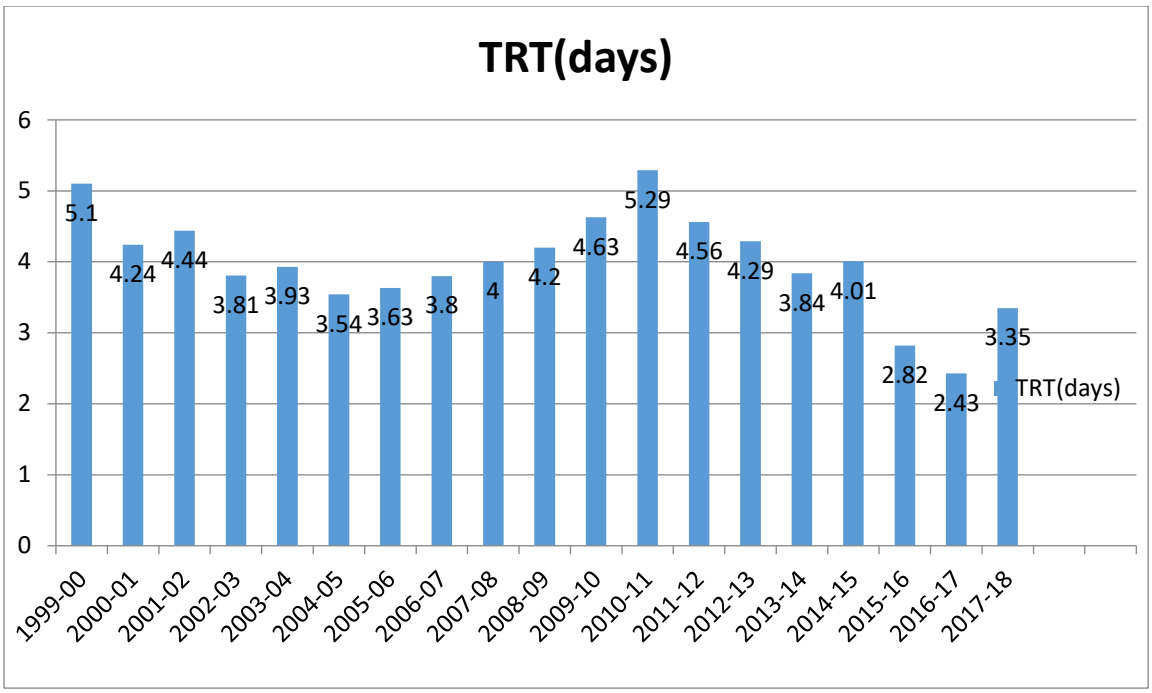


Figure 2.2Average turnaround time for major ports of India (in days)

The literature review reveals that there are a wide range of studies on port efficiency but curiously enough, these studies have never focused on turnaround time in ports, despite this being considered as a key performance indicator. More often we see studies in operation research about queuing models of vessels in relation to port planning and berth allocation and port productivity, but there is a drastic lack of systematic recording and analysis of ship turnaround times. Indian ports play a crucial role in trade and economy, as 95 % of merchandise trade is handled by ports. However, port turnaround time remains a key problem. It is significantly slower than across peer ports in other developing countries, being several times higher than for ports in China, Singapore and Malaysia.

The purpose of the research is identification of factors responsible for delays in turnaround time in the New Mangalore Port Trust as well as modelling them as optimization techniques. The objective function is to minimize time relative to the identified constraint factors. In pursuant of this goal, the following objectives will be addressed. The main objective is to evaluate the time optimization factors, which

causes delay in turnaround time of vessels calling on to the Port. The specific objectives include.

1. To identify the specific factors influencing the turnaround time of vessels, to know the port performance
2. To determine the weightage for each factor which causes the delay in TRT, to take corrective measures
3. To determine the critical factors responsible for higher TRT for optimisation of TRT
4. To develop a general vessel turnaround time optimisation model

CHAPTER 3
MATERIALS AND METHODOLOGY

3.1 General

Turnaround time in a seaport expresses the capability and ability of a port in providing efficient services. Ship turnaround time is one of the most significant indicators of service to ship operators. This is the total time, spent by the vessel in port, during a given call. It is the sum of waiting time, berthing time, service time (i.e. ship's time at berth), and sailing delay. Indian ports play a crucial role in trade and economy, as 95 % of merchandise trade is handled by ports. However, port turnaround time remains a key problem. It is significantly slower than across peer ports in other developing countries, being higher than for ports in China, Singapore and Malaysia. The port processes are to be streamlined and capacity augmented to reduce the turnaround time. The provision of more berths or the quays relative to the number of ships calling on to the port through the application of queuing technique has reduced waiting time for most global ports to the barest minimum. Optimal number of berths for any port could be calculated with precision. However, the advent of larger or bigger vessels at the quays, as ship operators try to enjoy the benefits of economy of scale in the shipping industry, this means that Vessel Turnaround Time problem. The return on investment depends on the earning of vessel during the entire life span. The voyage time of a vessel is the only earning period of the vessel, whereas the time spent in seaports is expenditure for the ship owners. Therefore, every ship owners expect a very low turnaround time to get maximum benefits. The search for better turnaround time of vessels in port cannot be over emphasized.

3.2. Data Products

The primary data of vessel arrival/departure in New Mangalore Port trust recorded at VTMS were collected and used to develop optimization model that relates the turnaround time to the port facility and port operations. The real time data is collected from NMPT for each and every vessel called on to port from 2015-2016 to 2018-19. The real time data consists of time measures of various activities and delays that took

place, from the point of port of call of a vessel to NMPT to its departure from the port limits. This source is considered to be among the most comprehensive databases on vessel arrival /departure information related to NMPT. The real time data provides arrival and departure times from terminals for all vessels on most major trade lanes. It is thus possible to determine the amount of time, ships spend in port on each port call. The categories and the details of the real time data observed and recorded for each and every vessel calling on to the port are given Table. 3.1.

Table.3.1. Real time data captured for a vessels calling on to NMPT

Sl.No.	Major groups of Data	Details of Data
1	Basic Vessel data	Unique vessel identifier number Vessel name Category Export/Import Tonnage/ TEU's Name of the Commodity Total tonnage NRT GRT LOA Nationality Original Port of departure Previous port o Next port of call Draft
2	Date and Time parameters	Arrive at anchorage date and time Readiness of the vessel date and time Departure for berth (Pilot boarding) Date and time Arrive at berth(Berthing) date and time Cargo operation start date and time Cargo operation completed date and time Departure from the Berth date and time Departure from the port date and time
3	Pre commencement and post Commencement(Documentation)	Customs Formalities inward Documentation inward Survey inward Customs Formalities outward Documentation outward Survey outward

3.3. Methodology

From the point of time a ship approaches to a port of call to the time that it sails again with loading and unloading complete, there are a number of activities to be performed. Any one or more of these activities can cause the vessel to be delayed to a great extent. The time required for the turnaround time of a vessel comprise of time required for pre-berthing waiting of the vessel at the anchorage point before getting the signal for inward movement of the vessel for the berthing to the allocated berth inside the port. The time required for departure of the vessel from within the port limits and the time required to service of the vessel for next voyage. Time required to make it ready for loading/unloading and the time actually spent in loading/unloading the cargo. Thus, the Turn Round Time shall comprise the following components:

(i) Pre-Berthing Waiting Time,(ii) Inward Movement Time,(iii) Berthing/Shifting Time(iv) Service Time, (v) Outward Movement Time

TRT = PBWT (T1) +IM (T2) +BT (T3) +ST (T4) +OM (T5)

It is a measure of ports capability and ability to provide tremendous services with high productivity and performance to port user. It is also a function of port facilities and the level of service provided at a seaport. The shorter the turnaround time, it is beneficial to both the ports and port users. The port user will have to pay fewer amounts of port dues and at the same time the port authority can accommodate more number of vessels in a given time and increase the through put of the Port. Delays can occur during each of the above stages of vessel turnaround process and can be caused by a lot many numbers of factors. Not all of which are within the control of either port authority or the shipping agents/owners. Each and every delay causing factor is identified and amount of delay (time duration) is recorded for every vessel calling on to the port. When any vessel approaches a seaport, a harbour pilot has to board the vessel, since the port is the pilotage authority within the harbour waters. This procedure intern causes the delay as the pilot has to move against the tidal conditions, restrictions on approach channel, time duration of the day or night. The next activities that causes the delay in turnaround time of a vessel include the basic logistic requirements such as custom, immigration, documentation, survey of the cargo, inspection etc.. The main stake holders in this stage are

1. Port Authority: A port is the point of entry of goods and travellers into the country. It provides facilities for berthing of vessels and loading/unloading of cargo. A terminal is a part of the port, comprising of berth(s) which form a part of the terminal. It may be cargo-specific or designed to handle all types of cargo. The port allots berths and jetties, piloting of vessels in and out of the port and provides other vessel and cargo related services.
2. Shipping agent: The shipping agent provides the services on behalf of shipping lines and coordinates the arrangements to ship arrival, berthing, loading/unloading, departure of vessel from the port, customs and other regulatory bodies.
3. Customs: It is the official department of the government with the authority to check goods and travellers. In international trade, the customs collect duty on imported goods as levied by the government, and provide clearance on both export and import goods. The custom also enforces the provisions of Customs Act governing imports and exports of cargo, arrival and departure of vessels and prevention of smuggling including interdiction of narcotics drug trafficking.
4. Container Freight Station (CFS) and Inland Container Depot (ICD): A Container Freight Station is an extension of the port. It is the custodian of goods after they are evacuated from the terminal in case of import and before they are shifted to terminals in case of export. The process of customs clearance takes place inside the CFS. Inland Container Depots are located in different inland points away from the sea ports, offering services such as handling, temporary storage and clearance of goods.
5. Partner Government Agency: Partner Government Agencies (PGAs) are external agencies allied with the Central Board of Indirect taxes and Customs (CBIC) for providing clearance to sensitive goods such as food products, dyes, animal products, drugs etc. The other PGA's include Food Safety and Standards Authority of India (FSSAI), Plant Quarantine Information System (PQIS), Animal Quarantine and Certification Services (AQCS), Drug Controller (CDRUG), Wild Life Crime Control Bureau (WCCB) and the Textile Committee.

6. Port Health Organization (PHO): An office that is in charge of the review of cleanliness in the ship and among the group, to control the spread of irresistible infections from the approaching vessels. It likewise assesses nourishment/agrarian items entering the port, for healthiness, wellness and consistence with Indian enactment.

7. Immigration: An organization that is in charge of applying the movement laws of the nation and giving the required reports to remote group and travellers to land and set out the vessel.

Coming up next are the vessel turnaround movement stream in an ordinary import/trade process from the voyage hint till the take-off of the vessel from the port

- The shipping line/shipping operator enlists his vessel by presenting the vessel profile alongside essential testaments, for example, endorsement of vault to the port, which after study confirms and affirms the vessel profile.

- Once the normal time of landing (ETA) is known, the transportation operator presents the voyage subtleties of the vessel including ETA to the port expert by furnishing the vessel subtleties alongside the normal time of entry.

- The port registers the voyage and produces a special vessel distinguishing proof number, which is utilized as a kind of perspective number for any exchange identified with that specific voyage.

- After the enrolment of voyage, the transportation specialist records the Import General Manifest (IGM) to the traditions containing cargo show, compartment subtleties alongside the vessel subtleties.

- Customs assigns the IGM Number for the IGM documented and the equivalent is sent to the port specialist and Shipping operators.

- The shipping specialist sends the berthing application with expected entry plan including the freight subtleties and cove plan after the date of landing is affirmed.

- The shipping specialist co-ordinates with Port Health Organization (PHO) to acquire free Pratique Certificate, later he contacts with MMD for some other vessel endorsements. Plant Quarantine (PQ) from the concerned controlling operator.

- Then the shipping specialist applies for the passage internal to traditions. The passage internal is sent to the Shipping operator and the port by the traditions

- The port distributes the billet and distributes the subtleties of designation of all compartments in the port to all shipping operators.(The progressions to the billet application can be sent to the port and port needs to affirm the progressions to produce results to the distributed allotment if vital)

- The shipping operator does the self-evaluation of the charges (Vessel related and others) according to the relevant port levy and makes advance instalment at the bank. The bank sends instalment subtleties to port, the cargo related appraisal is finished by shipper/exporter offer loading/discharging is finished.

- Port dispenses explicit area in the yard for releasing the freight/compartment and sends yard plan to the shipping operator.

Before the actual operation of loading/unloading, activities like hatch opening, cleaning of hulls and cleaning of pipe lines, fittings in case of POL cargo are to be completed. When the actual loading/unloading process is started then there comes a lot of factors that cause delay such as lack of storage space in berth/transit sheds/storage tanks, breakdown of equipments, non-deployment of required labour gangs, shift in labour gangs and shifting of vessel from one berth to other berth to accommodate other vessel which requires high draft these activities may necessitate during the peak periods and causes delay in the overall vessel turnaround time. The

present study is carried out by systematic recording of the delay causing factor and time duration for each and every delay causing factors. Further these delay causing factors are grouped into different categories based on the cause for their occurrence and analysis of these categorised factors in a systematic way as brought out in the vessel turnaround time optimisation model.

3.4 Vessel Turnaround Time Optimization Model

The real time data of vessel arrival/departure in NMPT recorded at VTMS were used to develop optimization model. The different port activities that determine optimum turnaround times have been closely observed and the time spent in each and every activity are recorded. The various factors which are responsible for the increased vessel turnaround time (V-TRT) are identified from the real time data collected and from the ground truth verification and the total time consumed by each and every constraint are recorded. The identified factors/constraints are tabulated are then categorized into seven categories based on the activities involved in the turnaround process and the constraints faced by a vessel calling on the port.

1. Pre-berthing delay factors
2. Pre-commencement and post-commencement factors(Documentation)
3. Port constraints
4. Non-port constraints
5. Idle time at berth
6. Environmental factors
7. Vessel constraints

A vessel turnaround time optimization model has been developed. The model/software is developed by using the following programming languages and other available modules

- PHP
- MySQL
- HTML5
- CSS3
- JQuery
- Google Charts

- Apache Tomcat Server
- Ubuntu Operating System

3.4.1 Primary vessel data entry panel

The following is the Vessel Turnaround Time Optimisation (VTRTO) model primary data entry page layout. The contents of this page include the primary vessel data like vessel identification number, vessel name, type of cargo, tonnage, GRT, NRT and DWT. The date and time parameters related to various turnaround activities from the vessel arrival to the port until the departure of the vessel are also included. The primary vessel data entry panel of VTRTO model is shown in figure.3.1

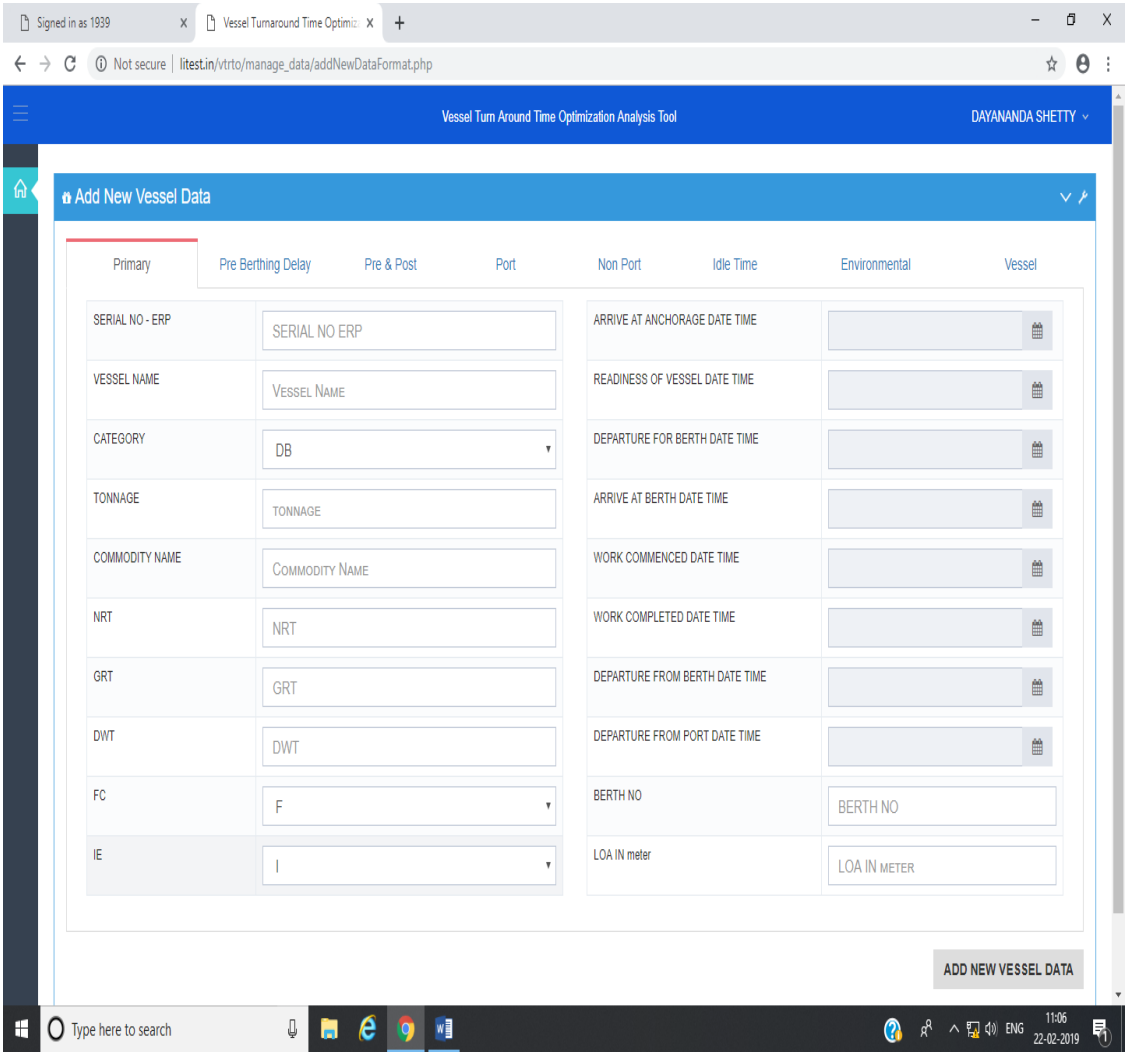


Figure 3.1.Primary vessel data entry panel of VTRTO model

3.4.2 Pre berthing delay factors entry panel

The recorded time duration for the identified pre- berthing delay factors are entered to the model through this page. The factors responsible for delay of a vessel before berthing of the vessel in allotted berth are non-availability of berth, non-availability of tugs/crafts, non availability of mooring gangs, condition and capacity of tugs, on availability of pilots, pilots not ready, delay in pilot boarding, delay in notice to signal station, bunching of vessels, draft restriction, unidirectional channel, night navigation, channel buoys, strike/stoppage, ships account, shippers account, documents not ready, tidal/weather restrictions, want of cargo or any other factors. The pre berthing delay factors entry panel of VTRTO model is shown in figure.3.2

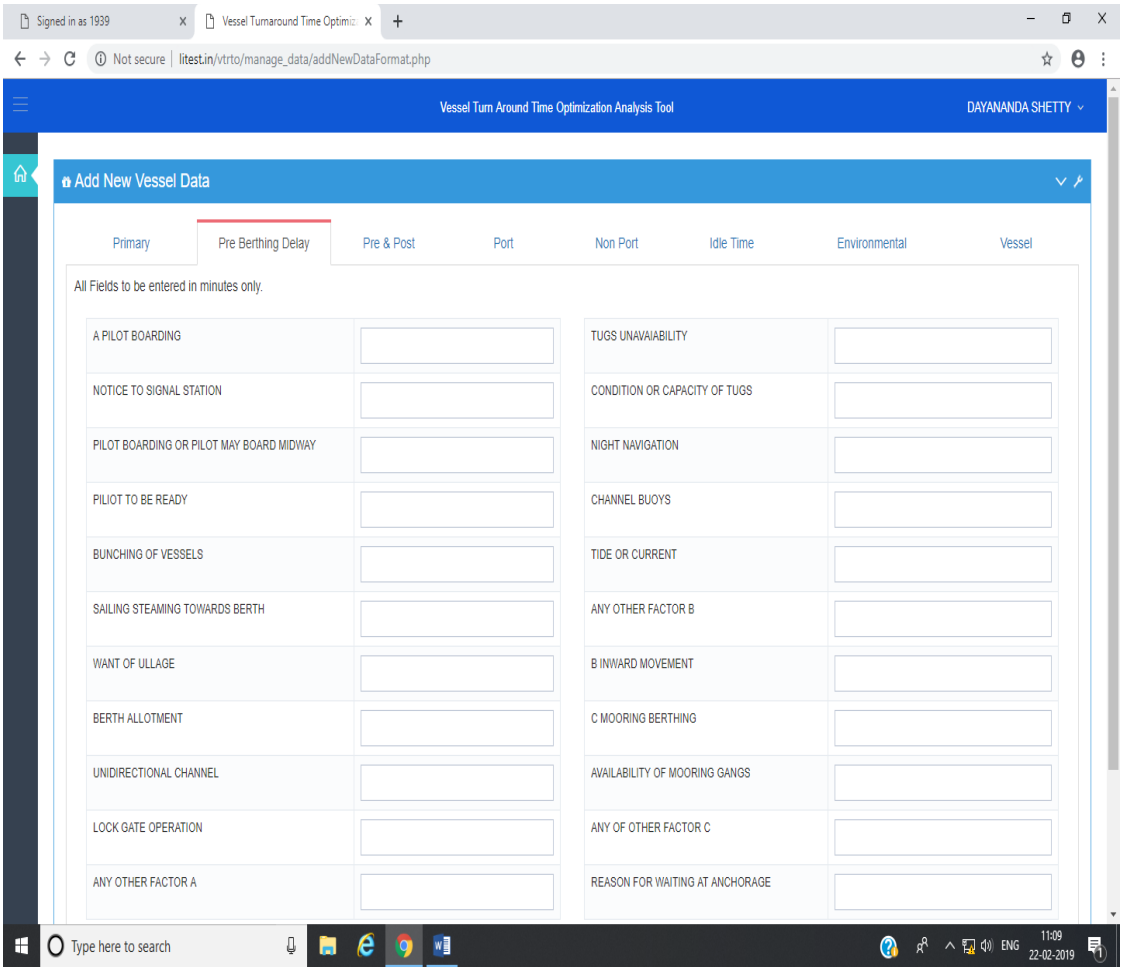


Figure 3.2.Pre berthing delay factors entry panel of VTRTO model

3.4.3 Pre-commencement and post-Commencement Factors entry Panel

The factors responsible for high turnaround time on account of documentation process during the arrival and departure of the vessel are customs formalities inward, documentation inward, survey inward, immigration documentation, customs formalities outward, documentation outward, sealing and inspection, survey outward and departure formalities. The actual time taken for the above activities recorded is entered in to the model through this page. The pre-commencement and post-commencement factors entry panel of VTRTO model is shown in figure.3.3

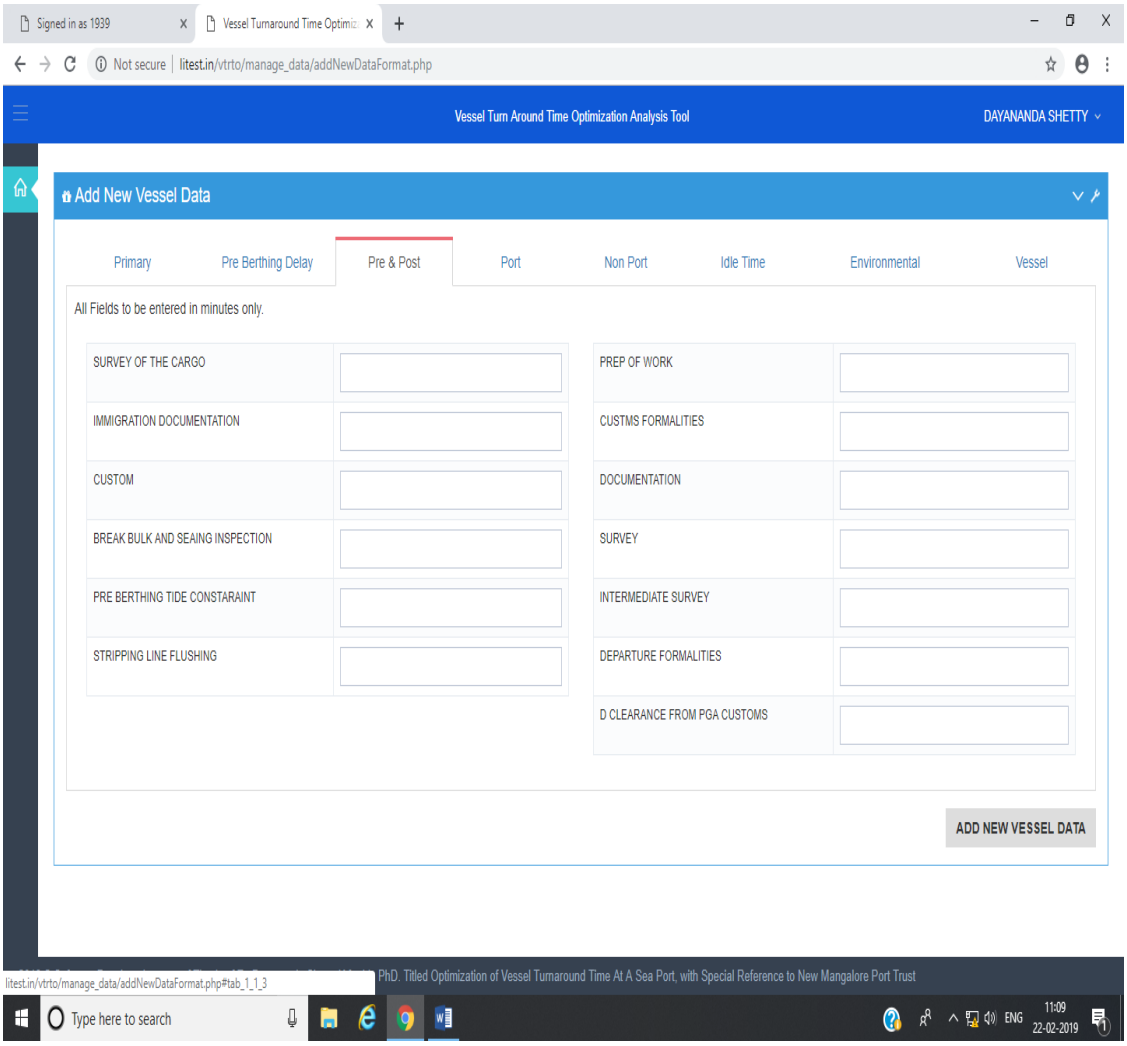


Figure 3.3. Pre-commencement and post-commencement factors entry panel of VTRTO model

3.4.4. Port constraints entry panel

Through this web page the time lost in the delay causing factors on account of port for every vessel is entered and recorded in to the model. The main port constraints are constrains from the port side and some of the identified constraints are power problems, gang not deployed, gangway up and down process, pipe line fitting, pipe line cleaning, draft survey, non-availability of cargo handling equipment, non-availability of labour gangs, lighting, lack of storage space, no availability of tugs etc..The Port constraints entry panel of VTRTO model is shown in figure.3.4

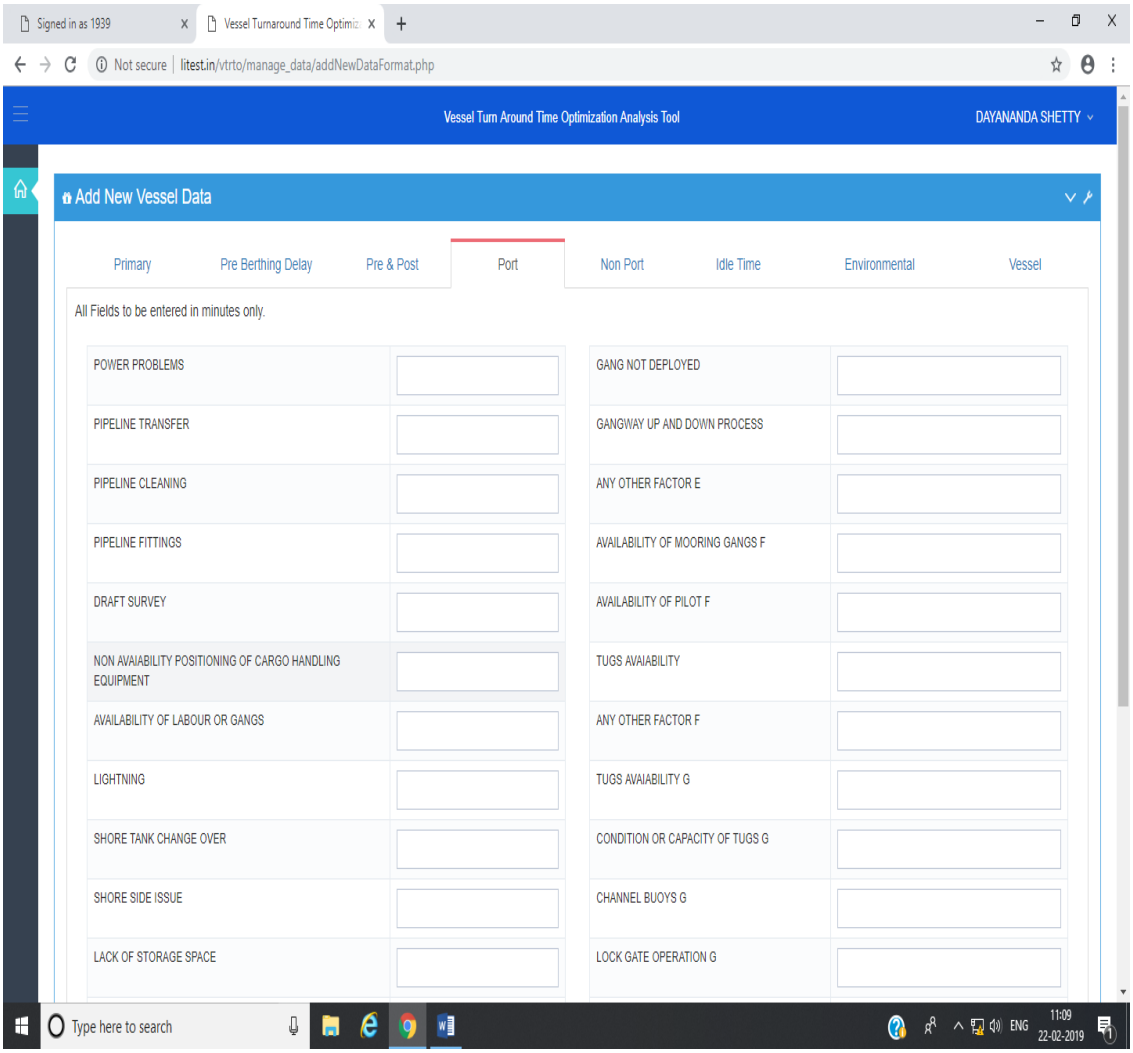


Figure 3.4. Port constraints entry panel of VTRTO model

3.4.5. Non-Port Constraints entry panel

The non-port constrains are from the shippers/shipping agents side. The actual time lost is recorded for each identified factors are entered through this page of the model. Some of the observed constraints are want of cargo, breakdown of equipment's, sampling, lab tests, PHO's role, immigration, waiting for shore side readiness, hatch arrangements, hatch opening/closing, nature of cargo, trimming of cargo post loading, berth cargo evacuation truck turnaround, intermediate stoppage for shifting to other cargo, detained by MMD, bunkering and line changing process. The Non-Port constraints entry panel of VTRTO model is shown in figure.3.5

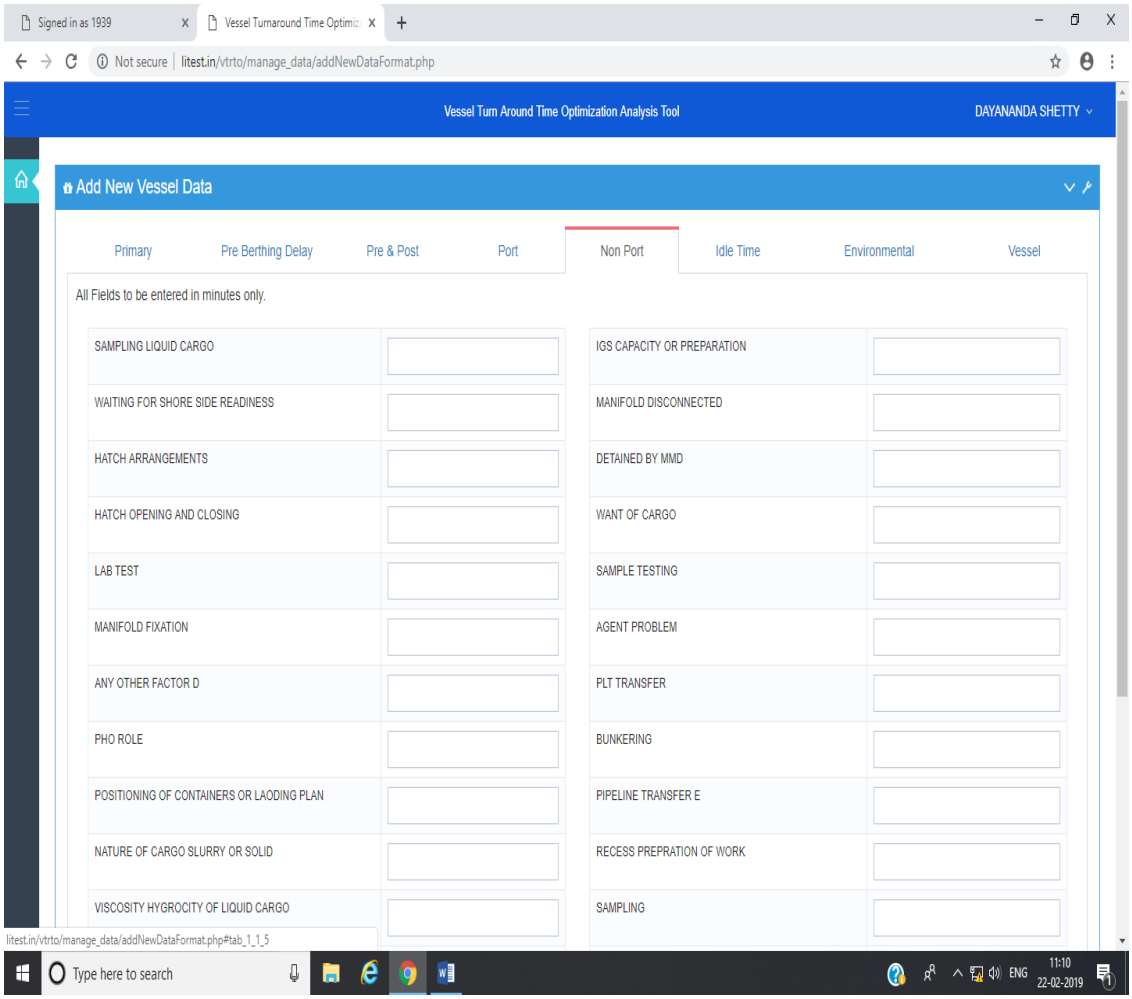


Figure 3.5.Non-Port constraints entry panel of VTRTO model

3.4.6. Idle time entry panel

Through this web page the recorded time lost due to idling of loading/unloading process are entered into the model. Some of the observed causes of idle time in the berth are no work, holiday recess, ports equipment break down, power problems, labour breakup, stoppage for mock drill, break during shifts, shifting or evacuation of cargo from berth and any other factors. The Idle time entry panel of VTRTO model is shown in figure.3.6

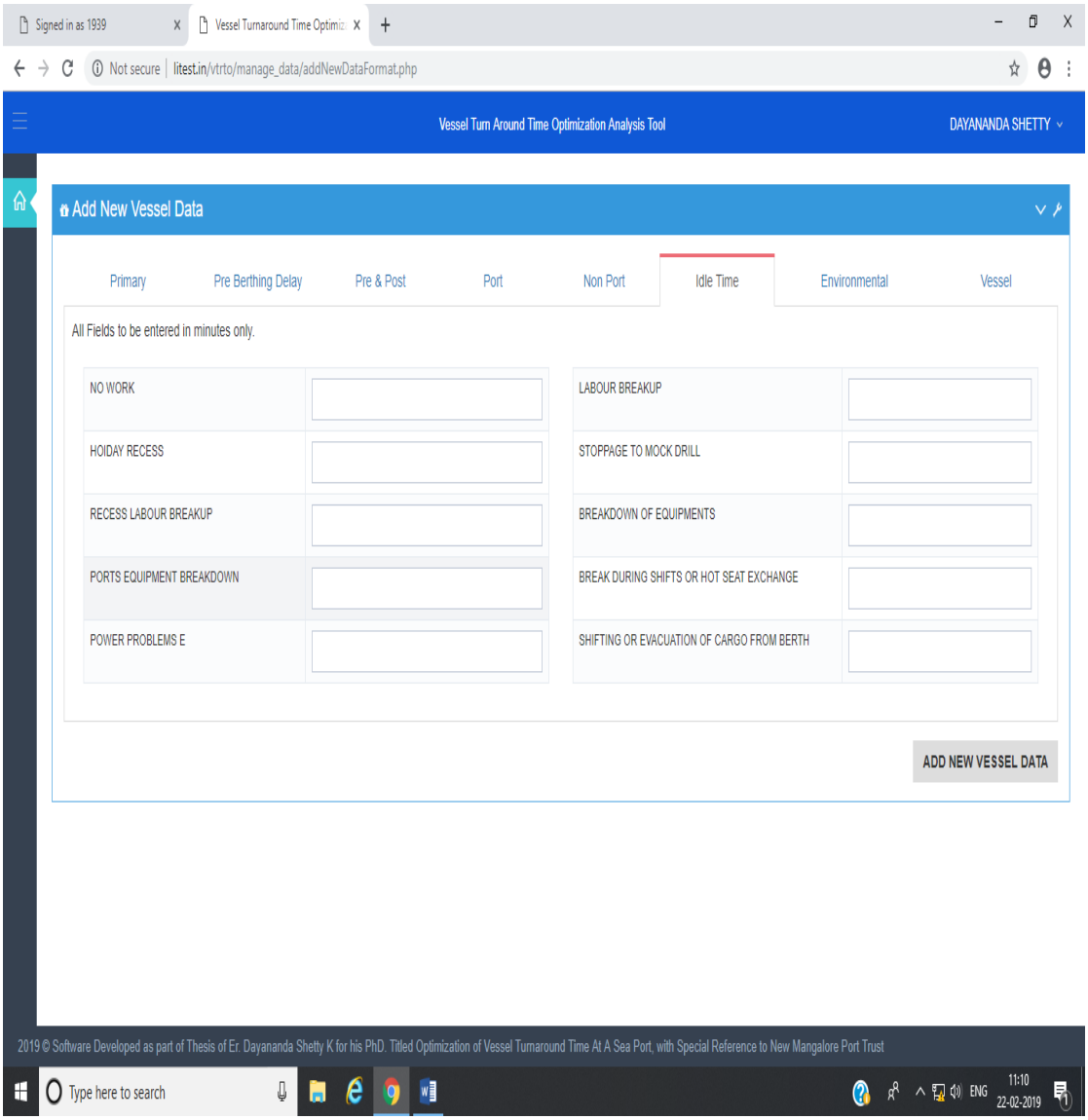


Figure 3.6.Idle time entry panel of VTRTO model

3.4.7. Environmental constraints entry panel

The time lost due to environmental constraints are recorded and entered to the model in this page, some of the observed environmental parameters are: weather/rain, tide, cyclone, night navigation and any other related factors. The environmental constraints entry panel of VTRTO model is shown in figure 3.7

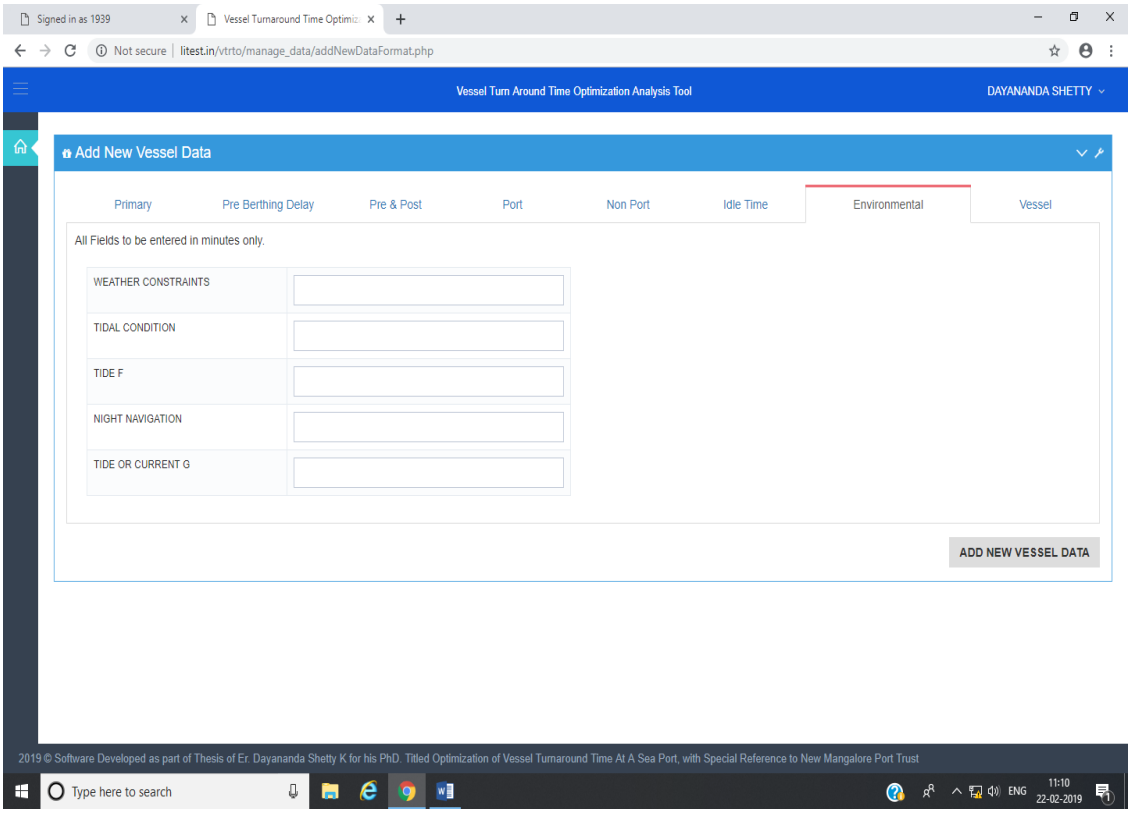


Figure 3.7.Environmental constraints entry panel of VTRTO model

3.4.8. Vessel constraints entry panel

The delay occurring due to the vessel related constraints are recorded for each and every vessel entering the port are fed into the model through this page. Some of the factors observed in the present research are: engine failure, lashing/unlashing, vessel advance berthing, vessel ullage constraints, hot water flushing, line flushing, tank value problems, vessel repair or its equipments, pump capacity, waiting for ship side readiness, slope discharge, delay in sailing and any other factors. The vessel constraints entry panel of VTRTO model is shown in figure 3.8

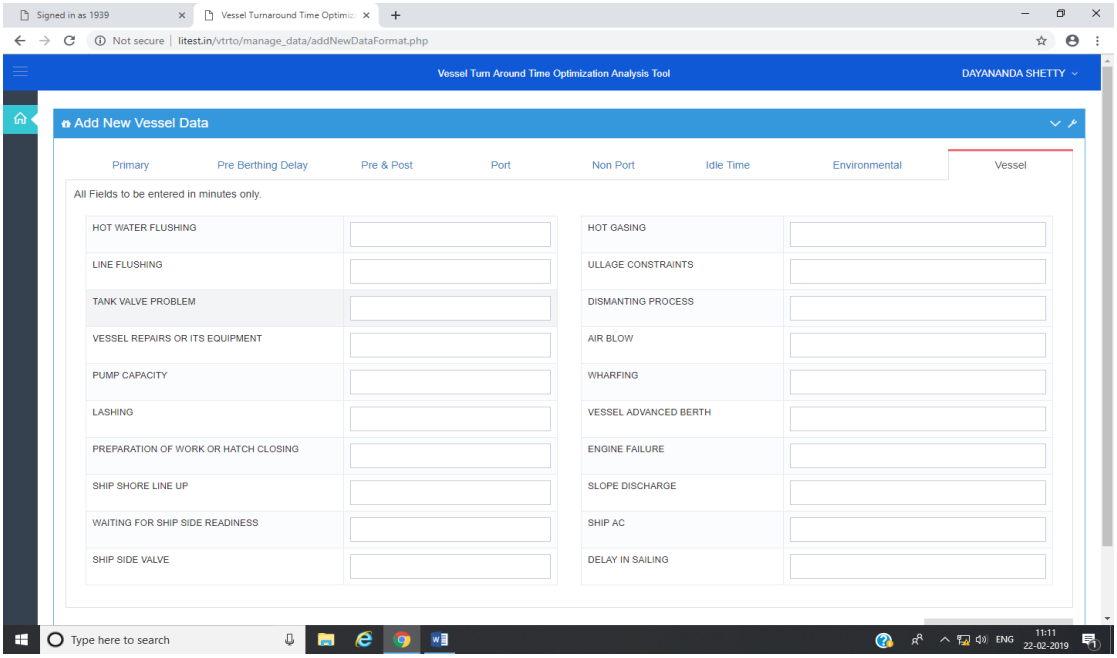


Figure 3.8.Vessel constraints entry panel of VTRTO model

3.4.9. Editing Panel

Through the editing panel the user can search the data entered for any specific vessel details and also able to edit or modify the already entered data. The editing panel of VTRTO model is shown in figure.3.9

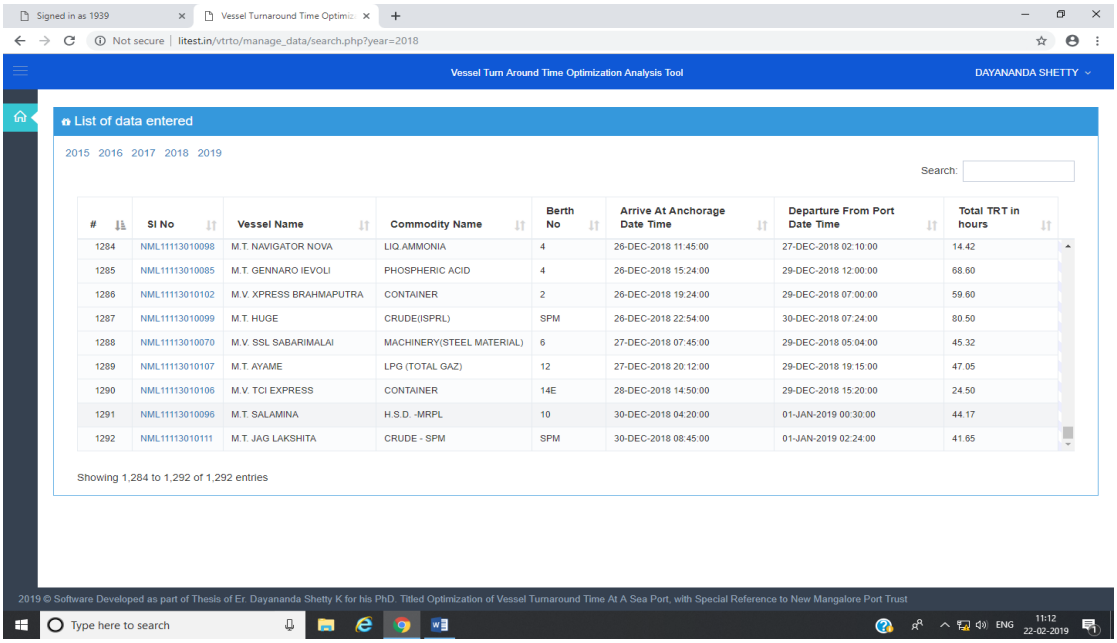


Figure 3.9.Editing entry panel of VTRTO model

CHAPTER 4
RESULTS AND DISCUSSION

4.1 General

The maritime transportation is reached to a stage of development in which the world's ports gaining importance as they are the key link between the producer and the consumer. The cost reduction has been achieved through the economics of scale by deploying very large bulk carriers and container vessels and with the adaptation of new technologies. But now, time has come to search for economies in a more complex area of port operation and management with a view to reduction in turnaround time of the vessels in sea ports. If the greatest benefits gained in the sea transportation are to be transferred to the end users, the time lost in and around the port terminals are to be recovered. Because of the fast increase in the fixed cost of present day vessels, the time lost in the ports become considerably more expensive. The extent to which the port time increases for a vessel of call is a very important consideration for the choice of the port for a particular trade. The present study aims to investigate the turnaround times of vessels calling on to the New Mangalore Port. The turnaround time of a vessel is comprised of large number of constituent factors. Delays can occur during any of these operations because of the great complexity and interrelation of the port system and operations. No single reason can be attributed to the poor performance of port or increased vessel turnaround time. The developed vessel turnaround time optimisation model relates turnaround time with identified pre-berthing delay factors, Pre-commencement and post- commencement factors, Port constraints, Non-Port constraints, Vessel constraints, Environmental Constraints and available port facilities.

Using the optimization model, the following analysis was carried out and results were generated.

1. The factors affecting the vessel turnaround time.
2. Year on year TRT in days, which is the average of monthly TRT of all the vessels sailed from the port.
3. Year wise analysis of TRT

4. Commodity wise TRT analysis
5. Seasonal TRT analysis
6. Year wise TRT Constraints analysis
7. Commodity wise TRT constraints analysis.
8. Sensitivity Analysis

4.2 Factors affecting the vessel turnaround time

The various factors which are responsible for the vessel turnaround time (VTRT) are identified from the real time data collected and from the ground truth verification. The identified factors tabulated are then categorized in to seven categories based on the activities involved in the turnaround process and the constraints faced by a vessel calling on the port. The identified factors responsible for the vessel turnaround time are tabulated in the Table.4.1

Table.4.1 Identified factors responsible for V-TRT

Sl.No.	Category	Factors
1	Pre-Berthing Delay factors	Non-availability of berth Non-availability of tugs/crafts Non-availability of mooring gangs Condition and capacity of tugs Non-availability of pilots Pilots not ready Delay in pilot boarding Delay in notice to signal station. Bunching of vessels Draft restriction Unidirectional channel Night Navigation Channel Buoys Strike/stoppage Ships account Shippers account Documents not ready Tidal/weather restrictions Want of cargo
2	Pre commencement and post Commencement Factors(Documentation)	Customs Formalities inward Documentation inward Survey inward

		Immigration documentation Customs Formalities outward Documentation outward Sealing and Inspection Survey outward Departure formalities
3	Port Constraints	Holiday Recess Ullage Constrains Pipe line fittings Draft restrictions Shifting Time Non-availability of Berths Non-availability of Labour gangs Non-availability of Ports crafts/Tugs Non-availability of cargo handling equipment's Non-availability of Pilots Lighting Equipment beak down Non-availability of labour gangs Shore tank change over Priority berthing Other vessel movement Strike/stoppage Power failure Shed congestion Breakdown of equipment Lack of storage/silos Any other factors
4	Non-Port Constraints	Want of Cargo Break down of equipment's Sampling Lab tests PHO's Role Immigration Waiting for shore side readiness Hatch arrangements Hatch opening/closing Nature of cargo. Trimming of cargo post loading Berth cargo evacuation truck turnaround Intermediate stoppage for shifting to other cargo Detained by MMD

		Bunkering Line changing process Any other factors
5	Idle Time at Berth	No work Holiday Recess Ports Equipment break down Power problems Labour breakup Stoppage for mock drill Break during shifts Shifting or evacuation of cargo from berth Any other factors
6	Environmental Factors	Weather/rain Tide Cyclone Night Navigation Any other factors
7	Vessel Constraints	Engine failure Lashing/unlashing Vessel advance berthing Vessel ullage constraints Hot water flushing Line flushing Tank value problems Vessel repair or its equipment's Pump capacity Waiting for ship side readiness Slope discharge Delay in sailing Any other factors

The major constraints in the pre-berthing delay categories are non-availability of berths. It is observed that in case of liquid bulk (POL) vessels have to wait at the anchorage for want of berth, generally all the available 5 liquid cargo berths at NMPT have highest berth occupancy rate and fully occupied by the vessels. This indicates

that in the Liquid Bulk cargo categories, the number of berths provided are not optimum. The other constrains are non-availability of pilots in time after allotment of berth and signal for inward movements for the vessels from VTMS. There is shortage of regular pilots at NMPT and most of the pilots are on contract basis with less expertise in handling the vessels. These contract pilots when experienced,leave the port for better prospects and higher earnings to the sailing in the sea in merchant ships. There is also lack of coordination between the pilots, port control station and the shipping agents and the berth allotting authority of the port. Non-availability of mooring gangs, delay in notice to VTMS after the allotment of berths to the vessels and tidal/weather restrictions in the monsoon periods are also some of the frequently observed constrains which contribute to the increased delay in per-berthing of the vessels.

In case of pre-commencement and post-commencement factors the main constraints that contribute to the increased vessel turnaround time are customs formalities, custom documentation both in inward and outward movement of vessels, inspection, survey of the cargo and immigration documentation. It is observed that the frequency of occurrence of documentation delay is about 70 to 80 % in every month under the period of observation. The non-port constraints are limited to want of cargo in some cases, breakdown of equipments and waiting for shore side readiness. These are attributable to the shipping agents/ship liners are not ready with the stored cargo in required quantity for the anticipated vessel on call to the port or poor maintenance of equipments from the shipside. The major observed port constraints are non-availability of labour gangs, non-availability of port crafts/tugs, priority berthing of coastal cargo vessels and other vessel movement. In the single approach channels inward and outward movement cannot be performed simultaneously, a vessel is in movement. The idle time at berth observed are break during the shifts, shifting of vessel from one berth to other for operational requirements and want of draft and ports equipment breakdown.

4.3 Year on year TRT

From the model one can generate the year on year vessel turnaround time. This is the monthly aveage of turnaround time of all the vessels sailed from the port for the month in consideration. The figure 4.1 represents the out put from the model for the year on year TRT for the year 2015-16 to 2018-19 up to month of Dec.2018 and it also gives the yearly average turnaround time of all the vessels sailed from the port for a particular year. The top management can get the details by click on botton using this model output.

Figure 4.1 Year on year TRT in days for the year 2015-16 to 2018-19

From this module, one can also generate the port performance indicators such has pre-berthing waiting time (PBWT), vessel turnaround time (TRT), Non-working time at berth(NWTB), Number of vessels handled, output per ship berth day(OSBD) and port productivity. The model is also useful in generating various MIS outputs required for the top port management such as Port performance indicators (PPI),cargo through put, number of vessels sailed/berthed etc. with respect to the category of cargo handled, berth wise, on daily/monthly/yearly basis.

4.4. Year wise analysis of TRT

This module analyses the various components of turnaround time year wise by taking the average monthly turnaround time. The turnaround time shall comprise the following components:

- Pre-Berthing Waiting Time
- Inward Movement Time
- Berthing/Shifting Time
- Service Time
- Outward Movement Time

TRT = PBWT (T1) +IM (T2) +BT (T3) +ST (T4) +OM (T5)

The percentage contribution of each of the above components to the vessel turnaround time are depicted in the figures 4.2 to 4.5 for the year 2015-16 to 2018-19 up to December 2018.

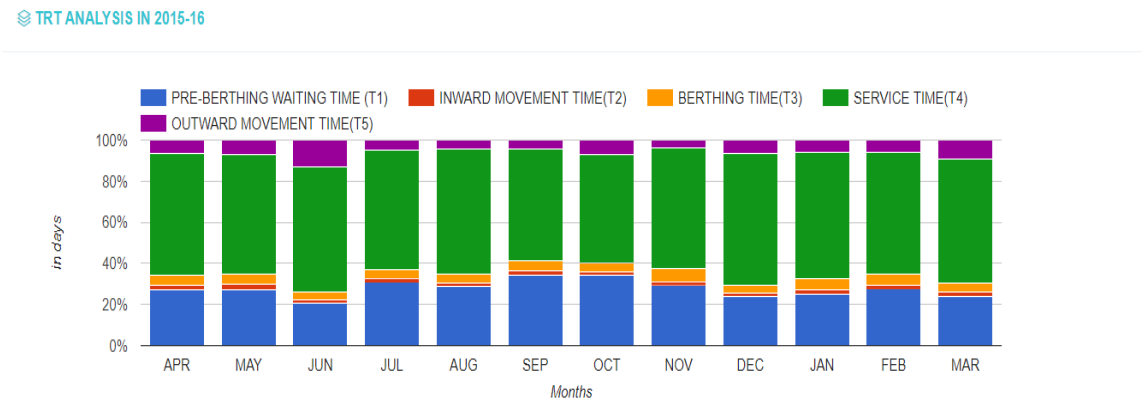


Figure 4.2 TRT Components (in percentage) for the year 2015-16

For the year 2015-16 the average pre-berthing waiting time is highest (34.48%) in the month of September and lowest (20.44%) in the month of June. The inward movement time is highest (2.32%) in the month of May and lowest (1.51%) in the month of October. The berthing time is highest (6.23%) in the month of November and lowest (3.77%) in the month of June. The service time is highest (64.01%) in the month of December and lowest (52.27%) in the month of October. The outward movement time is highest (12.89%) in month of June and lowest (4.05%) in the month of November.

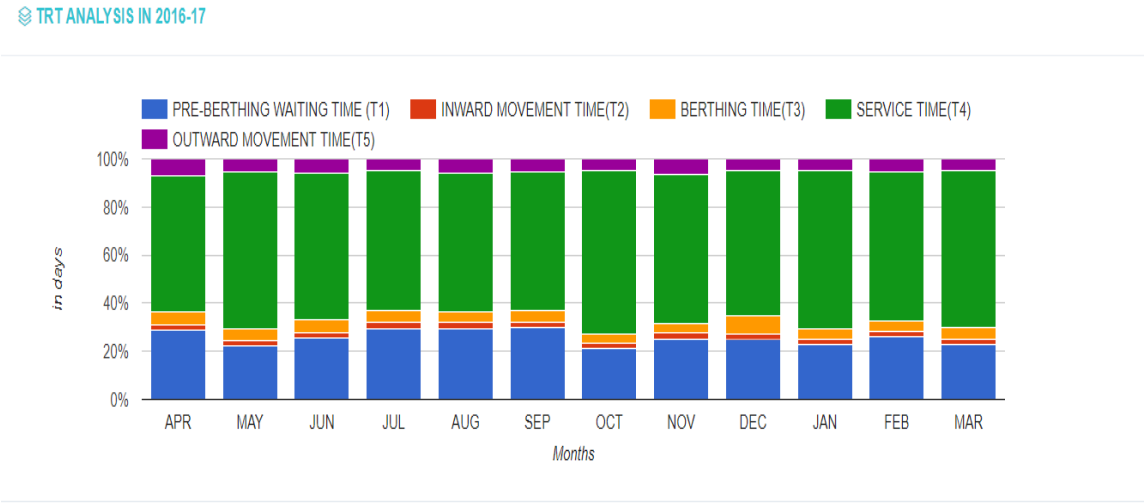


Figure 4.3 TRT Components (in percentage) for the year 2016-17

For the year 2016-17 the average pre-berthing waiting time is highest (29.88%) in the month of September and lowest (21.03%) in the month of June. The inward movement time is highest (2.67%) in the month of August and lowest (2.13%) in the month of April. The berthing time is highest (7.54%) in the month of December and lowest (3.77%) in the month of June. The service time is highest (68.27%) in the month of October and lowest (56.17%) in the month of April. The outward movement time is highest (7.23%) in month of April and lowest (4.80%) in the month of October.

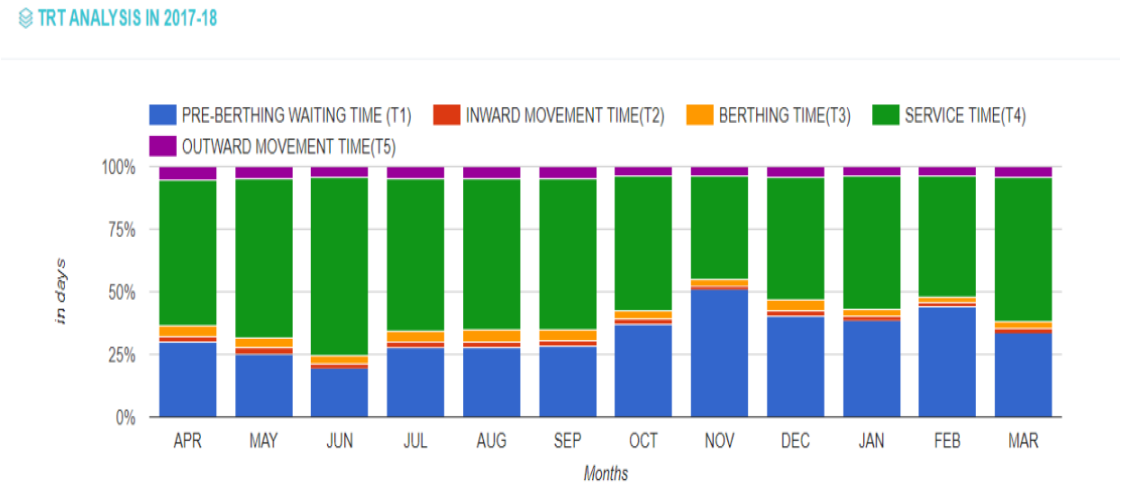


Figure 4.4 TRT Components (in percentage) for the year 2017-18

For the year 2017-18 the average pre-berthing waiting time is highest (50.93%) in the month of November and lowest (19.40%) in the month of June. The inward movement time is highest (2.39%) in the month of April and lowest (1.39%) in the month of November. The berthing time is highest (4.62%) in the month of August and lowest (2.21%) in the month of February. The service time is highest (71.31%) in the month of June and lowest (41.44%) in the month of November. The outward movement time is highest (5.58%) in month of April and lowest (3.54%) in the month of February.

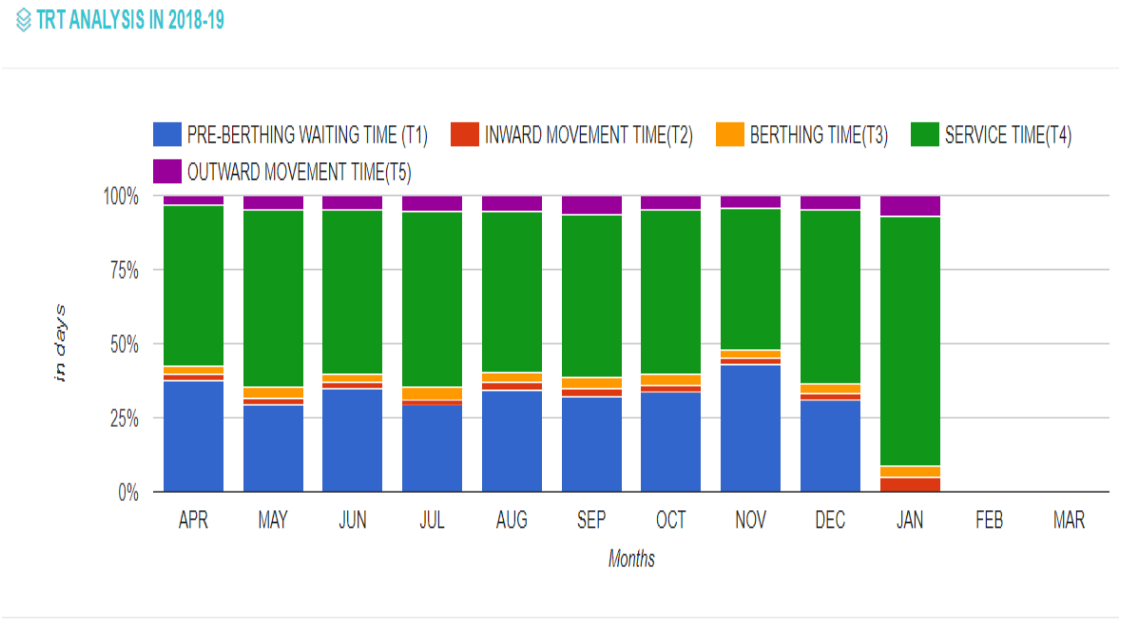


Figure 4.5T RT Components (in percentage) for the year 2018-19(up to Dec.18)

For the year 2018-19 the average pre-berthing waiting time is highest (42.91%) in the month of November and lowest (29.14%) in the month of May. The inward movement time is highest (2.64%) in the month of September and lowest (1.9%) in the month of April. The berthing time is highest (3.82%) in the month of July and lowest (2.70%) in the month of November. The service time is highest (60.26%) in the month of May and lowest (47.97%) in the month of November. The outward movement time is highest (6.79%) in month of September and lowest (3.53%) in the month of April.

From the results of year wise analysis of TRT, it is observed that the pre-berthing time and service time contributes to the maximum percentage of vessel turnaround time. The service time is on the higher side during the monsoon months and lower during the non-monsoon months. It is observed that during the monsoon months the rate of loading/unloading is very slow and there is intermittent stoppage of loading process in case of bulk and break bulk cargos during heavy rain. The pre berthing waiting time is on the higher side in the non-monsoon months due to the higher frequency of the arrival of ships calling on to the port and at the same time the number of the berths available for especially Liquid cargo/POL are not sufficient. It is also observed that the outward movement time is more compared to inward movement time of vessels calling on to the port.

4.5. Commodity wise TRT analysis

This module analyses the various components of vessel turnaround time of the vessels calling on to the port on commodity wise. The commodities handled in New Mangalore Port are categorised into Dry Bulk- manual handling, Dry bulk-mechanical handling, Break bulk, Liquid bulk and containers based on the cargo handling methods adopted in the port. The percentage contribution of each components of the vessel turnaround time for commodity wise cargo vessels handled at NMPT are depicted in the figures 4.6 to 4.9 for the year 2015-16 to 2018-19 up to December 2018.

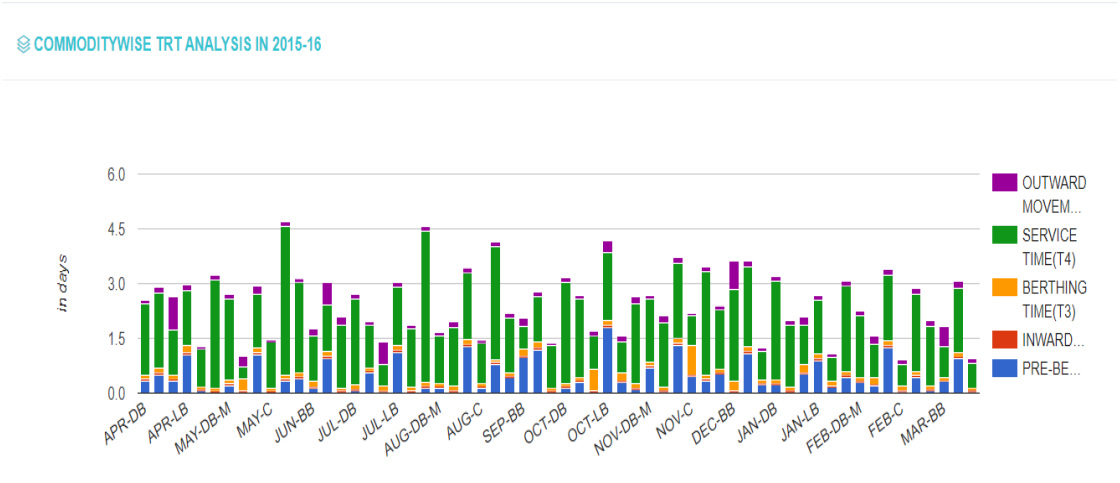


Figure 4.6 Commodity wise TRT Components (in percentage) for the year 2015-16

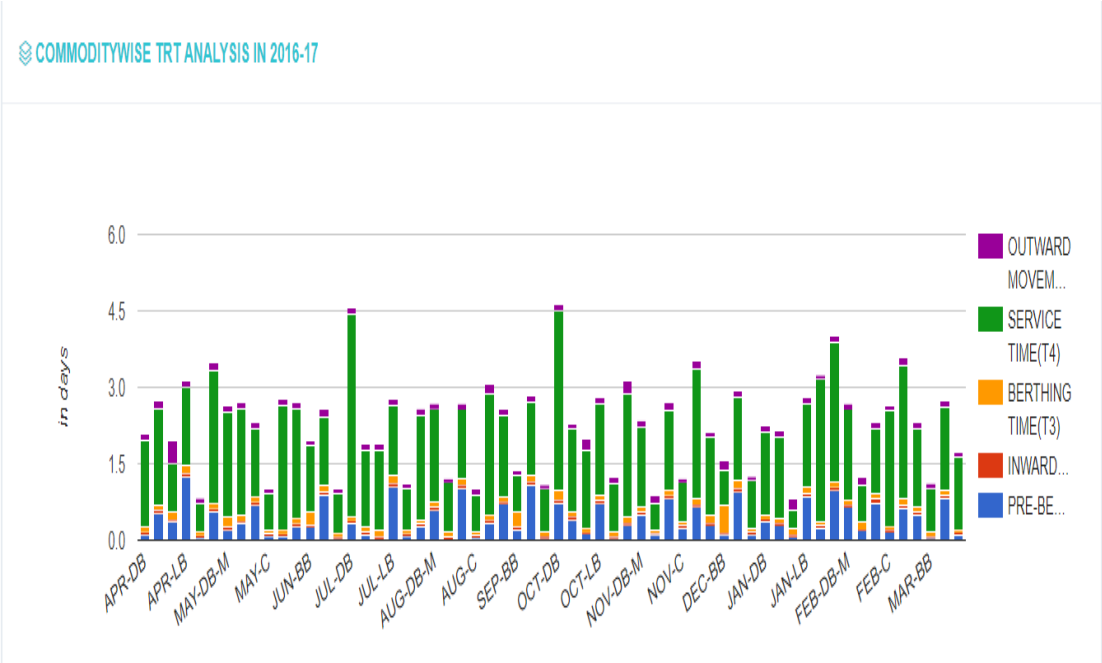


Figure 4.7 Commodity wise TRT Components (in percentage) for the year 2016-17

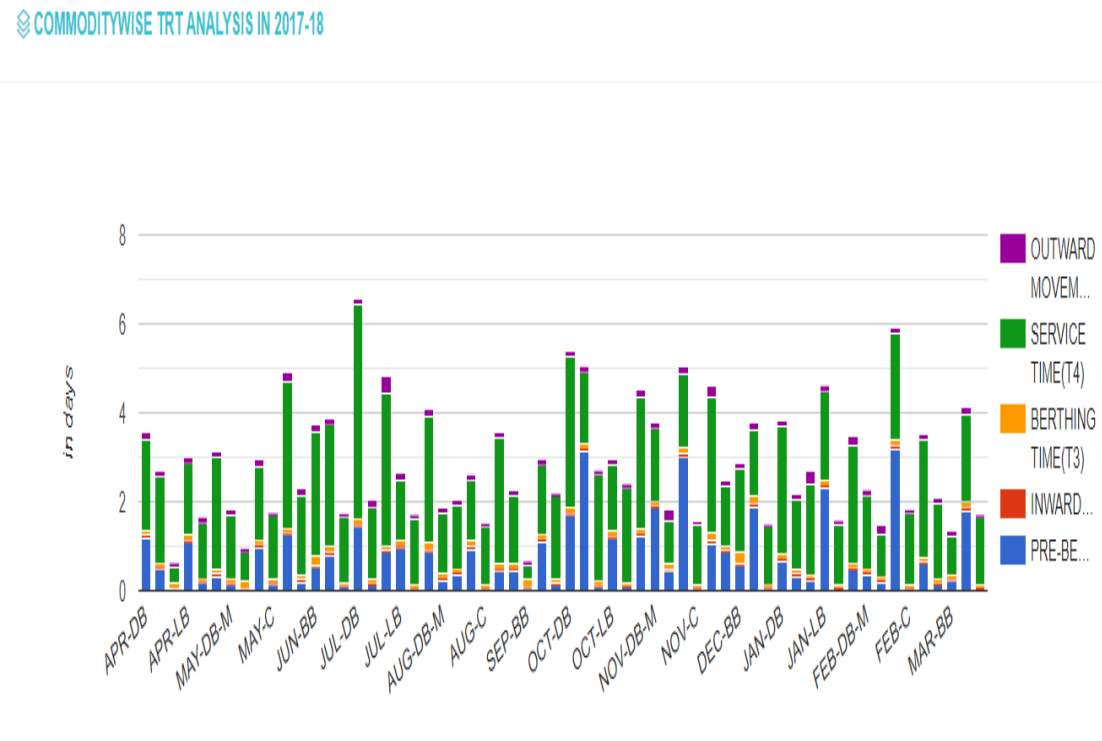


Figure 4.8 Commodity wise TRT Components (in percentage) for the year 2017-18

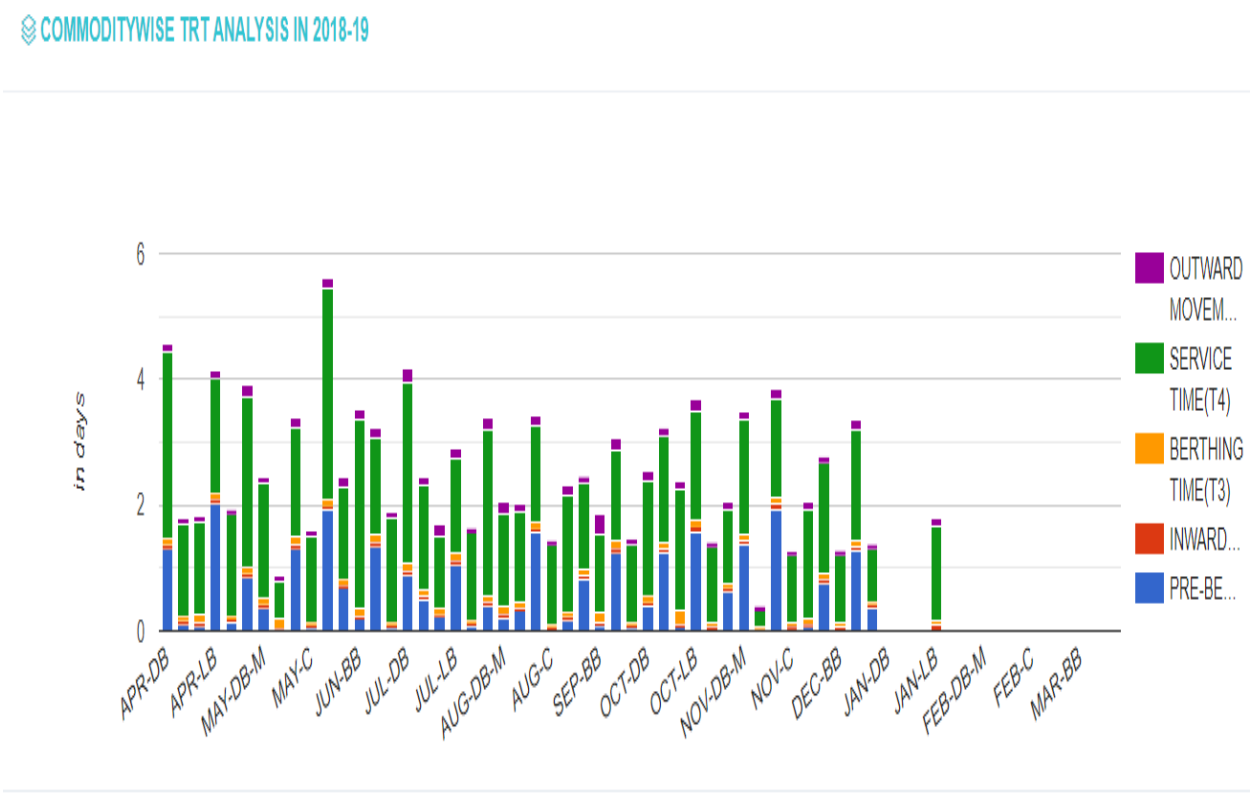


Figure 4.9 Commodity wise TRT Components (in percentage) for the year 2018-19 (up to Dec.18)

The commodity wise analysis of the TRT reflects that the TRT for the dry bulk cargo with manual handling is highest due to traditional method of loading/unloading which in turn increases the total service time component. The TRT for container cargo is the least as the container loading/unloading is totally mechanised and which reduces the total service time. The service time for dry bulk is high and service time for liquid bulk is low. From this analysis, it is also observed that the pre berthing weighting time for liquid bulk is always high compared to all other categories of cargo. From this we can again conclude that the number of berths to handle liquid berth at NMPT are not optimal. The liquid cargo vessels are to wait for want of berths even though the service time required for Liquid bulk cargo is reduced due to mechanisation of all the process of loading/unloading through automated loading/unloading arms installed in all oil berths/jetties.

4.6 Seasonal TRT analysis

In order to study the effect of monsoon on the vessel turnaround time calling on to the port, seasonal TRT analysis is carried out in the model. The service year is divided into pre monsoon (From the month of February to May),Monsoon (From the month of June to September) and post monsoon periods (From the month of October to January)

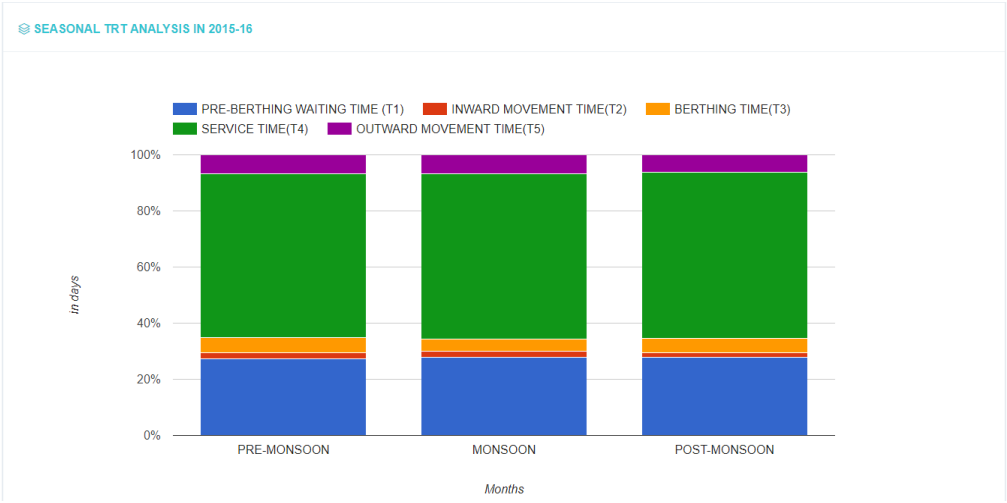


Figure 4.10 Seasonal TRT Components (in percentage) for the year 2015-16

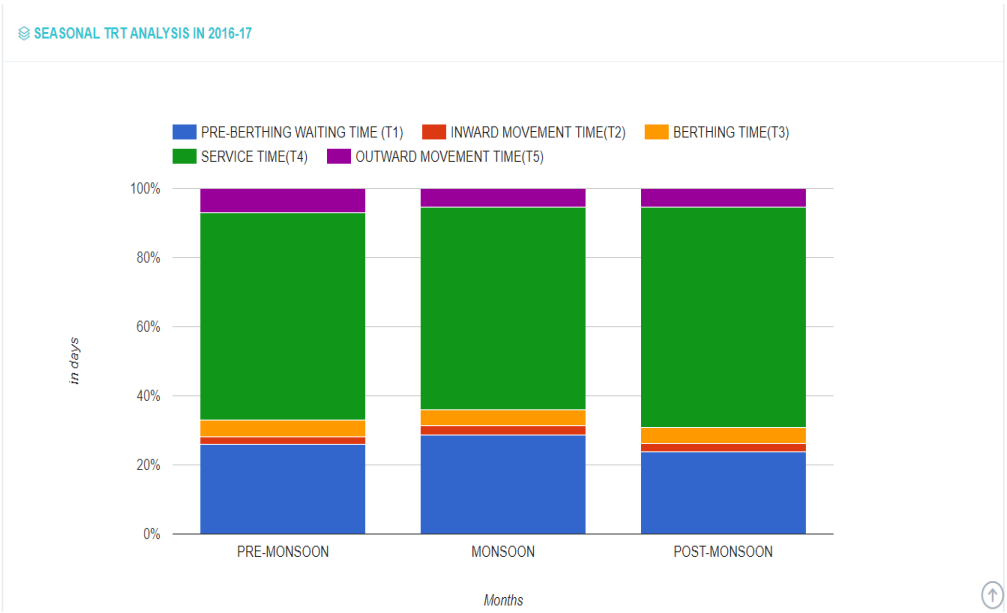


Figure 4.11 Seasonal TRT Components (in percentage) for the year 2016-17

Figure 4.12 Seasonal TRT Components (in percentage) for the year 2017-18

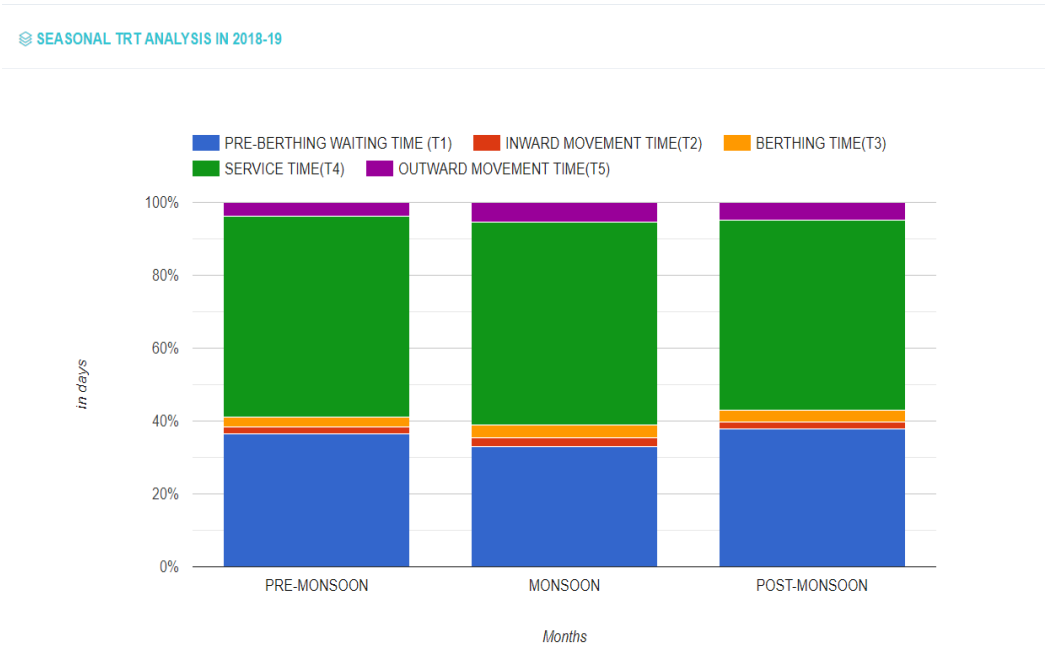


Figure 4.13 Seasonal TRT Components (in percentage) for the year 2018-19

This analysis reveals that the service times is on higher side during the monsoon months and lower during the non-monsoon months. It is observed that during the monsoon months the rate of loading/unloading is very slow and there is intermittent stoppage of loading process in case of bulk and break bulk cargos during heavy rain. The pre berthing waiting time is higher side in the non-monsoon months due to the higher frequency of the arrival of ships calling on to the port and at the same time the numbers of the berths available for especially Liquid cargo/POL are not sufficient.

4.7 Year wise TRT constraints analysis

The identified constraints are categorized into seven categories based on the activities involved in the turnaround process and the factors that affects the turnaround process of a vessel calling on the port. These constraints are pre-berthing delay causing factors, pre commencement and post commencement factors, constraints from port side, non-port constraints, and idle time at berth, environmental factors and constraints related to vessels. These constraints are analysed year wise to know their contribution in increased vessel turnaround time in the port.

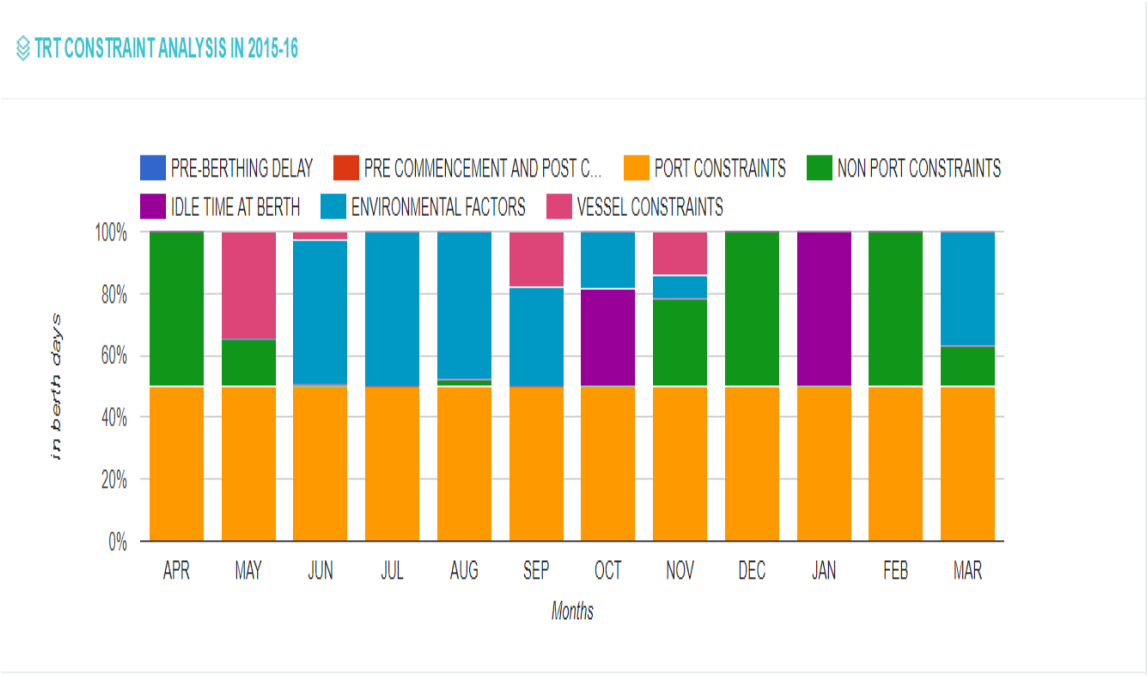


Figure 4.14 TRT Constraints (in percentage) for the year 2015-16

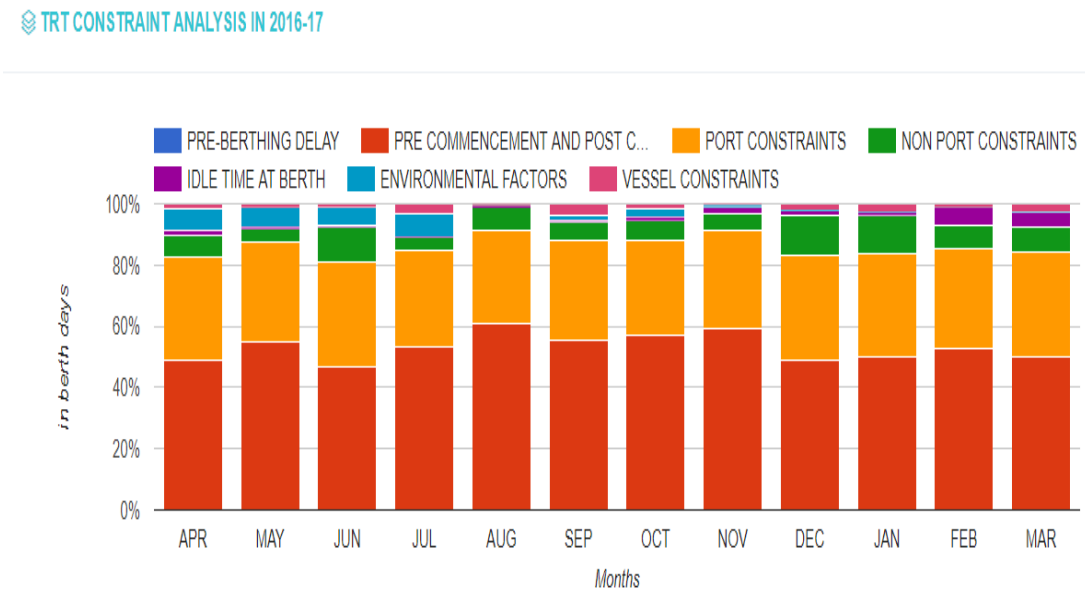


Figure 4.15 TRT Constraints (in percentage) for the year 2016-17

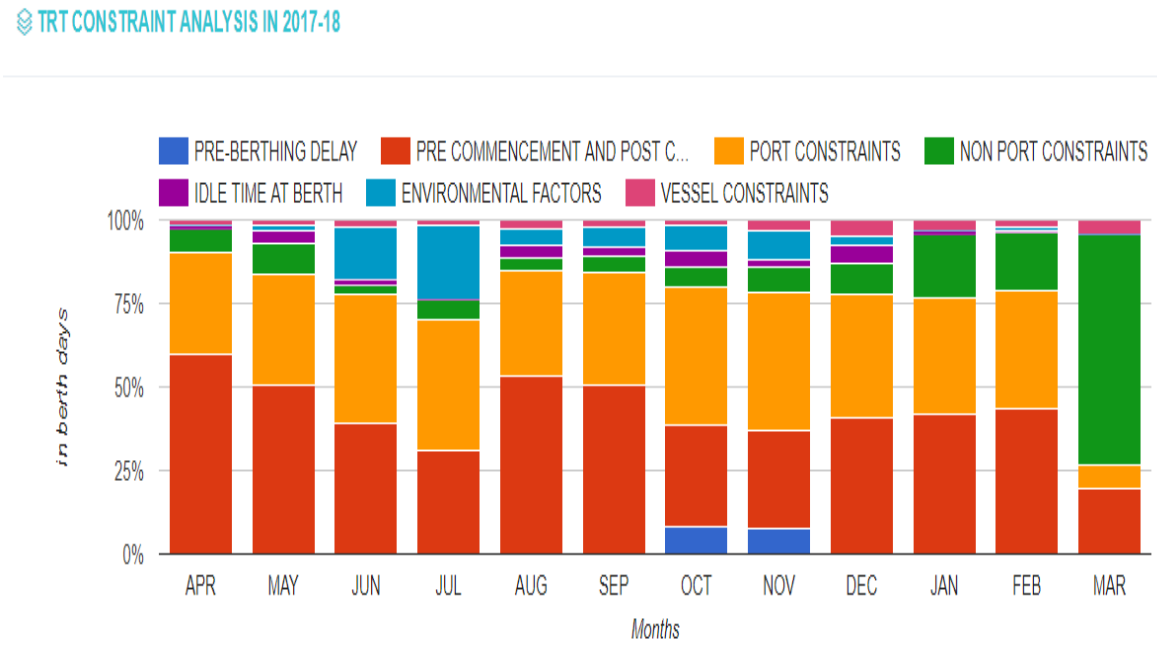


Figure 4.16 TRT Constraints (in percentage) for the year 2017-18

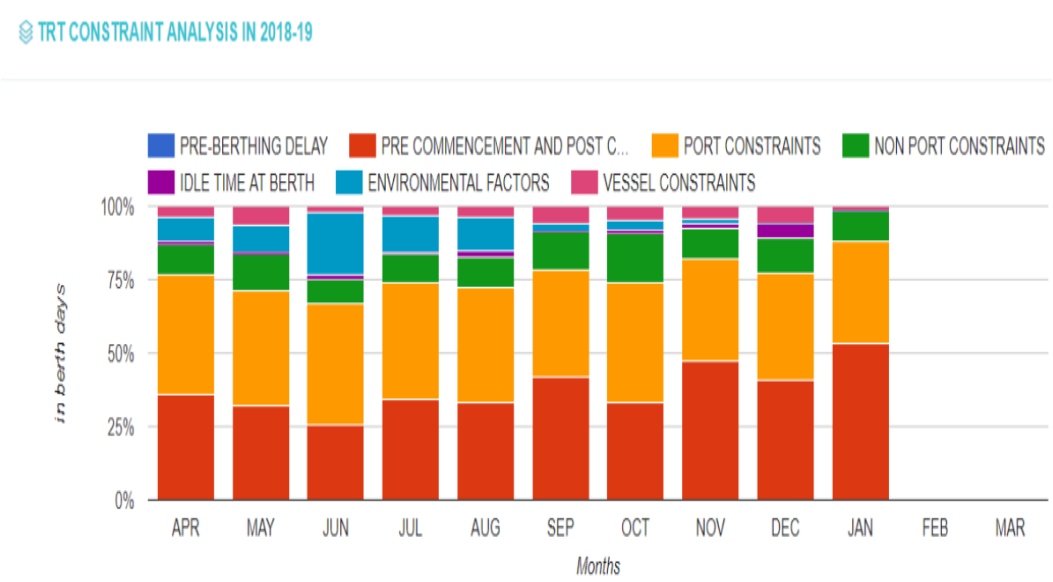


Figure 4.17 TRT Constraints (in percentage) for the year 2018-19(Up to dec.18)

The year wise TRT constraint analysis reveals that pre-commencement, post commencement factors and port constraints are the major contributing the delay in the TRT. In the monsoon months, the environmental constrains are also having a share on the increased TRT of the vessels. Other than the monsoon months, the non-port constraints also affect the TRT.

4.8 Commodity wise TRT constraints analysis

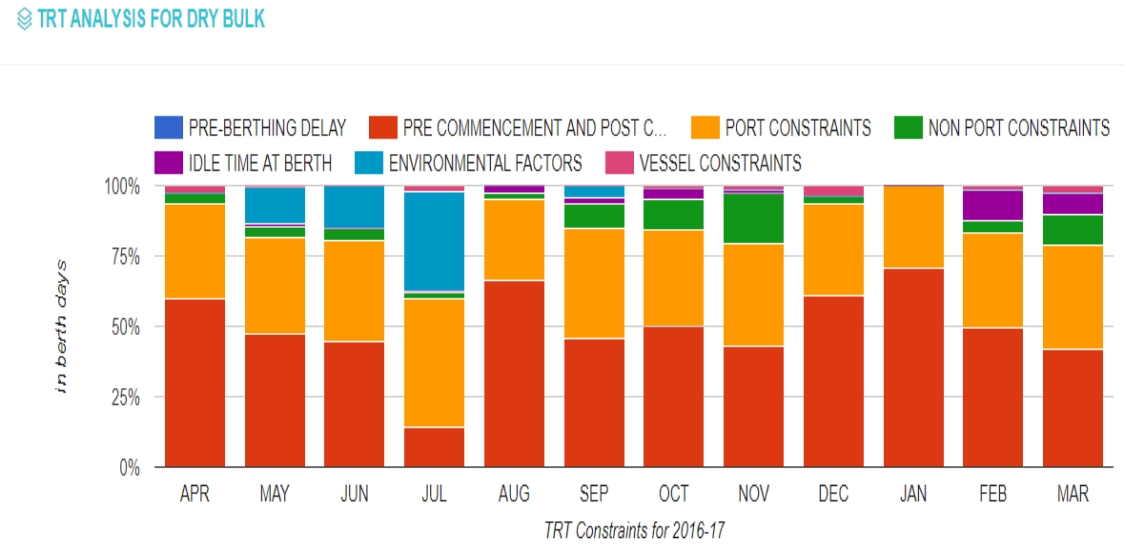


Figure 4.18 Commodity wise TRT Constraints (Dry Bulk) for the year

2016-17

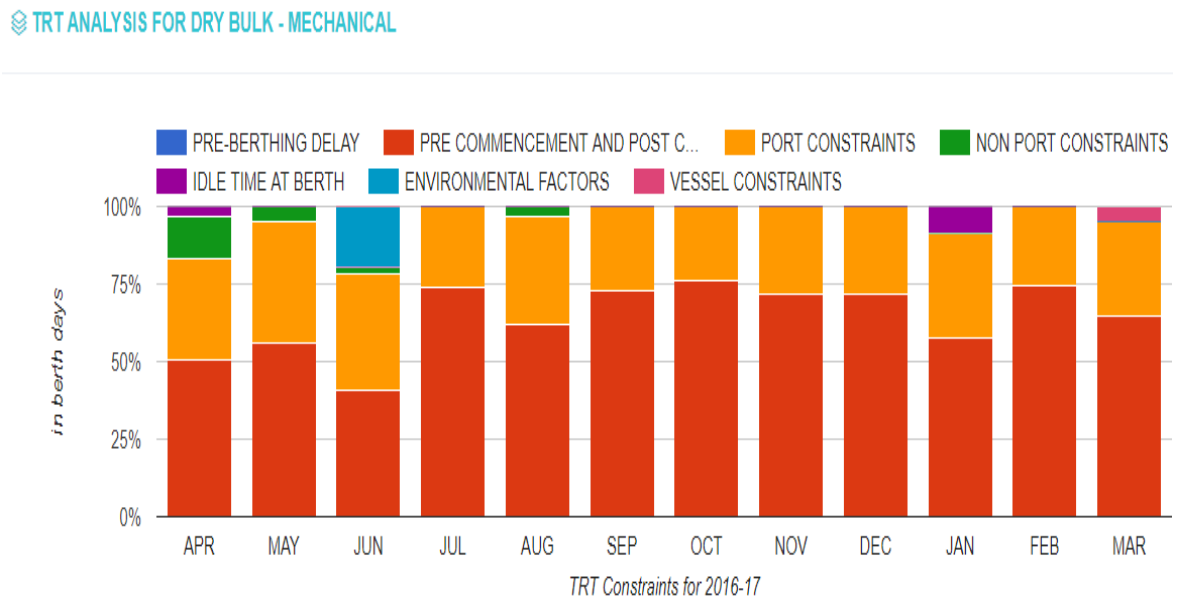


Figure 4.19 Commodity wise TRT Constraints (Dry Bulk-M) for the year 2016-17

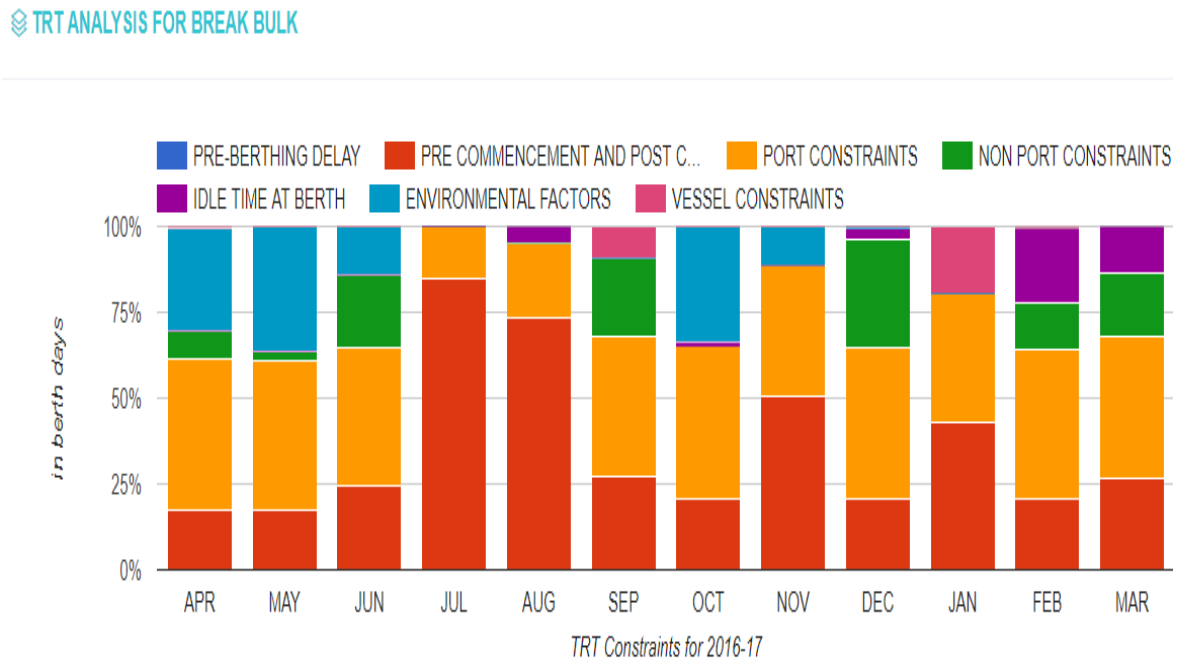


Figure 4.20 Commodity wise TRT Constraints (Break Bulk) for the year 2016-17

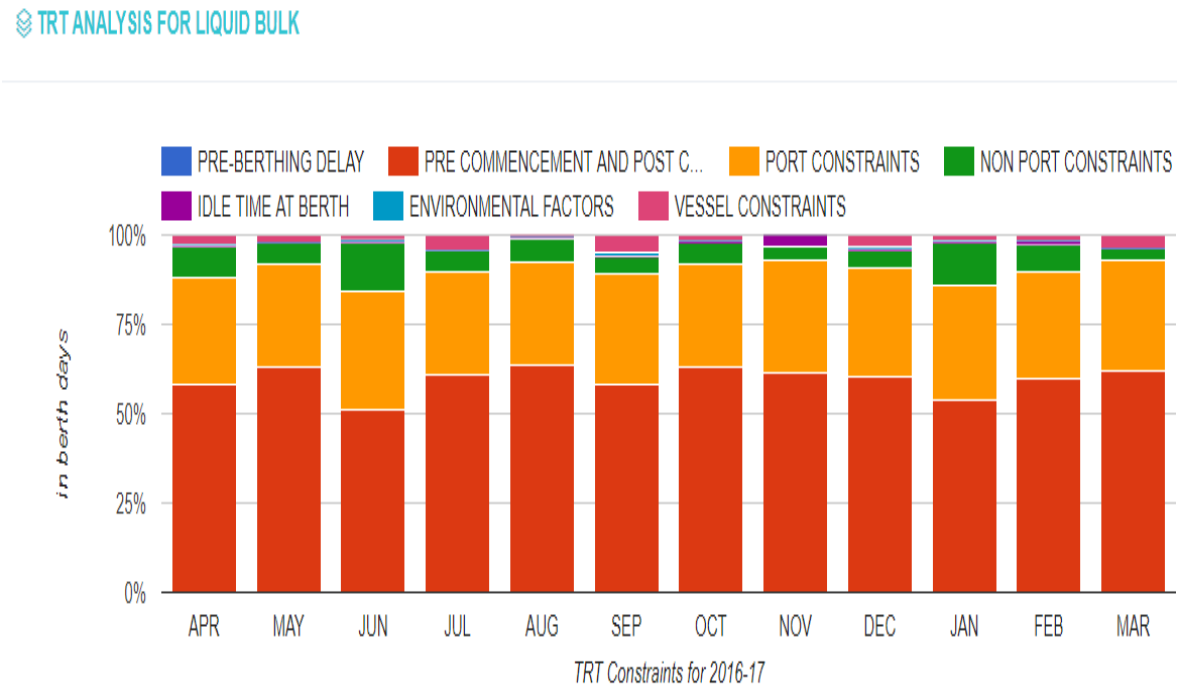


Figure 4.21 Commodity wise TRT Constraints (Liquid Bulk) for the year 2016-17

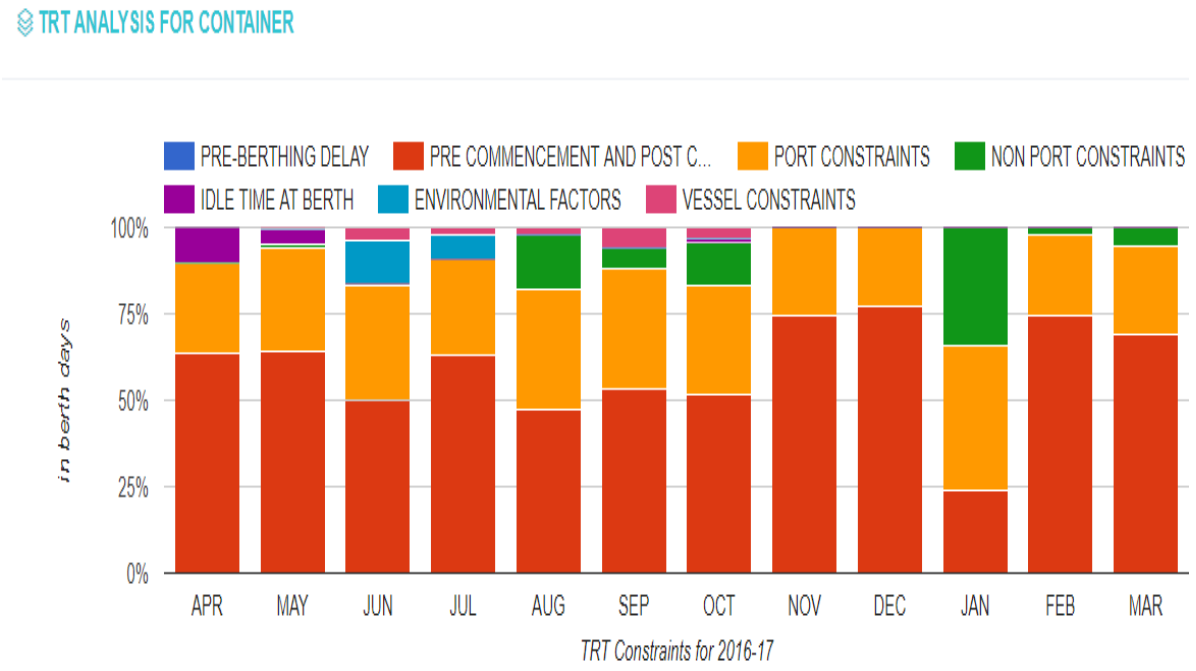


Figure 4.22 Commodity wise TRT Constraints (Container) for the year 2016-17

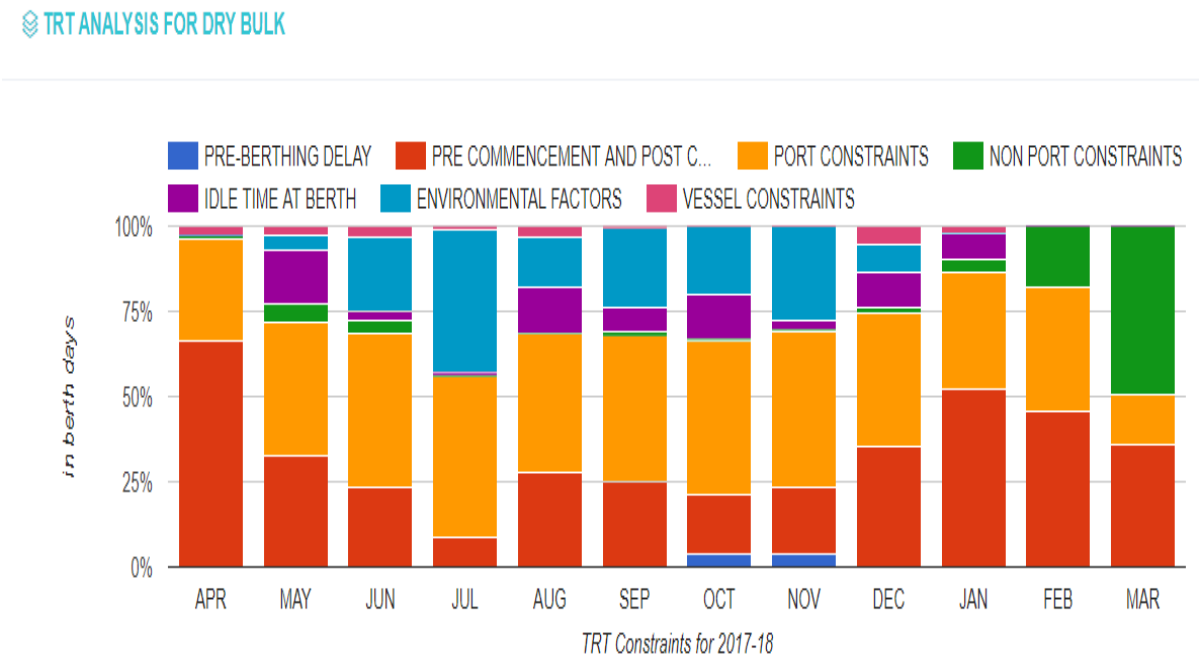


Figure 4.23 Commodity wise TRT Constraints (Dry Bulk) for the year 2017-18

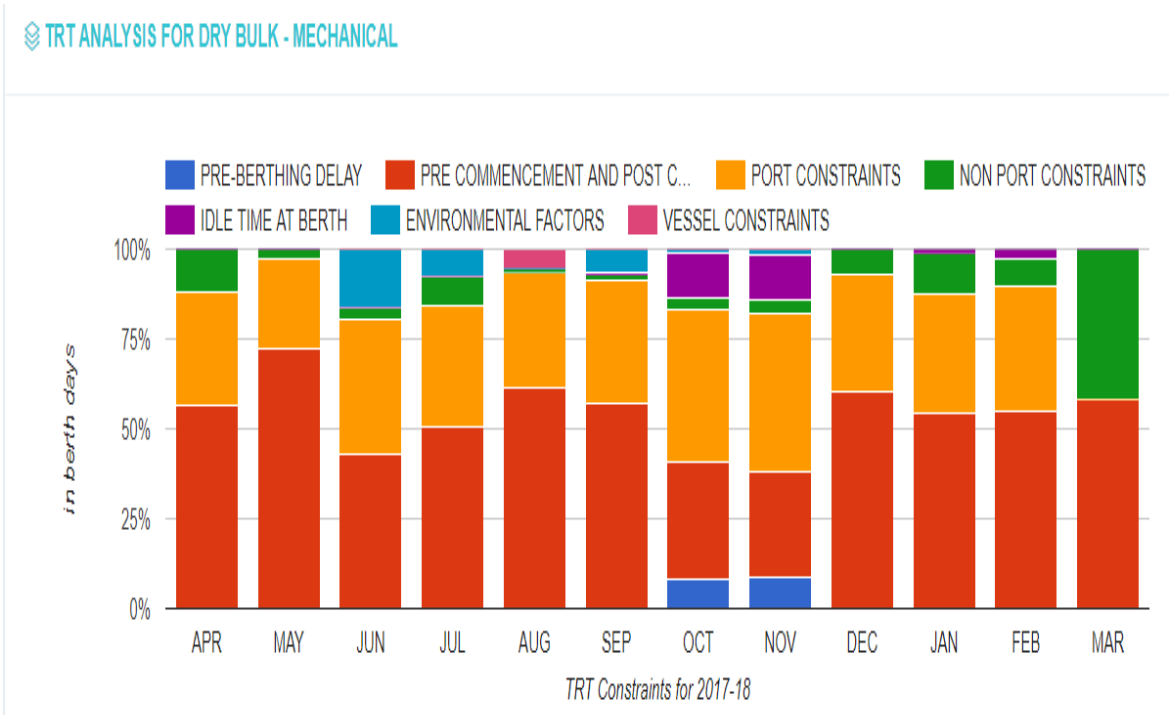


Figure 4.24 Commodity wise TRT Constraints (Dry Bulk-M) for the year 2017-18

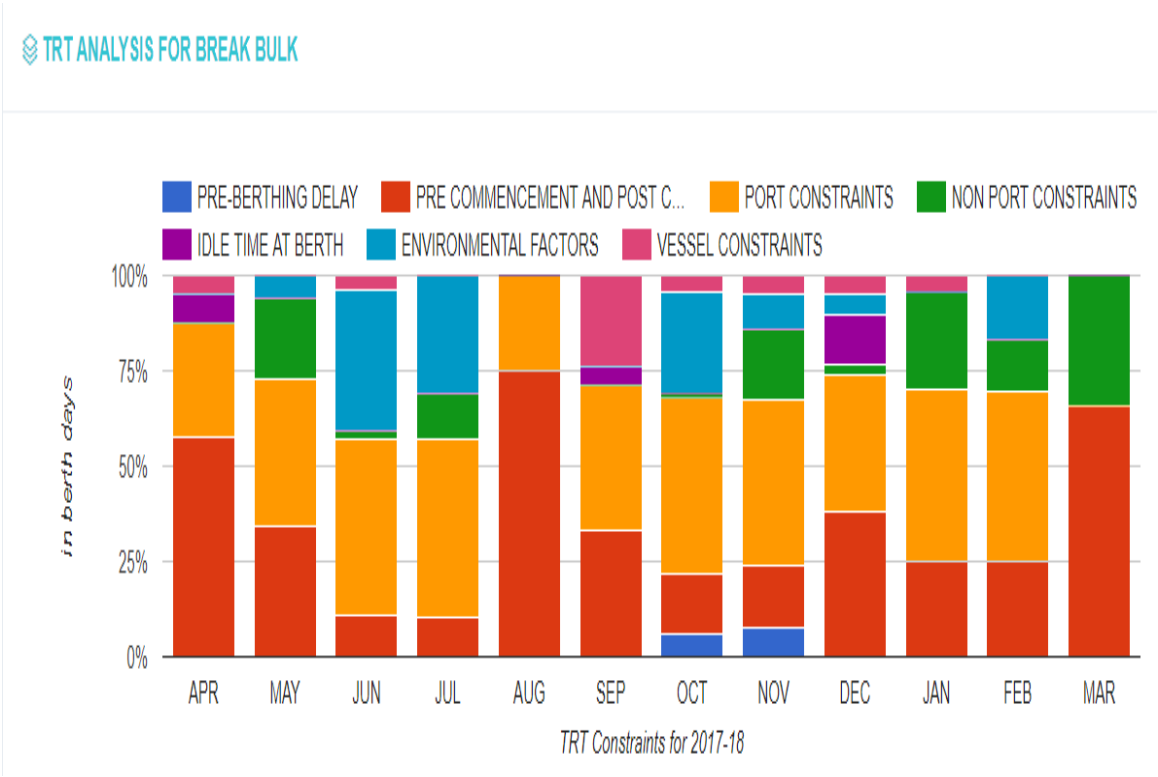


Figure 4.25 Commodity wise TRT Constraints (Break Bulk) for the year 2017-18

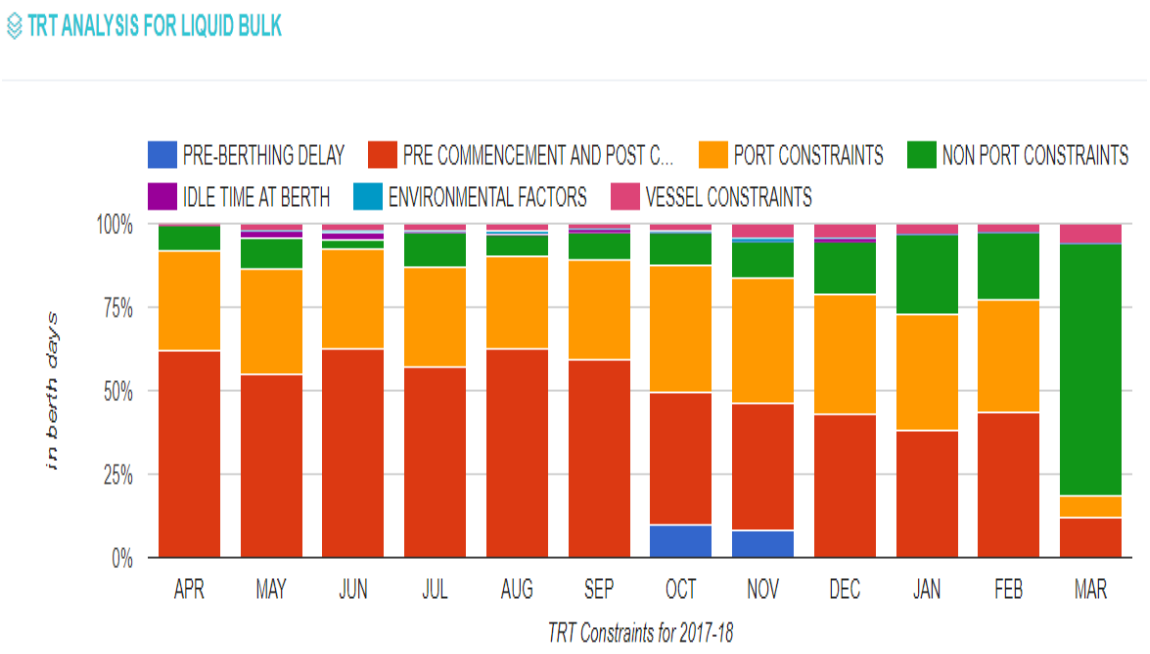


Figure 4.26 Commodity wise TRT Constraints (Liquid Bulk) for the year 2017-18

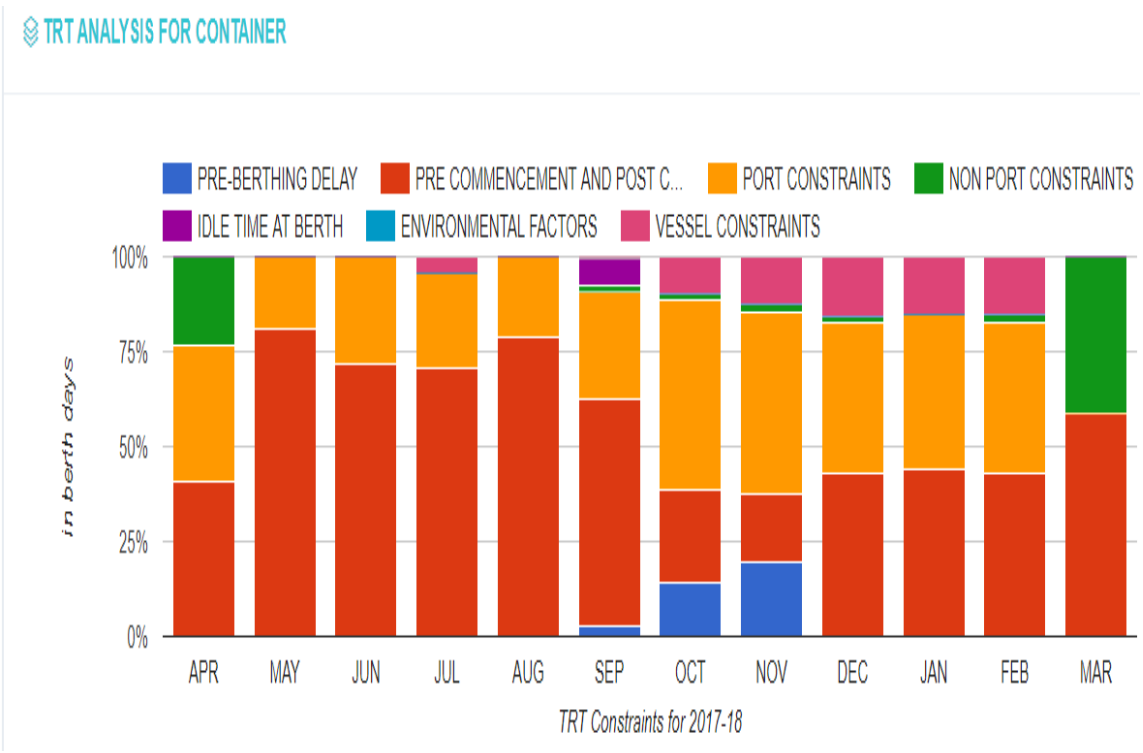


Figure 4.27 Commodity wise TRT Constraints (Container) for the year 2017-18

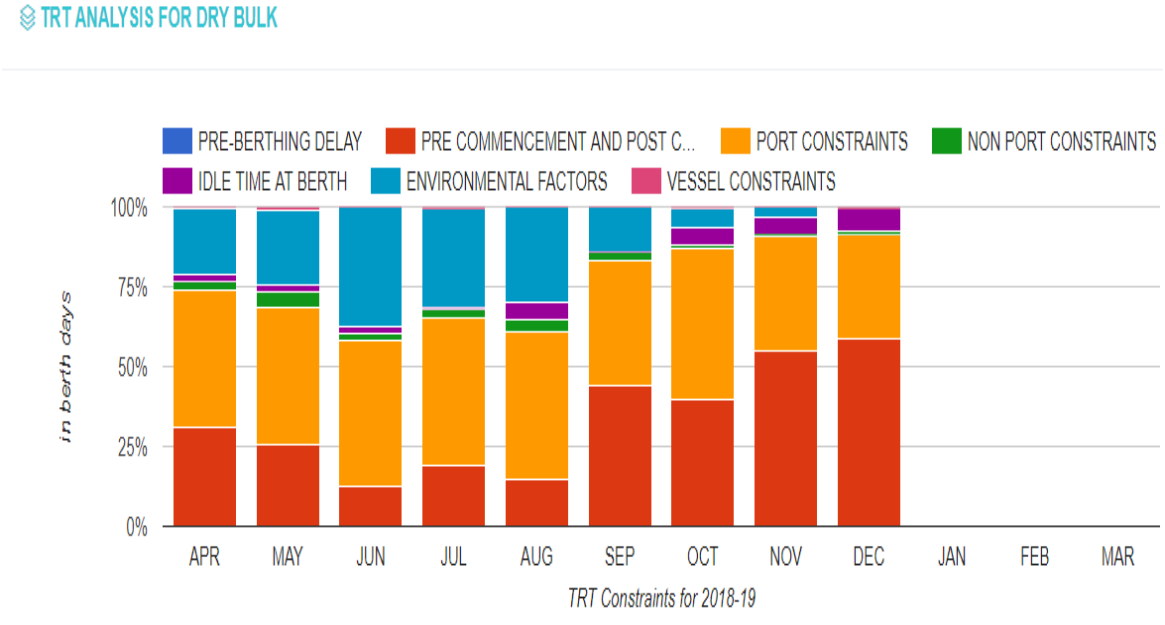


Figure 4.28 Commodity wise TRT Constraints (Dry Bulk) for the year 2018-19 (Up to Dec.18)

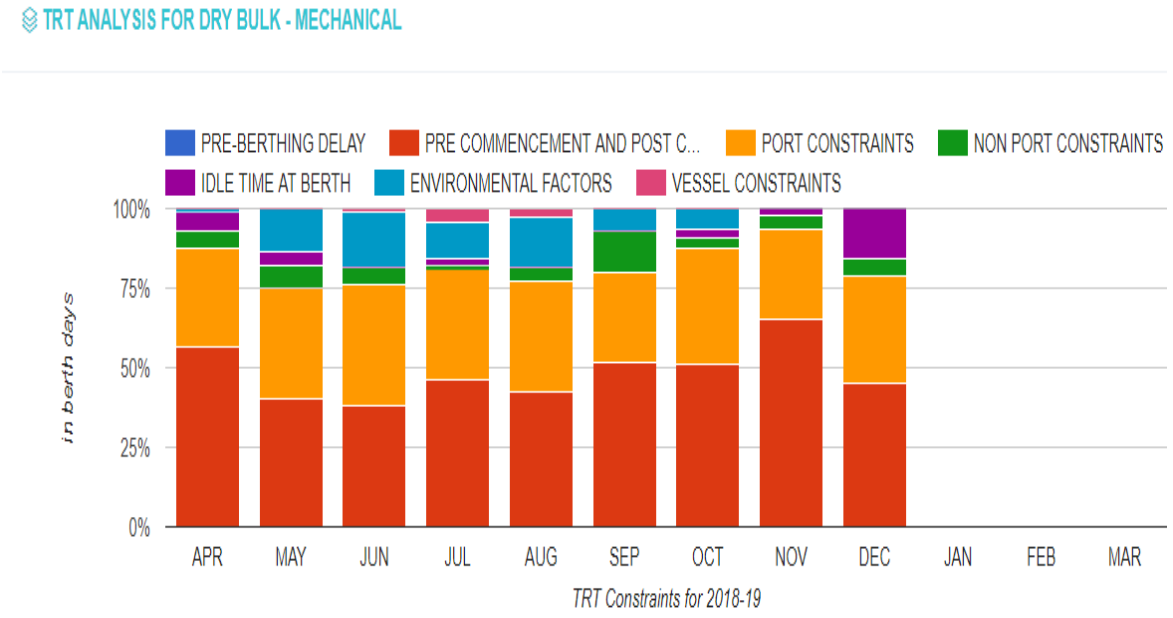


Figure 4.29 Commodity wise TRT Constraints (Dry Bulk-M) for the year 2018-19(Up to Dec.18)

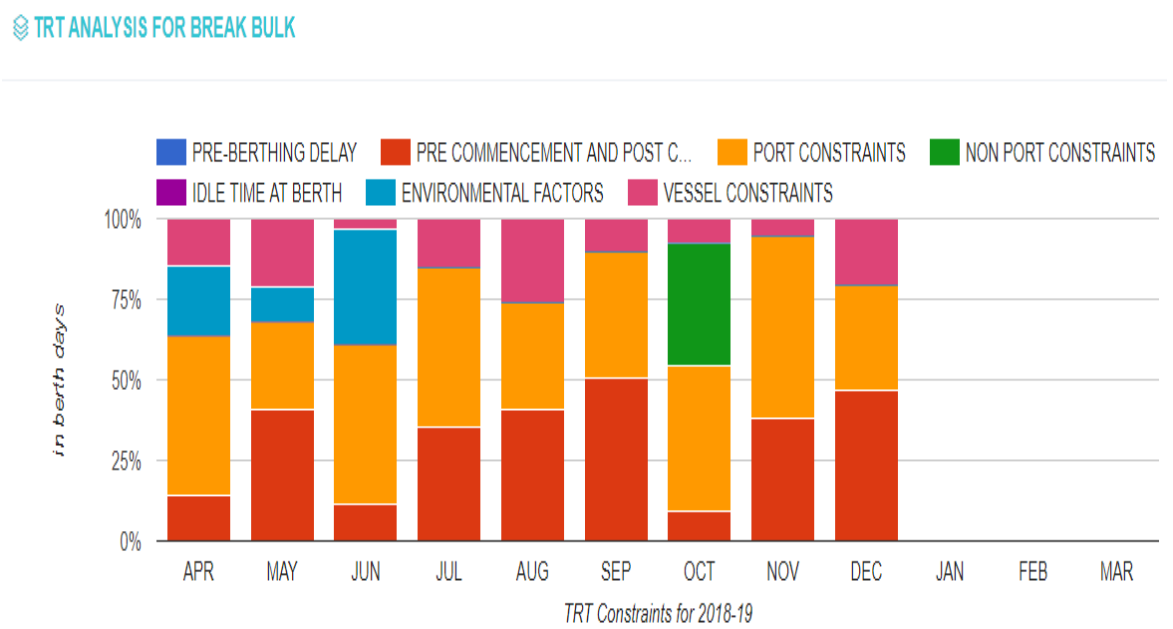


Figure 4.30 Commodity wise TRT Constraints (Break Bulk) for the year 2018-19 (Up to Dec.18)

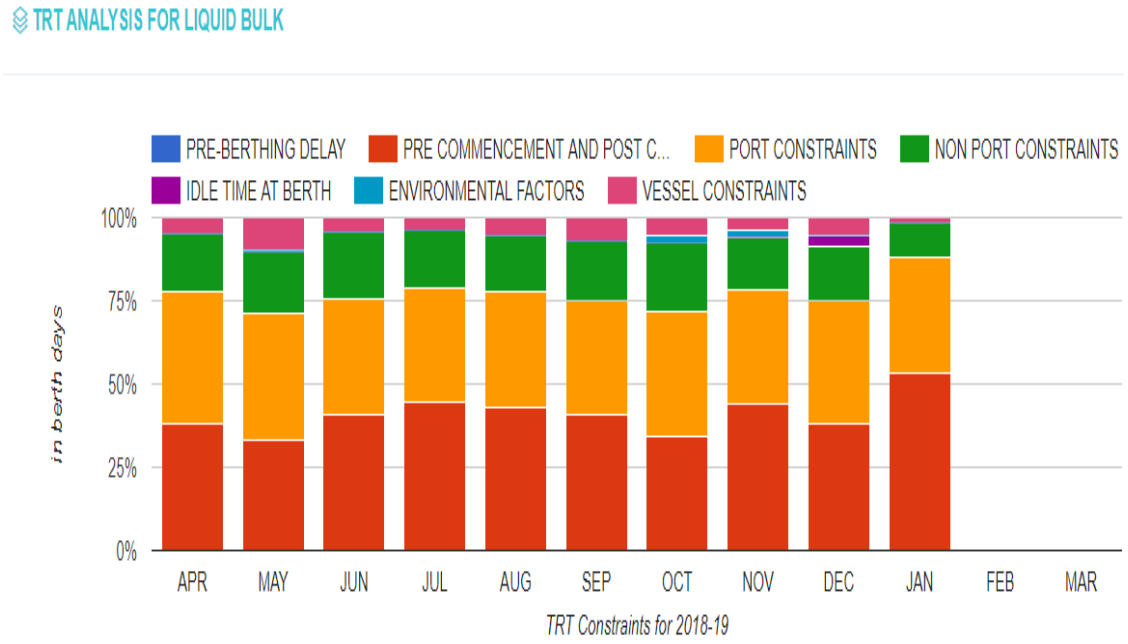


Figure 4.31 Commodity wise TRT Constraints (Liquid) for the year 2018-19 (Up to Dec.18)

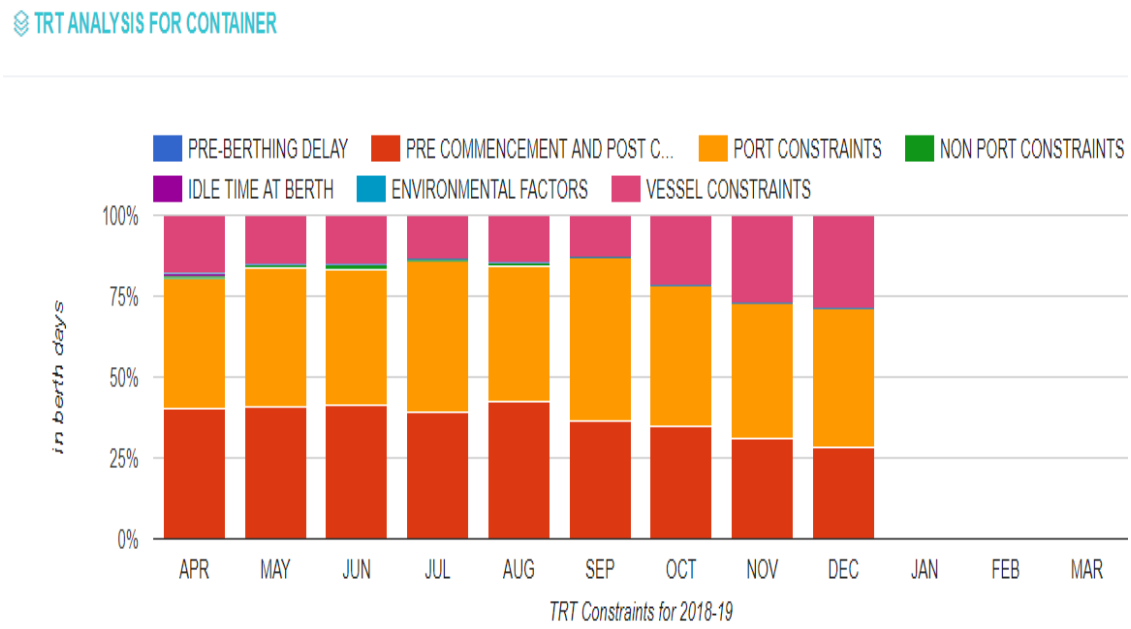


Figure 4.32 Commodity wise TRT Constraints (Container) for the year 2018-19 (Up to Dec.18)

The commodity wise TRT constraint analysis for the rear 2018-19, reveals that in case of dry bulk pre-commencement and post-commencement factors and port constraints are the major contributing the delay in the TRT. During the monsoon months the environmental constrains also having the share on the increased TRT of the vessels. Idle time at berth and non-port constraints also affects to a certain extent the TRT. In case of break bulk cargo pre commencement and post commencement factors, port-constraints and vessel constraints are the major factors contributing to the increased TRT. In case of liquid bulk cargo pre commencement and post commencement factors, port constraints and non-port constraints are the major contributing the delay in the TRT. In case of container cargo pre commencement and post commencement factors, port constraints and vessel constraints are the major contributors for delay in TRT.

4.9. Sensitivity Analysis

Using the vessel turnaround time optimization model, the total time consumed, percentage of TRT and frequency of occurrence on monthly basis are analyzed for each of the identified factors which are responsible for vessel turnaround time. From this analysis the top 20 factors which are most sensitive to TRT are identified on month on month basis and results are tabulated for the months of January 2018 to December 2018 in Table 5.1 to 5.12. The sensitivity analysis shows that in the year 2018-2019 on an average 1350 hours per month are lost, which is around 17.50% of the total monthly turnaround time of the all vessels calling on to the port during the year in consideration. The major constrains which contribute to this increased turnaround time are the total time lost during loading and unloading operations, documentation procedures, custom clearance, survey of the cargo and the time lost due to non-port account, which are attributable to the account of shipping lines/agents. The sampling of cargo and lab test for quality assurance before loading and unloading the cargo by the concerned authority also contributes to the delay in turnaround time of the vessel. Weather constraints and some of the port constraints like shifting of vessel from one berth to the other for draft requirements, idle time at berth are some of the factors which also contribute to the increased vessel turnaround time in NMPT.

Table.5.1: Top 20 sensitive factors responsible for High TRT for the Month of JAN **2018**

Sl.No	TRT CONSTRAINT	TOTAL HOURS CONSUMED	PERCENTAGE OF TRT	FREQUENCY OF OCCURANCE
1	LOADING/UNLOADING OPERATIONS	583.92	5.51%	115
2	CLEARANCE FROM CUSTOMS	288.88	2.72%	115
3	NONPORT ACCOUNT	166.37	1.57%	11
4	SURVEY INWARD	92.42	0.87%	97
5	DEPARTURE FORMALITIES	86.30	0.81%	87
6	SURVEY OUTWARD	81.58	0.77%	89
7	DOCUMENTATION	78.08	0.74%	103
8	SAMPLING	40.47	0.38%	58
9	CUSTOM INWARD	39.27	0.37%	105
10	SAMPLE TESTING	30.52	0.29%	3
11	LABTEST	26.25	0.25%	41
12	MANIFOLD FIXATION	24.62	0.23%	68
13	CUSTMS OUTWARDS	20.05	0.19%	28
14	IMMIGRATION DOCUMENTATION	19.40	0.18%	104
15	VESSEL ADVANCED BERTH	17.43	0.16%	5
16	PREBERTHING TIDE CONSTARAINT	14.70	0.14%	1
17	PHOROLE	14.43	0.14%	81
18	SHIFTING	13.42	0.13%	5
19	HOT WATER FLUSHING	12.50	0.12%	3
20	INTERMEDIATE SURVEY	11.92	0.11%	8
	TOTAL	**1662.53**	**15.68%**	

Table.5.2: Top 20 Sensitive factors responsible for High TRT for the Month of FEB **2018**

Sl.No	TRT CONSTRAINT	TOTAL HOURS CONSUMED	PERCENTAGE OF TRT	FREQUENCY OF OCCURANCE
1	LOADING_UNLOADING_OPERATIONS	402.72	6.61%	86
2	CLEARANCE FROM CUSTOMS	171.48	2.81%	86
3	DEPARTURE FORMALITIES	79.52	1.30%	69
4	DOCUMENTATION	60.47	0.99%	68
5	SURVEY INWARD	53.90	0.88%	70
6	SURVEY OUTWARD	46.60	0.76%	51
7	DETAINED BY MMD	37.00	0.61%	1
8	WANT OF CARGO	35.60	0.58%	1
9	SAMPLE TESTING	21.60	0.35%	2
10	NON PORT ACCOUNT	20.53	0.34%	18
11	CUSTOM INWARD	19.03	0.31%	73
12	LABTEST	17.78	0.29%	31
13	MANIFOLD FIXATION	16.58	0.27%	48
14	HOT WATERF LUSHING	16.00	0.26%	2
15	WEATHER CONSTRAINTS	16.00	0.26%	1
16	OTHER_VESSEL_MOVEMENT	15.03	0.25%	12
17	SAMPLING	15.00	0.25%	28
18	IMMIGRATION DOCUMENTATION	13.68	0.22%	75
19	SHIFTING	12.10	0.20%	3
20	PHOROLE	11.03	0.18%	63
	Total	**1081.65**	**17.72%**	

Table.5.3: Top 20 sensitive factors responsible for High TRT for the Month of MARCH **2018**

Sl.No	TRT CONSTRAINT	TOTAL HOURS CONSUMED	PERCENTAGE OF TRT	FREQUENCY OF OCCURANCE
1	NON PORT ACCOUNT	234.05	2.14%	114
2	LOADING/UNLOADING OPERATIONS	148.07	1.36%	14
3	SURVEY INWARD	57.48	0.53%	79
4	SAMPLING LIQUID CARGO	50.45	0.46%	51
5	CLEARANCE FROM CUSTOMS	45.77	0.42%	99
6	MANIFOLD FIXATION	22.45	0.21%	70
7	LAB TEST	21.53	0.20%	49
8	ULLAGE CONSTRAINTS	21.02	0.19%	3
9	IMMIGRATION DOCUMENTATION	19.83	0.18%	98
10	WANT OF CARGO	19	0.17%	2
11	PLT TRANSFER	18.07	0.17%	3
12	PHOROLE	16.23	0.15%	80
13	DOCUMENTATION	10.68	0.10%	7
14	PREP. OF WORK	8.98	0.08%	12
15	SURVEY OUTWARD	4.53	0.04%	3
16	OTHER VESSEL MOVEMENT	4.25	0.04%	2
17	TANK INSPECTION	3	0.03%	2
18	SHIP ACCOUNT	3	0.03%	1
19	STRIPPING /LINE FLUSHING	2.9	0.03%	1
20	HOT GASING	2.77	0.03%	4
	TOTAL	**714.06**	**6.56%**	

Table.5.4: Top 20 sensitive factors responsible for High TRT for the Month of APRIL **2018**

Sl.No	TRT CONSTRAINT	TOTAL HOURS CONSUMED	PERCENTAGE OF TRT	FREQUENCY OF OCCURANCE
1	LOADING/UNLOADING OPERATIONS	505.92	6.57%	101
2	CLEARANCE FROM CUSTOMS	205.62	2.67%	101
3	WEATHER CONSTRAINTS	109.03	1.42%	10
4	DOCUMENTATION	100.02	1.30%	93
5	SURVEY INWARD	62.42	0.81%	76
6	SURVEY OUTWARD	53.48	0.69%	48
7	SAMPLE TESTING	44.3	0.58%	2
8	CUSTMS FORMALITIES	34.87	0.45%	64
9	CUSTOM DOCUMENTATION	26.07	0.34%	93
10	NON PORT ACCOUNT	19.08	0.25%	22
11	IMMIGRATION DOCUMENTATION	17.58	0.23%	92
12	LAB TEST	17.5	0.23%	37
13	MANIFOLD FIXATION	15.5	0.20%	52
14	SAMPLING LIQUID CARGO	15.33	0.20%	38
15	SHIFTING	14.2	0.18%	4
16	LASHING	14.03	0.18%	13
17	PHOROLE	13.45	0.17%	74
18	TANK INSPECTION	13.35	0.17%	19
19	BREAKBULK AND SEAING INSPECTION	12.08	0.16%	29
20	NON AVAIABILITY OF EQUIPMENT	11.98	0.16%	2
	Total	**1305.81**	**16.96%**	

Table.5.5: Top 20 sensitive factors responsible for High TRT for the Month of MAY **2018**

Sl.No	TRT CONSTRAINT	TOTAL HOURS CONSUMED	PERCENTAGE OF TRT	FREQUENCY OF OCCURANCE
1	LOADING/UNLOADING_OPERATIONS	626.53	8.14%	102
2	CLEARANCE FROM CUSTOMS	212.12	2.76%	102
3	WEATHERS CONSTRAINTS	188.92	2.46%	23
4	DOCUMENTATION	130.25	1.69%	100
5	SURVEY INWARD	63.48	0.83%	70
6	SURVEY OUTWARD	42.92	0.56%	40
7	CUSTOM DOCUMENTATION	25.47	0.33%	93
8	CUSTOMS FORMALITIES	22.43	0.29%	59
9	LABTEST	18.35	0.24%	39
10	NONPORT ACCOUNT	18.28	0.24%	26
11	IMMIGRATION DOCUMENTATION	17.97	0.23%	93
12	STRIPPING LINE/FLUSHING	17.6	0.23%	8
13	WAITING FOR SHIPSIDE READINESS	17.33	0.23%	2
14	TANK INSPECTION	17.05	0.22%	19
15	MANIFOLD FIXATION	16.83	0.22%	56
16	BUNKERING	16.72	0.22%	2
17	SAMPLING LIQUID CARGO	15.65	0.20%	40
18	VESSEL REPAIRS OR ITS EQUIPMENT	13.65	0.18%	2
19	LASHING	13.47	0.18%	17
20	SAMPLE TESTING	13.4	0.17%	2
	TOTAL	**1508.42**	**19.62%**	

Table.5.6: Top 20 sensitive factors responsible for High TRT for the Month of JUNE **2018**

Sl.No	TRT CONSTRAINT	TOTAL HOURS CONSUMED	PERCENTAGE OF TRT	FREQUENCY OF OCCURANCE
1	LOADING/UNLOADING OPERATIONS	965.35	10.35%	111
2	WEATHERS CONSTRAINTS	515.05	5.52%	29
3	CLEARANCE FROM CUSTOMS	228.67	2.45%	111
4	DOCUMENTATION	149.4	1.60%	111
5	SURVEY INWARD	65.05	0.70%	80
6	SURVEY OUT WARD	61.47	0.66%	48
7	TANK INSPECTION	41.85	0.45%	22
8	NONPORTA/C	31.65	0.34%	32
9	PORTS EQUIPMENT BREAKDOWN	28.75	0.31%	3
10	CUSTOM DOCUMENTATION	25.72	0.28%	101
11	CUSTOMS FORMALITIES	22.1	0.24%	55
12	IMMIGRATION/DOCUMENTATION	20.08	0.22%	103
13	MANIFOLD FIXATION	19.92	0.21%	64
14	LABTEST	18.32	0.20%	50
15	OTHER VESSEL MOVEMENT	15.58	0.17%	12
16	SAMPLING LIQUID CARGO	15.58	0.17%	47
17	PHOROLE	14.82	0.16%	81
18	SAMPLE TESTING	14.8	0.16%	3
19	VESSEL ADVANCED BERTH	14.18	0.15%	3
20	BUNKERING	13.75	0.15%	2
	Total	**2282.09**	**24.49%**	

Table.5.7: Top 20 sensitive factors responsible for High TRT for the Month of JULY **2018**

Sl.No	TRT CONSTRAINT	TOTAL HOURS CONSUMED	PERCENTAGE OF TRT	FREQUENCY OF OCCURANCE
1	LOADING/UNLOADING_OPERATIONS	702.62	8.93%	114
2	CLEARANCE FROM CUSTOMS	286.87	3.65%	114
3	WEATHER CONSTRAINTS	200.5	2.55%	16
4	DOCUMENTATION	162.1	2.06%	114
5	SURVEY INWARD	64.77	0.82%	77
6	SURVEY OUTWARD	54.88	0.70%	40
7	OTHER VESSEL MOVEMENT	42.35	0.54%	20
8	NONPORT ACCOUNT	26.73	0.34%	29
9	CUSTOM DOCUMENTATION	26.45	0.34%	104
10	LABTEST	24.03	0.31%	57
11	CUSTMSF ORMALITIES	22.47	0.29%	53
12	TANK INSPECTION	21.62	0.27%	26
13	MANIFOLD FIXATION	20.67	0.26%	72
14	SHIFTING	20.4	0.26%	6
15	SAMPLING LIQUID CARGO	20.25	0.26%	55
16	IMMIGRATION DOCUMENTATION	19.15	0.24%	105
17	DETAINED BY MMD	19	0.24%	1
18	SAMPLE TESTING	17.33	0.22%	3
19	WAITING FOR SHORESIDE READINESS	15.3	0.19%	3
20	INTERMEDIATE SURVEY	11.92	0.11%	8
	TOTAL	**1782.39**	**22.66%**	

Table.5.8: Top 20 sensitive factors responsible for High TRT for the Month of AUG **2018**

Sl.No	TRT CONSTRAINT	TOTAL HOURS CONSUMED	PERCENTAGE OF TRT	FREQUENCY OF OCCURANCE
1	LOADING/UNLOADINGOPERATIONS	595.9	8.50%	103
2	CLEARANCE FROM CUSTOMS	217.47	3.10%	103
3	WEATHERS CONSTRAINTS	161	2.30%	13
4	DOCUMENTATION	147.8	2.11%	103
5	SURVEY INWARD	56.63	0.81%	71
6	SURVEY OUTWARD	40.37	0.58%	36
7	HOLIDAY RECESS	24	0.34%	1
8	CUSTOM DOCUMENTATION	23.87	0.34%	95
9	SAMPLE TESTING	23.1	0.33%	2
10	LAB TEST	21.68	0.31%	53
11	CUSTMS FORMALITIES	20.85	0.30%	48
12	NONPORT ACCOUNT	19.28	0.28%	21
13	MANIFOLD FIXATION	19	0.27%	65
14	TANK INSPECTION	18.7	0.27%	23
15	SAMPLING LIQUID CARGO	18.63	0.27%	49
16	OTHER VESSEL MOVEMENT	18.15	0.26%	16
17	WHARFING	17.37	0.25%	3
18	DETAINED BY MMD	17	0.24%	1
19	IMMIGRATION DOCUMENTATION	16.43	0.23%	96
20	LASHING	12.88	0.18%	18
	Total	**1490.11**	**21.27%**	

Table.5.9: Top 20 sensitive factors responsible for High TRT for the Month of SEP **2018**

Sl.No	TRT CONSTRAINT	TOTAL HOURS CONSUMED	PERCENTAGE OF TRT	FREQUENCY OF OCCURANCE
1	LOADING/UNLOADING_OPERATIONS	440.2	6.39%	96
2	CLEARANCE FROM CUSTOMS	195.52	2.84%	96
3	DOCUMENTATION	138.45	2.01%	96
4	SURVEY INWARD	48.83	0.71%	63
5	SURVEY OUTWARD	43.33	0.63%	40
6	NONPORT ACCOUNT	42.05	0.61%	31
7	WEATHERS CONSTRAINTS	33.28	0.48%	8
8	CUSTOM DOCUMENTATION	22.9	0.33%	91
9	MANIFOLD FIXATION	21.92	0.32%	64
10	CUSTOMS FORMALITIES	20.67	0.30%	44
11	LABTEST	20.48	0.30%	43
12	TANK INSPECTION	18.57	0.27%	22
13	SAMPLE TESTING	18.1	0.26%	3
14	SAMPLING LIQUID CARGO	17.22	0.25%	42
15	SHIPSHORELINEUP	15.28	0.22%	41
16	IMMIGRATION DOCUMENTATION	14.78	0.21%	91
17	HOT WATER FLUSHING	13.6	0.20%	1
18	HOT GASING	13.25	0.19%	18
19	WAITING FOR SHORESIDE READINESS	11.8	0.17%	3
20	PHOROLE	11.02	0.16%	71
	TOTAL	**1161.25**	**16.86%**	

Table.5.10: Top 20 sensitive factors responsible for High TRT for the Month of OCT **2018**

Sl.No	TRT CONSTRAINT	TOTAL HOURS CONSUMED	PERCENTAGE OF TRT	FREQUENCY OF OCCURANCE
1	LOADING /UNLOADINGOPERATIONS	646.4	7.39%	115
2	CLEARANCE FROM CUSTOMS	254.6	2.91%	115
3	DOCUMENTATION	143.62	1.64%	115
4	NON PORT ACCOUNT	100.47	1.15%	20
5	SURVEY INWARD	70.6	0.81%	79
6	SURVEY OUTWARD	69.32	0.79%	60
7	CUSTOMS FORMALITIES	31.57	0.36%	63
8	WEATHERS CONSTRAINTS	29.25	0.33%	9
9	MANIFOLD FIXATION	26.62	0.30%	63
10	CUSTOM DOCUMENTATIN	26.6	0.30%	107
11	WANT OF CARGO	26.5	0.30%	1
12	SAMPLE TESTING	26.5	0.30%	3
13	LASHING	23.85	0.27%	19
14	TANK INSPECTION	23.12	0.26%	25
15	PORTS EQUIPMENT BREAKDOWN	22.92	0.26%	6
16	OTHER VESSEL MOVEMENT	21.22	0.24%	19
17	NON AVAIABILITY EQUIPMENT	20.5	0.23%	1
18	LABTEST	20.28	0.23%	41
19	SAMPLING LIQUIDCARGO	18.62	0.21%	45
20	IMMIGRATION DOCUMENTATION	15.7	0.18%	107
	Total	**1618.26**	**18.46%**	

Table.5.11: Top 20 sensitive factors responsible for High TRT for the Month of NOV **2018**

Sl.No	TRT CONSTRAINT	TOTAL HOURS CONSUMED	PERCENTAGE OF TRT	FREQUENCY OF OCCURANCE
1	LOADING/UNLOADING_OPERATIONS	402.5	4.88%	117
2	CLEARANCE FROM CUSTOMS	202.85	2.46%	117
3	DOCUMENTATION	128.55	1.56%	117
4	SURVEY INWARD	62.1	0.75%	77
5	SURVEY OUTWARDS	61.58	0.75%	52
6	CUSTOM DOCUMENTATIOM	26.32	0.32%	109
7	LASHING	25.3	0.31%	22
8	CUSTOMS FORMALITIES	23.9	0.29%	63
9	SAMPLE TESTING	21.73	0.26%	2
10	MANIFOLD FIXATION	19.2	0.23%	61
11	TANK INSPECTION	18.6	0.23%	21
12	LABTEST	16	0.19%	40
13	IMMIGRATION DOCUMENTATION	15.6	0.19%	109
14	OTHER VESSEL MOVEMENT	13.75	0.17%	11
15	SAMPLING LIQUID CARGO	13.53	0.16%	40
16	TIDAL CONDITION	13	0.16%	2
17	NON PORT ACCOUNT	11.82	0.14%	23
18	WHARFING	11.43	0.14%	2
19	PHOROLE	10.75	0.13%	74
20	HOT GASING	8.78	0.11%	13
	TOTAL	**1107.29**	**13.43%**	

Table.5.12: Top 20 Sensitive factors responsible for High TRT for the Month of DEC **2018**

Sl.No	TRT CONSTRAINT	TOTAL HOURS CONSUMED	PERCENTAGE OF TRT	FREQUENCY OF OCCURANCE
1	LOADING/UNLOADINGOPERATIONS	448.75	6.41%	106
2	CLEARANCE FROM CUSTOMS	191.05	2.73%	106
3	DOCUMENTATION	129.93	1.86%	106
4	SURVEY INWARD	61.63	0.88%	49
5	SURVEY OUT WARD	52.93	0.76%	65
6	SAMPLE TESTING	33.5	0.48%	4
7	LASHING	28.3	0.40%	21
8	NO WORK	27.5	0.39%	1
9	CUSTOM DOCUMENTATION	24.8	0.35%	97
10	LAB TEST	20.8	0.30%	42
11	NON PORT ACCOUNT	20.25	0.29%	28
12	CUSTOMS FORMALITIES	19.37	0.28%	55
13	POWERP ROBLEMS	19.25	0.27%	2
14	MANIFOLD FIXATION	18.57	0.27%	63
15	TANK INSPECTION	15.7	0.22%	22
16	IMMIGRATION DOCUMENTATION	15	0.21%	96
17	SAMPLING LIQUID CARGO	13.47	0.19%	39
18	SHIFTING	11.62	0.17%	6
19	PORTS EQUIPMENT BREAKDOWN	11.22	0.16%	5
20	PHOROLE	10.17	0.15%	68
	Total	**1173.81**	**16.77%**	

From the top 20 sensitive factors, which are responsible for the high vessel turnaround time from the month of January to December for the year 2018, it is observed that the total hours lost is highest in the month of June is 2282.09 hours amounting to 24.49% and it is least for the month of March is 714.06 hours amounting to 6.56% of the total monthly turnaround time of all the vessels calling on to the port. This also shows that during the monsoon period i.e in the months of June, July and August TRT is high and percentage of time lost is above 20%. This shows that the time lost due to various constraints is more for the monsoon months compared to other months. The highest percentage of time lost and the frequency of occurrence are for the TRT constraints of loading/unloading operations, custom clearance, non port account, survey of cargo and documentation. The major constrains which contribute to this increased turnaround time are the total time lost during loading and unloading operations, documentation procedures, custom clearance, survey of the cargo and the time lost due to non-port account, which are attributable to the account of shipping lines/agents. The sampling of cargo and lab test for quality assurance before loading and unloading the cargo by the concerned authority also contributes to the delay in turnaround time of the vessel. Weather constraints and some of the port constraints like shifting of vessel from one berth to the other for draft requirements, idle time at berth are some of the factors which also contribute to the increased vessel turnaround time in NMPT.

CHAPTER 5
CONCLUSIONS, RECOMMONDATIONS, LIMITATIONS AND SCOPE FOR THE FUTURE WORK

5.1 General

Optimization in a seaport does not only mean improving the productivity but also reducing the operational cost. Optimization represents a new approach to managing the port terminals. The most important factor in providing high quality service in ports is to ensure on-time services to the port users by minimizing the vessel delay and increasing the gross berth productivity. New Mangalore port plays a crucial role in handling the liquid bulk and dry bulk cargo to serve the needs of the petrochemical and thermal power industries in the this region. However, the vessel turnaround time remains the key problem. It is much higher than the ports in the other developed nations. It is being several times higher than the ports in China, Malaysia and Singapore. The factors attributable for high turnaround time at NMPT are mainly due to the pre-commencement and post-commencement documentation/custom formalities and the total time lost during loading unloading process. Non-availability of berths in case of liquid bulk cargo and non-availability of equipments and lack of mechanization in the dry bulk cargo handling are also contributes to increased turnaround time of vessels. Indian ports are phasing high competition in trading across borders due to its high cost of cargo handling and cumbersome documentation procedures involved in import/export process.

A high performing port can boost the local economy and industry, while a poor performing port can do the opposite. Therefore, NMPT terminals have to focus on reducing the vessel turnaround time, minimizing operation expenses, ensuring and scheduling full operational control. Thus, decision of port authorities as well as ship operators in any given budget and resource input, results in time and cost minimization and it is possible to tackle all the delay causing factors by the port management in providing efficient and cost effective services and increased port productivity, and to achieve optimum port performance.

5.2. Conclusions

The main objective of the research is to identify the factors that affects the high vessel turnaround time of vessels at NMPT and to optimise the same. About more than120 factors are identified which contributes to the high VTRT in the port. These factors are grouped into seven categories based on the activities involved in the turnaround process and the constraints faced by a vessel calling on the port. The main seven categories of VTRT constraints are i) pre berthing delay factors, ii) pre-commencement and post commencement factors, iii) port constraints, iv) non-port constraints, v) idle time at berth, vi) environmental constraints, vii) vessel constraints.

The major constraints in the pre berthing delay categories are non-availability of berths, non-availability of pilots ,non-availability of mooring gangs, delay in notice to VTMS and tidal/draft. In case of pre-commencement and post-commencement factors the main constraints that contribute to the increased vessel turnaround time are customs formalities, custom documentation both in inward and outward movement of vessels, inspection, survey of the cargo and immigration documentation are some of the factors. The non-port constraints are limited to want of cargo in some cases, breakdown of equipments and waiting for shore side readiness. The main observed port constraints are non-availability of labour gangs, non-availability of port crafts/tugs, priority berthing of coastal cargo vessels, other vessel movement. The idle time at berth observed are break during the shifts, shifting of vessel from one berth to other for operational requirements and want of draft and ports equipment breakdown. The study revealed that, the major constraints that cause delays are: delay in loading and unloading operations and delay occur during pre-commencement and post commencement of turnaround process mainly in the documentation and custom clearance.

From the developed vessel turnaround time optimisation model, in the year on year TRT module, one can generate the port performance indicators such has pre-berthing waiting time (PBWT), vessel turnaround time (TRT), Non-working time at berth (NWTB), Number of vessels handled, output per ship berthday (OSBD) and port productivity. The model can also be useful in generating various MIS outputs required

for the top port management such as Port Performance Indicators (PPI), cargo through put, number of vessels sailed/berthed etc. with respect to the category of cargo handled, berth wise, on daily/monthly/yearly basis. The top management can get the details by click on botton using this module output.

From the year wise analysis of TRT it is observed that the pre-berthing waiting time and service time contributes to the maximum percentage of vessel turnaround time in NMPT. On an average 30 to 35% of the total turnaround time the vessels are waiting at the anchorage point before entering into the port and around 50 to 60% of time is consumed in the service time with in the ports. The increased pre berthing waiting time is mainly attributable to insufficient port infrastructure like want of berths in case of liquid bulk cargo, want of mechanised loading and unloading systems in case of dry bulk and break bulk cargo. From the seasonal TRT analysis, it is observed that service time is on higher side during the monsoon months and the pre berthing time is on higher side in the non-monsoon months. It is also observed that the outward movement time is more compared to inward movement time of vessels calling on to the port.

The year wise TRT constraint analysis reveals that in NMPT the pre commencement and post commencement factors and port constraints are major contributing factors to high turnaround time. In case of commodity wise analysis for the year 2018-19 the TRT of dry bulk cargo is mainly affected by the documentation and custom formalities during the inward as well as outward movement of the vessels. In case of break bulk cargo port constraints and vessel constraints are the major contributing factors in addition to the time lost in documentation and custom formalities. In case of liquid bulk cargo port and non-port constraints such as want of berth and want of cargo are also contributing to increase in TRT.

Using sensitive factors module, top 20 factors which are most sensitive to TRT are identified on month on month basis which are responsible for high vessel turnaround time at NMPT. The sensitivity analysis shows that in the year 2018-2019 on an average 1350 hours per month are lost, which is around 17.50% of the total monthly turnaround time of the all vessels calling on to the port during the year in consideration. The major constrains which contribute to this increased turnaround

time are the total time lost during loading and unloading operations, documentation procedures, custom clearance, survey of the cargo and the time lost due to non-port account, which are attributable to the account of shipping lines/agents. The sampling of cargo and lab test for quality assurance before loading and unloading the cargo by the concerned authority also contributes to the delay in turnaround time of the vessel. Weather constraints and some of the port constraints like shifting of vessel from one berth to the other for draft requirements, idle time at berth are some of the factors which also contribute to the increased vessel turnaround time in NMPT.

Thus, the present vessel turnaround time optimization model will help the port management to verify the factors in the problematic area and to take corrective action to provide efficient services and improve the port performance to ensure increased productivity and efficiency. The developed VTRTO model is also very useful in making quick decision by the port authorities as well as ship operators in any given budget or resource input and to achieve the results in time and cost minimization. It is also possible to tackle all the delay causing factors by the port management by providing effective and efficient port services and increased port productivity, with the aim to achieve optimum port performance. The objective of the research is to determine the factor(s) which are most significant cause for increased turnaround time of the vessel. The model can also be useful in generating various MIS outputs, port performance indicators (PPI) with respect to the category of cargo handled, and berth wise, on daily/monthly/yearly basis.

5.3. Recommendations

The findings of the research show that the pre-commencement and post-commencement factors are the most influential factors for the increased vessel turnaround time at the NMPT. These cause delays in berthing operations, and vessels has to spend more time at the port. Among the main factors considered, the time taken by the importers or their customs brokers for completing various procedures like payment of duty and registration of goods with the customs. In large number of cases, delays in payment of duty by the importers or in the clearance process occur due to reasons such as, paucity of funds for clearances; this also contributes in delay

loading/unloading process .The market speculation by the traders before releasing goods from the custodian is also a cause for high VTRT.

Secondly, cargo transferring operation is also a influential factor for the Vessel TRT at the New Mangalore Port Trust. Terminal managers point out this issue, out of their control as supplying and managing the service time during loading and discharging operations and to reduce ideal time at berths. Port constraints and non-port constraints are also have a considerable contribution towards Vessel TRT but the amount of importance varies with the type of commodity. Hence, based on the present study, following recommendations were drawn for the better port management.

- To have proper coordination between various stake holders of the turnaround process like port authority, custom authority, shipping agents/vessel liners, port security and other agencies concerned in the documentation process during the pre-commencement and post commencement of loading/unloading operations of the cargo into the vessels. Further assistance for preparation of documents can be provided by the port management. At present, to prepare the documents for export of goods, exporter has to directly go to the customs department and prepare the documents. This process takes time as the exporters will not be so aware of the procedures. As a result, it creates a delay for the preparation of documents and without the documents; the ship cannot sail from the berth. So a separate unit can be created at the port for customs liaison. This can make the process faster and preparation of documents can be started in advance once the ship has registered with the port for loading/unloading of cargo.
- Implementing computerised single window systems for issuance of various clearance and port entry passes with Enterprise Resource Planning (ERP) so that all the port users can get the clearance and port entry permission on line with least interference from the port staff.
- Proper scheduling for shift gang and supervision during work time and attendance of labour may be arranged by the traffic department. While scheduling gang per ship, the contractors who are in-charge of bringing labour to work should ensure that all the labours are available on the spot and shift should be scheduled such that there is no gap between each shift. The loss of

time in between the change of shift of gangs and the operators may be minimised.

- Double cycle loading/unloading method may be adopted .Turnaround time of vessel includes the time taken to load and discharge cargos/containers. When loading and discharging a vessel, wharf cranes usually spend only half of their moves carrying a cargo/container. During the time of discharging, the crane comes without cargo while moving to the hatch of the vessel. During the time of loading, the crane is without load when returning to the wharf. Double cycling is the practice of making use of these "No Load" movements of cranes to carry a cargo/container, thus making the crane moves contributing to increased productivity, and there is a reduction in vessel turnaround time. With current single cycling or status quo methods, the number of moves necessary to turn-around the ship is fixed, and does not depend on the order in which the crane operates on the ship's columns. With double cycling, however, the number of moves depends on the order of operations. Therefore, the problem of double cycling is one of scheduling jobs, or finding the order in which to operate on the columns that minimizes ship turn-around time. The benefits of double cycling are significant for both hatched and hatch less ship, and are robust to constraints on the sequence of operations.
- Properly planning and managing the pilotage services and informing the vessels to be prepared for boarding of pilots could minimize the loss of time in pilot boarding and non-availability of pilots. The proper communication of date and time of boarding the vessel to the port pilots well in advance may also be recommended to avoid the loss of time due to non-availability of pilots on the specified date and time assigned to a particular vessel movement operations for inward/outward movement of vessels from the port area.
- Further delays in inward and out ward movement are due to lack of tug boats is also an issue causing berthing delays at the port. Employing new and more powerful tugs while scheduling the tug boats for maximum effectiveness are recommended to reduce delays caused by them.

- Another major finding is that the unavailability of berths delays in oil terminal catering the vessels carrying the liquid bulk cargo. Hence, the optimum number of oil berths shall be planned in the oil dock of the port.
- Research findings indicate that equipment operator's availability is also causing considerable delays. The terminal managers could properly schedule shifts with minimum interruptions to operations and introduce methods such as hot seat systems to avoid such delays.
- Lack of storage area transfer equipment and wharf crane operating rate are the two most important factors for every terminal. Investing on more cargo handling equipment is the most direct suggestion to resolve this problem.
- Purchase of additional equipment and preventive maintenance. Purchase of additional equipment and preventive maintenance like cranes for lease has to be performed to prevent equipment unavailability. Since, it is purchased on the lease, it does not impose many financial obligations on the port. Also, good preventive maintenance has to be carried out at regular intervals to prevent equipment breakdown. Normally what happens is that when a period of inactivity occurs equipments are not maintained and when a sudden surge of activity (ship arrival) occurs, equipment is being used without any maintenance. This leads to equipment breakdown and hence creates delays. Regular maintenance and monitoring is highly recommended to improve work efficiency of labours.

5.4 Limitations and Scope for future work

This study is aimed at identification of factors affecting the vessel turnaround time and analysis of the same for the root cause for high TRT at NMPT. The present study is limited to the vessels arrived /departed from the port for the year 2015-16 to 2018-19 up to December 2018 on the observed real time vessel arrival/departure at the port. Due to lack of systematic recording and documentation of various activities of vessel turnaround process it was not possible to analyse the causes of delay in turnaround time prior to the time frame considered for the research work. The study can extended to a longer duration from the inception of the port so that the effects of stages of developments, addition of infrastructures like berths, cargo handling equipment,

storage sheds/yards on the turnaround time can be studied. Further, the sensitivity analysis of identified factors can be carried out commodity wise, berth wise and day wise. This gives the very clear idea of actual delay causing factor and the port management can take immediate corrective action to have reduced turnaround time and increased port productivity. Due to time and access to the data the area of study was limited to only to the NMPT and the model is generated only based on the finding in this port. To generalise the research model and findings, future research may be extended to all the other major ports of India.

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APPENDIX- I

DATA MODEL OF EACH VESSEL

UNIQUE IDENTIFIER	NML11112019388	NML11112019426	NML11112019598	NML11113010111	NML11113010066
COMMODITY NAME	IOP (KIOCL)	CONTAINER	MACHINERY (STEEL COILS)	CRUDE - SPM	MET. COKE
CATEGORY	DB-M	C	BB	LB	DB
NAME OF VESSEL	M.V. PISTIS	M.V. SARAYU	M.V. ADINATH	M.T. JAG LAKSHITA	M.V. OASIS ISLAND
TONNAGE	50802	13291	7481	143974	22000
NRT	18207	12454	2913	45810	12101
GRT	30053	25535	5222	80870	23226
DWT	52388	33917	8184	147093	37816
F C	F	C	C	F	F
I E	E	I/E	I	I	I
ARRIVE AT ANCHORAGE DATE TIME	24-06-2018 12:15	03-07-2018 02:54	16-08-2018 12:30	29-12-2018 08:42	26-12-2018 01:18
READINESS OF VESSEL DATE TIME	24-06-2018 12:20	03-07-2018 03:00	17-08-2018 10:00	30-12-2018 08:00	26-12-2018 01:18
DEPARTURE FOR BERTH DATE TIME	24-06-2018 12:25	03-07-2018 03:12	17-08-2018 10:35	30-12-2018 08:12	26-12-2018 01:24
ARRIVE AT BERTH DATE TIME	24-06-2018 13:50	03-07-2018 04:24	17-08-2018 11:30	30-12-2018 09:42	26-12-2018 02:30
WORK COMMENCED DATE TIME	24-06-2018 15:15	03-07-2018 06:35	17-08-2018 15:15	30-12-2018 11:24	26-12-2018 04:00
WORK COMPLETED DATE TIME	25-06-2018 20:50	04-07-2018 14:25	18-08-2018 23:30	01-01-2019 00:30	28-12-2018 01:00
DEPARTURE FROM BERTH DATE TIME	25-06-2018 23:45	04-07-2018 15:18	19-08-2018 04:06	01-01-2019 01:54	28-12-2018 02:40
DEPARTURE FROM PORT DATE TIME	26-06-2018 01:45	04-07-2018 15:54	19-08-2018 04:45	01-01-2019 02:24	28-12-2018 03:20
BERTH NO	8	2	4	SPM	14E
A PILOT BOARDING	0	0	0	0	0
NOTICE TO SIGNAL STATION	0	0	0	0	0
PILOT BOARDING OR PILOT MAY BOARD MIDWAY	0	0	0	0	0
PILIOT TO BE READY	0	0	0	0	0
BUNCHING OF VESSELS	0	0	0	0	0
SAILING STEAMING TOWARDS BERTH	0	0	0	0	0
WANT OF ULLAGE	0	0	0	0	0
BERTH ALLOTMENT	0	0	0	0	0
UNIDIRECTIONAL CHANNEL	0	0	0	0	0
LOCK GATE OPERATION	0	0	0	0	0
ANY OTHER FACTOR A	0	0	0	0	0

B INWARD MOVEMENT	0	0	0	0	0
TUGS UNAVAIABILITY	0	0	0	0	0
CONDITION OR CAPACITY OF TUGS	0	0	0	0	0
NIGHT NAVIGATION	0	0	0	0	0
CHANNEL BUOYS	0	0	0	0	0
TIDE OR CURRENT	0	0	0	0	0
ANY OTHER FACTOR B	0	0	0	0	0
C MOORING BERTHING	0	0	0	0	0
AVAILABILITY OF MOORING GANGS	0	0	0	0	0
ANY OF OTHER FACTOR C	0	0	0	0	0
D CLEARANCE FROM PGA CUSTOMS	85	35	225	96	90
SURVEY OF THE CARGO	27	0	0	21	50
PHO ROLE	0	0	0	6	5
IMMIGRATION DOCUMENTATION	12	15	20	7	5
CUSTOM	16	20	20	10	20
BREAK BULK AND SEAING INSPECTION	0	0	0	0	10
PRE BERTHING TIDE CONSTARAINT	0	0	0	0	0
STRIPPING LINE FLUSHING	0	0	0	0	0
PREP OF WORK	0	0	0	0	0
POWER PROBLEMS	0	0	0	0	0
PIPELINE TRANSFER	0	0	0	0	0
PIPELINE CLEANING	0	0	0	0	0
PIPELINE FITTINGS	0	0	0	0	0
DRAFT SURVEY	0	0	0	0	0
SAMPLING LIQUID CARGO	0	0	0	20	0
WAITING FOR SHORE SIDE READINESS	0	0	0	0	0
HATCH ARRANGEMENTS	0	0	0	0	0
HATCH OPENING AND CLOSING	0	0	0	0	0
LAB TEST	0	0	0	0	0
MANIFOLD FIXATION	0	0	0	20	0
ANY OTHER FACTOR D	0	0	0	0	0
E LOADING UNLOADING OPERATIONS	465	149	276	90	190

NON AVAIABILITY POSITIONING OF CARGO HANDLING EQUIPMENT	0	0	0	0	0
AVAILABILITY OF LABOUR OR GANGS	0	0	0	0	0
SHIFTING OR EVACUATION OF CARGO FROM BERTH	0	0	0	0	0
BREAK DURING SHIFTS OR HOT SEAT EXCHANGE	0	0	0	0	0
BREAKDOWN OF EQUIPMENTS	0	0	0	0	0
SHORE TANK CHANGE OVER	0	0	0	0	0
SHORE SIDE ISSUE	0	0	0	0	0
HOT WATER FLUSHING	0	0	0	0	0
LINE FLUSHING	0	0	0	0	0
TANK VALVE PROBLEM	0	0	0	0	0
VESSEL REPAIRS OR ITS EQUIPMENT	0	0	0	0	0
POSITIONING OF CONTAINERS OR LAODING PLAN	0	0	0	0	0
NATURE OF CARGO SLURRY OR SOLID	0	0	0	0	0
LACK OF STORAGE SPACE	0	0	0	0	0
PRIORITY BERTHING OR OUSTING PRIORITY AND DEBERTHING	0	0	0	0	0
CONDITION OF PIPELINE	0	0	0	0	0
VISCOSITY HYGROCITY OF LIQUID CARGO	0	0	0	0	0
PUMP CAPACITY	0	0	0	0	0
LASHING	0	96	120	0	0
TRIMMING OF CARGO POST LOADING	0	0	0	0	0
BERTH CARGO EVACUATION TRUCK TURNAROUND	0	0	0	0	0
PREPARATION OF WORK OR HATCH CLOSING	0	0	185	0	0
INTERMEDIATE STOPPAGE FOR SHIFTING TO OTHER CARGO	0	0	0	0	0
IGS CAPACITY OR PREPARATION	0	0	0	0	0
MANIFOLD DISCONNECTED	0	0	0	0	0

CUSTMS FORMALITIES	15	13	60	0	10
DOCUMENTATION	60	40	30	78	30
SURVEY	100	0	0	0	60
LOADING ARM DISCONNECTIVITY ISSUE	0	0	0	0	0
DETAINED BY MMD	0	0	0	0	0
WANT OF CARGO	0	0	0	0	0
WEATHER CONSTRAINTS	290	0	0	0	0
STOPPAGE TO MOCK DRILL	0	0	0	0	0
SHIP SHORE LINE UP	0	0	0	6	0
WAITING FOR SHIP SIDE READINESS	0	0	0	0	0
SHIP SIDE VALVE	0	0	0	0	0
INTERMEDIATE SURVEY	0	0	0	0	90
SAMPLE TESTING	0	0	0	0	0
HOT GASING	0	0	0	0	0
ULLAGE CONSTRAINTS	0	0	0	0	0
DISMANTING PROCESS	0	0	0	0	0
AIR BLOW	0	0	0	0	0
AGENT PROBLEM	0	0	0	0	0
WHARFING	0	0	0	0	0
LIGHTNING	0	0	0	0	0
PLT TRANSFER	0	0	0	0	0
BUNKERING	0	0	0	0	0
VESSEL ADVANCED BERTH	0	0	0	0	0
POWER PROBLEMS E	0	0	0	0	0
PIPELINE TRANSFER E	0	0	0	0	0
RECESS PREPRATION OF WORK	0	0	0	0	0
ENGINE FAILURE	0	0	0	0	0
SLOPE DISCHARGE	0	0	0	0	0
LABOUR BREAKUP	0	0	0	0	0
SAMPLING	0	0	0	0	0
TIDAL CONDITION	0	0	0	0	0
TANK INSPECTION	0	0	0	0	0
NON PORT AC	0	0	0	6	0
SHIP AC	0	0	0	0	0
DELAY IN SAILING	0	0	0	0	0
OTHER VESSEL MOVEMENT	0	0	66	0	0

PORTS EQUIPMENT BREAKDOWN	0	0	0	0	0
RECESS LABOUR BREAKUP	0	0	0	0	0
HOIDAY RECESS	0	0	0	0	0
NO WORK	0	0	0	0	0
GANG NOT DEPLOYED	0	0	0	0	0
GANGWAY UP AND DOWN PROCESS	0	0	0	0	0
DEPARTURE FORMALITIES	0	0	0	0	0
LINE CHANGING PROCESS AND RECOMMENCEMENT	0	0	0	0	0
ANY OTHER FACTOR E	0	0	0	0	0
F UNBERTHING AND UNMOORING	0	0	0	0	0
AVAILABILITY OF MOORING GANGS F	0	0	0	0	0
AVAILABILITY OF PILOT F	0	0	0	0	0
TUGS AVAIABILITY	0	0	0	0	0
TIDE F	0	0	0	0	0
ANY OTHER FACTOR F	0	0	0	0	0
G OUTWARD MOVEMENT	0	0	0	0	0
TUGS AVAIABILITY G	0	0	0	0	0
CONDITION OR CAPACITY OF TUGS G	0	0	0	0	0
NIGHT NAVIGATION G	0	0	0	0	0
CHANNEL BUOYS G	0	0	0	0	0
TIDE OR CURRENT G	0	0	0	0	0
LOCK GATE OPERATION G	0	0	0	0	0
ANY OTHER FACTOR G	0	0	0	0	0
LOA IN METERS	190	200	120	274	180
SHIP NO	180290	180325	180477	180969	180952
REASONS FOR WAITING AT ANCHORAGE		OTHERS	AGENTS OPTION	OP. CONSTRAINT	

APPENDIX- II

IDENTIFICATION AND GROUPING OF TIME SPENT UNDER SEVEN CONSTRAINT GROUPS					
UNIQUE IDENTIFIER	NML11112019388	NML11112019426	NML11112019598	NML11113010111	NML11113010066
COMMODITY NAME	IOP (KIOCL)	CONTAINER	MACHINERY (STEEL COILS)	CRUDE - SPM	MET. COKE
CATEGORY	DB-M	C	BB	LB	DB
NAME OF VESSEL	M.V. PISTIS	M.V. SARAYU	M.V. ADINATH	M.T. JAG LAKSHITA	M.V. OASIS ISLAND
TONNAGE	50802	13291	7481	143974	22000
NRT	18207	12454	2913	45810	12101
GRT	30053	25535	5222	80870	23226
DWT	52388	33917	8184	147093	37816
F C	F	C	C	F	F
I E	E	I/E	I	I	I
BERTH NO	8	2	4	SPM	14E
ARRIVE AT ANCHORAGE DATE TIME	24-06-2018 12:15	03-07-2018 02:54	16-08-2018 12:30	29-12-2018 08:42	26-12-2018 01:18
DEPARTURE FROM PORT DATE TIME	26-06-2018 01:45	04-07-2018 15:54	19-08-2018 04:45	01-01-2019 02:24	28-12-2018 03:20
PRE BERTHING DELAY FACTORS	0	0	0	0	0
PRE COMMENCEMENT POST COMMENCEMENT	315	123	355	212	365
PORT CONSTRAINTS	465	149	342	90	190
NON PORT CONSTRAINTS	0	0	0	52	5
IDLE TIME AT BERTH	0	0	0	0	0
ENVIRONMENTAL FACTORS	290	0	0	0	0
VESSEL CONSTRAINTS	0	96	305	6	0

Code snippet for frequency occurance calculation

```
for($i=0;$i<count($constraints);$i++){
        $constraint_name=$constraints[$i];  //Getting each constraint out of 120 and findings its occurance

        $sql="select count(".$constraint_name.") as constraint_frequency from data_from_excel_cleaned where
        ".$constraint_name.">0 and arrive_at_anchorage_date_time like '".$year."-".$month."%'";
        $result=getResult($sql);
        $constraint_frequency=0;
        while($row=mysqli_fetch_assoc($result)){
           $constraint_frequency=$row['constraint_frequency'];
        }
        if($constraint_frequency>0){
           $sql="insert into data_constraints_count values
(","".$year."","".$month."","".$constraint_name."","".$constraint_frequency."")";
           executeQuery($sql);
           $sql="update data_contraints_count set constraint_frequency='".$constraint_frequency."' where
           year='".$year."' and month='".$month."' and constraint_name='".$constraint_name."'";
           executeQuery($sql);
        }
     }
```

APPENDIX- III

CONSTRAINT FREQUENCY FOR SENSITIVITY ANALYSIS					
YEAR	MONTH	CONSTRAINT NAME	CONSTRAINT FREQUENCY OCCURANCE	TOTAL HOURS CONSUMED	TOTAL VESSLES IN THAT MONTH
2018	8	AIR BLOW	8	2.42	103
2018	8	BREAK BULK AND SEAING INSPECTION	15	4.33	103
2018	8	BUNKERING	1	8.00	103
2018	8	CUSTMS FORMALITIES	48	20.85	103
2018	8	CUSTOM	95	23.87	103
2018	8	DETAINED BY MMD	1	17.00	103
2018	8	DOCUMENTATION	103	147.80	103
2018	8	D CLEARANCE FROM PGA CUSTOMS	103	217.47	103
2018	8	E LOADING UNLOADING OPERATIONS	103	595.90	103
2018	8	HOIDAY RECESS	1	24.00	103
2018	8	HOT GASING	14	10.57	103
2018	8	IMMIGRATION DOCUMENTATION	96	16.43	103
2018	8	INTERMEDIATE STOPPAGE FOR SHIFTING TO OTHER CARGO	3	5.50	103
2018	8	INTERMEDIATE SURVEY	1	1.00	103
2018	8	LAB TEST	53	21.68	103
2018	8	LASHING	18	12.88	103
2018	8	MANIFOLD FIXATION	65	19.00	103
2018	8	NON PORT AC	21	19.28	103
2018	8	OTHER VESSEL MOVEMENT	16	18.15	103
2018	8	PHO ROLE	71	11.43	103
2018	8	PIPELINE FITTINGS	1	4.00	103
2018	8	PORTS EQUIPMENT BREAKDOWN	1	5.33	103
2018	8	PREPARATION OF WORK OR HATCH CLOSING	4	4.52	103
2018	8	SAMPLE TESTING	2	23.10	103
2018	8	SAMPLING LIQUID CARGO	49	18.63	103
2018	8	SHIP SHORE LINE UP	38	6.67	103
2018	8	STRIPPING LINE FLUSHING	1	1.20	103
2018	8	SURVEY	36	40.37	103
2018	8	SURVEY OF THE CARGO	71	56.63	103
2018	8	TANK INSPECTION	23	18.70	103
2018	8	TIDAL CONDITION	2	12.25	103
2018	8	ULLAGE CONSTRAINTS	8	2.50	103
2018	8	VESSEL REPAIRS OR ITS EQUIPMENT	1	3.80	103
2018	8	WAITING FOR SHORE SIDE READINESS	1	0.83	103
2018	8	WEATHER CONSTRAINTS	13	161.00	103
2018	8	WHARFING	3	17.37	103

Code Snippet for Populating Data Constraint Count Model

```
AA $sql="select count(*) as total_vessles_in_that_month from data_from_excel_cleaned where
    arrive_at_anchorage_date_time like '".$year."-".$month."%'";


    $total_vessles_in_that_month=0;
    $result=getResult($sql);
    while($row=mysqli_fetch_assoc($result)){
       $total_vessles_in_that_month=$row['total_vessles_in_that_month'];
    }

    for($i=0;$i<count($constraints);$i++){
       $constraint_name=$constraints[$i];
       $sql="select count(".$constraint_name.") as constraint_frequency from data_from_excel_cleaned where
       ".$constraint_name.">0 and arrive_at_anchorage_date_time like '".$year."-".$month."%'";


       $result=getResult($sql);
       $constraint_frequency=0;
       while($row=mysqli_fetch_assoc($result)){
          $constraint_frequency=$row['constraint_frequency'];
       }
       if($constraint_frequency>0){
          $sql="select sum(".$constraint_name.") as total_hours_consumed from data_from_excel_cleaned where
          ".$constraint_name.">0 and arrive_at_anchorage_date_time like '".$year."-".$month."%'";
          $result=getResult($sql);
          $total_hours_consumed=0;

          while($row=mysqli_fetch_assoc($result)){
             $total_hours_consumed=$row['total_hours_consumed']/60;
          }

          $sql="insert into data_constraints_count values ('','".$year."','".$month."','".$constraint_name.
          "','".$constraint_frequency."','".$total_hours_consumed."','".$total_vessles_in_that_month."')";

          executeQuery($sql);
          $sql="update data_contraints_count set
          constraint_frequency='".$constraint_frequency."',
          total_hours_consumed='".$total_hours_consumed."',
          total_vessles_in_that_month='".$total_vessles_in_that_month."'
          where
          year='".$year."' and month='".$month."' and constraint_name='".$constraint_name."'";
          executeQuery($sql);
       }

    }
```

TRT Calculation				
SL NO	NML11112018939	NML11112018953	NML11112018943	NML11112018954
COMMODITY NAME	PARAXYLENE	CONTAINER	BITUMEN	IOP (KIOCL)
CATEGORY	LB	C	LB	DB-M
NAME OF VESSEL	M.T. NAVIG8 UNIVERSE	M.V. SSL MUMBAI	M.T. YUE LIANG WAN	M.V. MAITHILI
TONNAGE	19145	7047	2803	53917
NRT	11677	9382	2706	18492
GRT	29279	18602	9020	30704
DWT	45313	24374	10766	55707
F C	F	C	F	C
I E	E	I/E	I	E
ARRIVE AT ANCHORAGE DATE TIME	27-02-2018 06:30	26-02-2018 19:10	20-02-2018 11:50	23-02-2018 19:54
READINESS OF VESSEL DATE TIME	27-02-2018 13:15	26-02-2018 19:15	21-02-2018 10:00	24-02-2018 22:00
DEPARTURE FOR BERTH DATE TIME	27-02-2018 14:06	26-02-2018 19:18	21-02-2018 10:20	24-02-2018 22:36
ARRIVE AT BERTH DATE TIME	27-02-2018 15:36	26-02-2018 21:00	21-02-2018 11:54	25-02-2018 00:24
WORK COMMENCED DATE TIME	27-02-2018 18:30	26-02-2018 22:30	21-02-2018 13:40	25-02-2018 02:00
WORK COMPLETED DATE TIME	28-02-2018 17:24	28-02-2018 12:15	23-02-2018 10:00	26-02-2018 00:35
DEPARTURE FROM BERTH DATE TIME	28-02-2018 20:00	28-02-2018 16:54	23-02-2018 12:00	26-02-2018 03:06
DEPARTURE FROM PORT DATE TIME	28-02-2018 20:55	28-02-2018 17:48	23-02-2018 12:35	26-02-2018 03:48
BERTH NO	13.00	3.00	6.00	8.00
PRE BERTHING WAITING TIME	7.60	0.13	22.50	26.70
INWARD MOVEMENT TIME	1.50	1.70	1.57	1.80
BERTHING TIME	2.90	1.50	1.77	1.60
SERVICE TIME	22.90	37.75	44.33	22.58
OUTWARD MOVEMENT TIME	3.52	5.55	2.58	3.22
TOTAL TRT	38.42	46.63	72.75	55.90

LIST OF PUBLICATIONS BASED ON PHD RESEARCH WORK.

International Journals

1. **Dayananda Shetty K**and G.S.Dwarakish (2018):"Measuring port performance and productivity" – ISH Journal of Hydraulic Engineering. DOI: https:// doi.org/10.1080/09715010.2018.1473812.
2. **Dayananda Shetty K** and G.S.Dwarakish (2018) "Performance appraisal of Indian major ports", Indian Ports - Journal of Indian Port Association, Volume 48, 29-34.
3. **Dayananda Shetty K** and G.S.Dwarakish (2019) "Optimisation of vessel turnaround time in a seaport", - Journal for Maritime Policy and management(under review)

International Conferences

1. **Dayananda Shetty K** and G.S.Dwarakish (2017):"Optimization of vessel turnaround time at a seaport" Proceedings Volume of International Conference, ISBN: 978-93-5267-355-1, [ICGCSC-2017], MITE, Moodbidri, INDIA, 17th – 18th March, 2017, pp 263-267

2. **DayanandaShetty K** and G.S.Dwarakish(2016):"Measuring port performance and productivity" 21st International Conference on Hydraulics, Water Resources and Coastal Engineering. [HYDRO 2016] CWPRS, Pune, India, 8th-10th December 2016, 83

BIO-DATA

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EDUCATION

M.B.A (HR),	Indira Gandhi National Open University, New Delhi. India
B.E (Civil),	National Institute of Technology Karnataka, Surathkal, India.
DCE (GL),	Vivekananda Polytechnic Puttur Karnataka India
	(Board of Technical Education, Karnataka, India.)

PROFESSIONAL EXPERIENCE

14.12.2017	Till Date	Assistant Engineer (Civil)-NMPT
13.01.2012	14.12.2017	Assistant Engineer (Vigilance)-NMPT
31.10.2003	12.01.2012	Assistant Engineer (Civil)-NMPT
03.06.2000	30.10.2003	Technical Assistant (Civil)-NMPT
07.08.1999	31.05.2000	Lecturer (Civil)-VPT Puttur
01.08.1998	06.08.199	Structural Engineer-Puttur

LIFE MEMBERSHIP OF PROFESSIONAL BODIES

Member : Institution of Engineers (India)

Member : Kodagu, Dakshina Kannada and Udupi Engineers Association

Member : Association of Consulting Civil Engineers Association (India)