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IMPACT ASSESMENT OF DISASTER ON COASTAL AREA ROAD NETWORK AND PORT LOGISTICS

May, 2021

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A case study of Kakinada Coastal Zone

MASTER OF PLANNING

Transport Planning and Logistics Management

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2019MTPLM013

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IMPACT ASSESSMENT OF DISASTER ON COASTAL AREA ROAD NETWORK AND PORT LOGISTICS:

A case study of Kakinada Coastal Zone

Thesis submitted in partial fulfilment of the requirements for the award of the degree of

MASTERS IN TRANSPORT PLANNING AND LOGISTICS MANAGEMENT

By

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May 2021

Declaration

I **MONIKA**, Scholar No. **2019MTPLM013** hereby declare that the thesis titled **"Impact assessment of disaster on coastal area road network and port logistics: A case study of Kakinada coastal zone"** submitted by me in partial fulfilment for the award of **Master of Planning**, at School of Planning and Architecture, Bhopal, India, is a record of Bonafide work carried out by me. The matter/result embodied in this thesis has not been submitted to any other University or Institute for the award of any degree or diploma.

_____

Signature of the Student

Date: May 27th, 2021

Certificate

This is to certify that the declaration of **Monika** is true to the best of my knowledge and that the student has worked under my guidance in preparing this thesis.

RECOMMENDED

_____

Signature of the Guide

Dr. N. Sridharan

ACCEPTED

Dr. Natraj Kranthi

Head, Department of Transport Planning

May, 2021, Bhopal

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Signature of the Student

Date: May 28th, 2021

Certificate

This is to certify that the declaration of **MONIKA** is true to the best of my knowledge and that the student has worked under my guidance in preparing this thesis.

RECOMMENDED

Signature of the Guide

Prof. Dr. N. Sridharan

ACCEPTED

Dr. Natraj Kranthi

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May, 2021, Bhopal

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Monika Goyal

Thesis Abstract

Global Climate change has become a rising concern in Indian subcontinent especially coastal regions has been experiencing increasingly more frequent and extreme climatic events and climate-induced disasters like recent cyclone Nivar, Fani, Gaja, Hudhud, Amphan etc. as well as flood has also caused utter destruction to country's coastal states because of its exposure, rapid urbanization, high densities of population and associated economic activities such as agriculture, industries, trade, aquaculture, tourism etc. . As per UN Office for Disaster Risk Reduction (UNISDR) survey, India ranks third among the five countries most affected by natural disasters over the last 20 years, after the United States and China. While efficient disaster preparedness has saved many lives, restoring destroyed infrastructure and returning to normalcy after the disruptions remain significant challenges.

Infrastructure development and productivity plays a crucial role in economic development. India's is the sixteenth largest maritime country with a mainland coastline of 7,517 km, 14500 km navigational waterways forming the biggest peninsula in the world has been the hub of commercial and tourism activities. Together, the nine coastal states and two union territories contribute over 50 percent of India's GDP while every year natural disasters cause 2% drop in GDP. Majority of these urban agglomerations are vital infrastructure assets like ports, agriculture, aquaculture, industries, tourism etc. that generates wealth, economy and growth for the country. Local and global economies are for highly dependent on the import and export of goods as more than 90% of global trade by volumes and 70% by value is carried by sea. India is also aiming for sustainable port lead development under the Sagarmala programme. As a result, assessing existing infrastructure and recommending entry points at multiple stages of decision-making for promoting climate-resilient growth has become critically essential.

This study aims to plan for economic and efficient movement of domestic cargo from Kakinada Port to its hinterland through roadways during and post natural disasters by assessing the current infrastructure capacities and losses. This research intends to examine the impact of disaster on road infrastructure and freight movement by

identifying hazards affecting the vulnerability, then assessing the criticality and vulnerability of identified hazards on road network based upon current capacity. Accessibility and operational thresholds. Based upon the same forecasting the future surge of disasters and travel demand and suggesting adaptation strategies to make the current infrastructure resilient, accommodating future needs.

कार्यकारी सारांश

वैश्विक जलवायु परिवर्तन भारतीय उपमहाद्वीप में एक बढ़ती चिंता का विषय बन गया है, विशेष रूप से तटीय क्षेत्रों में हाल ही में चक्रवात निवार, फानी, गाजा, हुदहुद, अम्फान, आदि के साथ-साथ बाढ़ जैसी अधिक लगातार और चरम जलवायु घटनाओं और जलवायु-प्रेरित आपदाओं का सामना करना पड़ रहा है। इसके जोखिम, तेजी से शहरीकरण, जनसंख्या के उच्च घनत्व और कृषि, उद्योग, व्यापार, जलीय कृषि, पर्यटन आदि जैसी आर्थिक गतिविधियों के कारण देश के तटीय राज्यों को भी पूरी तरह से नष्ट कर दिया है। यूएन ऑफिस फॉर डिजास्टर रिस्क रिडक्शन (यूएनआईएसडीआर) के सर्वेक्षण के अनुसार, भारत संयुक्त राज्य अमेरिका और चीन के बाद पिछले 20 वर्षों में प्राकृतिक आपदाओं से सबसे अधिक प्रभावित पांच देशों में तीसरे स्थान पर है। जबकि कुशल आपदा तैयारियों ने कई लोगों की जान बचाई है, नष्ट हुए बुनियादी ढांचे को बहाल करना और व्यवधानों के बाद सामान्य स्थिति में लौटना महत्वपूर्ण चुनौतियां हैं।

बुनियादी ढांचे का विकास और उत्पादकता आर्थिक विकास में महत्वपूर्ण भूमिका निभाते हैं। भारत सोलहवां सबसे बड़ा समुद्री देश है, जिसकी मुख्य भूमि 7,517 किमी, 14500 किमी नौवहन जलमार्ग है, जो दुनिया का सबसे बड़ा प्रायद्वीप है, जो वाणिज्यिक और पर्यटन गतिविधियों का केंद्र रहा है। कुल मिलाकर, नौ तटीय राज्य और दो केंद्र शासित प्रदेश भारत के सकल घरेलू उत्पाद में 50 प्रतिशत से अधिक का योगदान करते हैं जबकि हर साल प्राकृतिक आपदाएँ सकल घरेलू उत्पाद में 2% की गिरावट का कारण बनती हैं। इन शहरी समूहों में से अधिकांश बंदरगाह, कृषि, जलीय कृषि, उद्योग, पर्यटन इत्यादि जैसी महत्वपूर्ण आधारभूत संरचना संपत्तियां हैं जो देश के लिए धन, अर्थव्यवस्था और विकास उत्पन्न करते हैं। स्थानीय और वैश्विक अर्थव्यवस्थाएं माल के आयात और निर्यात पर अत्यधिक निर्भर हैं क्योंकि वैश्विक व्यापार का 90% से अधिक मात्रा में और 70% से अधिक मूल्य समुद्र द्वारा किया जाता है। भारत सागरमाला कार्यक्रम के तहत सतत पोर्ट लीड विकास का भी लक्ष्य

बना रहा है। नतीजतन, मौजूदा बुनियादी ढांचे का आकलन करना और जलवायु-लचीला विकास को बढ़ावा देने के लिए निर्णय लेने के कई चरणों में प्रवेश बिंदुओं की सिफारिश करना गंभीर रूप से आवश्यक हो गया है।

इस अध्ययन का उद्देश्य मौजूदा बुनियादी सुविधाओं और नुकसान का आकलन करके प्राकृतिक आपदाओं के दौरान और बाद में सड़क मार्गों के माध्यम से काकीनाडा बंदरगाह से घरेलू कार्गो की आर्थिक और कुशल आवाजाही की योजना बनाना है। इस शोध का उद्देश्य भेद्यता को प्रभावित करने वाले खतरों की पहचान करके सड़क के बुनियादी ढांचे और माल ढुलाई पर आपदा के प्रभाव की जांच करना है, फिर मौजूदा क्षमता के आधार पर सड़क नेटवर्क पर पहचाने गए खतरों की गंभीरता और भेद्यता का आकलन करना है। अभिगम्यता और परिचालन सीमा। उसी पूर्वानुमान के आधार पर आपदाओं और यात्रा की मांग के भविष्य में वृद्धि और वर्तमान बुनियादी ढांचे को लचीला बनाने, भविष्य की जरूरतों को समायोजित करने के लिए अनुकूलन रणनीतियों का सुझाव देना।

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Abbreviations

GDP	Gross Domestic Product
CZ	Coastal Zone
DMP	Disaster Management Plan
DRR	Disaster Risk Reduction
MMT	Million Metric Ton
MT	Metric Ton
SCM	Supply Chain Management
BoB	Bay of Bengal
UNISDR/ UNDRR	United Nation Disaster Risk reduction
MoUD	Ministry of Urban Development
DM Act	Disaster Management Act

CHAPTER 1 INTRODUCTION

Climate change is the shift in average weather occurring in a given region normally based on average weather pattern but it has become a rising concern around the globe due to its adverse effects like rise in sea levels, intensity of precipitation, more frequent cyclones, increase in temperature etc. and its impact is further projected to rise global average temperature by 2.6^0 – 4.8^0 C by 2050 (Burkett 2014). India has been experiencing increasingly more frequent and extreme climatic events and climate-induced disasters like recent cyclone Nivar, Fani, Gaja, Hudhud, Mail regarding reporting back Amphan etc. as well as flood has also caused utter destruction to country's coastal states.

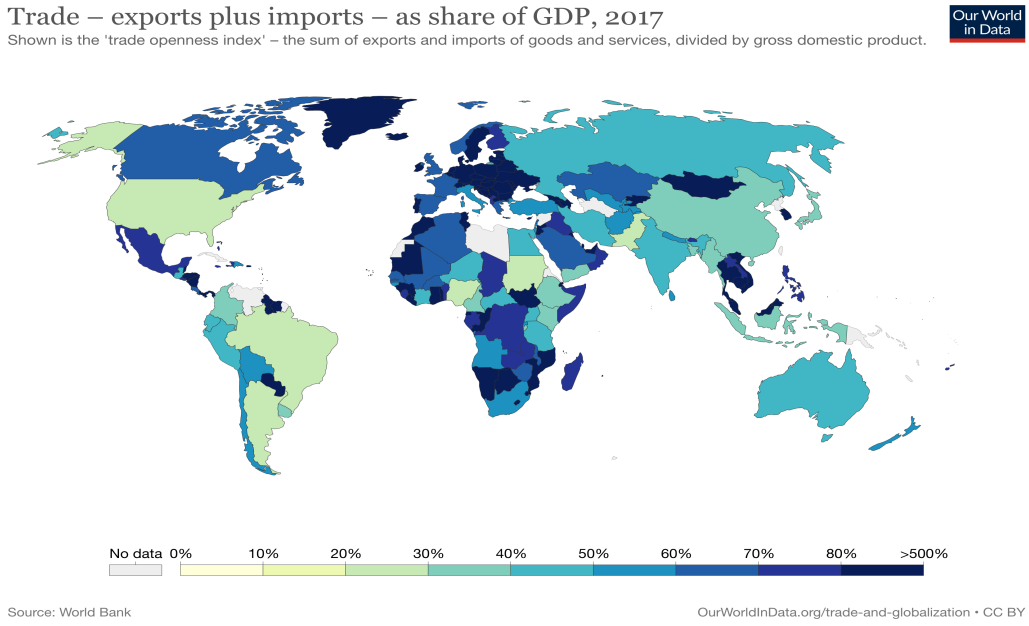
While efficient disaster preparedness has saved many lives, restoring destroyed infrastructure and returning to normalcy after the disruptions remain significant challenges. India being the sixteenth largest maritime country in the world, with a coastline length of 7,517 km spread among the 9 coastal states and 2 union territories with 13 major and more than 200 minor ports. There costal districts are a house for 1/3 of India's population. Also, as per ministry of shipping 90% of the global trade by volume and 70% value is carried out by sea in India. India exports 7500 commodities to about 190 countries and imports 6000 commodities from 140 countries around the globe (Sustainable Port Development and Inproving port productivity ESCAP Member Countries : POLICY BREIF 2020). So, these coastal districts play an important role in India's economic growth and global trade. But due to their geographical location, exposure, rapid urbanization, high densities of population and allied economic activities such as aquaculture, agriculture, industries, trade and tourism these districts are highly affected by climate change. As per UNDRR Office report India ranks third, after the US and China, among the five countries hit the most by natural disasters over the last 20 years.

The coastal areas are among the most diverse part on the surface of the earth. As it comprises of the world's most sensitive habitats such as mangrove forests, coral reefs, dunes wetlands, and beaches. Furthermore, they are home to a significant human habitat. Approximately 23% of the world's population resides within 100 kilometres of the coast. They have many important purposes, such as controlling

water flow between island and mainland, regulating the chemical composition of sediments and water, storing and treating nutrients and human wastes, maintaining genetic and biological diversity, allowing ground for agriculture, transport and navigation, and providing leisure and tourism opportunities as well as offering a wide range of information on aesthetics, historical, educational, and scientific themes.

The economies of the coastal areas is quite small and majorly dependent upon logistics activities, thus coastal infrastructure plays important role. Coastal transportation infrastructure is made up of complex networks and multimodal hubs, with seaports being the most important coastal transportation facilities. They are points of interaction between marine and inland transport, providing all countries with links to global markets. In addition to working as (international) trading gateways, they also generate economies and contribute to national GDP, and encourage nearby urban/ industrial agglomerations.

Figure 1 Global trade contribution to GDP

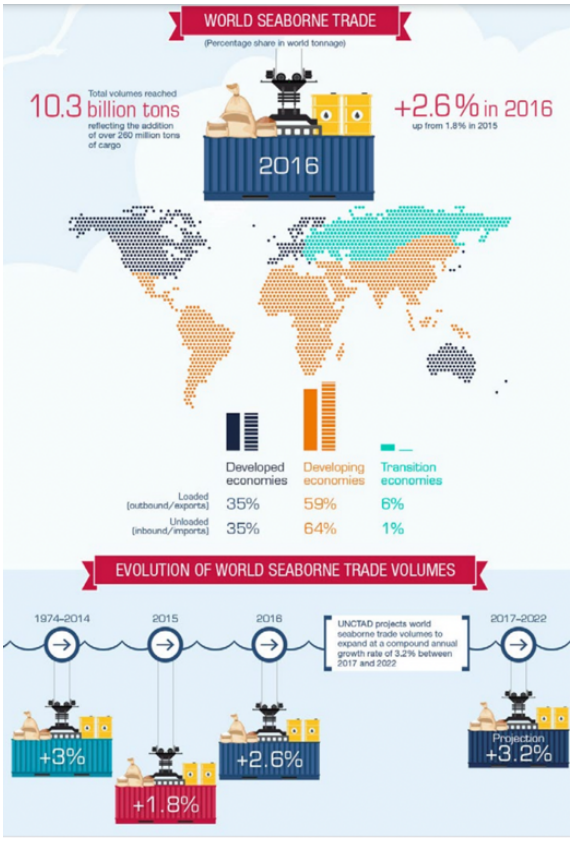


Source: World Bank

Infrastructure has been defined as the important preconditions of economic growth and it is the system of public works in a region, state or country, including infrastructure like roads, utility lines, and public buildings will be highly affected (UN DESA 2000). Port growth and competitiveness are important for economic growth of the region as

well as enhancing regional connectivity in Asia countries and the Pacific countries. It forms the lifeline of world's trade, as about 80 % of goods have at least one maritime transport leg (UNCTAD 2017). In recent years, the Asia-Pacific region's economic and trade growth rates have been much higher than global average, and this trend is projected to continue, but to a minimal degree.

Figure 2 World seaborne trade



The growth rate of maritime, traffic driven by global trade and economic growth that is projected to decline marginally due to global climatic changes that result in more regular disasters, but the growth pattern is expected to continue.

While Asian countries have traditionally relied on port development and maritime trade to drive growth of the economy, the state of port development remains fractured and widely disparate throughout the region. This is attributed mainly to gaps in economic growth, financial capabilities, technological capability, and a lack of successful implementation. The inequity of port growth eventually eases the importance of the regional port infrastructure. To fully achieve its potential, concrete outputs, proper governance, compliance, and delivery methods must be implemented. There is a general recognition among government sector and private sector the area that every procurement structure should be designed in such a way that port capability and value are maximized. Regional coordination and cooperation are critical in this regard, as they enable maximum interoperability and tailoring solutions to local conditions. According to UNCTAD, ports should adopt sustainable development policies in order to safeguard themselves from climate change while simultaneously strengthening for more sustainable ports growth and development.

India's coastal zone is also teeming with activities under the Sagarmala programme. Launched in 2015 by the Ministry of Shipping, it "aims to promote port-led development". So, it has become extensively important to assess the vulnerability of infrastructure of developing countries like India and recommends points of entry of various stakeholders at multiple levels of decision-making for promoting climate-resilient development.

This study aims to identify, assess and highlight the issues related to transport connectivity and port logistics activities in disaster affected of Kakinada CZ, Andhra Pradesh. Kakinada port is an all-weather deep water port is an intermediate port and second largest port in state after Vishakhapatnam, strategically located at the centre of the state. This port has shortest distance to the broad gauge rail that connects Kakinada Port to the (Howrah-Chennai) main rail line at Samalkota, also Kakinada port offers savings in terms of transportation due to proximity to its hinterland and all the allied industries are located on the same route ADB road that attracts the investors to trade. However, Kakinada has a huge disadvantage because it has the longest coastline in the east and is frequently strike by the natural disasters that create impendence in logistics activities also, the Golden Quadrilateral National Highway No. 16 and Asian Highway No. 45 are far from the Port.

So, study intends to prepare a framework for coastal regions of developing countries where economy are small and depends upon port logistic activities by identify natural disasters affecting the vulnerability of roads in coastal areas using past disaster records, then assessing the criticality and vulnerability of identified hazards on road network by mapping their exposure, then identifying the important transport routes by looking at the movement of traffic at port gate, from port to allied industries and at the hinterland in two scenarios pre-disaster and post disaster and finally synthesising the vulnerability and criticality based on exposure of disaster and flow of cargo. Secondly, developing alternative freight routing and investment strategies to reduce the impact of disasters and at third level suggesting resilient infrastructures infrastructure development technologies reducing cost of operation and maintenance.

1.1 AIM

The study aims to identify, assess and resolve the issues related to transport connectivity and logistics activities in disaster affected areas along the coast of Kakinada, Andhra Pradesh.

1.2 Objective

- To identify the hazards affecting the vulnerability of roads in coastal areas.
- To assess the criticality and vulnerability of identified hazards on road network.
- To synthesize the vulnerability and criticality based on accessibility.
- To develop adaptation strategies.

1.3 Scope and Limitations of Study

The study will analysis the impact of multiple natural disasters in the Kakinada coastal zone from the lens of logistics perspective. The scope of the study is limited to domestic cargo movement, from port to hinterland only. Also, among the critical infrastructure only Road infrastructure is targeted.

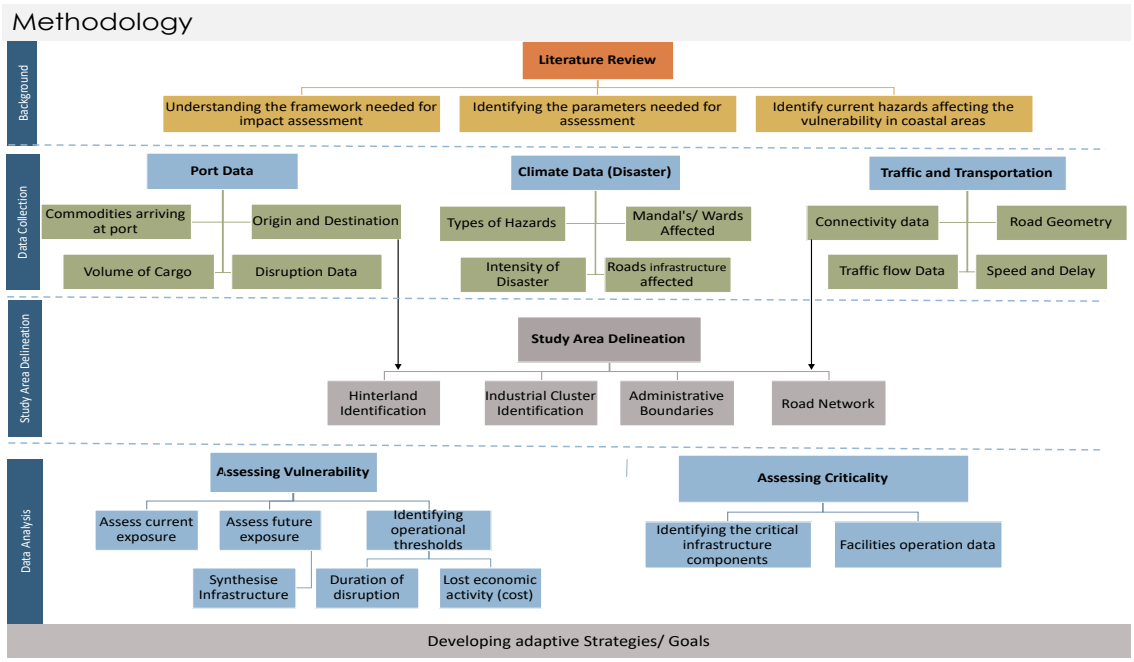
1.4 Methodology

The methodology adopted for the study has been shown in Figure 1. The research process initiated by establishing the background for study, climate change and its impacts, importance of costal area and allied infrastructure, importance of port logistics in global and Indian scenario and establishing the current need for the topic. Chapter 2: provides important contextual information by reviewing the current vulnerability of Indian coastal regions to natural disasters and climate change, range of policies and acts by government of India for disasters management and finding the loopholes from the perspective of infrastructure, then describing the importance and role of road and port infrastructure specifically and establishing the linkage between the them by looking into supply chain logistics of port to hinterland, then describing the port profile of India in terms of total cargo handled by major and minor ports, commodities handled by them, and major trade routes also the impact of climate change on port operations, finally looking into various literature studies related to climate change frameworks, resilient infrastructure strategies and technologies.

Chapter 3: focuses on study area by delineating the study area region based on various parameters for cost selection followed by region delineation and narrowing down to study area as Kakinada revenue division, then describing the study area profile in terms of area, population, connectivity, growth of town, regional context, land use and future growth projects in the area.

Chapter 4: Analysis the objective wise data collected from primary and secondary surveys starting with the disaster profile of Kakinada based upon the seasonality and past major disasters identifying the hazards the based upon various parameters mapping the vulnerability- exposure of identified hazards, then from the port profile of Kakinada identifying the primary, secondary and tertiary hinterlands also analyzing the impact of disaster based upon vessel movement data and finding the issues and impact on coast of operation, further assessing the criticality based upon accessibility and detailing the issues concluded from vessel movement data by identifying the major routes, analyzing the current geometry and capacity of infrastructure and computing level of services for the current year then performing speed and delay on the major routes and identifying the critical points. Finally, forecasting the traffic to build future scenarios using econometric model and drawing conclusions from both.

Chapter 5: compiles the issues from each sector and recommending strategies for future infrastructure development at four stages of disaster management.



1.5 Expected Outcome:

The intention of this study is to create a framework for impact assessment of disasters in relation to port activities in developing countries like India where the economies are small and are dependent on inbound and outbound logistics for the development and prepare are regional plan with resilient infrastructure strategies to overcome these climate change impacts.

CHAPTER 2 LITERATURE STUDY

2.1 Vulnerability of India's costal region to natural disasters and climate change

India is highly vulnerable to various natural hazards such as droughts, floods, heat-waves and cyclones. About 76% of the coastline is prone to tsunamis and cyclones, while 68% is vulnerable to droughts, 59% of the country's area is highly prone to earthquakes and 10% to river erosion and floods. India is amongst the 3rd worst climate- induced natural disasters affected country due to its long coastline of 7,517 km forming one of the biggest peninsula in the world. These costal region comprises of 9 costal states and 2 union territories with 84 coastal districts comprising of 130 towns and 77 cities. Around, 260 million people that is 1/ 3 of India's population, lives within 50 km of seacoast.

These costal states hubs of critical infrastructure and backbone of Indian economy. The 9 coastal states collectives contribute approximately 50% to gross domestic product, also attracts 60% of India's foreign direct investments. Climate change's effects, such as sea-level rise, floorings, storm surges, and cyclones, are negatively impacting development gains. Warming seas contribute to sea-level rise by inducing thermal expansion of sea water, which leads to more severe and regular storm surges and cyclones in coastal areas.

Temperature: It is projected that in South Asian countries by mid-21st century 2ºC rise in average annual temperatures which is further projected to be exceeding 3ºC by the late 21st century. These estimates are based on a high-emissions scenario developed by the Intergovernmental Panel on Climate Change (IPCC). A 2°C rise in global mean surface temperatures will make India's monsoon highly volatile, while a 4°C increase will result in an unusually rainy monsoon (which actually happens once every 100 years) happening once every ten years.

Rainfall: Similarly, India is expected to see a rise in precipitation. According to the CMIP3 model predictions, the western areas will see a rise in overall rainfall by up to 20% or more, whilst the rest of the world will see an increase of 5–10%, and the east coast will likely see a decrease of 1–5 days per year. The combination of

increased rainfall and less rainfall days is projected to result in less but more severe rain events. This would result in additional run-off and fewer usable surface and freshwater in marine catchments.

Sea level: The impact of rising global temperatures would be thermal expansion of ocean water and glacier melting. This would lead to sea-level increase, which is predicted to occur at a rate of up to 10 mm per year in the twenty-first century under a high-emission scenario. Rising saline infiltration into farm fields would be helped by sea-level rise and coastal erosion.

2.2 Range of Acts and Polies by Government of India for disaster management

Disasters are never solely natural. These are the result of natural events interacting with factors such as a lack of preparedness, inadequate capacity and adaptation, a lack of resilience, and hypersensitivity and vulnerability to disasters. It is primarily a result of human actions and development decisions. The relationship of these elements can be described as: Hazards can be categorized as either “stress” incidences (long-term and gradual) or “shock” incidences (immediate or sudden) and it can be known or unknown.

Emergency Events Database (EM-DAT) is an online disaster dataset platform launched by Centre for Research on the Epidemiology of Disasters (CRED). It includes statistics from previous disasters, information on the human effects of disasters - such as the number of deaths, injured, or affected - EM-DAT provides disaster economic cost estimates, and crisis-specific international aid efforts, and acts as an authoritative framework for vulnerability evaluation and sound decision-making in disaster circumstances.

As per EM-DAT disasters can be classified into two categories:

Natural Disasters: are naturally occurring physical phenomena caused either by rapid or slow onset events which can be geophysical, hydrological, climatological, meteorological or biological.

- Geological disasters are devastating events caused by changes in the earth, generally above or below the surface. Ex: Volcanic events, Earthquakes.

- Hydrological Disasters are characterized as a due to the sudden occurrence triggered by a change in the quality, distribution, or movement of water underneath the earth's surface or in the atmosphere. A tsunami, for example, is a large column of water or waves generated by the movement of a large volume of water.
- Meteorological disasters are typically caused by severe weather conditions such as rain, snow, or drought. This has an effect on the earth's atmosphere and the weather-making process. Furthermore, these forms of meteorological disasters are especially harmful to the atmosphere and can have a devastating impact on human life. Hurricanes, hailstorms, and tornadoes are examples of meteorological events.

Technological or man-made hazards are incidents that are triggered by human's actions and occur in or around to human settlements. This can include environmental degradation, pollution, emergencies/conflicts, famine, displaced populations, industrial accidents and transport accidents etc.

After the tsunami of 2004, disaster management in India experienced a paradigm shift from a relief-centric approach to a comprehensive, proactive one focused on disaster risk reduction and encompassing all aspects of the disaster management spectrum.

2.2.1.1 Disaster management act, 2005

The DM act of 2005, passed by government of India for the efficient management of disasters and matters connected to it. Its major achievement was a first step in changing the paradigm of disaster recovery from a reactive relief-based solution to proactive preparedness, prevention, mitigation and response driven approach. The act establishes administrative framework at the central, state and district level.

Table 1 Outline of disaster management act

Administration Level	Institutional setup
National	Establishment of the followings: National Disaster Management Authority (NDMA) National Executive Committee (NEC) National Institute of Disaster Management (NIDM) National Disaster Response Force Preparation of a national disaster management plan (NDMP)

	Preparation of a national plan for the disaster management by every ministry or department of the GOI
State	Constitution of State Disaster Management Authority (SDMA) Establishment of State Executive Committee (SEC) Preparation of a state disaster management plan (SDMP)
District	Constitution of District Disaster Management Authority (DDMA) - Preparation of a district disaster management plan (DDMP)

Source: Disaster management act, 2005

Organizational structure of disaster management authority

The National Disaster Management Authority is responsible for developing policies and guidelines for disaster management, approving plans prepared by different concerned departments and coordinating the enforcement as well as implementation of policies, plans and guidelines to ensure effective and efficient response to disasters. Also preparing a national and state level plan.

Figure 3 Institutional Framework for Disaster management in India

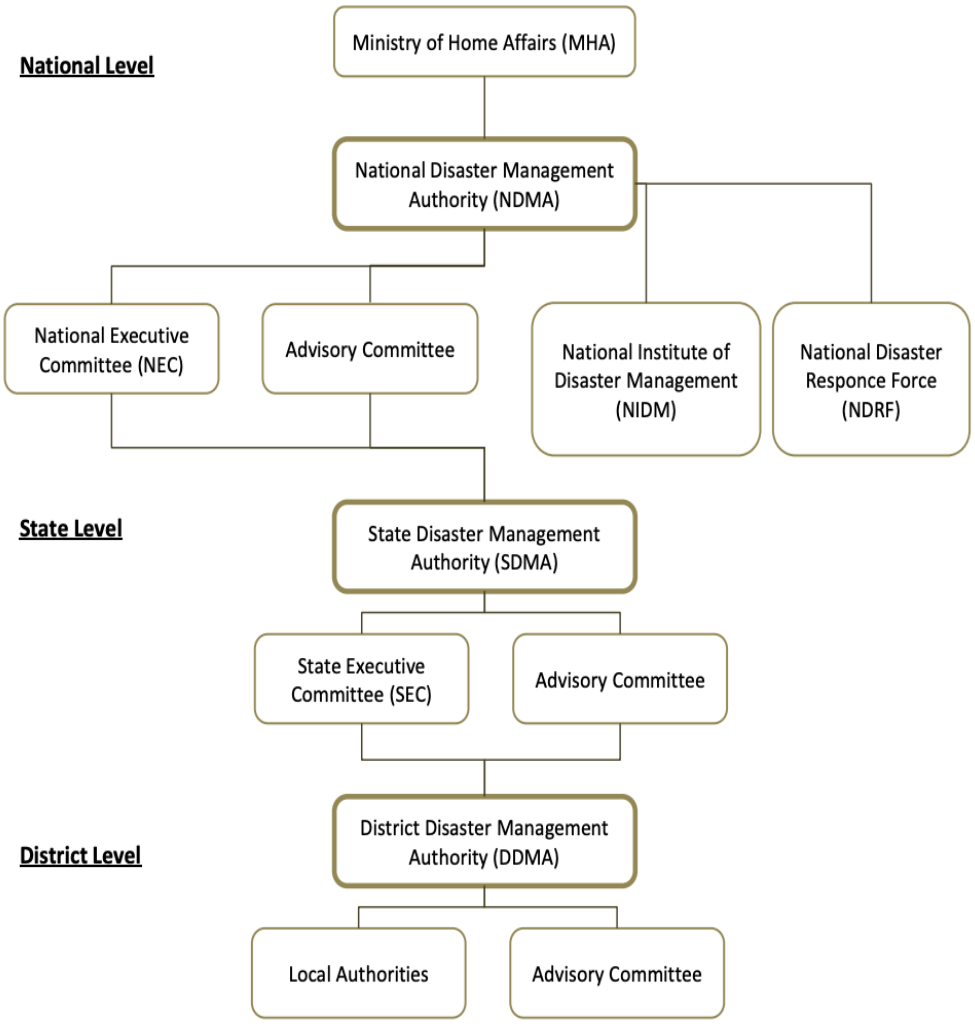


Table 2 state disaster management plan outline

Outline		Typical Content
Part I: General		
Chapter I	Introduction	- State profile: social, economic and demographic
Chapter II	Vulnerability Assessment and Risk Analysis	- History of vulnerability of the state to different types disasters - Hazard risk assessment and vulnerability mapping
Chapter III	Preventive Measures	- Natural disasters, specific to the state - Early warning and dissemination systems - Prevention and mitigation plans - Training needs analysis and development of state HR plan
Chapter IV	Mainstreaming DM Concerns into Developmental Plans/Programmes/ Projects	- Economic and social infrastructure - Elements of impact assessment, risk reduction, and the "do no harm" approach - Classification of disasters and residual agenda
Chapter V	Preparedness Measures	- Resource availability, both national and state resources: government, private, civil society - Techno-legal regime - Fail-safe communication including last mile connectivity
Chapter VI	Response	- Incident Command System - Emergency Operation Centres - Alert mechanisms - early warnings
Chapter VII	Partnership with other stakeholders	- Roles of academic institutions and scientific and technical organisations - Media
Chapter VIII	Financial Arrangements	- Arrangements for the funding of the components of the state plan
Part II: Disaster Specific Action Plan		
Chapter IX - XVII	Floods, Cyclones, Earthquakes, Landslides, Chemical Disasters (including emphasis on off-site plans - preparation and rehabilitation), Nuclear Disasters, Biological Disasters, Oil Spills and Mine Disasters, Tsunamis	Depending on the hazard assessment result in the state
Part III: Cross-cutting Issues		
Chapter XVIII	Review and updating of plans	Schedule for submitting Action Taken Reports
Chapter XIX	Coordination and Implementation	Coordination, as between and amongst the various agencies involved in the disaster management

Source: NDMA, "National Disaster Management Guidelines, Preparation of State Disaster Management Plans", (2007)

2.2.2 **National Policy on Disaster Management**

The NPDM was prepared by NDMA and approved by Union cabinet with a vision to build safe and disaster resilient India by developing a robust proactive, multi- disaster focused and innovative strategy based on framework of DM act i.e., Prevention, mitigation, preparedness and response.

The objects of NIDM are as follows:

- Through Knowledge, innovation and education promoting culture of Prevention, mitigation, preparedness and response amongst the states.
- Encouragement of mitigation strategies based on technologies, conventional wisdom, and environmental resilience
- Integrating disaster planning into the framework of development disaster planning process
- Creating an encouraging regulatory environment and a compliance regime by establishing operational and techno-legal structures
- Providing an effective framework for identifying, assessing, and tracking disaster threats
- Developing advanced forecasting and early warning network that area supported by responsive and fail-safe network and information technology assistance.
- Providing effective response and relaxation while taking a proactive view to the needs of the most vulnerable groups in society. Undertaking reconstruction as an incentive to build disaster-resistant buildings and habitat to ensure better living conditions.
- Promoting effective and proactive corporation with media.

2.2.3 **National Disaster Management Plan**

The National Disaster Management Plan (NDMP) provides a framework and direction to the government agencies for all phases of disaster management cycle.

Under the section 37 of DM act, it is mandatory to prepare NDMP for whole country. It consists of two parts:

Part I-Basic Plan and Framework and

Part II-Disaster Mitigation, Response and Function Plans.

For each hazard, the approach used in this national plan incorporates the four priorities enunciated in the Sendai Framework into the planning framework for Disaster Risk Reduction under the five Thematic Areas for Action:

1. Understanding Risk
2. Inter-Agency Coordination
3. Investing in DRR – Structural Measures

4. Investing in DRR – Non-Structural Measures

5. Capacity Development

Other Donor Assistance to Disaster Management

2.2.4 National Cyclone Risk Mitigation Project Phase -II

The National Cyclone Risk Mitigation Project has been launched to assist the Government of India in reducing the risk and exposure to natural disasters, particularly cyclones, to the citizens of India. The project is currently in the second phase with a loan of US $ 364 million; The second phase was expected due to cyclone Phyllin, which affected the states of Odisha and Andhra Pradesh.

Table 3 Components of National Cyclone Risk Mitigation Project (Phase II)

Number	Component	Activity
Component A	Early Warning Dissemination Systems (EWDS)	To reduce the vulnerability of coastal areas by addressing the current disparity in community alert distribution system.
Component B	Cyclone Risk Mitigation Infrastructure	To assist in the financing of critical infrastructures for reduction of coastal community insecurity, such as multipurpose emergency shelters, road developments, electrical transmission cabling, bridges, and saline embankments and bunds.
Component C	Technical Assistance for Disaster Risk Assessment and Recovery	To enhance the consistency of available data on multi-hazard threats for strategic planning, as well as the evaluation of risk funding methods, with two subcomponents: a) multi-hazard risk modelling and assessment b) strengthening emergency recovery capacity
Component D	Understanding and Strengthening Multi-Hazard Risk Management	Understanding and strengthening national multi-hazard risk management at the national level across three sub – components: a) enhancing non-coastal states' capacity for disaster risk assessment and response; b) developing a number of various risk funding strategy; and c) developing a national seismic risk reduction program.
Component E	Project Management and Implementation Support	To finance the Project Management Unit (PMU) and the State PIUs' incremental running costs.

2.2.5 Project Outline of the United Nations Development Programme (UNDP)

Table 4 Summary of UNDP projects for Disaster risk reduction

Period	Project Name	Project activity
2009-2011 (completed)	Kosi Flood Recovery and Reconstruction	To aid in the recovery from flood destruction, including rehabilitation and habitat planning, in order to minimize hazard risk.
2009-2012 (completed)	Urban Risk Reduction	To strengthen capacities of institutions and other stakeholders such as municipal officers, planners, NGOs, etc. to manage risks in 56 cities across the country in cooperation with MHA Raising community knowledge and resistance to disaster risks, as well as improving the capacities of state and district Disaster Management Authorities to effectively cope with disasters and post-disaster recovery activities in coordination with NDMA
2011-2014 (completed)	climate Change Adaptation	To address a crucial dimension of vulnerabilities by supporting specific activities to enhance climate change induced risk management capacities in districts across flood-prone areas of Odisha and drought-prone areas of Madhya Pradesh
2013-2017 (on-going)	Enhancing Institutional and Community Resilience to Disasters and Climate Change (Grant with USD 6 million)	To strengthen government, community, and institutional capabilities in order to accelerate the implementation of disaster risk reduction and adaptation to climate change plans.

2.2.6 Inferences drawn from studies: Need for an hour

Most of the disaster management plans focuses at emergency response operations and communications flow during hazard and other parts shows only general directions of planning to lower the impact at low administrative level only. Also, they are only focused towards humanitarian supply chain functions only like early warning system, providing emergency shelter, rehabilitation, evacuation routes etc. Despite the fact transport logistics is the backbone for running all the operations and accounts for higher amount and long-term economic losses. Though there are separate comprehensive mobility plans to look after them but both of them work in isolation and as a result there is no integration between the both and the aspect left untouched.

2.3 Role of transport infrastructure

The transport sector is generally regarded as the basis for the social and economic growth it also has an important part in the response's facilitation to environmental hazards. The transport segment, in specific the road infrastructure, is extremely vulnerable to these events.

Transportation infrastructure has a complex structure that, in essence, integrates with many other supplementary complex infrastructure systems, it that includes electricity, telecommunications, fuel, etc. Each if these systems has their own institutional design standards, and actor networks. Interdependence is the reciprocal practical dependence of basic resources on each other. There are several forms of interdependencies that are not simply result of physical proximity.

• Physical interdependency: occurs when the operational output from one infrastructure affects another, such as road infrastructure accommodates power supply lines and power generation facilities that feed the pumping facilities that are used during subway flooding.

• Geographical interdependency: Infrastructures such as power lines are often collocated with highways, bridges, and rail lines,. Etc.

• Organizational interdependence: where the status of the system is dependent on the other due to policy, socioeconomic, governance, and organizational links, Shared government, oversight, and ownership may also be used to connect them organizationally. Interdependence can occur in both upstream and downstream directions.

2.3.1 **Transport Links**

Roads

An extensive link of highways and state highways is absolutely necessary for the long-haul freight movement. These connect landlocked states, helping in the import as well as export of the global and local products respectively. In India, a large road network, including the Golden Quadrilateral connects the four metropolises together, supporting international trade. Secondly, the connections of the port access roads with the state highways and then further with quadrilateral (Settlements 2015) .Roadways are the sector handled by the government, in most cases. Roads, though offer the

most flexible option to the movement of goods, it has several externalities associated with it.

Railways

The mode of transport, which was originally computed for the freight movement were the railway lines. In India, dedicated freight corridors, which were sought to be constructed by mid 2000s, are one of an innovation in promoting intermodal transport in India. The eastern DFC connects Ludhiana in Punjab with Kolkata and the Western DFC connects Dadri near the capital city with Jawaharlal Nehru port in Mumbai. Proposed solely for freight movement, this project is still under construction phase and yet to come into full-fledged shape (Settlements 2015)). Though the railways have lost its importance as freight movers, an improved supply chain may aid the mode get back its long-lost value (National Council of Applied Economic Research, 2016).

Inland Waterways

Waterways are the corridors which facilitate the movement of cargo through ships or barges. There are multiple types of waterways, of which estuaries and tidal rivers are the best suited for cargo movement. It is one of the most efficient and low-cost mode when a huge amount of cargo has to be transported over a longer distance in regions where such corridors are available. Ability of a waterway to be used as a freight corridor is dependent upon the availability of facilities which allow loading and unloading of goods as well as those pathways which cannot be interrupted for purposes related to navigation and defense (Inland water ways Association n.d.). An efficient use of waterways can help in the decongestion of cities, reduce overall costs and reduce emissions as well (Bank. 2013) . Many countries have taken this aspect, including London, where Thames River is being utilized for the movement of freight, including municipal waste. Other examples include Rotterdam, where waterways are the lifelines of the country, moving almost everything on water. Moreover, in the recent past, the Indian Ministry of Shipping has also come up with an approach to use inland waterways for cargo movement and at the same time, have declared 111 waterways to be national waterways. A recent project of Jal Marg Vikas Project intends to entitle about 106 waterways of the country as National Waterways to enhance the navigability of the national waterways, especially NW-1, from Haldia port to Varanasi

(Developing India's First Modern Inland Waterway. 2018) Thus, a lot of emphasis is being given to the use of national waterways.

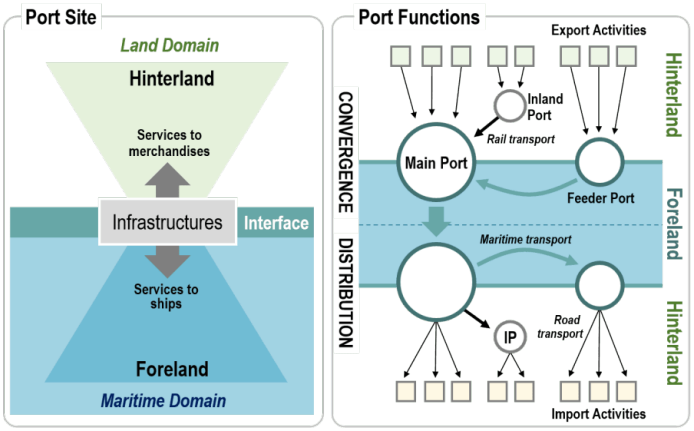
Coastal Shipping

Moving cargo as well as passengers between two ports along a coast is defined as coastal shipping. In the Indian context, it could be moving cargo from a major port to a minor port on a single coast or from east to the west coast. Also known as Short Sea shipping, it is a domestic mode of transport when the vessel is up to twenty-two nautical miles away from the coast of the country. Marine Highways in the United States, Motorways of the Sea in Europe and Nautical Highway in Philippines are synonymous to what Coastal Shipping is for the Indian Subcontinent. This underutilized mode of cargo transport is yet to be explored for the economic advantages that it could offer to the nation.

2.4 Port supply chain logistics

Supply Chain is defined as the network of organizations which are involved in the delivery of products as well as services from the producer to the customer (Bichou & Gray, 2007). Logistics is being defined as an aspect of SCM that manages reliable, effective forward and reverse flow and storage of products, services, and related points from the point of consumption to meet customer needs (Stroh, 2002). “Logistics is the planning, instigating and directing the efficient flow as well as storage of goods, services as well as information from origin to point of consumption so as to fulfil the customer requirements”. It is a process of transferring the right goods to the right location at the right time, in the right shape, and for the right price. (Leinbach 2007) Port Logistics is similar to this, except for the fact that port is essentially the origin of such services when commodities are being imported and the manufacturing hub is the source of such services when the goods are being exported. Thus, ports have become crucial elements of the global supply chain. This ‘derived advantage’ has proved to be advantageous to those linked with the port operations as well. The successive set of operations linked with logistics incorporate warehousing, depot operation, shipping, trucking, freight forwarding i.e., an overall end-to-end movement of freight (Robinson 2002).

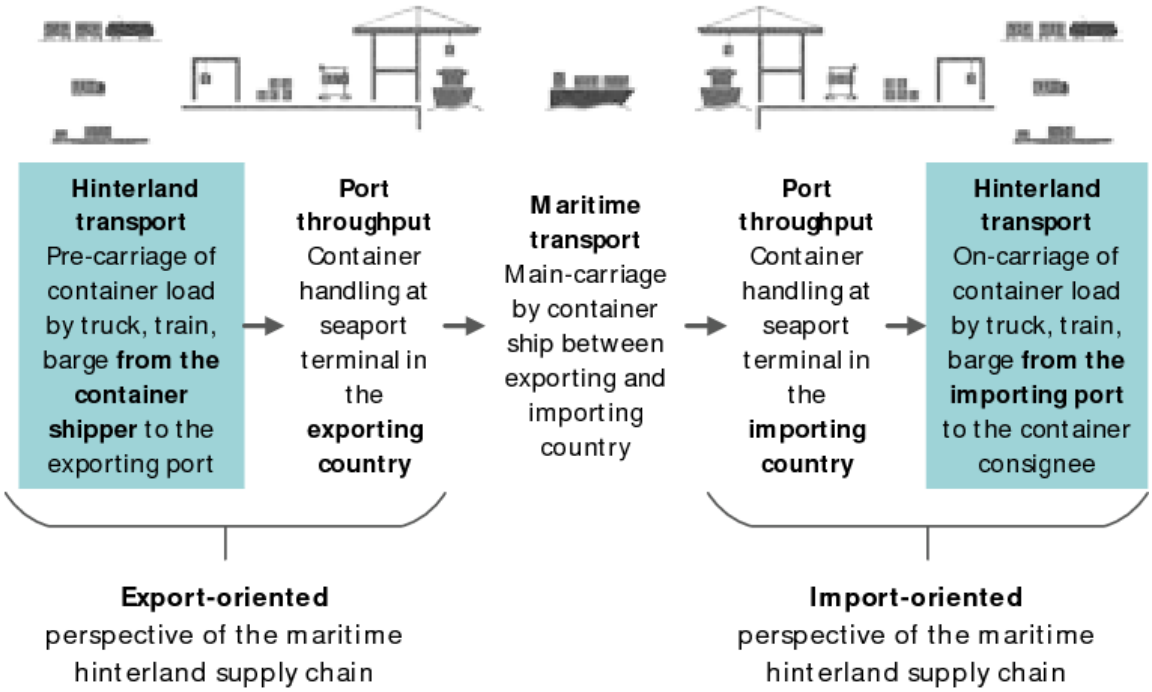
Figure 4 Port sites and functions



Source: Transport Geography

Port location is constrained by two physical characteristics first land access and other maritime access, both are crucial for port operations and can impair port operations. Hinterland is the space on the land the has dominant market share of the port and act as intermediate stop for cargo distribution for far off industries. Foreland is the space in the ocean mirror to hinterland like ports and inlands linked by shipping services of port.

Figure 5 Port- Hinterland supply chain



Source: Transport Geography

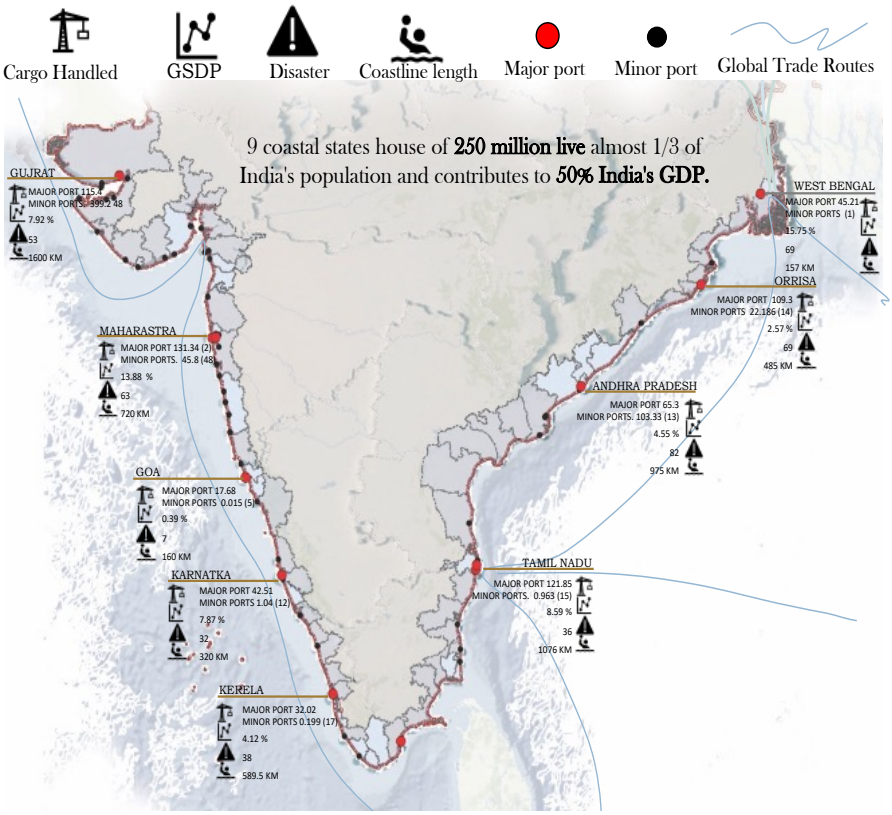
2.4.1 **Indian Ports profile**

India exports approximately 7,500 commodities to approximately 190 countries and imports approximately 6,000 commodities from approximately 140 countries. India exported 276 billion US dollars and imported 384 billion US dollars in 2017.

Engineering commodities, petroleum products, gems and jewelry, agricultural products, and textiles are among its most important exports (Sustainable Port Development and Inproving port productivity ESCAP Member Countries : POLICY BREIF 2020). It is also a significant exporter of information technology and business services. India is the world's sixteenth largest maritime region. According to the Ministry of Shipping, maritime transport accounts for approximately 95 percent of India's trade volume and 70 percent of trade value (India 2020). The Indian government is federal in nature, and maritime transport is to be governed by both the Central and State governments, according to the country's constitution.

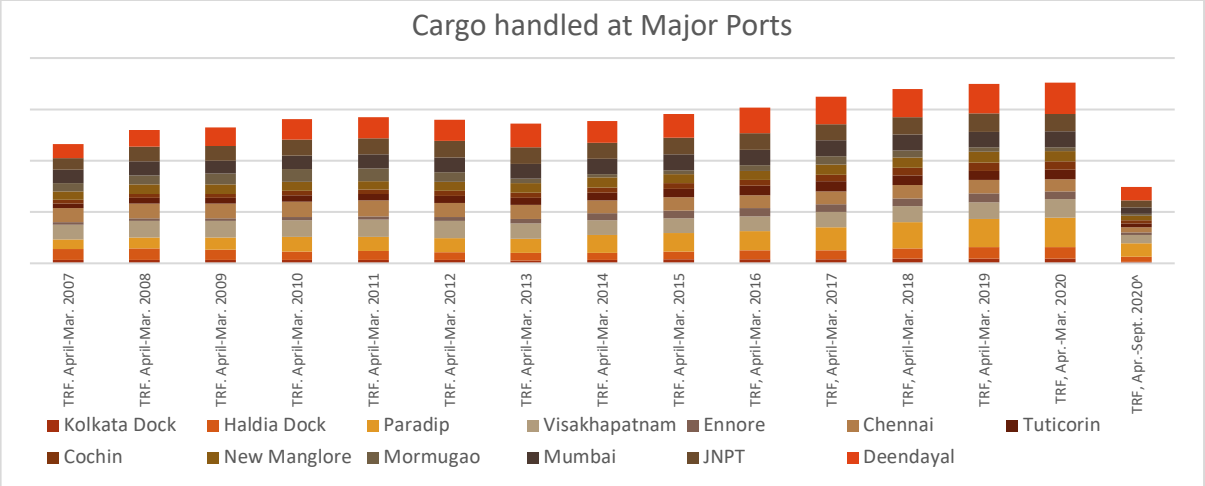
The Central Government operates 12 major ports in India, while the nine coastal State Governments control about 200 "non-major" ports. Meanwhile, the respective governments have established some of these minor and intermediate ports for phased growth, with a large portion of them including public-private partnerships.

Figure 6 Major and Minor cargo handling ports of India



The infrastructure sector, particularly the Maritime sector is expected to grow significantly with the increase in international and domestic trade volumes.

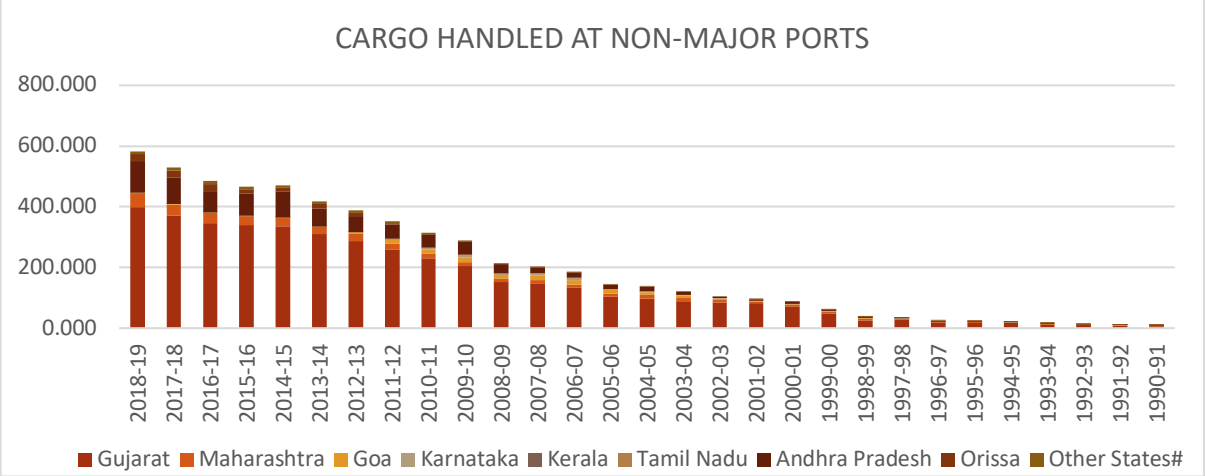
Figure 7 Cargo handled at Major Ports



Source: (Ministry of Ports 2020)

The above chart represent the cargo handled at major ports from 2007- 2020 till date in million metric tons. It can be observed that the cargo traffic at major ports is increasing constantly during past decade except there was a small depression during 2013. Amongst the major ports on the west major cargo share is taken by JNPT and Deendayal port due to its strategic location and on the east coast majority of traffic is handled at major traffic is handled by Paradip and Visakhapatnam port.

Figure 8 Cargo handled at Non- Major Ports 1991- 2019



Source: (Ministry of Ports 2020)

The above chart represent the cargo handled at major ports from 2007- 2020 till date in million metric tons. It can be observed that there is constant rise in traffic during the past decade also, the traffic handled at minor ports of India is significantly higher than major ports.

2.4.2 **Important trade routes**

1. Crude and product imports from the Gulf, Malaysia, and Nigeria

India imports around 40 million tonnes of crude and 20 million tonnes of products every year, chiefly from the Gulf, Malaysia, and Nigeria. While Indian ship-owners have a considerable stake in this trade, liberalization, and relaxation of norms has allowed private-sector refineries to make their own shipping arrangements.

2. Iron ore exports from India to East Asia

India produces about 30 million tonnes of iron ore per year, with 70 percent of it headed to Japan China, and South Korea. Iron ore shipments are still f.o.b., indicating a lack of opportunities for Indian shippers.

3. Coking coal imports from Australia to Visakhapatnam, Paradip, and Haldia

Around 10 million tonnes of coking coal are imported into India by Handymax vessels, mainly from Australia, for consumption by public sector steel majors such as SAIL & RINL and Tata Steel. Indian shipowners, led by SCI, have a 4 million-tonne stake.

4. Thermal coal from Haldia, Paradip, and Vizag to Chennai and Tuticorin

Approximately 14 MT of thermal coal moves along the coast from Haldia, Paradip, and Visakhapatnam to Chennai and Tuticorin primarily to meet the fuel requirements of coal-fired power plants of the Tamil Nadu Electricity Board.

5. Iron ore from Visakhapatnam and Paradip to JNPT and minor ports in Gujarat

Approximately 3 million tonnes of iron ore from eastern ports to JNPT and Magdalla is transported for shore-based steel plants of Ispat and Essar, respectively.

6. Crude oil from Bombay to various major ports like Kandla, Cochin, and Chennai

Coastal crude oil movement accounts for approximately 10 million tonnes, while the above routes account for approximately 8 million tonnes. Crude is produced by ONGC's Bombay High oil fields off the coast of Mumbai and is primarily purchased by oil majors such as IOC, HPCL, and BPCL for their shore-based refineries.

7. Fertilizer and fertilizer material

India had been an importer of 5 million tonnes of fertilizer and 3 million tonnes of rock phosphate and sulphur, chiefly in small size Handymax and Handy size vessels. Imports are made nearly at all the major ports of the country, of which, more than 60 percent of the imports are routed through the East India ports.

8. Containers

India trade approximately one million TEUs per year, primarily through the ports of Bombay, JNPT, and Chennai. The key destinations via transhipment ports in Dubai, Colombo, and Singapore are the United States, Western Europe, and East Asia.

9. Coastal shipping

When compared to foreign trade, coastal trade has been relatively stable, accounting for about 40 million tonnes of freight today, consisting of four bulk commodities: oil, products, thermal coal, and iron ore. This is due to the terrain of our region, which facilitates road rail freight for inbound logistics.

10. Cement

Cement is another important commodity moving between various minor ports, in smaller 2,500 - 4,000 dwt vessels. (Bukrediwala)

2.4.3 **Impact of climate change on port operations**

- Rates: during the period of natural disaster, freight transport prices will increase. During and post disaster the roads will become impassable, alternate routes may be required to turn into action, that may lead to increased fuel burning and prolonging driver duty time, all of which would be passed on to operating costs. Freight costs would also escalate due to the tighter market power of outbound equipment or carriers unwilling to fly to areas with imminent or expected extreme weather conditions.
- Capacity: Post- disaster, there is tremendous competition for scarce transport services and supplies. This limited ability would naturally hike costs, but even if it can be availed at higher cost , it can be difficult to find the capacity.
- Transit time: If the usual transit time is two to three days, it may extend to four, five or more days if the hurricane is on the east coast. The driver may have to wait inland until the roads are passable, and the warehouse or factory or other facilities are open again for company, or he may just be stuck in traffic. This is going to increase the travel time.
- Fuel: Since fuel stations and refineries are often located near where storms make landfall, leading to increase fuel prices in the aftermath of a disaster,

especially cyclones/ storms/ hurricanes. This will force a refinery to close or be destroyed, raising the cost of fuel.

- Refused loads: Carriers would also negate to pick up or transport shipment during a natural calamity. If the carriers refuse to allow the loads, the supply chain will tend to block or collapse. The factories may go idle, awaiting for supplies or production plants may go idle, due to this delay supplies retailers may run out of stock all of resulting in a lack of potential and sales.

2.5 Literature studies Assessment frameworks and resilient infrastructure technologies

2.5.1 Prioritization of Road Interventions based on Economic Development Potential and Flood Risk

Location: Mozambique

Authors: Julie Rozenberg, Xavier Espinet, and Satoshi Ogita

The Zambezia and Nampula provinces of Mozambique are highly exposed to natural events the road infrastructure is highly exposed to flooding and storms which creates extended isolation for communities. So, to overcome this the road authority of provinces created a road network investment prioritization plan with the help of world bank to maximize the connectivity of farmers to markets and enhance the reliability of the transport network under extreme weather conditions. It was done in four steps:

Step 1: Defining the criticality of road infrastructure: by mapping the road infrastructure and classifying them, identifying the critical roads based on loss incurred, proximity to potential agriculture and marketing clusters and socio- economic factors like production, poverty, market scale and etc. and lastly identifying the origin- destination nodes. Network performance was evaluated based on cumulative road user costs, distances travelled, and travel time.

Step 2: Assessing the exposure: water depth maps were produced using modelling for three scenarios i.e., present, future and changes in land use conditions and analysis was done on the basis of flood reoccurrence from 5-1000 years. Finally overlapping the flood maps with transport infrastructure.

Step 3: Calculating the vulnerability and hazard risk district wise

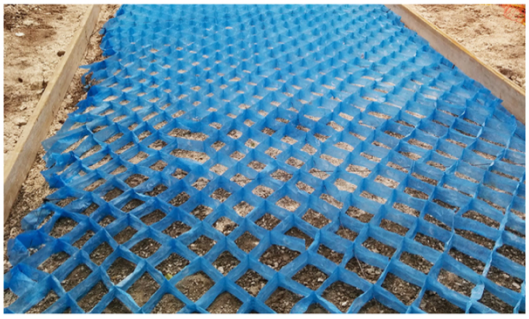
Step 4: Prioritizing districts and road networks for intervention

2.5.2 Climate and Disaster Resilient Roads Using Geocell Concrete Pavements

Location: Kiribati and Tuvalu

Author: Oliver Whalley

Figure 9 Geocell framework pavements



Intensity and duration of rainfall also affects the road paving's causing debris and obstructing the movement. So, to address the issue Small Island Developing states has developed Geocell concrete Pavements to provide climate resilient and low volume road infrastructure. This technique consists of unreinforced concrete blocks 75-150 mm thick and 150- 300 mm square cells shaped by high-density polyethylene formed by pouring cement concrete into a thin plastic lattice and arranging them in an interlocking structure. The structure serves as flexible and impermeable pavement surface. It is cost effective, light and easy transport and founded affective against tough weather conditions.

2.5.3 Geosynthetic Reinforced Soils for Rapid and Low Cost Brides

Location: Sri Lanka

Author: Oliver Whalley

Figure 10 Geogrid technology

Sri Lanka's bridges serve as critical in transport network 50% of the country's bridges suffering from deterioration due to flood and traditionally pile foundation for bridge abutments were used that were costly and slow in construction, it takes months for restoration. To address the challenge the state implemented locally sourced material Geosynthetic Reinforced Soil (GRS) technology. GRS are "geogrids" a plastic mesh made up of high-density polyethylene. In this technology layers of soil and geogrids are combined with basic earthmoving and compaction to create a solid base deck. This is a low-cost high impact and time saving resilient infrastructure technology to withstand ground shake.

2.5.4 Climate Risk Assessment for Muelles el Bosque Port

Author: Vladimir Stenek

Location: Cartagena, Colombia

Transport infrastructure especially port is most exposed to climate change. Ports are critical for national economic performance, growth and development. So, to study the impact of climate change and plan for uncertainty the study was conducted. the study assessed potential effects of climate change on the entire chain of transport responsible for moving goods, including the supply and demand of goods, maritime transport, and ground transport with the goal to assess the material vulnerability and risks that affects port operations. The study adopted practical approach to study the impact foe MEB trade. The author reviewed the economics of climate change by estimating the average cost of climate change as 1.25% of global per capita consumption. The study assessed the risk of disaster like flood on ground handling and storage of goods on ports also linking it with the drainage system of the city and forecasted the future surge of hazards and stated the current drainage infrastructure is incapable of addressing the future climate change impact. Finally, addressing the impact on building and equipment's infrastructure's and founded these not be significant parameter.

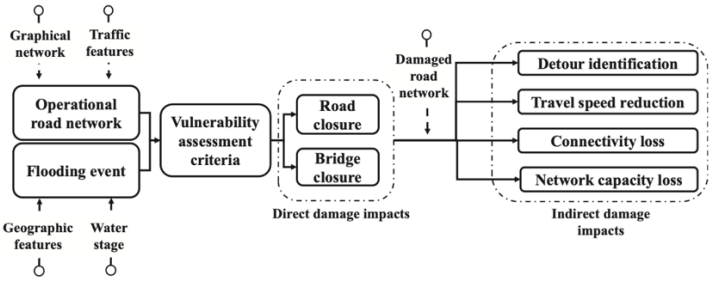
The study also addressed other relevant aspects like insurance policies which do not cover the area and infrastructure outside the port that are not effective for business disruptions (Group 2011).

2.5.5 Integrated Framework for Risk and Resilience Assessment of the Road Network under Inland Flooding

The paper presents an integrated method for assessing the adverse effects of flood activities on an Iowa road network composed of 12 counties and two major towns, Cedar Rapids and Iowa City. This model integrates direct damage analyses on road and bridge closures based on the flooding water level, network functionality analysis using graph theoretical indexes, as well as flow-based network capacity analysis using the traditional four-step traffic model. This model was applied to a primary road system in Iowa District 6 for multiple flooding scenarios, reflecting flood events of 2, 50, 200 and 500-year return intervals. Network robustness and redundancy can be

described using network knowledge on closure and residual capabilities, and relative optimization steps can be introduced to increase network responsiveness to adverse flooding events. Meanwhile, the lack of social-economic values suffered by human and freight vehicles during their travels may be estimated depending on the magnitude of flooding's effects on them. (Alipour 2019).

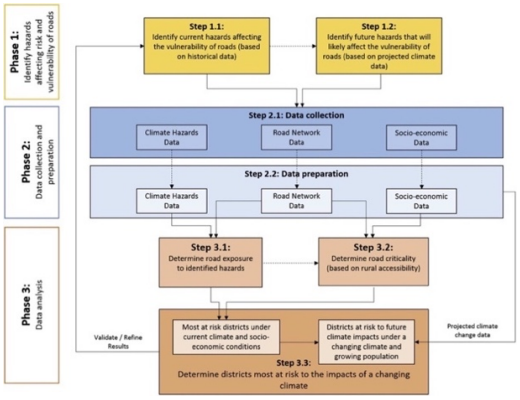
Figure 11 Case study: Model Framework for assessment



2.5.6 **A framework for assessing the risks and impacts of rural access roads to a changing climate**

African communities are worst affected by climate-related natural disasters such as metrological, geophysical and climatological and road infrastructure in rural areas is critical for improving quality of live. So, to address the issue the author developed an indicator-based vulnerability assessment framework to study the impact of climate change on rural road network using network data, socio economic data and disaster data. In first stage determining road exposure to identified climate hazards using exposure index, then determining the road criticality based on accessibly. In third stage determining the districts most prone to hazards risk and impact of climate change furcating. Finally, by doing the overlay analysis analyzing the impact and validating model and making conclusions about the region (T Alize le Rouxa 2019).

Figure 12 Case Study: conceptual framework for rural roads accessibility and vulnerability



2.6 Freight models

The research related to modelling of freight movement form the port to handling facility has been attempted by many professionals. Forecasting traffic accurately, defining the applicability of any model in a particular context, and finally enhancing the usability of the model are essential components of a freight model.

2.6.1 Good Trip Model

Developed by researchers from Delft University of Technology and The Netherlands Research School of Transport, Infrastructure and Logistics, this model is a demand driven model, which focuses on the flow of commodities before considering it a flow of traffic. This model identifies the various activities going on so as to define the nodes for the supply chain. It comprises of four major components, i.e., geographical implications of activities, flow of commodities, flow of traffic and finally, infrastructure supporting multimodal transport. An estimate of flow of goods is made through the calculation of volume of goods demanded per goods type in every zone, according to end user demand. After this, vehicle tours are allocated to the flow of goods based on their origins and destinations. Then finally, O-D matrices are created with tours per mode, to generate network loads. Vehicle mileage per mode can also be calculated using network loads per mode which shall further aid in quantifying emissions and energy use. This model is applicable when passenger flow data and all data related to consumer and logistics is available (Fugisawa 2008)

2.6.2 Leach man Port elasticity model

This model is again a commodity-based model, which is aimed at estimating freight flows in terms of monetary changes. Both economic as well as behavioral aspects of flow, at all the levels are captured through this model. It is applicable for modelling freight from ports to handling facilities further to customers as economic and shipper decisions are taken into consideration. Two kinds of cost are estimated, capital cost, i.e., finance for goods in transit, also called ‘pipeline stock’ and the finance required for handling at the distribution centers. The total transportation cost is estimated using trans-load channels, direct rail channels as well as the trans-loading to trucks. The methods used include cost matrix, transit time matrix and so on. A comparison in terms of cost calculation for different scenarios has been done to generate a least cost

logistics strategy. Elasticity is dependent upon the costs, including shipping costs, inventory costs as well as delay costs with respect to the physical conditions like size of consignment, congestion conditions, fees related to container movement etc. Different scenarios shall be created thereafter. The scenarios are built under two scenarios, as usual and congestion relief scenario. On a whole, the choice of the shippers related to making an economically choice is taken into consideration. For instance, replacement of small trucks by a big truck may prove to be economically viable on account of cutting costs upon driver charges (Fugisawa 2008).

CHAPTER 3 STUDY AREA

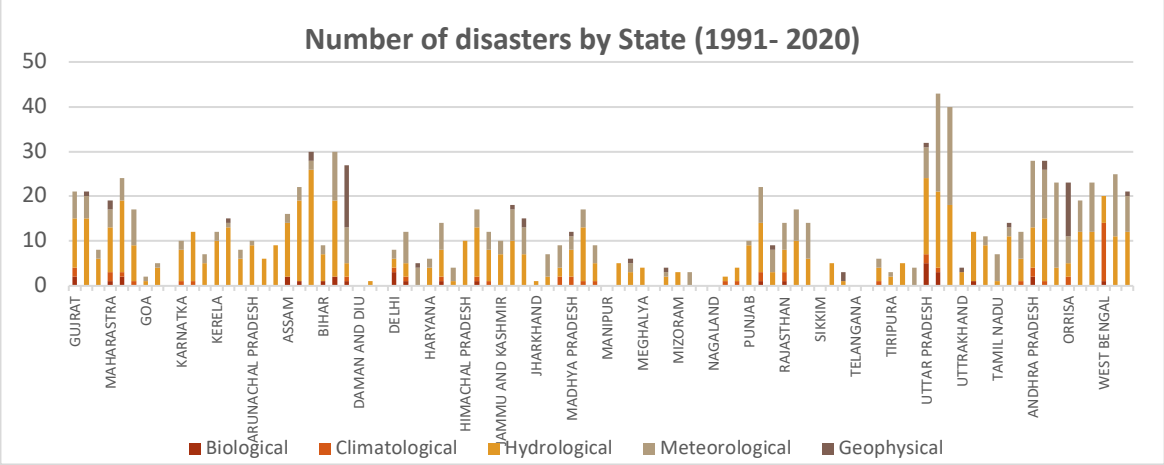
3.1 Site Selection

India has 7,516 km long coastline with unique features on both the sides spread across of 9 costal states and 2 union territories. The Indian Coast can be divided into the East and West coast. And there is a plethora of ports on both of these coasts.

3.1.1 Criteria for Coast and Port Selection

1. Disasters vulnerability
2. Coastline length
3. Number of ports
4. Cargo Traffic Handled by state and
5. GDP Contribution

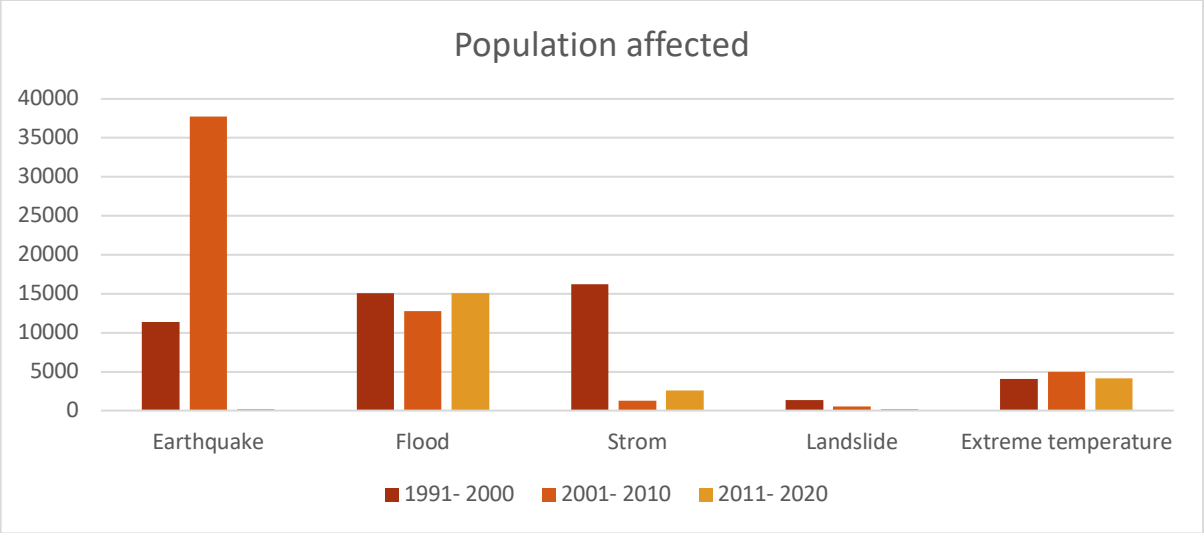
Figure 13 Number of disasters by states 1991- 2020



Source: EM- DAT statistical data, November, 2020

The above graph shows the occurrence of disasters by state in past 30 years. It can be observed that the frequency of disaster's hitting the eastern coast is more the western cost due to its geography. Also, among the east coast state of Andhra Preash has been stroked a greater number of times than others. As per the statistic, flooding prevailed on a regular basis with high frequency; as a result, flood disasters caused extensive damage in the region. Weather anomalies, cyclones, winds/ storms and sediment disasters have happened on a yearly or more frequent basis. These kinds of disasters have wreaked havoc and caused high damages. While earthquakes and tsunamis do not occur on a regular basis, but they have huge impact once they occur.

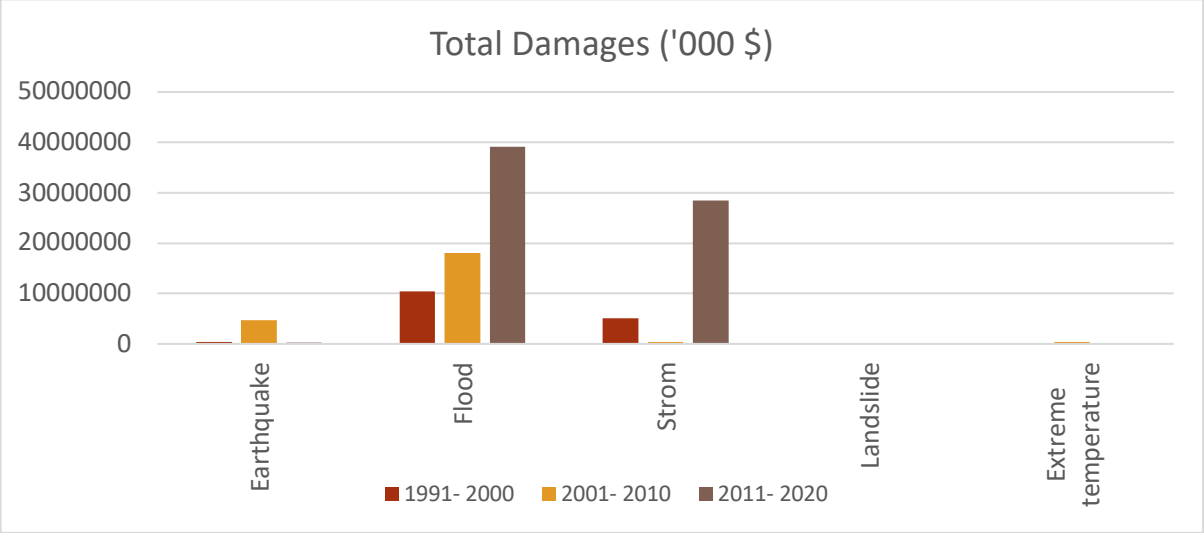
Figure 14 Population affected by disasters 1991- 2020



Source : EM- DAT statistical data, November,2020

Looking at population statistics it can be observed that in past three decades the total population affected by earthquake's is highest 37.5 % followed by floods 33.8%, storms 15.03%, extreme temperature 9.01% And least by landslides 3.7%.

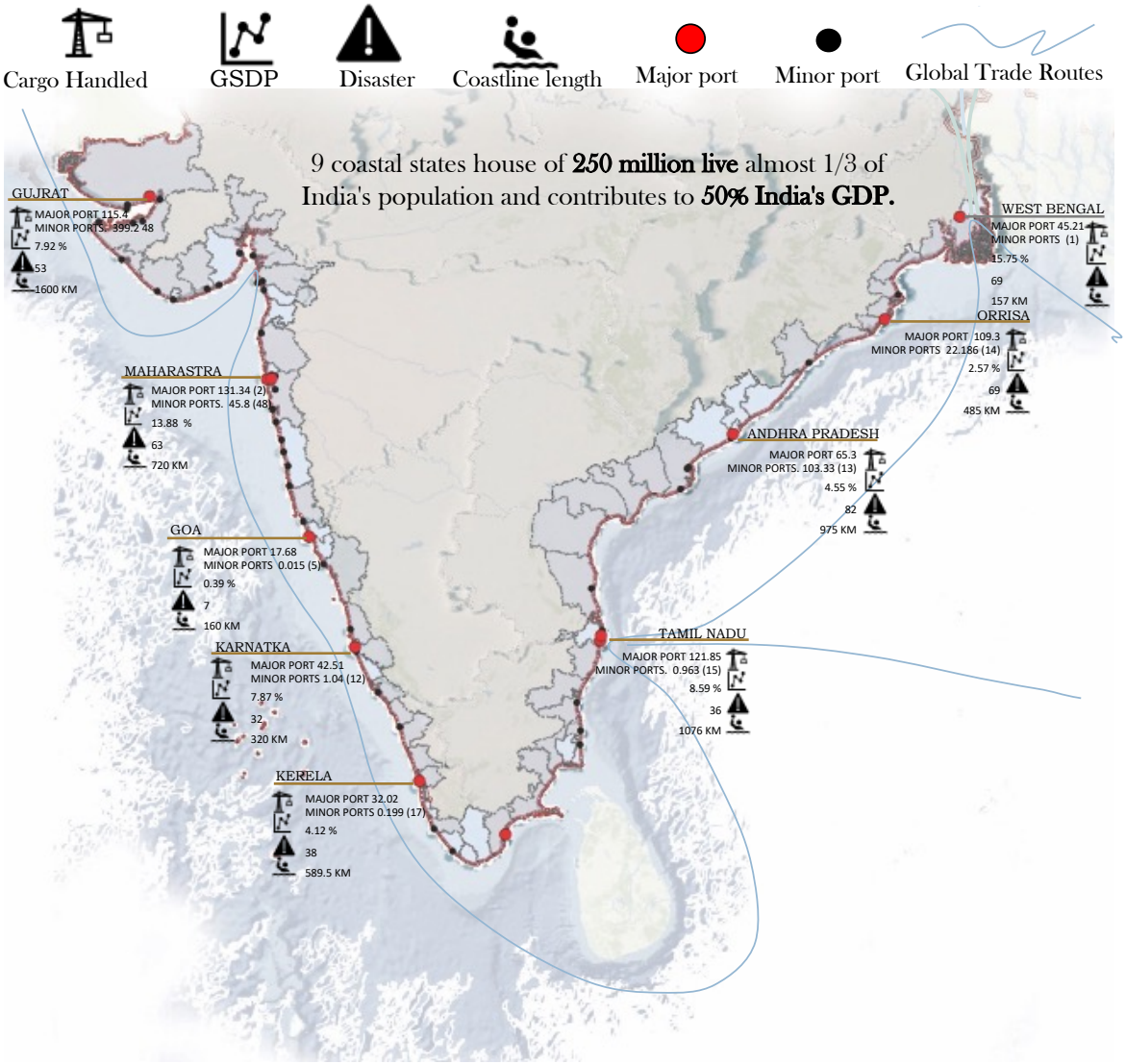
Figure 15 Total losses incurred due to disasters 1991- 2020



Source: EM- DAT statistical data, November,2020

Though the population affected by floods and storms is less compared to earthquakes while the total damages caused is more. It can be observed from above graph that the total damage incurred by flood is approximately 10 times higher than earthquake and storm activities is storm is approximately 6 times higher than earthquake.

Figure 16 Ports of India and their economy

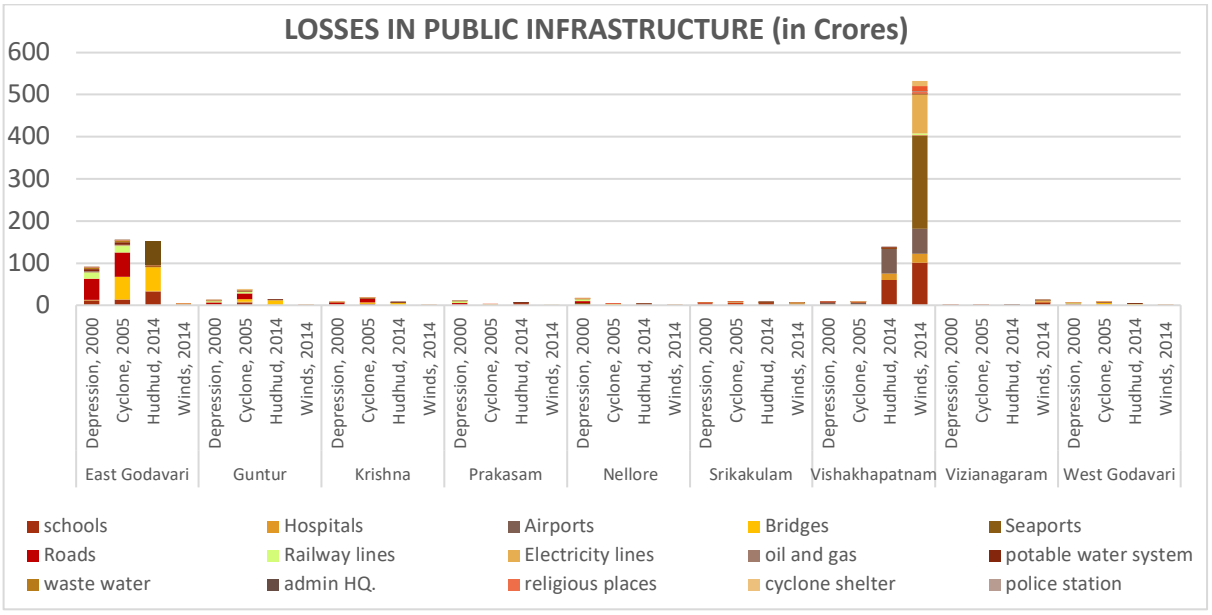


Source: Socio economic survey 2019-20; Indian National Port trust, November2020, EM- DAT data

East coast of India has a total coastline length of 2545 km. Amongst the eastern coast of India Andhra Pradesh have the longest coastline of 975 km. followed by Tamil Nadu 928 km, Orrisa 485km. and West Bengal 157 km. Also, the total cargo tonnage handled by Andhra Pradesh state is much higher than the other states. Andhra Pradesh state has 1 major port and 5 minor cargo handling port, which totally handles 168.63 million metric ton of cargo in 2019- 2020 followed by Orrisa have 1 major and 14 minor cargo handling ports which handles 131.486 million metric tons, Tamil Nadu has 3 major port and 15 minor cargo handling port, which handles 123.813 million metric tons, and West Bengal have 2 major and 1 minor cargo handling ports which

handles 45.21 million metric tons for the year 2019-2020. Though Orrisa and Tamil Nadu have a greater number of ports but the output is less.

Figure 17 Losses in public infrastructure of costal districts of AP due to disasters



Source : Report by world bank Group

Figure 18 Andhra Pradesh storm surge map

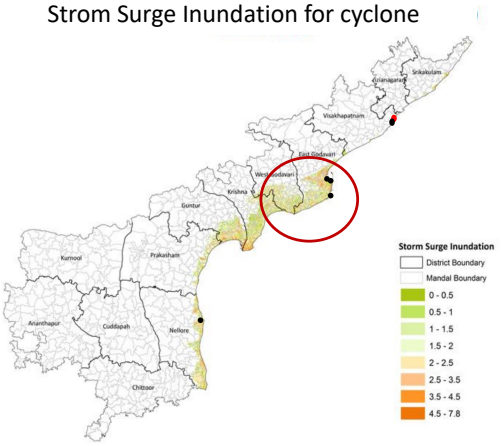
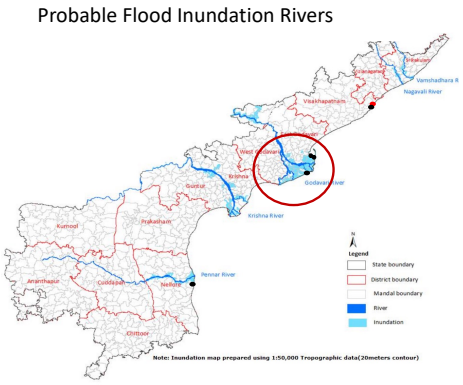


Figure 19 Andhra Pradesh Wind surge map



Source : Andhra Pradesh state disaster website

While looking at the losses incurred by the coastal states of Andhra Pradesh of public infrastructure it can be observed that the among the past four major disasters deep depression 2000, cyclone 2000, super cyclone 2014 and cyclonic winds 2014 the total damages incurred is highest in Vishakhapatnam during cyclonic winds of 2014 and major infrastructure damages is to school, seaport and airport while the damages

incurred by east Godavari low compared to Vishakhapatnam during cyclonic winds 2014 but the losses are more frequent comprising of majorly comprising of roads, Bridges, railway lines, electricity lines.

Amongst the coastal districts of Andhra Pradesh, East Godavari, West Godavari and Krishna district have high future surge of cyclones. Also, with a rise in 1 m of sea level these districts have high probability of flood inundation. So, the infrastructure in this district is highly vulnerable to climate changes.

Table 5 Port profile of Andhra Pradesh

Port	District	Capacity	Cargo (handle in MMT 2018-19)	Draft available	Hinterland
Vishakhapatnam Port	Vishakhapatnam	127	65.3	14	Srikakulam, Chhattisgarh, orrisa, Jharkhand
Gangavaram Port	Vishakhapatnam	45	30.3	21	Srikakulam, Chhattisgarh, orrisa, Jharkhand, East Godavari, Rajahmundry, Telangana
Kakinada Deep water Port	East Godavari	22	15.69	12	Hyderabad, Nalagonda, Rangareddy, West godavri Samarlakota, Pithapuram, Kakinada SEZ, Guntur, Rajahmundry
Kakinada Anchorage port	East Godavari	4	1.64	12	
Ravva Port	East Godavari		0.80		
Krishnapatnam Port	Nellore	64	54.37	18.5	Guntur, Prakasam, Kurnool, chuddupah,

(SOCIO ECONOMIC SURVEY 2018-19 2019)

Though the traffic at ports of east Godavari is less while the surge of disasters and losses incurred in infrastructure is high for east Godavari. Hence, the selection of district and port is Kakinada Port, East Godavari district.

3.2 Study area Delineation

3.2.1 Parameters considers for Delineation

- Distance from the port
- Administrative Boundaries
- Flow of commodities from port to hinterland
- Land use.

Distance from the port: One of the most significant aspects influencing hinterlands is distance. Because of the nature of the goods and the costs of transportation involved, hinterlands are typically small and serviced by high-capacity corridors to the point of production or processing.

Flow of commodities from port to hinterland: Since servicing the hinterland is their primary role, the origins and destinations of traffic are critical concerns for terminals. Terminal competition can be seen as a challenge to capture particular business areas. Terminals that have successfully expanded their hinterlands to capture business areas formerly served by a rival are considered successful. So, based upon the flow rate of commodities primary secondary and tertiary hinterlands were delineated.

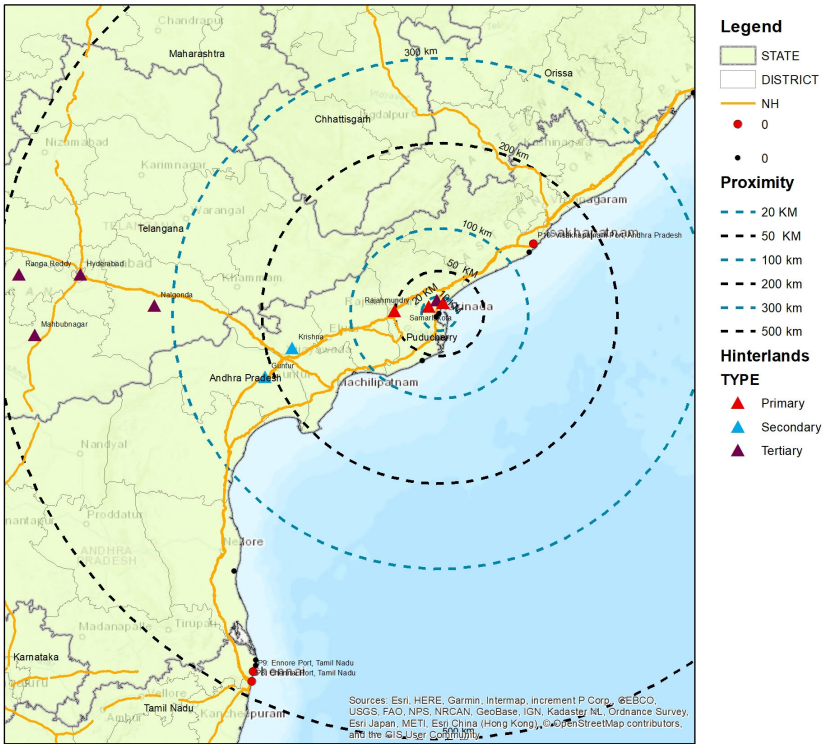
Figure 20 Flow of commodity from port to hinterland.

Flow of Commodity Port- Shipper (February, 2021- March 2021)				
Traffic analysis zones	Number of Shipments	Distance from the port	Volume of Goods flow	Type of Hinterland
External				
Orissa	6	500 and beyond	0.05	Tertiary
Nellore	3	0- 500	0.029	Tertiary
Hyderabad	8	0- 500	0.07	Tertiary
Krishna	5	0- 200	0.049	Secondary
Pedapuram	3		0.029	Secondary
Internal				
Samalkota	15	10- 20	0.15	Primary
Pithapuram	9	10- 20	0.088	Primary
Kakinada	48	0- 10	0.47	Primary
Karapa	2	10- 20	0.019	-

Kotthapalle	2	10- 20	0.019	-
Thallarevu	0	10- 20	0	-
Gollaprola	1	20- 50	0.009	-

Source: Kakinada sea port limited vessel schedule

Figure 21 Hinterland delineation

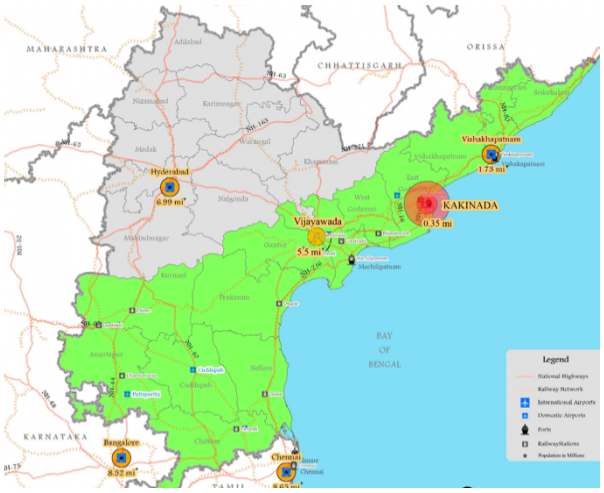


Source: Author generated using ArcMap

Administrative Boundaries: The entire area Andhra Pradesh is divided into mandals which is the local government of the area similar to tehsil, several mandals combine and make a revenue division. East Godavari district has been divided into 7 revenue divisions: Kakinada, Amalapuram, Peddapuram, Etapaka, Rampachodavaram, Rajamahendravaram and Ramachandrapuram which is further divided into 64 mandals. All the financial stands at the district level are taken by revenue divisions in Andhra Pradesh. It plays a pivotal role during the disaster by providing immediate mitigation activities like providing shelter during such disaster times, providing food and relief during such emergencies, also all the infrastructure loses are born by revenue divisions.

Landuse: The landuse pattern has a direct influence on the movement of goods and port growth as industrial land use attracts the trips and facilitates the growth of port.

3.3 Study Area Profile



Kakinada is in Andhra Pradesh North-Eastern portion. With a population of 325,985 urban agglomerations (2011 Census) it is listed as the 7th highly populated city in the state.

Kakinada has a low decadal growth rate of 5.37 per cent. The urban district covers an area of 31,69 sq. Km while the township occupies 57.3 sq. Kilometers. Kakinada was one of 109 cities selected by the MoUD for the Smart City Mission introduced in 2015. In 2016 Kakinada was selected as one of the first 20 smart cities in India.

Kakinada, Andhra Pradesh's biggest city and East Godavari district headquarters, is also known as the Port City. Spread over 192.3 sq of area. Kms, Kakinada is a popular destination for tourists and draws a large number of visitors every day. It is situated next to such cities as Visakhapatnam (155 km) and Vijayawada (210 km).

The Port of Kakinada is on India's East Coast's Southern Portion. It is the second largest port in the province, and the first port around the world to be established under Public Private Partnership project (PPP). In terms of population size Kakinada ranks 8th in the state and is home to 376,861 residents. They are one of the state's educational centers.

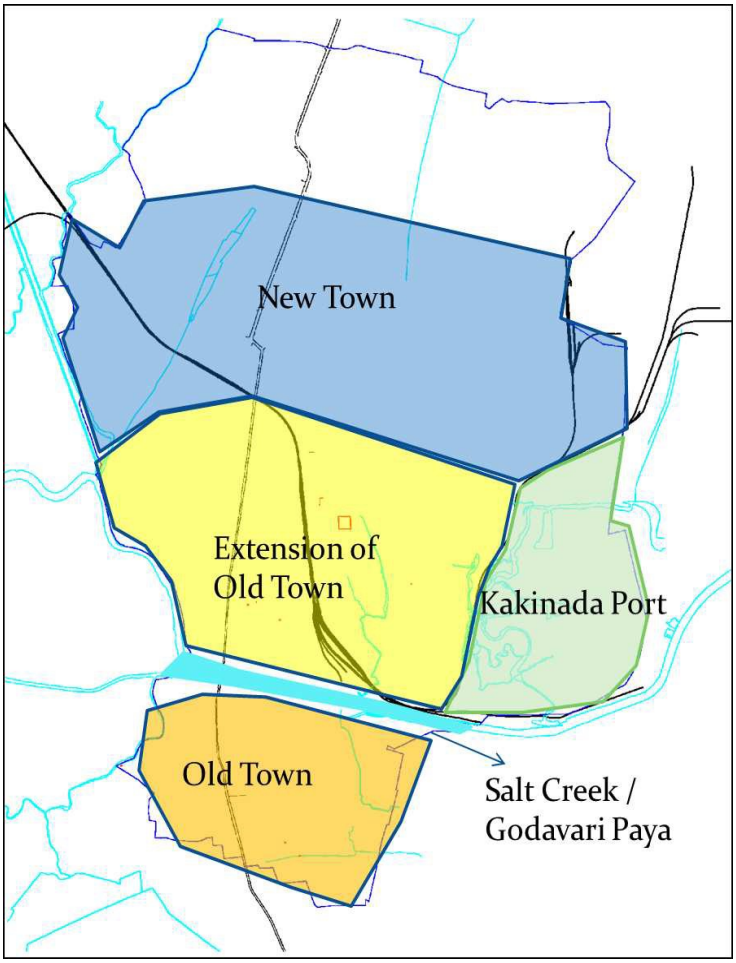
Kakinada is recognized as Andhra Pradesh "Fertilizer City" Recently the region has been granted the status of a Special Economic Zone (SEZ), which also leads to its rapid growth. It is also a potential Area for Energy, Mineral, and Petrochemical Production (PCPIR). Kakinada has a strong shipping sector and a diverse manufacturing footprint including textiles, car parts and steel, due to its port-based and sea port industries. Kakinada's other main sectors include the sugar, oil refineries, fisheries and aquaculture sectors. The town produces primarily seafood and fertilizers. Kakinada is the eastern offshore hub of the Oil and Natural Gas Corporation (ONGC),

and is well known for its oil industry. The area also houses about 39 information management companies and several other public sector businesses.

3.3.1 Growth of the town

The town is oriented north-south and its development is limited to a long narrow strip parallel to the sea shore, which restricts expansion of town towards the east and the entire east coast of the Kakinada town is bordered by an industrial belt which also houses the Port Premises.

Figure 22 City form and growth



Source: Zonal Development plan Kakinada

Towards the southeast is Kakinada Bay and a marshy wetland that currently host the India's second largest mangrove plantation and the Coringa Wildlife Sanctuary. Also, at this point, a branch of the River Godavari, the river Gouthami, joins and flows into the Bay of Bengal. The northern and north western regions of Kakinada are the most modern and developed part of the town, with its recent approved development layouts.

The town is divided into two distinct parts by the back waters on the approach channel to the sea.

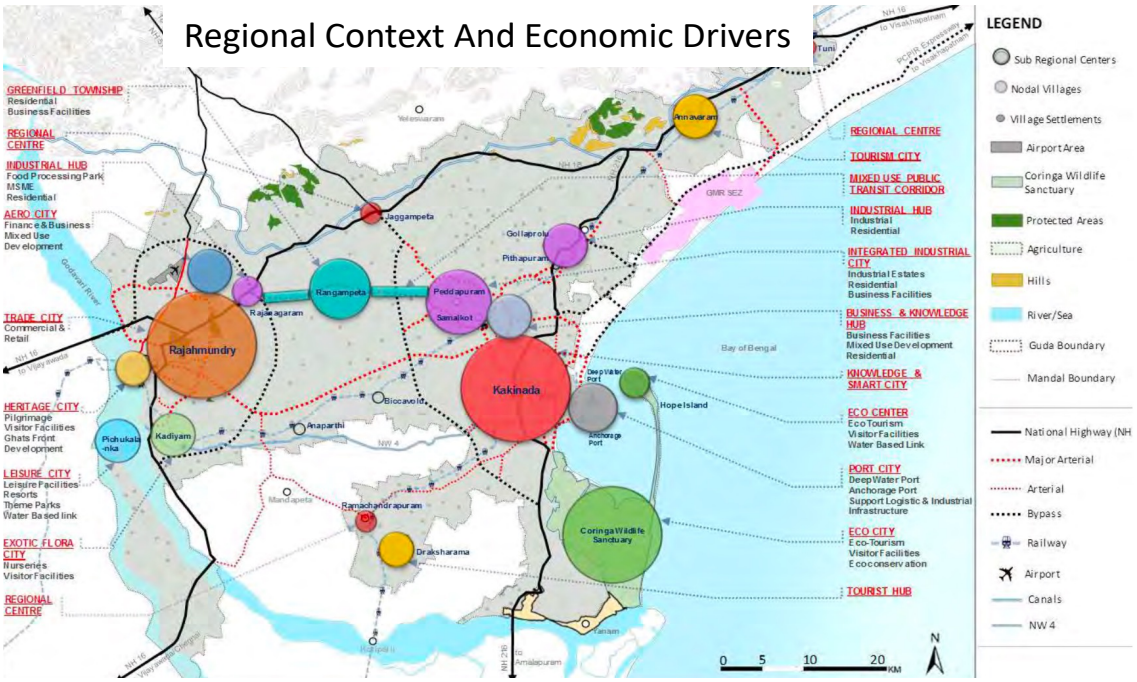
- The area in the south of the creek is the old town with some historical importance. (Jagannatha temple, Dutch, French architecture)
- North of the creek is an extension of the old town (Planned Town)

- Major Spine of the town is the National Highway and state Highway. Rail Network and the sea port connectivity has led the concentration of town' growth horizontally. New Layouts have come up on the northeast towards Samarlakota. (Overall, 663 approved layouts). Influence of VKPCPIR, the North direction towards Uppada and Samarlakota also has the potential for development. VKPCPIR, Kakinada – SEZ, Port Connectivity, Good Road connectivity, Educational and Health hub, Hope Island & Coringa Wildlife Sanctuary.

3.3.2 Regional Context of Study Area

Planning for the development of Kakinada town cannot be constrained within its Municipal boundaries. It significantly influences and is persuaded by developments/activities beyond it especially the settlements located within 60 km radius as shown below in case of Kakinada.

Figure 23 Regional context of the study area



Source: GUDA Perspective plan 2050

While, Kakinada situated along the sea cost; its growth is restricted towards eastern side. So, the town has sprawled along the corridors i.e., the NH and the Railway Line which connects the nearby cities and towns. East Godavari is the most populous

district in the State; with Rajahmundry and Kakinada being the 2 largest cities in Godavari district.

Rajahmundry: is situated 63 kilometers away on the holy banks of the Godavari River and encompasses the largest rail and road bridges on the river Godavari, linking Kovvur and Rajahmundry. It is most popular because of its agricultural, commercial, and cultural historical backgrounds. Hence, this town is also regarded as Andhra Pradesh's Cultural Capital.

Yanam: A town in the union territory of Puducherry; is located at a distance of 30kms from Kakinada. It is well known for its blend of French and Telugu culture prevailing till date. A lot of tourist visits the town for its pilgrimage importance as it houses a number of religious centres, host many cultural festivals and for its strategic location (over the banks of the Gauthami Godavari river).

Samarlakota: It is just 12 kilometres from Kakinada and is the third largest and most developed indstrialized city after Rajahmudry and Kakinada. East Godavari's twin towns are Peddapuram and Samarlakota.

Samarlakota railway station is a major railway station on the Visakhapatnam-Vijayawada part of the Howrah-Chennai main line. The rail line to Kakinada splits at this railway junction, which functions as the town's main station for passenger travel as it connects the town to the remaining states.

Pithapuram: Located at 14 kms from Kakinada, Pithapuram Railway Station is on the Chennai– Howrah Railway line and the town is famous for its Ancient Hindu temples. It is located between Kakinada and Rajahmundry and the town is dependent on Kakinada for its economic activities as it is a landlocked.

3.3.3 Regional connectivity

Road System: National Highway 216 passes through the city that connects Karthipudi to Ongole (both lies on NH 16). State Highway 40 also connects the town to Rajahmundry and other major towns in the district. ADB Road and Samarlakota – Kakinada By Pass Road considered as Sate Highways. Visakhapatnam is 154 Km far flowed by Vijayawada, Hyderabad and Bangalore with 216,484 and 853 Km.

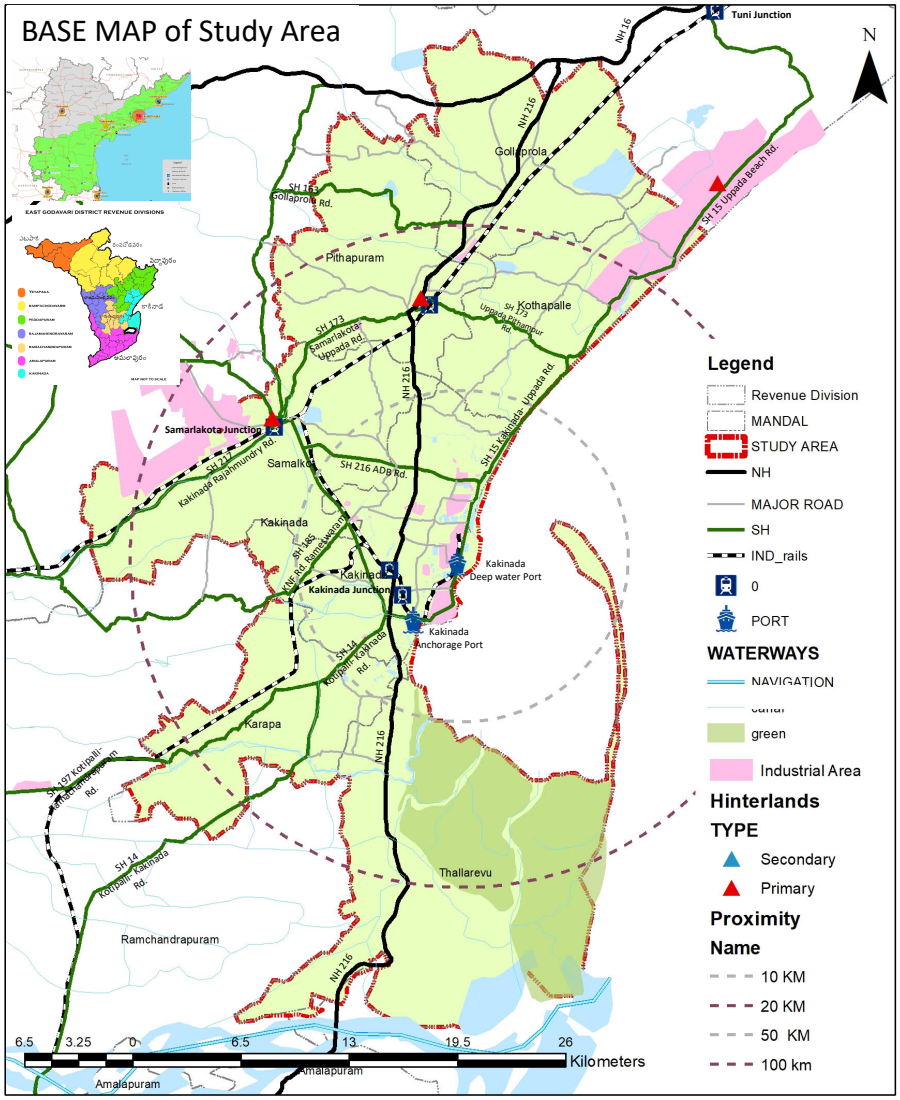
Rail Ways: Kakinada is a railway terminus, being a shore town, and has three stations, namely Kakinada Port (COA), Kakinada Town Junction (CCT), Sarpavaram

Referred as Samaralakota junction (that is 13 km away) and lies on the trunk line of Chennai-Howrah broad gauze.

Airways: Rajahmundry airport is Nearest Airport which is 61 Km away, offers Air services to Hyderabad, Bangalore and Chennai. Visakhapatnam is the Nearest International Airport which is 145 Km away, offers direct services to Singapore, Andaman, Delhi, Hyderabad, Chennai and Bangalore

Water ways: Connects rivers and canals between NW-4 Bhadrachalam-Rajahmundry- Kakinada- Uluru- Vijayawada and Chennai. Length of the water ways is 1,095 km.

Figure 24 Base map of study area



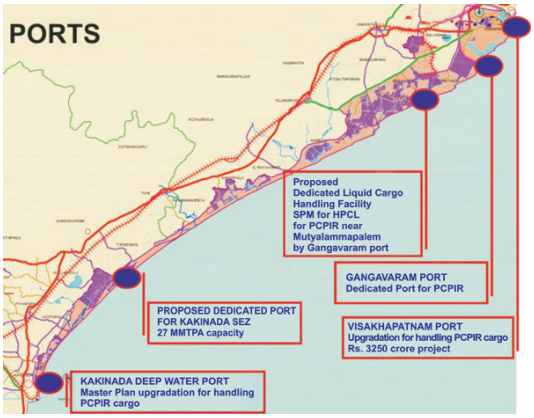
Source: Author generated Using ArcMap

Figure 25 Major clusters and Industrial corridors of region

Kakinada is also a part of the East Coast Economic Corridor (the first coastal corridor of the nation) and is capable of playing a crucial role in pushing India's current "Act East Strategy." It aims to increase the opportunities for industrial production & jobs, increase labor productivity & wages, foster competitive SMEs and broaden exports over the next two decades. Promoted by Andhra Pradesh's Asian Development Bank and State ADB operates under the guidance of the Department of Industrial Policy and Promotion (DIPP), Ministry of Trade and Industry, GoI& Gap for VCIC field development. Vizag – Chennai Industrial Corridor Development: One of the major Growth Node – Kakinada Node (Kakinada Cluster &Rajahmundry Airport). It involves Port, Road & Rail centric project. It includes Sector and Node based development along with Policy & Regulatory Reforms. Creation of economic Zones &manufacturing clusters served by efficient logistic services.

Kakinada SEZ: Spread over 10,000 acres in an oil- and natural gas-rich region, the SEZ has the potential to generate up to 70,000 jobs over the next 5 years. Established as a 'Special Economic Zone for Port-related Multi Products,' the site will tackle existing businesses and extend into new and developing sectors located in and around Kakinada.

Figure 26 PCPIR Project between Kakinada Vishakhapatnam



PCPIR: City is part of the PCPIR district of Vishakhapatnam- Kakinada, which will be Region's biggest petrochemical Centre. This growth would mean that Kakinada would have to balance the rapid economic change caused by the new construction with the current city in order to prepare the growth and encourage good quality of life for the Kakinada citizens.

CHAPTER 4 DATA COLLECTION AND ANALYSIS

4.1 Disaster Profile of Kakinada

Kakinada has a tropical savanna climate. The hottest part of the year is late May to early June with maximum temperatures hover around 38–42° C (100–108° F). The coolest part of the year is January, with minimum temperatures around 18–20° C. Due its geographical location frequency of cyclones in the area is high leading to induced flooding in Godavari River and Kakinada canal and other canals. Also, cyclones lead to high currents in the sea and river line flood leading to rise in mean sea level causing landfall along the shoreline.

4.1.1 Seasonality of hazards

Figure 27 Seasonality of hazards in Kakinada

Disaster	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Earthquake												
Cyclone												
Floods												
Heatwave												
Tsunami												
Landslide												
Draught												
Epidemic												

Source: Primary survey District Fire Officer

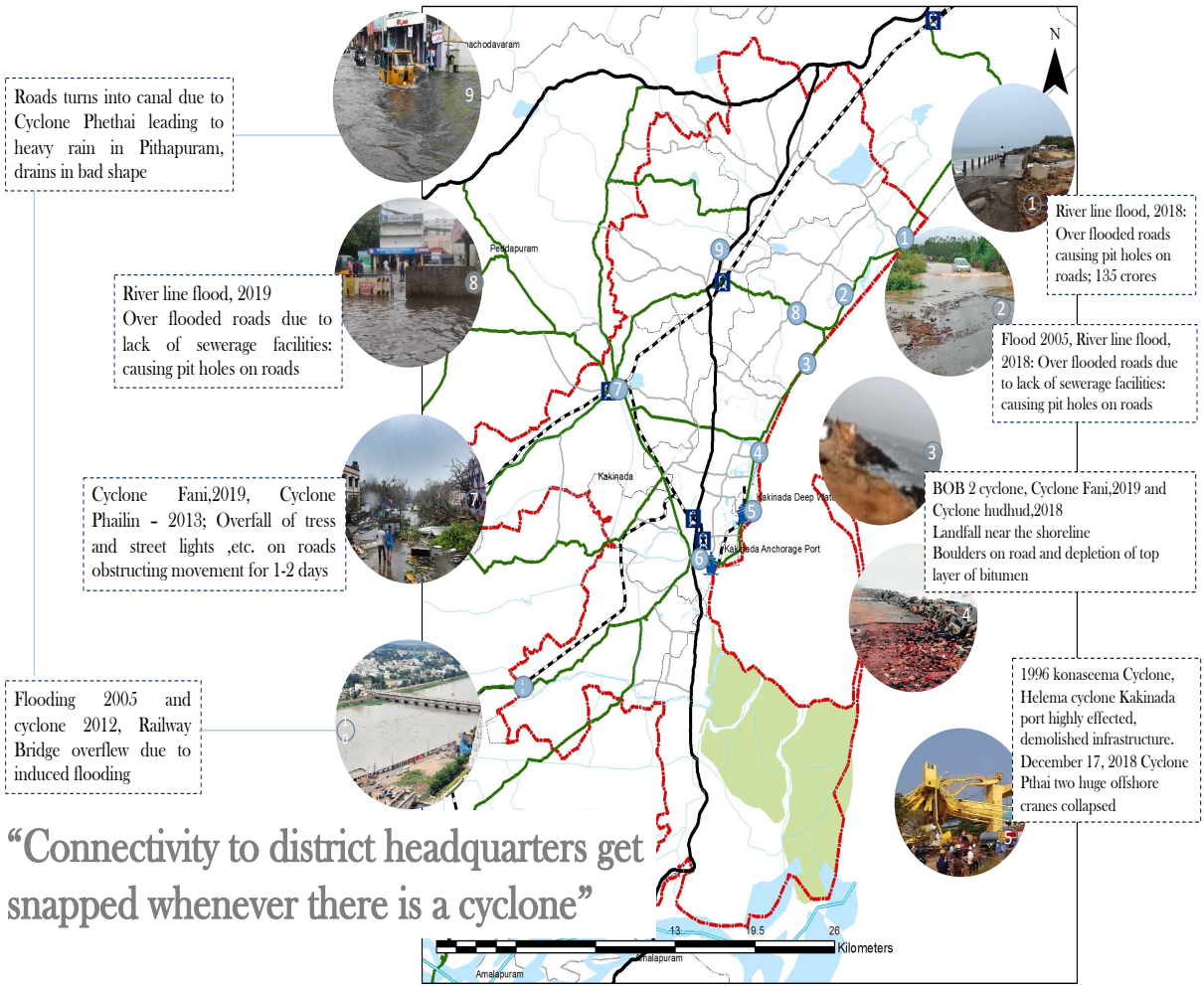
4.1.2 Past major disasters in Kakinada

S. No.	Disaster	Year	Impact
1.	Cyclone Koshima	1996	About 1210 fishermen have died in this cyclone Port infrastructure highly affected ; became unfunctional for months
2.	Cyclone 7B	1996	flooded over 250 villages, dropped heavy rainfall across a 40 km of region, About 1,300 km of roads were damaged or washed out total damage US$1.3 billion
3.	Tsunami	2004	The Port Trust reported some disruption in activities and its functions. All the operations were partly suspended for one day
4.	Tsunami	2005	
5.	Cyclone Nilam	2012	Heavy rains and property damaged; Railway Bridge overflew due to induced flooding

6.	Cyclone Helen and Leher	2013	Heavy rains and property damaged;
7.	Cyclonic winds	2014	Post cyclone Hudhud, heavy property and road infrastructure damaged
8.	Cyclone Phethai and Titlli	2018	Uprooted trees, infrastructure damaged at port 2 cranes, heavy rainfall and landfall on beach road
9.	Cyclone Fani	2019	damage to the Kakinada-Uppada beach road, washed away the wall of Geo Tube near Uppada.
10.	BoB 2 Deep depression	2020	Landfall on Kakinada Uppada road, port activities disrupted for 1 day due to landfall
11.	Cyclone Nirvar	2020	-

Source: Indian Meteorological department- Vishakhapatnam

Figure 28 Past disasters Hazards impact mapping of Kakinada



Source : News Articles Times of India, Hindustan Times; Compiled by author

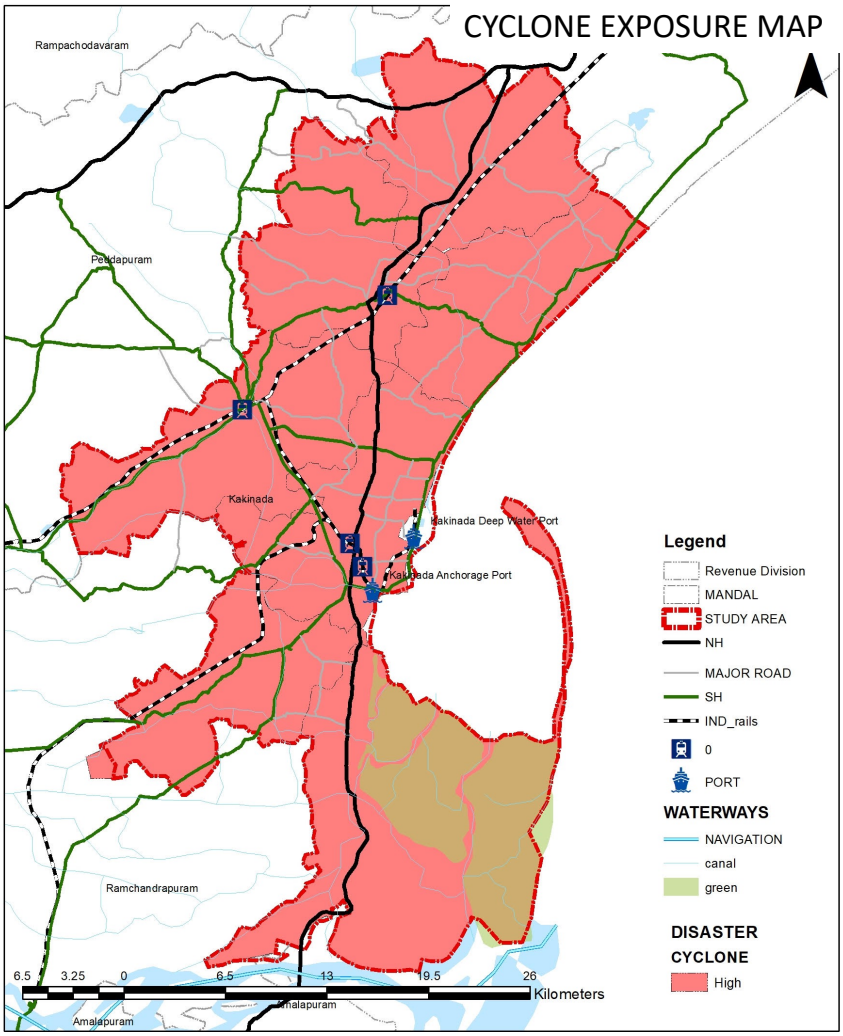
4.1.3 Vulnerability mapping of hazards

Table 6 Frequency and area affected by cyclones in kakinada revenue division

Mandal	Total Area	Zone Vb = 50 m/s Area	Zone Vb = 50 m/s POP
GOLLAPROLU	105.3	105.38	60130
Kakinada Rural	72.81	73.88	242929
Kakinada Urban	19.41	19.38	163458
Karapa	85.52	87.21	86936
Samarlakota	160.55	163.51	177146
Pithapuram	146.82	147.77	94623
Thallarevu	265.30	231.34	53404

Source: Disaster Management Plan East Godavari Volume 1

Figure 29 Cyclone affected areas in Kakinada Revenue Division



Source : Disaster Management plan East Godavari Volume 1; Map generated by author

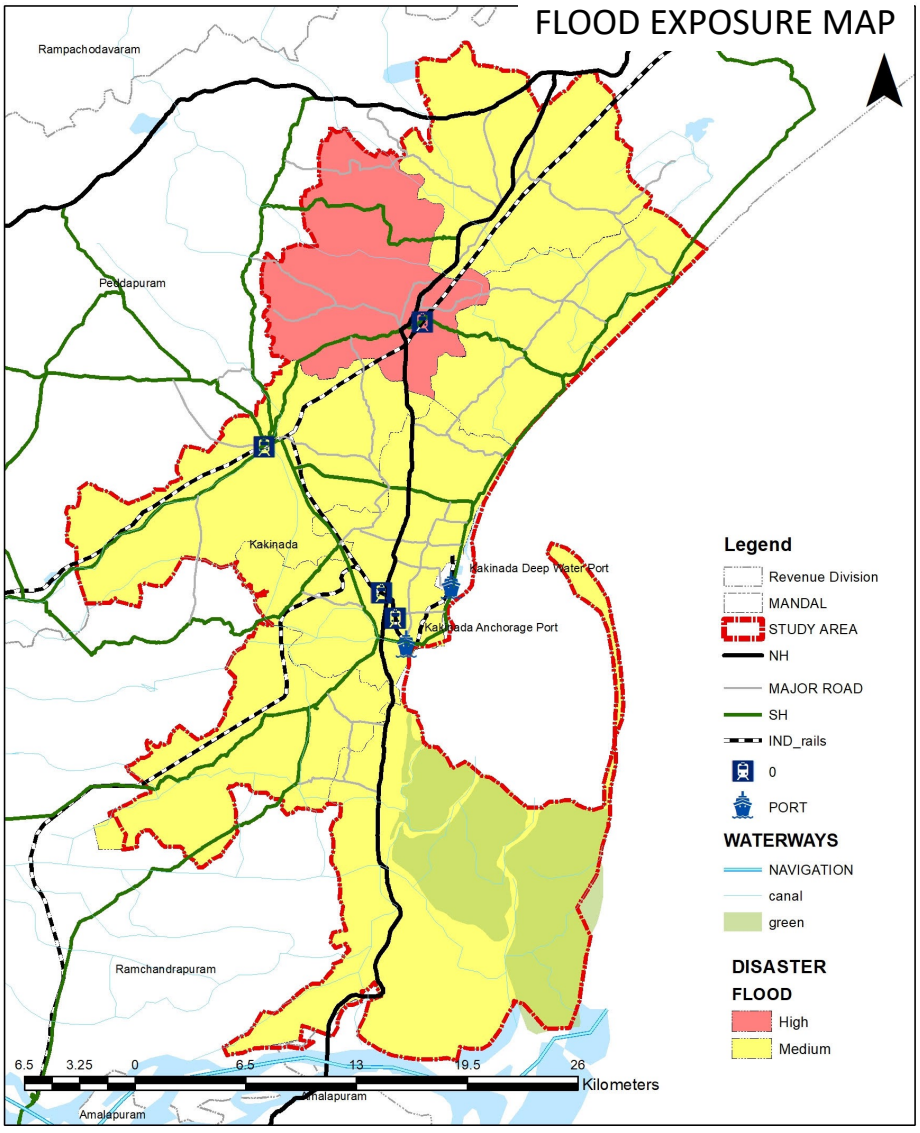
Kakinada is frequently subjected to cyclones and storm surge. As per the Wind and Cyclone Hazard Map of India, Kakinada revenue division lies in Very High Damage Risk Zone – B (Vb = 50m/s).

Table 7 Population affected by floods, waterlogging in Kakinada revenue division

Mandal	Total Area	Population
GOLLAPROLU	105.3	2942
Kakinada Rural	72.81	81,549
Kakinada Urban	19.41	105,095
Karapa	85.52	5,596
Samarlakota	160.55	14,895
Pithapuram	146.82	175
Thallarevu	265.30	24,429

Source: Disaster Management Plan East Godavari Volume 1

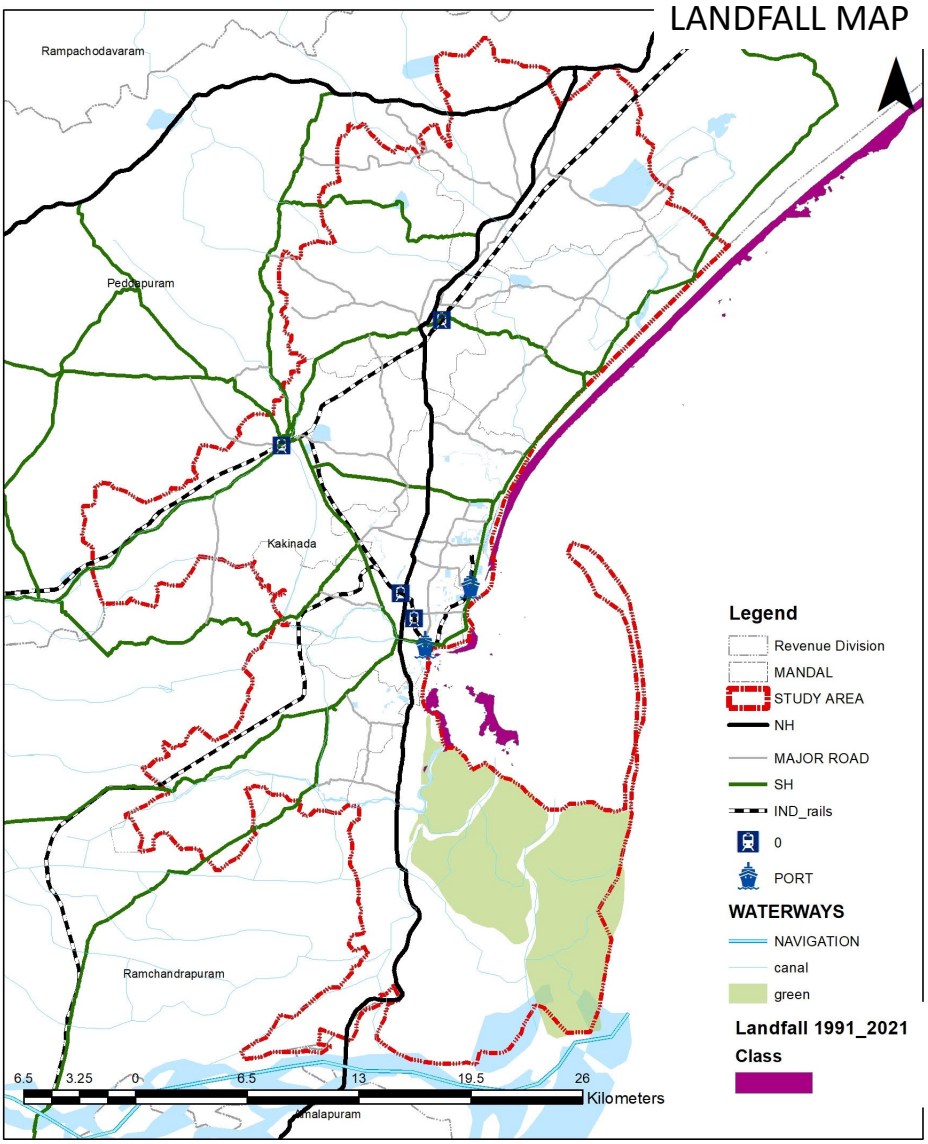
Figure 30 Flood affected areas in Kakinada Revenue Division



Source : Disaster Management plan East Godavari Volume 1; Map generated by author

All the mandals of Kakinada revenue division are moderately prone to flooding while samarlakota is highly prone to flooding due to lack of sewerage facility.

Figure 31 Landfall affected areas in Kakinada Revenue Division



Source: USGS imagery 1996, 2011,2020; Map generated by author

Cyclones lead to induces flooding in the area causing soil erosion and landfall along the coast. It can be observed from the map that the complete shoreline of Kakinada revenue division is highly vulnerable to erosion comprising of SH- 15 Kakinada Uppada beach road with a route length of 20.1 km. It can also be observed from

- 1991- 2011: approximately 20m - 289m landfall.
- 2011- 2021: approximately 347m -467m landfall
- In total 1991- 2021 756m landfall on Kakinada- Uppada SH16 road.

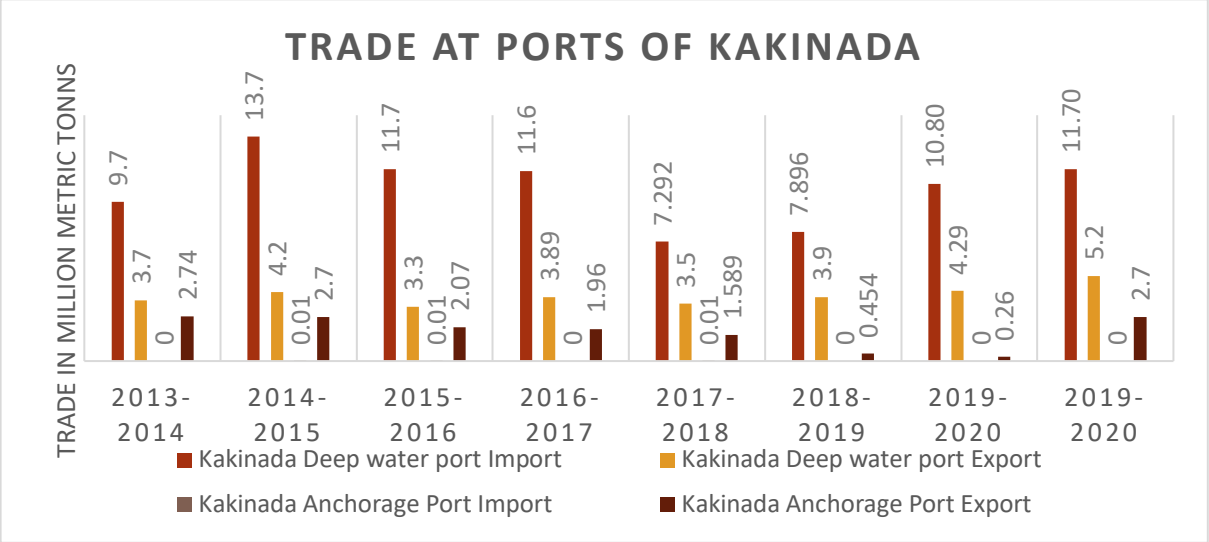
4.2 Ports of Kakinada:

Kakinada has two port and one fishing harbors namely Kakinada deep water port and Kakinada anchorage port.

Kakinada Anchorage and Deep Water Port

- Anchorage port is functioning under the AP government and deep-water port is operated by Kakinada Seaports Ltd., and it is the first privatized port in East coast of India.
- It is the main gateway port for agriculture rich East Godavari District, West Godavari Districts and Krishna District of Andhra Pradesh.
- It is an intermediate port naturally protected by Hope Island. KDWP also enjoys the benefit of a well-developed primary industrial hinterland, which gives it assured volumes of captive cargo movement.

Figure 32 Trade at ports of Kakinada

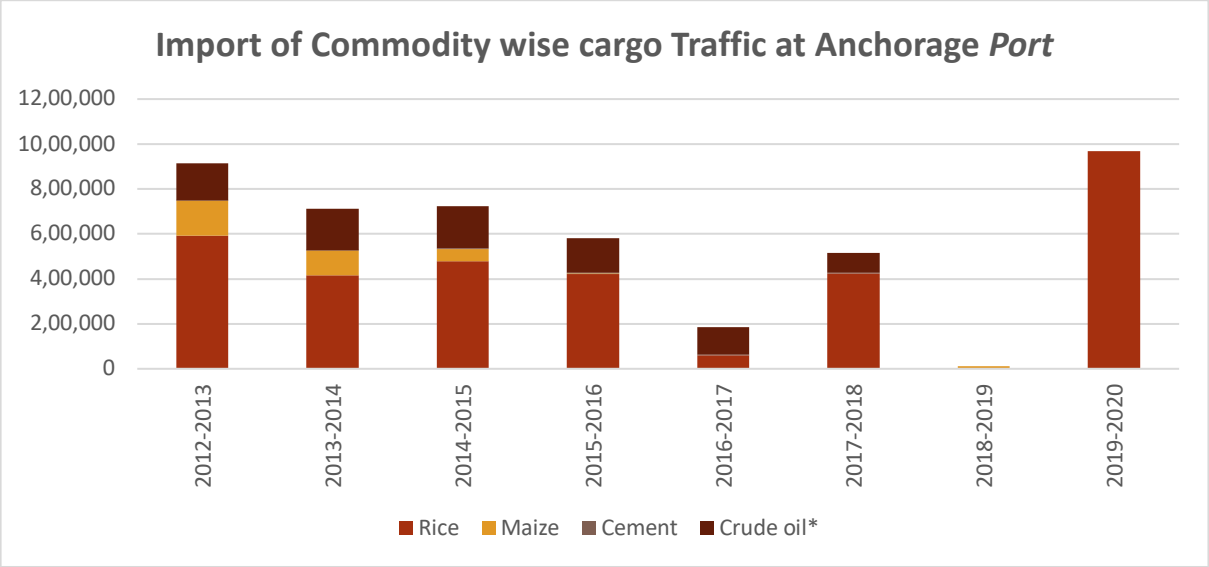


Source :Kakinada sea port Limited

It can be observed amongst the two ports of Kakinada major trade takes from Kakinada deep water port due its capacity i.e., number of operational births 5 under KSPL and only 2 at anchorage port i.e., under the state government also due to the draft availability at deep water port is 10.5 m while its lesser near anchorage port. Deep water port is majorly used for export activities and very less tonnage for export. Though the total traffic is less at anchorage but it is significantly used for export when compared with deep water port.

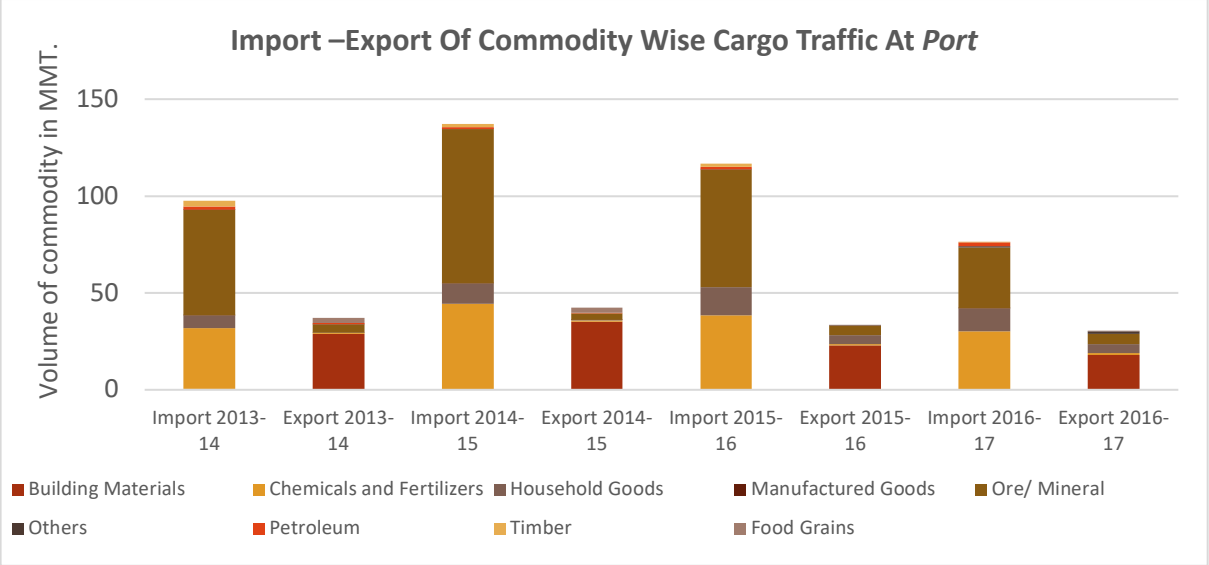
4.2.1 Import and Export at ports

Figure 33 Import commodity wise cargo traffic at Kakinada anchorage port



Source :Kakinada sea port Limited

Figure 34 Import –Export of Commodity Wise Cargo Traffic At Port



Source :Kakinada sea port Limited

The major commodities imported at deep water port include timber, followed by chemicals and fertilizers from deep water port. It can be inferred from Figure that timber and chemical and fertilizers are largely in demand in this region than other products. It is observed that there is an increase in import of household goods from other countries. While the principal commodities of exports include Building Materials,

followed by ore / Mineral, Food Grains etc. These commodities are exported to countries such as African countries and other parts of the south-East Asian countries. Since there are industries which are established in this region, manufactured goods are exported from the Deep-water port.

4.2.2 Flow of Commodity from port

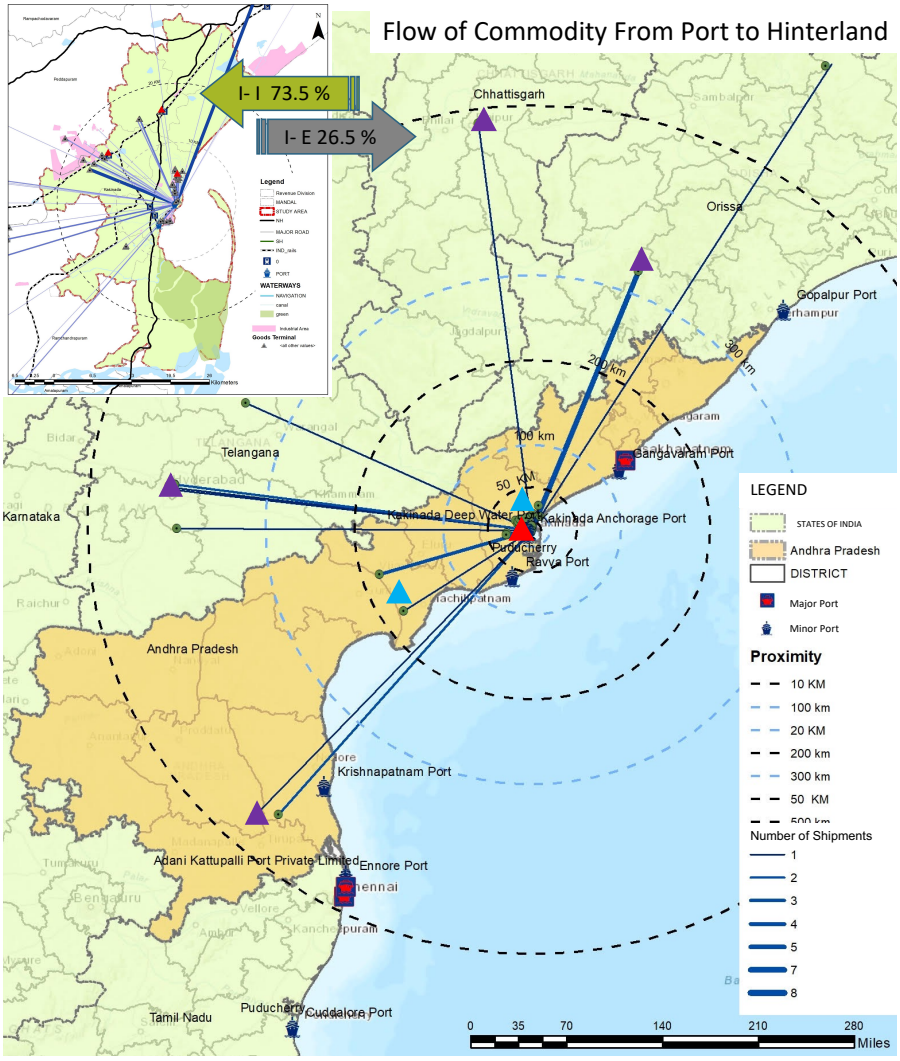
Table 8 Flow of commodity from port to hinterlands of Kakinada deep water port

Flow of Commodity Port- Shipper (February, 2021- March 2021)				
Traffic analysis zones	**Number of Shipments**	**Distance from the port**	**Volume of Goods flow**	**Type of Hinterland**
External				
Orrisa	6	500 and beyond	0.05	Tertiary
Chhattisgarh	2	0- 500	0.019	Tertiary
Nellore	3	0- 500	0.029	Tertiary
Hyderabad	8	0- 500	0.07	Tertiary
Krishna	5	0- 200	0.049	Secondary
Pedapuram	3	20- 50	0.029	Secondary
Internal				
Samarlakota	15	10- 20	0.15	Primary
Pithapuram	9	10- 20	0.088	Primary
Kakinada	48	0- 10	0.47	Primary
karapa	2	10- 20	0.019	-
Kotthapalle	2	10- 20	0.019	-
Thallarevu	0	10- 20	0	-
Gollaprola	1	20- 50	0.009	-

Source :Kakinada sea port Limited vessel schedule; table computed by author

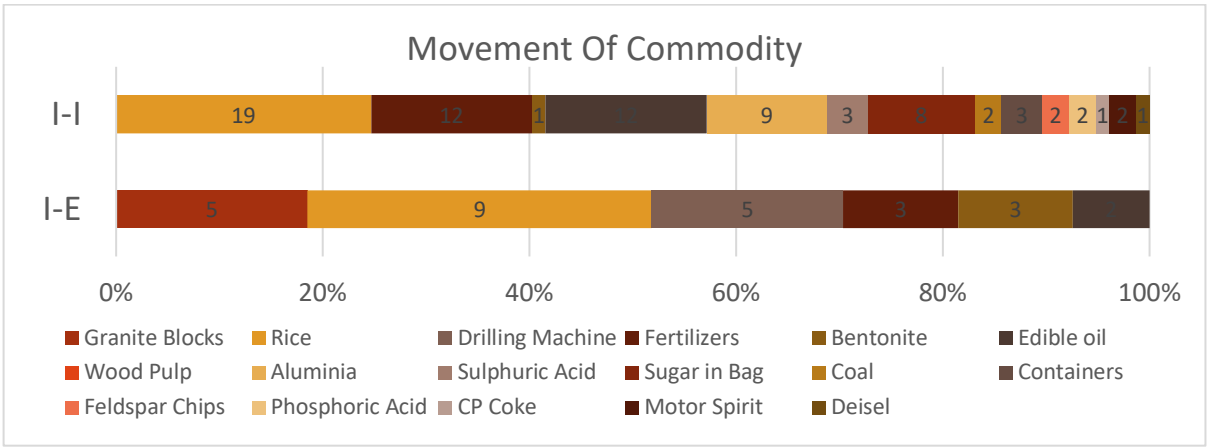
It can be observed majority of commodity flow is within study area i.e., 73.5 percent of the total traffic due to dominance of industries within the region while 26.5 percentage is inter- regional goods traffic. Trip length Frequency distribution shown in figure shows that 80% of the trips for all modes are below 50Km and 20% of the trips for all purposes except recreation are between 50- 500 km.

Figure 35 flow of commodity from Port to hinterland



Source :Kakinada sea port Limited vessel schedule; Map generated by authority

Figure 36 Moment of commodity

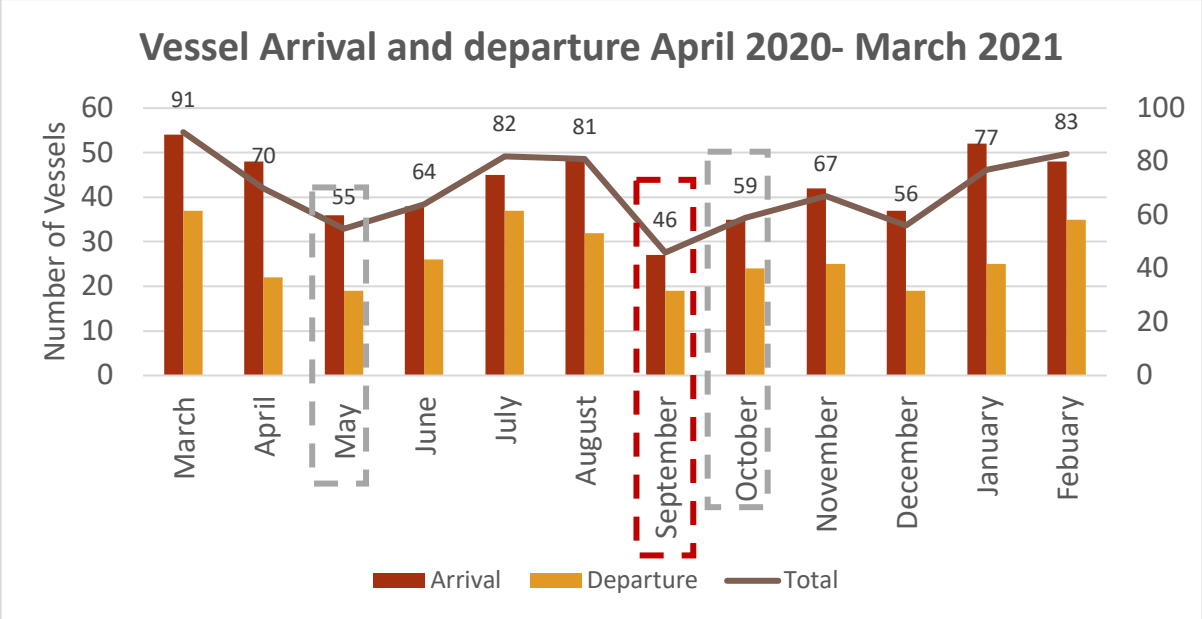


Source :Kakinada sea port Limited vessel schedule; Map generated by authority

Amongst the commodity Rice 19%, Fertilizers 12%, Alumina 9%, edible oil 12% and sugar 8% as it is an agriculture rich state and presence of two large fertilizers company's while the commodities are also imported from adjoining states like rice 9%, Drilling machine and granite blocks 5% due to presence of mining activities in the region.

4.2.3 Impact of climate change on port vessel activities

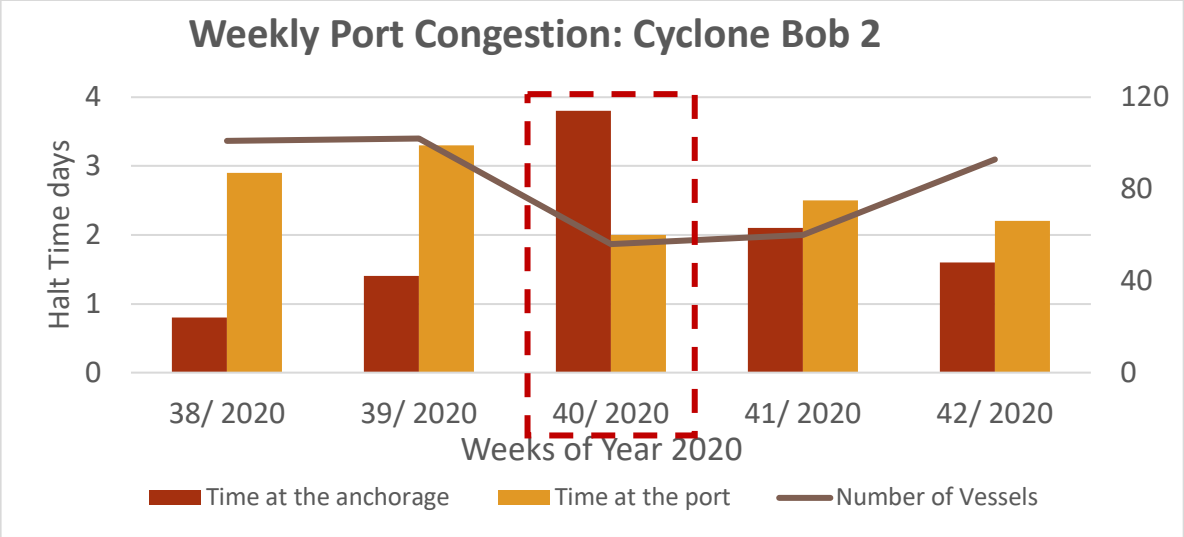
Figure 37 Vessel Arrival and departure April 2020- March 2021



Source :Maritime Transport historical records

Three major cyclones hitted near Kakinada port during the year 2020 first during 18 may cyclone Amphan which was a super cyclone as per the disaster protocol 15 days warning was issued to Kakinada port by Indian metrological department Vishakhapatnam following the same all the export activities were slowed down during the period. As a result of super cyclone deep depression was formed near Kakinada-Uppada beach on May 2,2020 resulting in rivierline flooding and landfall on the SH-16 due to which all the port activities were put halt for 1 day. Another cyclone formed on 25 November, 2020 storm surge of about 2 meters above the sea level is likely around the time of landfall, causing inundation of low-lying areas. The sea waters crossed the geo-tube wall and touched the Mayapatnam road at Konapapapet village in U Kothapalli mandal and fishermen moved their boats to safer places.

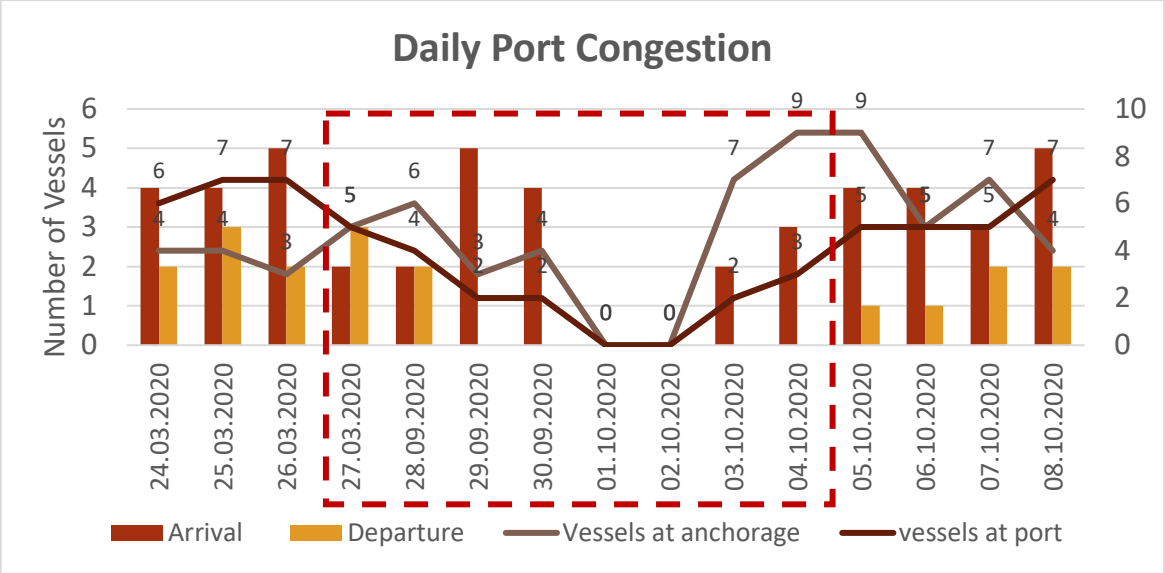
Figure 38 Weekly Port Congestion: Cyclone BOB 2



Source :Maritime Transport historical records

Due to cyclonic activities and river line flooding port operations were shut down for 1 day and vessels waiting at anchorage were parked at safe places resulting in heavy congestion at anchorage post disaster the traffic increased at port from 1.5- 2 times.

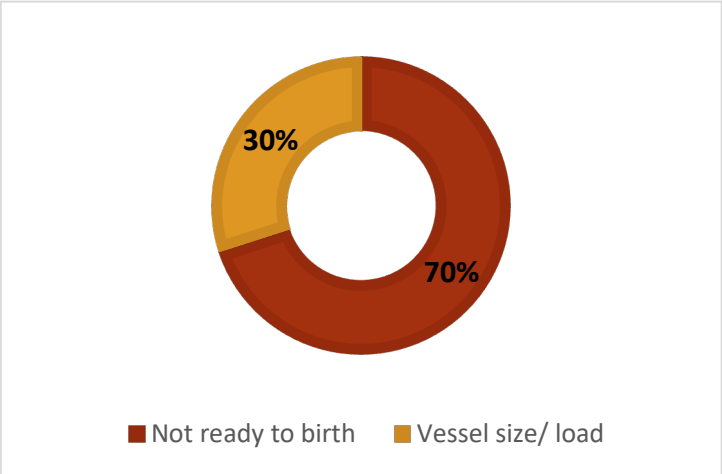
Figure 39 Daily Congestion at the port during deep depression BoB2 2020



Source :Maritime Transport historical records

The figure shows daily port congestion during BoB 2 cyclone it can be observed that the exports activities are being stopped for around 1 week despite that the vessels waiting at the anchorage has increased leading to congestion. It may be due to various reasons:

Figure 40 Reasons for refused loads

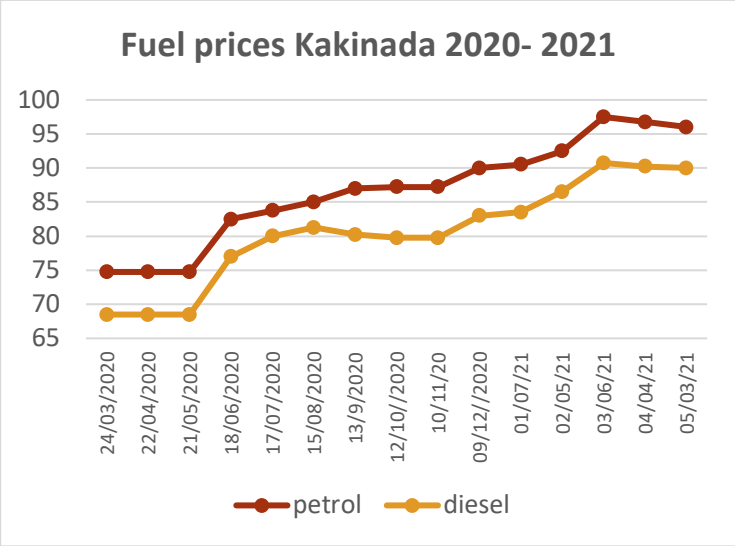


Source: Maritime Traffic

Refuse Loads:

Due to cyclone and induced flooding carriers would also negate to pick up or transport shipment during a natural calamity the supply chain will tend to block or collapse. As the industries may go idle, waiting for supplies. I can be observed that 70% of the congestion is due to shippers not ready to birth while only 30% goes into port logistics to reduce congestion first vessels having less load and commodities that requires less time is taken into account for birthing.

Figure 41 Tends in fuel prices Kakinada 2020- 2021



Fuel prices:

Due to natural calamities the supply chain of petrol, diesel and other fuels also get disrupted resulting in increased cost of fuel. approximately post each cyclonic activity fuel prices raises by 5- 10 rupees per liters.

- **Inadequate capacity and Transit time** are also two factors causing disruption in logistics activities due to its inadequate capacity of infrastructure that is further discussed in detail.

4.3 Traffic and Transportation characteristics of the Study area

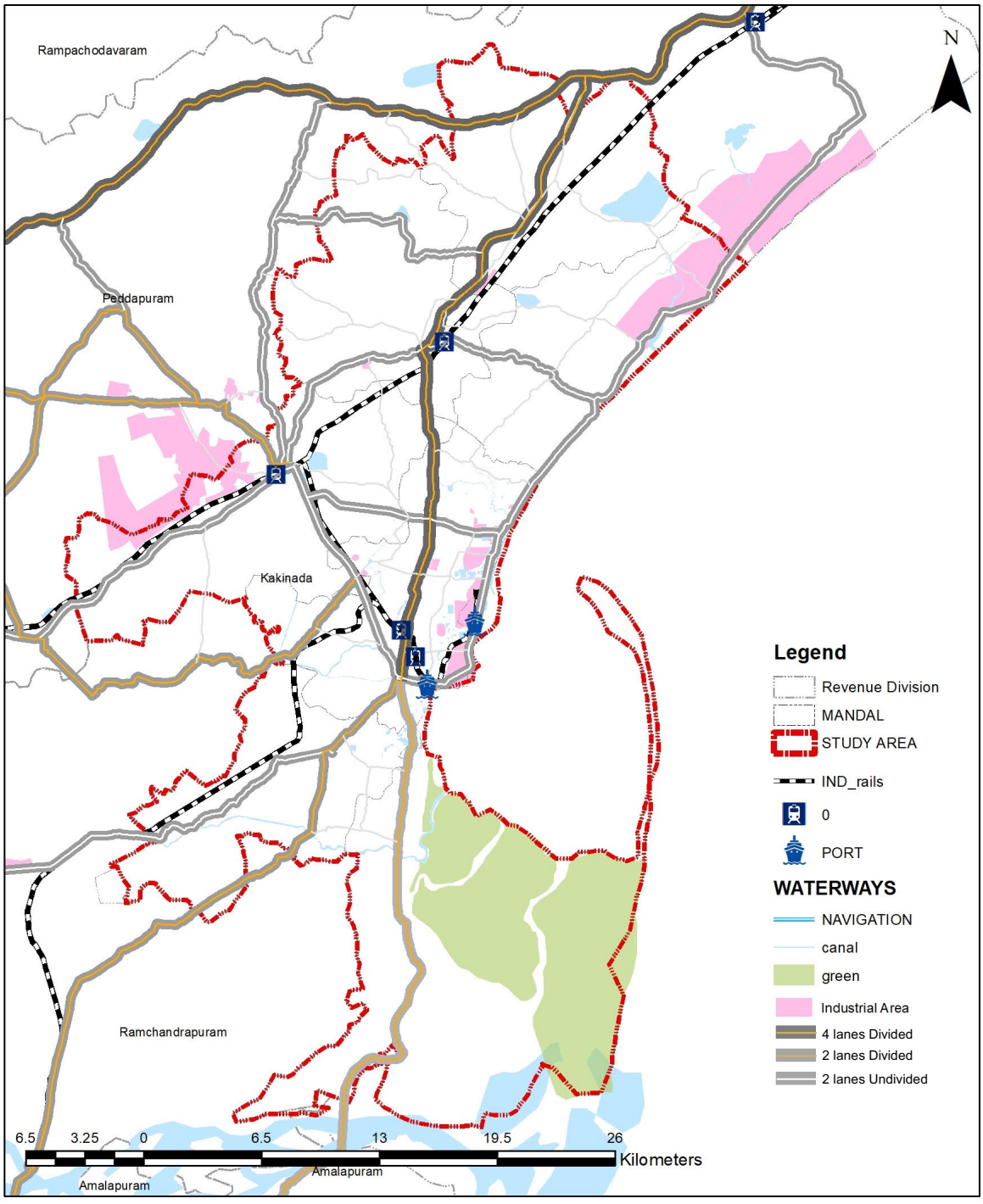
To study the traffic and transportation characteristics of the region road inventory and classified traffic volume count was carried out various locations.

Table 9 Classified traffic volume counts

TVC Point	Location	Total Vehicle	Total PCU	Goods Vehicle	V/c Ratio	LOS	No. of Lanes	Carriageway width	Median
OC 1	SH Uppada road	8823	7059	794	1.2	F	2	5.5	Undivided
OC 2	NH 16, Annavaram Bypass Road	19886	32515	3381	1.3	F	4	15	Divided
OC 3	Gollaprollu Rajupalem Rd.	4612	2678	92	0.9	E	2	8	Undivided
OC 4	Samalkot jn	8407	3392	34	0.6	B	2	11	Divided
OC 5	NH 216, near Matlapalem	19757	16820	1581	0.9	E	2	8	Divided
OC 6	SH14, near Patharlagadda bus stop	9964	7453	797	0.7	C	2	7	Divided
OC 7	SH 197, near Essar Oil	18202	13594	910	0.7	C	1	7	Undivided
OC 8	Kakinada - Rajahamundry road	12212	9770	614	0.8	D	2	7	Undivided
MB 1	Pithapuram Junction	11942	7335	1449	0.8	D	4	18	Divided
MB 2	SH 15 (ADB Road)	21968	13429	678	1.1	F	2	7	Undivided
MB 3	Jagannaickpur Junction	21968	43746	6967	0.7	C	4	15	Divided
MB 4	Kakinda Uppada Road	4941	4625	840	0.9	E	2	5.2	Undivided
SL 1	SH 17, near Jaganmatah Ashramam	24476	23517	3717	1.0	E	2	6	Undivided
SL 2	Samalkot jn	9315	8720	745	0.9	E	2	9	Divided

Source: Primary Survey

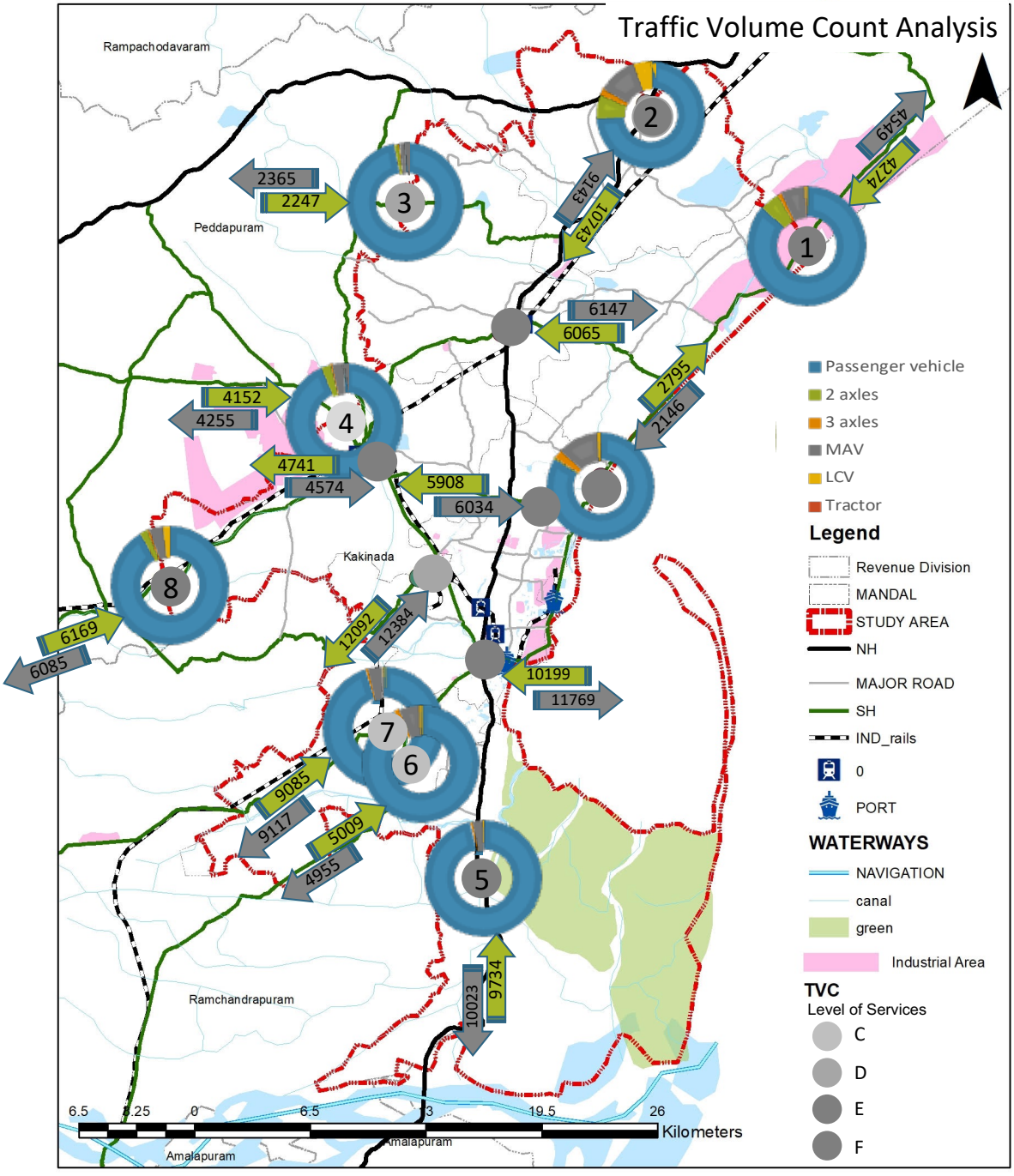
Figure 42 Road characteristics of the region



Source: Author Generated from primary survey

It can be observed that majority of the road infrastructure is intermediate lane (2 lane) undivided while only 15% of infrastructure is 4 lane divided rest 20% 2 lane divided that acts as a key constraint during and post- disaster for the flow of traffic.

Figure 43 Traffic volume count analysis



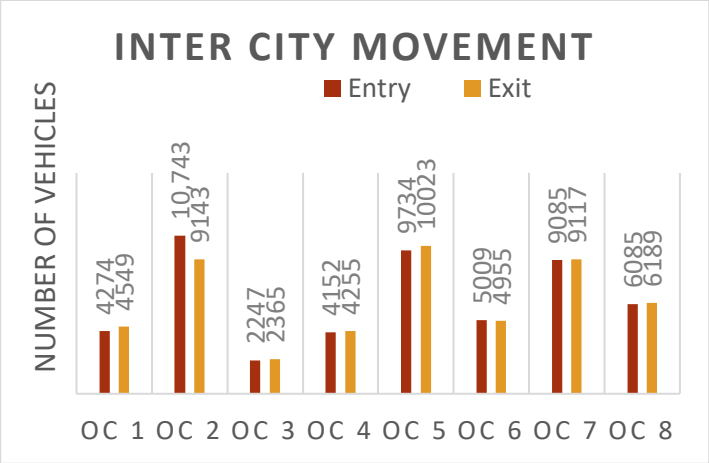
Source: Author Generated from primary survey

Major Goods Vehicle Route:

- NH 216 connecting NH-16 in North and South to Vijaywada.
- SH 15 connecting Kakinada-SEZ- Industrial area to Kakinada port to NH 216,

- SH 195 Connecting Rajahmundary and SH 173 Uppada – Pithapuram Road

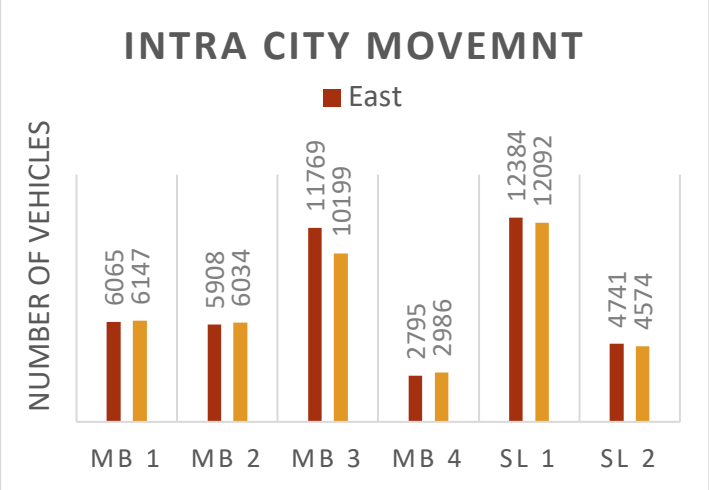
Figure 44 Inter city traffic movement 24- hours



Analyzing the traffic flow in 24 hours at the cordon locations it can be observed:

- Highest traffic is at Cordon Point-1 and OC 5 i.e., NH- 16 Lowest is at Cordon Point- 3
- Total vehicle Entry: 51329; Exit: 50596 almost equal traffic in each direction.

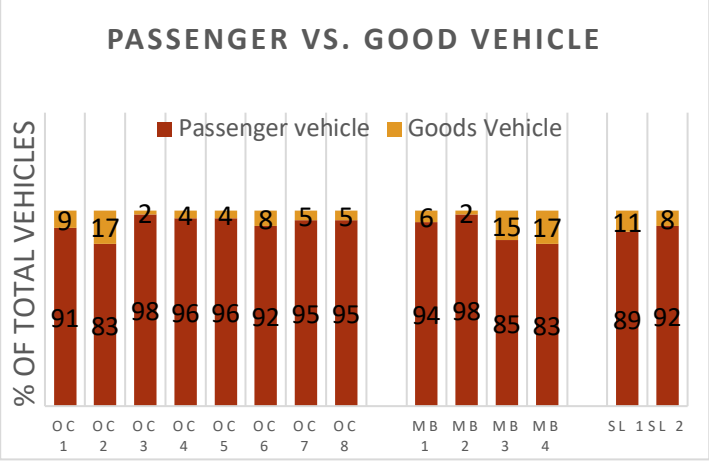
Figure 45 Intra city traffic movement 24- hours



Analyzing the traffic flow in 24 hours at the screen lines and mid block's locations it can be observed:

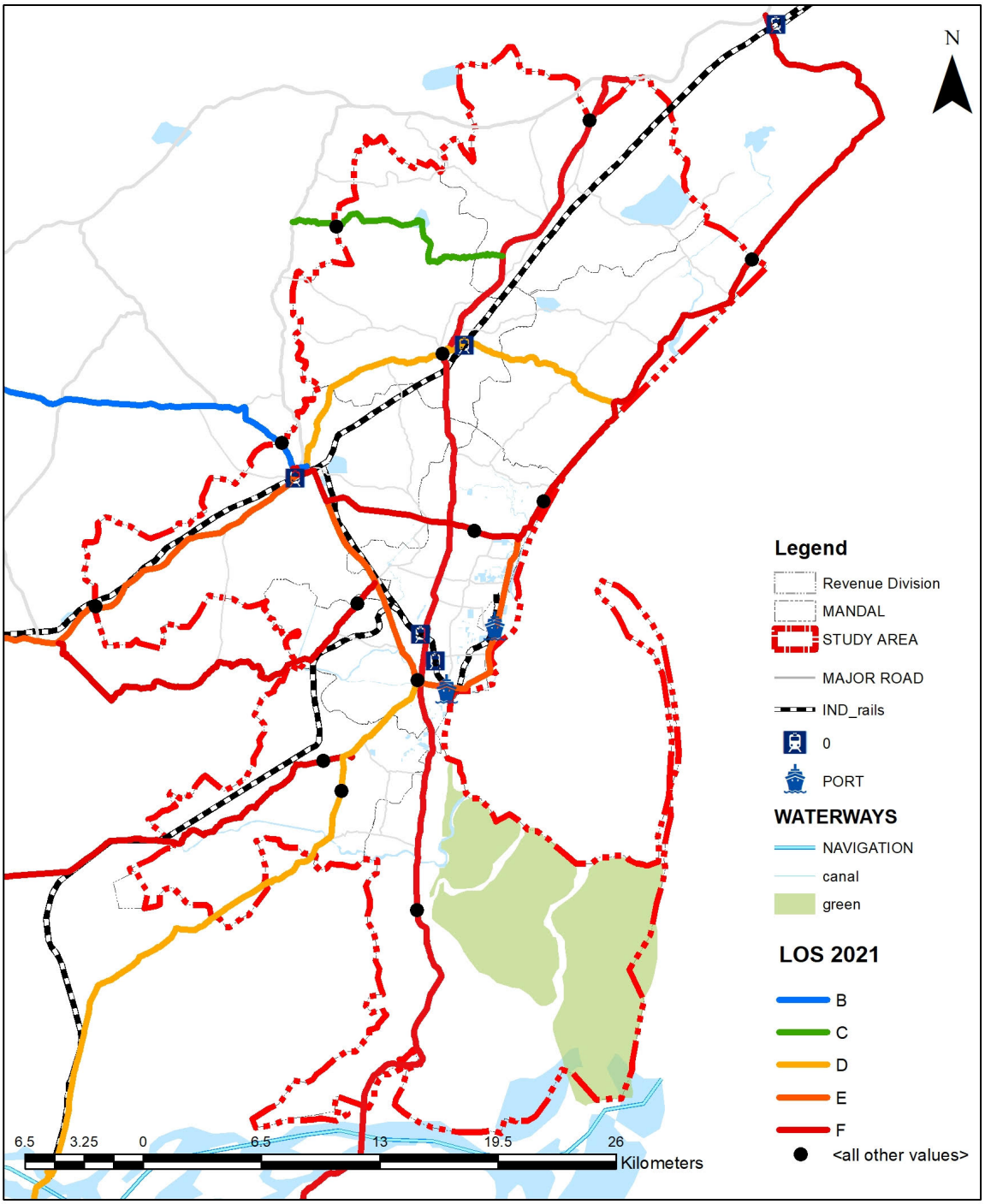
- Maximum traffic volume was observed at MB 3 and SL 1
- Total East to West movement 43662 and west to east is 42032 i.e. 84% N-S traffic.

Figure 46 Passenger vs. good vehicle 24- hours



- There is significant goods vehicle flow at OC 2, MB 3, SL 1, SC 2, OC 5 and OC 6 Major national Highway MB 5 and OC 1 because the attributing land use is industrial.

Figure 47 Current 2021 level of services of network



Source Author Generated

It can be observed that 72% of roads indicates forced and unstable flow, 32% stable flow while only 6% indicates free flow as the current traffic flow rate is higher while the capacity to accommodate the demand is low which is further projected to increase at a higher rate due to the economics of the town.

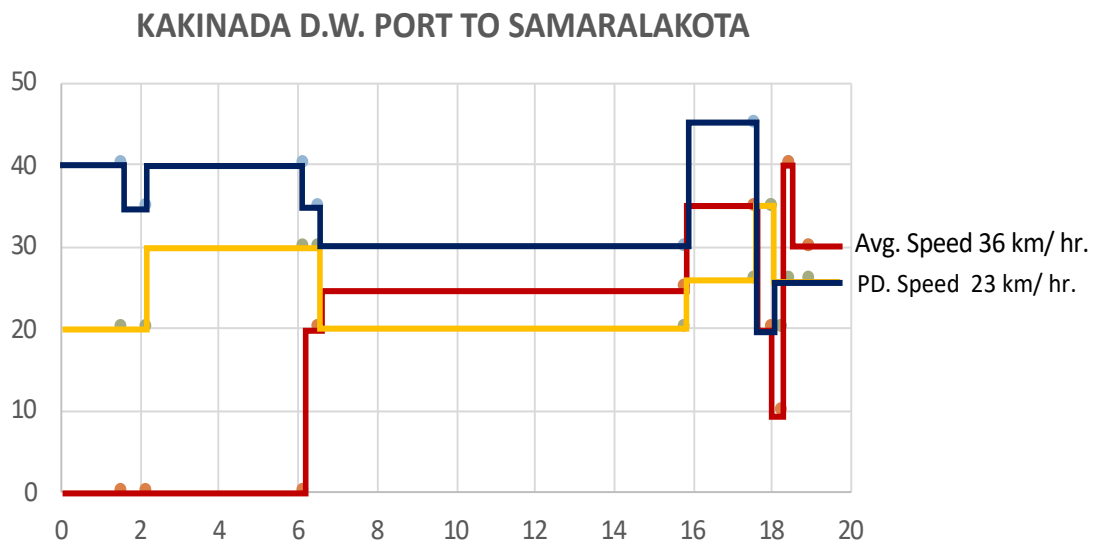
4.4 Speed And Delay Analysis for Primary hinterlands

One of the key indicators of traffic working conditions in the study area is journey speed. Different factors assessed for this survey are Journey speed, running speeds, reasons for delays, identification of bottlenecks, etc. on various corridors in the study area. In this case the speed and delay survey has been done using Google API platform such as Google Map. One typical working day i.e. Monday is taken for the study. Journey speed is calculated at a non-peak hour i.e. 11 pm and running speed is calculated at peak hour is i.e. at 7 pm. Each corridor is segmented into links. Both journey time and running time is measured for each link separately, by assigning origin and destination on Google map. Then using speed formula both the speeds are calculated. Here, the traffic that is moving from the centre of study area.

Selection of corridors: For the analysis some major corridors connecting primary hinterlands are selected based on road typology, functional characteristics.

1. Kakinada deep water port to Samarlakota via SH-15 -> ADB road

Figure 48 Kakinada deep water port to Samarlakota via Sh- 15 and ADB road speed and delay



Source Author Generated Using Google API

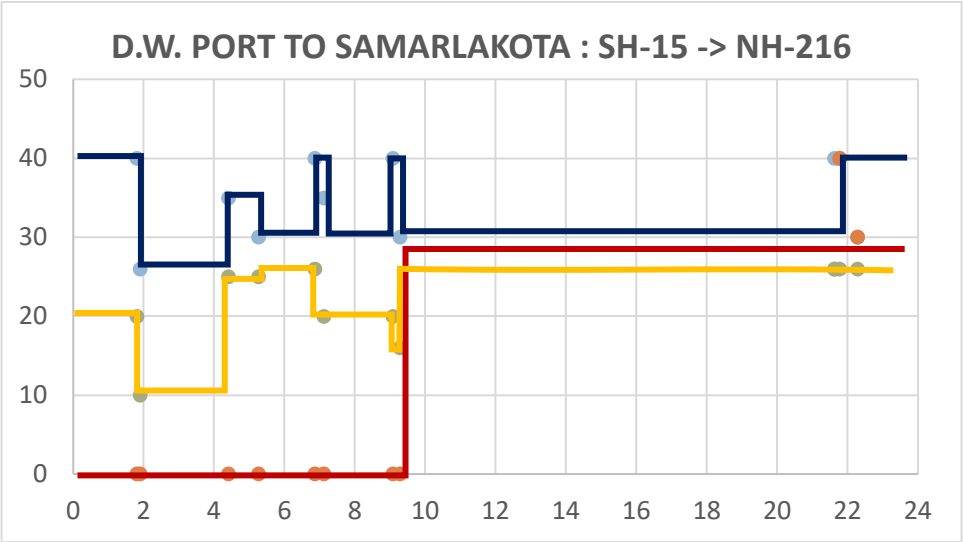
Route: Kakinada deep water port -> SH- 15 -> ADB road -> SH- 216 Kakinada Rajanagram rd. -> Samarlakota

Total length: 22.4 km

It can be observed from graph that the average speed during a normal working day is 36 km/hr. While during the disaster SH-15 Kakinada-Uppada Road becomes non-

functional due to high tides and probability of landfall causing disruption in supply chain and post-disaster also the speed drops due to heavy congestion and poor condition of the roads to 23 km/ hr.

Figure 49 Kakinada Deep water port and anchorage portto Samarlakota via SH- 15



Avg. Speed 33 km/ hr.

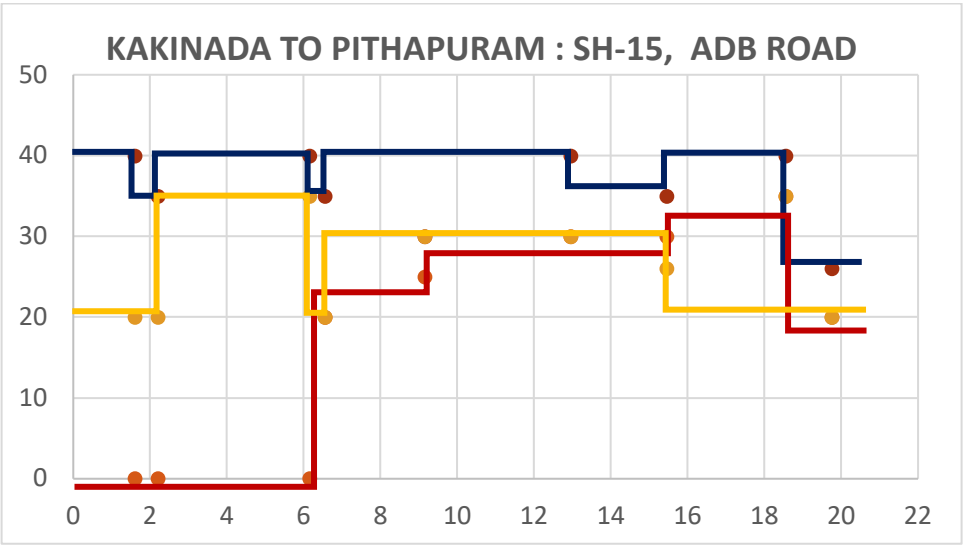
PD. Speed 24 km/ hr.

Route: Kakinada deep water port -> SH- 15 -> ADB road -> SH- 216 Kakinada Rajanagram rd. -> Samarlakota

Total length: 24.2 km It can also be observed from graph that the average speed during a normal working day is 33 km/hr. and post-disaster also the speed drops due to heavy congestion and poor condition of the roads to 24 km/ hr.

2. Kakinada Deep water port to Pithapuram

Figure 50 Kakinada deep water port to Pithapuram via SH- 15 and ADB road



Avg. Speed 31.1 km/ hr.

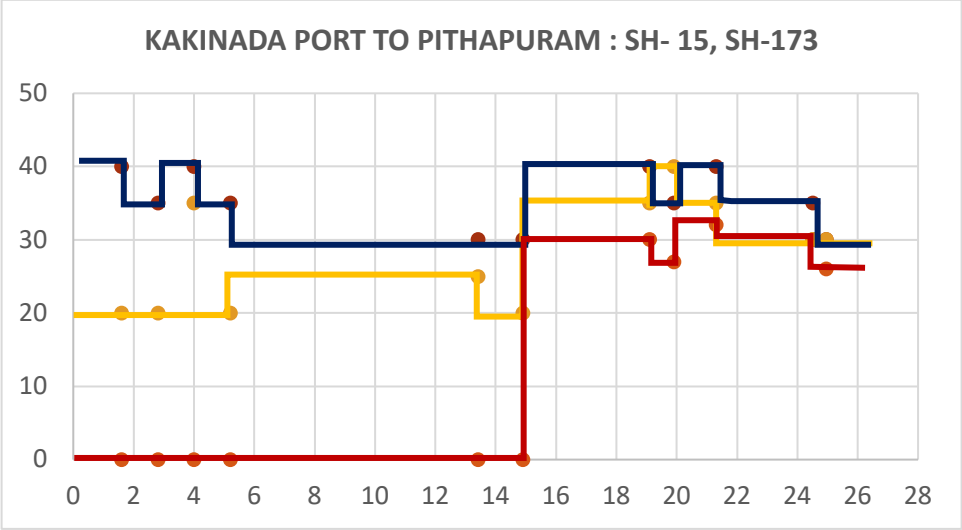
PD. Speed 24 km/ hr.

Route: Kakinada deep water port -> SH- 15 -> ADB road -> NH-16. -> Pithapuram jn

Total length: 20.6 km.

It can also be observed from graph that the average speed during a normal working day is 31.1 km/hr. While during the disaster same scenario for SH-15 Kakinada-Uppada Road and post-disaster also the speed drops due to heavy congestion and poor condition of the roads to 24 km/ hr.

Figure 51 Kakinada deep water port and anchorage port to Pithapuram via SH- 15 and NH- 16 and SH-173 speed and delay



Avg. Speed 32 km/ hr.
PD. Speed 23 km/ hr.

Source Author Generated Using Google API

Route: Kakinada deep water port -> SH- 15 connecting Kakinada anchorage port -> NH-16 -> Jagannaickpur Junction -> Pithapuram jn

Total length: 27 km

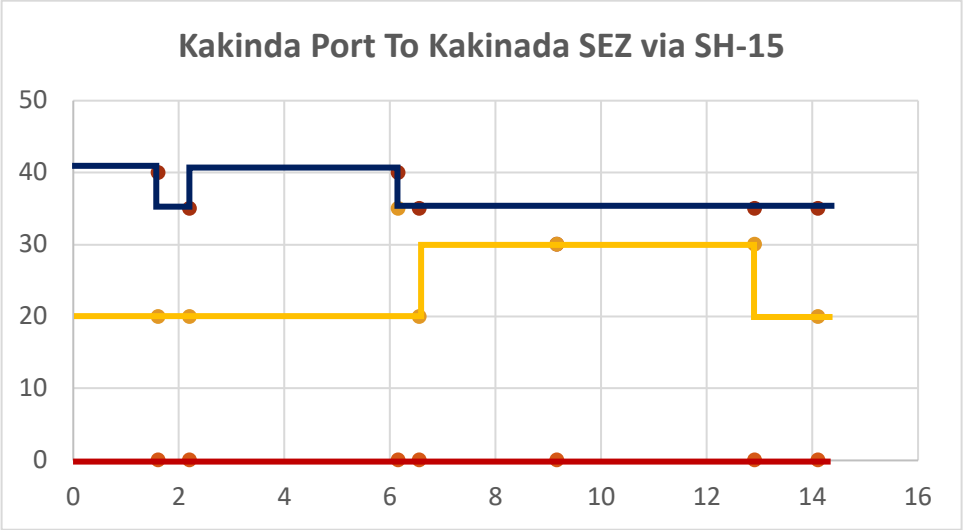
It can also be observed from graph that the average speed during a normal working day is 32 km/hr. While during the disaster same scenario for SH-15 Kakinada-Uppada Road and post-disaster also the speed drops due to heavy congestion and poor condition of the roads to 23 km/ hr.

3. Kakinada deep water Port to Kakinada SEZ

Route: Kakinada deep water port -> SH- 15 Kakinada Uppada beach road -> Kakinada SEZ

Total length: 14.2 km

Figure 52 Kakinada deep water port to Kakinada SEZ via SH- 15 speed and delay



It can also be observed from graph that the average speed during a normal working day is 37 km/hr. While during the disaster same scenario for SH-15 Kakinada-Uppada Road and post-disaster also the speed drops due to heavy congestion and poor condition of the roads to 27 km/ hr.

Inferences:

- The average speed is the study area is around 35 km/ hr.
- At the time of disaster SH- 16 becomes completely non- functional causing disruption in port activities and allied industries.
- Port disaster the speed on the network reduces to 24 km./ hr. causing delay in transshipment and congestion at the port gate.

Alternative routes:

Two routes have been identified using python that if strengthened can work as an alternative in case to disaster or other natural calamities.

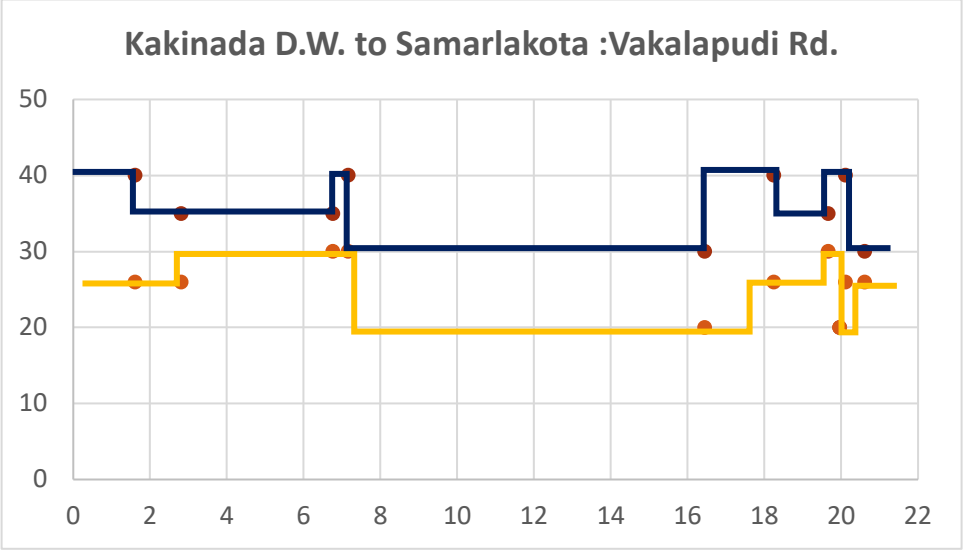
Table 10 Routes connecting hinterlands of Kakinada ports

Hinterland	Routes	Time	Kilometres
Guntur	NH16	5 hr 26 min	260
Hyderabad	NH16 and NH65	9 hr 18min	497
Krishna	NH16	4 hr 49 min	222
Nalgonda	NH16 and NH65	7 hr 47 min	415

Nellore	NH16	9 hr	502
Pithapuram	kakinada Rajanagaram Rd/Samalkota-Kakinada Bypass and NH216	30 min	20
	NH216	30 min	20.5
	Vakalapudi Rd and NH216	38 min	25.1
Kakinada SEZ	Uppada Beach Rd	35 min	20.5
Rajahmundry	kakinada Rajanagaram Rd	1 hr 35 min	67
	Someswaram-Rajanagaram Rd	2 hr	71.5
	Pyna Kakinada Rd and Kakinada Rajahmundry Rd	2 hr 6 min	67
Ranga Reddy	NH16 and NH65	10 hr 55 min	597
Samarlakota	kakinada Rajanagaram Rd/Samalkota-Kakinada Bypass and NH216	33 min	19.4
	kakinada Rajanagram Rd and NH216	41 min	22.2
Tuni	NH216 and NH16	1 hr 22 min	67
	Uppada Beach Rd	1 hr 39 min	58.4
Vishakhapatnam	AH45	3 hr 6 min	158

Source: Author compiled

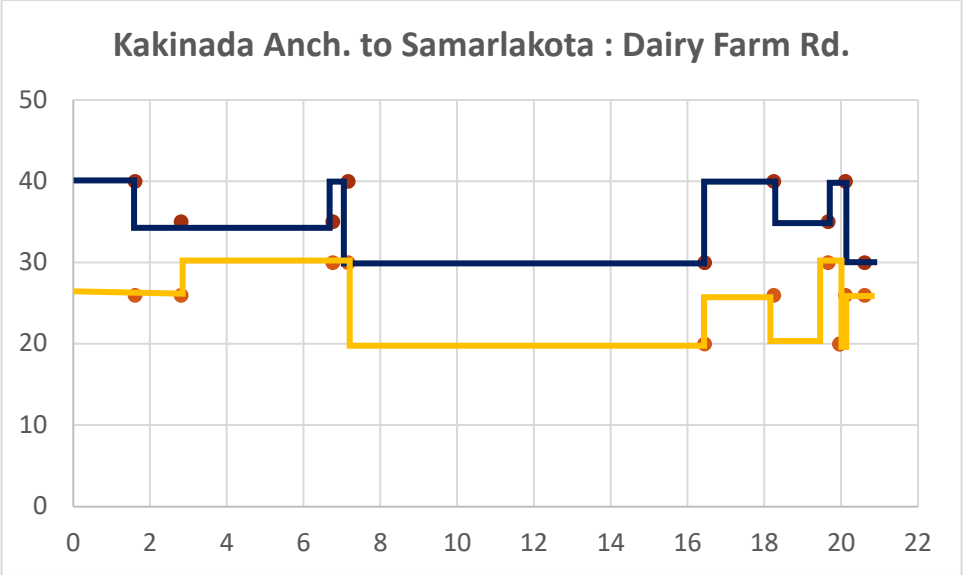
Figure 53 Kakinada deep water port to Samarlakota via Vakalapudi road speed and delay



Source Author Generated Using Google API

Major city road Vakalapudi road that connects port on east and NH- 16 on south is the shortest path to reach Samarlakota and development provides natural barrier to disaster can be strengthen and taken into consideration.

Figure 54 Kakinada deep water port to Samarlakota via Dairy farm Road speed and delay



Source Author Generated Using Google API

Also, the Dairy Farm Road that connects anchorage port on south and ADB road on north further connects NH-16 is naturally protected from disasters due to development around.

4.5 Cost of Operation

Cost of Operation has been assumed as a sum of Handling charges (loading and unloading charges), transportation charges as well as port related charges. For Roadways, handling charge is INR 150 (INR 75 each for loading and unloading). For Railways, handling charge is INR 150 for loading and INR 100 for unloading. (Indian Railways Conference Association, 2014) For Coastal Shipping, the loading and unloading charge per TEU is INR 1912. Considering 1 TEU as 24 tons, loading and unloading charges become INR 79.67/ton. (Jawaharlal Nehru Port Trust, 2017). Transportation cost for coastal shipping is least (INR 0.4/ton/km as compared to roadways which is INR 4.5/ton/km). For Railways, it is INR 1.5/ton/km. Port Related charges included the entry, exit and parking charges (for roadways), for rail, it is the terminal related charges. On the other hand, for coastal shipping, it includes a sum of cargo related charges and vessel related charges. For the purpose of calculation, a 400 TEU had been considered whose capacity utilization is 85%. Port dues, Pilotage charges (charges for driving the vessel to that port), mooring and unmooring charges

(tying and untying the vessel to the wharf) have been considered for a 400 TEU vessel, which have been later converted into INR/ton/km. Similarly, cargo related charges, i.e., terminal handling charges are INR 1688/TEU, i.e. INR 70.33/ton. The vessel related charges per ton have been calculated as INR 1.45/ton.

Table 11 Mode wise cost of operation

Mode	Handling charge/ ton/ km	Transportation cost / ton/ km	Port related charges/ ton/ km	Cost of delay/ ton / day	Cost of congestion /ton/ day	Total cost/ ton/ km	Cost of operation per day	Per day delay cost	Per day congestion cost	Total additional cost	% of total cost
Road	150	4.5	55	12.96	12.53	209.5	2828250	174960	169155	344115	12.17
Rail	250	1.5	60	7.78	5	311.5	9812250	245070	157500	402570	4.10
Coastal	159.34	0.4	71.79	0.96	0	231.53	1041850	43200	0	43200	0.41

Source: Author compiled

It can be observed that one day disruptions of activities can lead to 0.5- 15% of additional cost it is higher in case of road transport 13% while 4 % for rail and only 0.4% for coastal transport.

4.6 Travel demand forecasting

Using econometric model

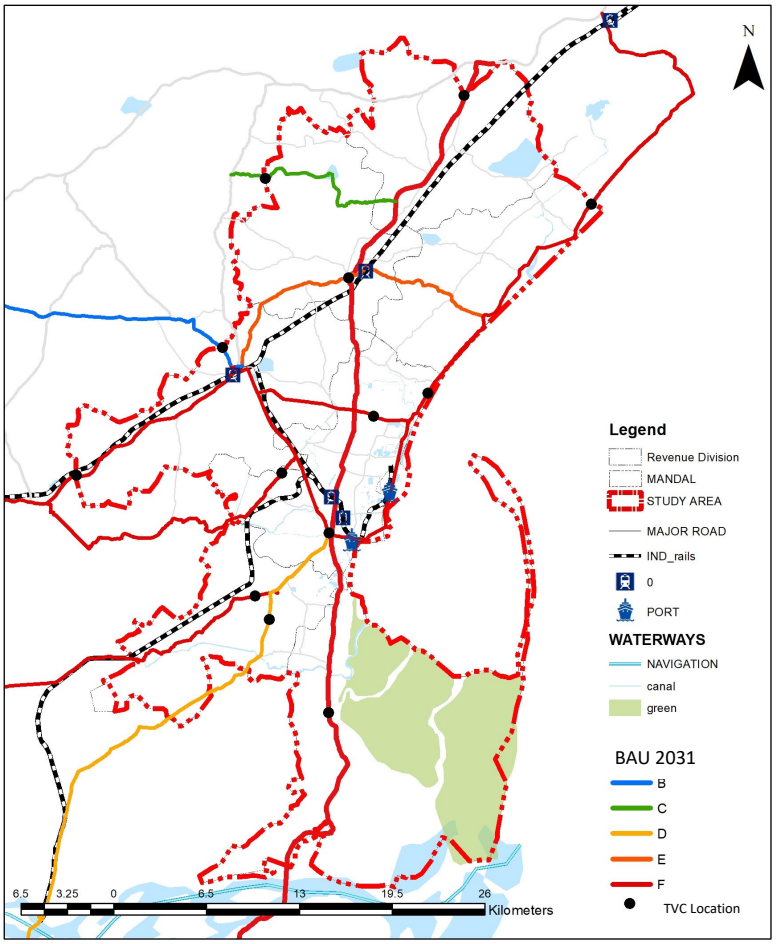
Ln(Pn)= A1 Ln (GSDP) + A0

- Traffic Growth Rate = A1 X GSDP (Expected)
- P is the Traffic Volume Data
- For GSDP we used the value for current prices from 20010 to 2020 and took out a weighted Average
- A0 is the constant and A1 is the coefficient of elasticity.
- Traffic Growth Rate= Elasticity X GSDP
- Traffic is expanded multiplying growth rate and traffic volume.

Table 12 Present traffic Scenario/ Business as usual Scenario

TVC Point	Location	Present scenario 2021			Traffic projection	Business As Usual Scenario		
		Total Vehicle	Total PCU	Carriageway	2031	Capacity	V/C 2031	LOS 2031
OC 1	SH Uppada road	8823	7059	5.2	8901	5000	1.8	F
OC 2	NH 16, Annavaram Bypass Road	19886	32515	15	41001	30000	1.4	F
OC 3	Gollaprollu Rajupalem Rd.	4612	2678	8	3377	5000	0.7	C
OC 4	Samalkot jn	8407	3392	9	4277	10000	0.4	B
OC 5	NH 216, near Matlapalem	19757	16820	7.5	21210	10000	2.1	F
OC 6	SH14, near Patharlagadda bus stop	9964	7453	7	9398	10000	0.9	D
OC 7	SH 197, near Essar Oil	18202	13594	7	17142	10000	1.7	F
OC 8	Kakinada - Rajahamundry road	12212	9769.6	7	12319	10000	1.2	F
MB 1	Pithapuram Junction	11942	7335	6.6	9249	10000	0.9	E
MB 2	SH 15 (ADB Road)	21968	13429	7.5	16934	5000	3.4	F
MB 3	Jagannaickpur Junction	21968	19771	9	24931	10000	2.5	F
MB 4	Kakinda Uppada Road	4941	4625	5.2	5832	5000	1.2	F
SL 1	SH 17, near Jaganmatah Ashramam	24476	23517	7	29655	10000	3.0	F
SL 2	Samalkot jn	9315	8720	8	10996	10000	1.1	F

Figure 55 Level of Services under Business as usual scenario 2031



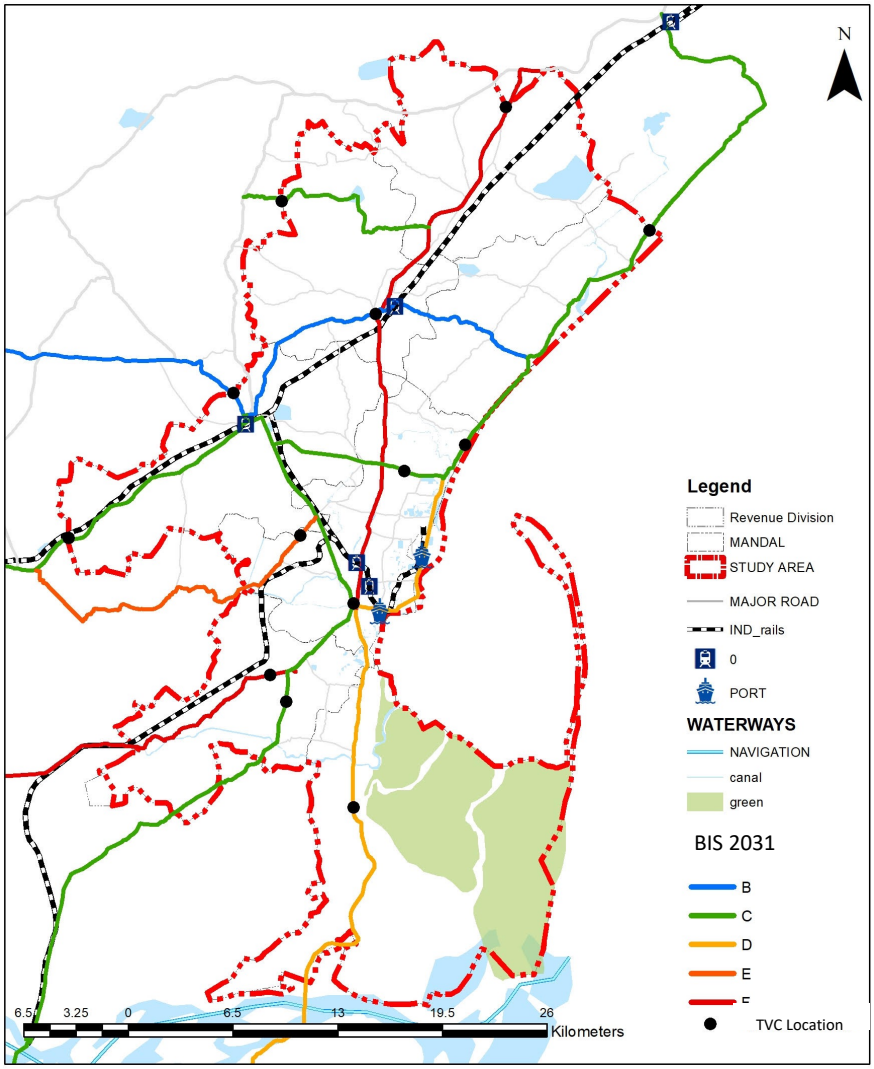
Source Author Generated ArcMap

Table 13 Business induced Scenario

TVC Point	Location	Traffic projection	Business Induced Scenario			
		2031	Proposals by Master Plan and ADB	Capacity	V/C 2031	LOS 2031
OC 1	SH Uppada road	8901	4 Lane Undivided (Two-way)	20000	0.4	C
OC 2	NH 16, Annavaram Bypass Road	41001	6 Lane Undivided (Two-way)	60000	0.7	F
OC 3	Gollaprollu Rajupalem Rd.	3377	–	5000	0.7	C
OC 4	Samalkot jn	4277	–	10000	0.4	B
OC 5	NH 216, near Matlapalem	21210	4 Lane Undivided (Two-way)	30000	0.7	D
OC 6	SH14, near Patharlagadda bus stop	9398	4 Lane Undivided (Two-way)	20000	0.5	C
OC 7	SH 197, near Essar Oil	17142	–	10000	1.7	F

OC 8	Kakinada - Rajahamundry road	12319	4 Lane Undivided (Two-way)	30000	0.4	C
MB 1	Pithapuram Junction	9249	4 Lane Undivided (Two-way)	20000	0.5	C
MB 2	SH 15 (ADB Road)	16934	4 Lane Undivided (Two-way)	30000	0.6	B
MB 3	Jagannaickpur Junction	24931	4 Lane Undivided (Two-way)	30000	0.8	D
MB 4	Kakinda Uppada Road	5832	4 Lane Undivided (Two-way)	20000	0.3	B
SL 1	SH 17, near Jaganmatah Ashramam	29655	4 Lane Undivided (Two-way)	30000	1.0	E
SL 2	Samalkot jn	10996	4 Lane Undivided (Two-way)	20000	0.5	C

Figure 56 Level of services under Business induced scenario 2031

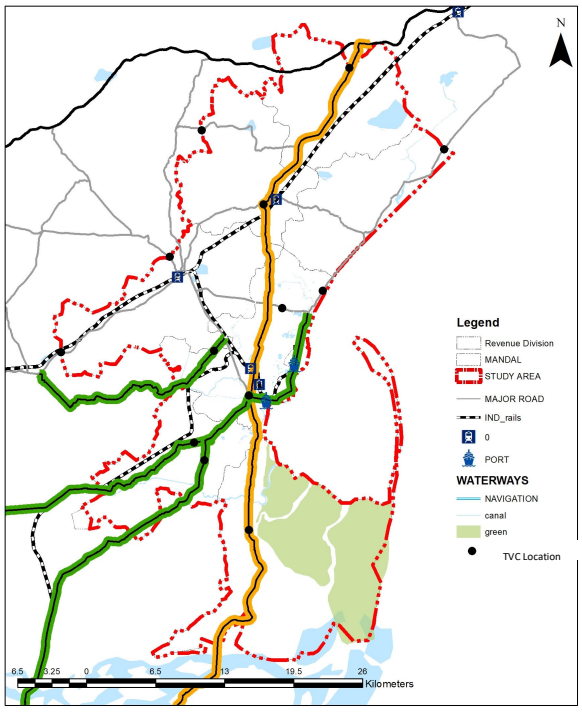


Source Author Generated Using ArcMap

Table 14 Proposed Scenario

TVC Point	Location	Traffic projection	Proposed Scenario			
		2031	Road widening Proposals	Capacity	V/C ratio 2031	LOS 2031
OC 1	SH Uppada road	8901	_	_	_	_
OC 2	NH 16, Annavaram Bypass Road	41001		_	_	_
OC 3	Gollaprollu Rajupalem Rd.	3377	_	_	_	_
OC 4	Samalkot jn	4277	_	_	_	_
OC 5	NH 216, near Matlapalem	21210	6 lnae divided (Two way)	60000	0.4	C
OC 6	SH14, near Patharlagadda bus stop	9398	_			
OC 7	SH 197, near Essar Oil	17142	4 Lane Undivided (Two-way)	30000	0.6	C
OC 8	Kakinada - Rajahamundry road	12319	_	_	_	_
MB 1	Pithapuram Junction	9249	_	_	_	_
MB 2	SH 15 (ADB Road)	16934	_	_	_	_
MB 3	Jagannaickpur Junction	24931	6 lnae divided (Two way)	60000	0.4	C
MB 4	Kakinda Uppada Road	5832	_	_	_	_
SL 1	SH 17, near Jaganmatah Ashramam	29655	6 lnae divided (Two way)	60000	0.5	C
SL 2	Samalkot jn	10996	_	_	_	_

Figure 57 Proposed interventions for 2031to achieve Level of Services C



4.7 Goods Terminal Surveys and Analysis

Urban Goods Movement (UGM) is a dynamic mechanism containing wide range of modes of transportation, commodities and a mix of intercity and local traffic. The movement of goods intra city movements of urban areas is characterized by bulk shipments, while inter-city goods movement of urban areas is characterized by smaller shipments. Though the physical boundary of urban area gets enlarged over time, the locations of goods activities remain unaltered. This leads to traffic congestions within the urban area. Kakinada area houses Kakinada Anchorage Port, Deep Water Sea Port, Nagarjuna Fertilizers and Chemicals Limited, Coromandel Fertilizers and Chemicals Limited, warehouses and major industrial areas, etc. which contribute lot of goods movements within Kakinada area and its interaction with rest of the world. Traffic volume count and OD surveys are carried out at select major goods terminals/ parking areas/ railway freight terminals and analysis of the information collected is presented here.

Goods Terminal	Data Analysis
Kakinada Anchorage Port	A total of 493 vehicles are enumerated at the time of the Survey at Kakinada Anchorage Port. The survey is conducted for 24hours on a normal working day; Vehicle Composition: Majority of vehicles are 2-Axles with 63.91%, followed by MAV with 16.65%, 3-Axles 14.41% and rest are LCV 3.78% and Tractor Trolly 1.26% Commodity Composition: Majority of Commodity is transported is Food grains with 84.80%, followed by Petroleum with 6.80%, Others with 5.20% Fruits & Vegetables, Chemicals & Fertilizers with 1.2% and Building Materials with 0.8%; Average Pay Load: Out of all Goods vehicles MAV are having a higher average pay load of 22.8 Tons followed by 3-Axle Trucks 18.0 Tons, 2 Axle Trucks 12.0 Tons, LCV/tempo with 11.5 Tons and Tractor-Trolly with 8.0 Tons;

	Trip Frequency: Majority of the trips are frequent trips 47.46% followed by Daily trips with 43.00% Weekly trips 8.32% and rest are occasional trips with 1.22%; and Average Trip Length: Out of all Goods vehicles 3-Axle Trucks are having a higher Average trip length of 83km, followed by LCV/Tempo with 70km, MAV with 69 km, 2-Axle Trucks with16 km and Tractor-Trolly with 7 km.
Kakinada Deep Water Port	A total of 997 vehicles are enumerated at the time of the Survey at Kakinada Deep Water Port. The survey is conducted for 24hours on a normal working day; Vehicle Composition: Majority of vehicles are MAV with 58.53%, followed by 3-Axle Trucks with 29.53%, 2-Axles 9.31% and rest are LCV/Tempo and Tractor Trolly 1.40%; Commodity Composition: Majority of Commodity is transported is Building Materials with 41.51%, followed by Household Goods with 25.15%, Chemical and Fertilizers with 15.54%, others with 9.82%, textiles with 3.48%, Ore/Minerals with 2.04%, Timber with 0.82%, Food Grains, Animals and Fruits and Vegetables with 0.2%; Average Pay Load: Out of all Goods vehicles MAV are having a higher average pay load of 27.0 Tons followed by 3- Axle Trucks 14.1 Tons, 2 Axle Trucks 13.3 Tons, Tractor-Trolly with 8.0 Tons and LCV/tempo with 5.0 Tons; Trip Frequency: Majority of the trips are frequent trips 45.34% followed by Daily trips with 24.87% Weekly trips 9% and rest are occasional trips with 12.64%; and Average Trip Length: Out of all Goods vehicles 3-Axle Trucks are having a higher Average trip length of 164km, followed by MAV with 154km, LCV/Tempo with 99km,2- Axle Trucks with 67km and Tractor-Trolly with 39km.

Coromandel International Limited	A total of 131 vehicles are enumerated at the time of the Survey at Coromandel Fertilizers and Chemicals Limited. The survey is conducted for 24hours on a normal working day; Vehicle Composition: Majority of vehicles are MAV with 76.47%, followed by 3-Axle Trucks with 16.04%, LCV/Tempo 4.81% and 2-Axles 2.67%; Commodity Composition: Majority of Commodity is transported Chemicals and Fertilizers with 90.54%, followed by textiles with 4.05%, Petroleum with Average Pay Load: Out of all Goods vehicles MAV are having a higher average pay load of 2.70%, Building Materials and Ore/Minerals with 1.35%; 15.9 Tons followed by 3- Axle Trucks 14.1 Tons, 2 Axle Trucks 9.0 Tons and LCV/tempo with 4.6 Tons; Trip Frequency: Majority of the trips are Daily trips with 76.34%, followed by Weekly trips with 15.27% and Occasional trips with 8.40%; and Average Trip Length: Out of all Goods vehicles 3-Axle Trucks are having a higher Average trip length of 145 km, followed by ,2-Axle Trucks with 91 km, MAV with 49 km and LCV/Tempo with 21 km;
Parry Sugars Refinery India Private Limited	A total of 317 vehicles are enumerated at the time of the Survey at Parry Sugars Refinery India Pvt Ltd. The survey is conducted for 24 hours on a normal working day; Vehicle Composition: Majority of vehicles are 2-Axles trucks with 57.58% followed by 3- Axles trucks with 37.88%, MAV with 2.27%, Tractor-Trolly with 1.52% and LCV/ Tempo with 0.76%; Commodity Composition: Majority of Commodity is transported Household Goods with 48.28% followed by Food grains with 45.40%, others with 3.45%, Ore/Minerals with 1.15%, Fruits and Vegetables, Animals, and Chemicals and Fertilizers with 0.57%; Average Pay Load: Out of all Goods vehicles 3-Axle Trucks 16.5 Tons followed by MAV are having a higher average payload of 15.0

	Tons, 2 Axle Trucks 12.0 Tons, Tractor-trolly with 9.0 Tons and LCV/tempo with 5.0 Tons; Trip Frequency: Majority of the trip's Daily trips with 40.38%, followed by frequent trips with 30.28%, Weekly trips with 27.76% and Occasional trips with 1.58%; and Average Trip Length: Out of all Goods vehicles LCV/Tempo with 22 km followed by 3- Axles trucks with 12 km, 2-Axles trucks with 10 km, Tractor-trolly with 5 km and MAV with 4 km.
KPW Warehousing	A total of 132 vehicles are enumerated at the time of the Survey at KPW Warehousing. The survey is conducted for 24 hours on a normal working day; Vehicle Composition: Majority of vehicles are 2-Axles with 81.82%, followed by MAV with 14.39%, and 3-Axles with 3.79%; Commodity Composition: Majority of Commodity is transported Food grains with 50.38% followed by Household's goods with 45.04%, Fruits and Vegetables with 3.82%, Timber with 0.76%; Average Pay Load: Out of all Goods vehicles Mav with 20.2Tons followed by 3-Axles trucks with 13.2 Tons and 2-Axles with 11.1 Tons; Trip Frequency: Majority of the trips are Daily trips with 52.27% followed by frequent trips with 37.38%, Weekly trips with 5.30%, Occasional trips with 4.55%; and Average Trip Length: Out of all Goods vehicles MAV with 129 km followed by 3-Axles trucks with 11 km, and 2-Axles trucks with 8 km
Gowthami Warehousing	A total of 71 vehicles are enumerated at the time of the Survey at Gowthami Warehouse. The survey is conducted for 24 hours on a normal working day; Vehicle Composition: Majority of vehicles are 3-Axles with 45.07%, followed by MAV with 32.39%, 2-Axles with 18.31% and LCV/Tempo with 4.23%;

	Commodity Composition: Majority of Commodity is transported Food grains with 90.91% and others with 9.09%; Average Pay Load: Out of all Goods vehicles Mav with 20.2 Tons followed by 3-Axles trucks with 16.6 Tons, 2-Axles with 13.3 Tons, and LCV/Tempo with 1.3 Tons; Trip Frequency: Majority of the trips are Daily trips with 52.11% followed by Weekly trips with 35.21%, Frequent trips with 7.04%, and Occasional trips with 5.63%; and Average Trip Length: Out of all Goods vehicles MAV with 68 km followed by 3-Axles trucks with 41 km, 2-Axles trucks with 27 km, and LCV/Tempo with 33 km.

CHAPTER 5 CONCLUSION AND RECOMMENDATION

The assessment of the impacts of Climate Variability and Change carried out for the major coastal road transportation assets of Port by creating an imamate assessment framework.

It has been observed the most critical asset i.e., road network and primary hinterlands are located on small elevations and along the coastal bank of the district that make it highly vulnerable to number of climatic factors and their projected changes.

It can be noted from historical climatic information that all the mandalas of Kakinada revenue division fall under high cyclone frequency zones (44 km/ hr. and above) and is frequently affected by cyclones every year causing flood inundation in the rivers, high tides un the sea and land fall along the coast it can be noted that every year 20-30m of land is getting submerged into sea affecting the road transportation of the port allied industries in Kakinada revenue division.

The port vessel schedule indicates 1.5- 2 times congestion at the anchorage compared to normal working day during and post- disaster due to refused loads because of increase in fuel prices, transit time, climatic conditions (vehicle and driver availability) and the capacity of the road network.

- 70% of the congestion at anchorage is due to refused loads because of cyclone and induced flooding carriers would also negate to pick up or transport shipment and the supply chain will tend to block or collapse.
- The major road connecting the Kakinada port and National Highway 16 leading to primary, secondary and tertiary hinterlands is a 2-lane road (approximately 20 km and SH-15 is leading to Kakinada SEZ is an intermediate lane (Approximately 12.4 km) experiencing landfall after every cyclonic activity. Almost 74% of the road network is either two lanes undivided or intermediate lane indicating unstable and forced flow during normal working day and is a key constraint. Also, there is a need of direct fright corridor and alternative resilient routes.
- The average speed in the study area is around 35 km/hr. but at the time of disaster and post disaster it drops to 24 km/hr. and SH- 16 becomes impassable causing disruption in port activities and allied industries, also

congestion at the port gate. This leads to increase increasing the coast of operation by 0.5- 13% so, alternative routes should be planned and strengthened.

- There is a single track with less capacity from Samarlakota to Kakinada port. So, the goods have to be routed through Pithapuram and the road infrastructure connecting it is highly vulnerable to disasters.
- Transport infrastructure accounts for high losses and the current technology adapted for construction of roads is not suitable for coastal areas so new resilient infrastructure technologies can be adapted to reduce losses.

So, adaptation strategies can be adopted at various stages of Disaster management states to reduce the impact of disaster on port- hinterland supply chain that can lead to resilient, reliable and port lead development and higher economic growth.

Figure 58 Recommendation measures for free flow of activities during and Post- disaster

<table>
<tr><td>Stages</td><td>Pro-Action</td><td>Prevention</td><td colspan="2">Preparation</td><td colspan="2">Response</td><td>Recovery</td></tr>
<tr><td>Objectives</td><td></td><td></td><td>In preparation of an extreme event</td><td>Just before an extreme event</td><td>During an extreme event</td><td>Just after an extreme event</td><td>After an extreme event</td></tr>
<tr><td></td><td colspan="2">Enable Smooth and safe traffic</td><td>Support disaster consequence reduction</td><td>Evacuation route</td><td>Minimizing loss of functions</td><td>Supply route</td><td>Supply route for recovery of affected area</td></tr>
<tr><td>Robust construction</td><td rowspan="2">Pro-active attitude</td><td></td><td></td><td colspan="3">Extreme event management</td><td></td></tr>
<tr><td>Legislation, regulations</td><td colspan="2">Prevention</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Resilient construction</td><td></td><td colspan="2">Upgrade, Retrofit, new construction</td><td></td><td></td><td></td><td></td></tr>
</table>

Maintenance and management			Preventive maintenance replacement				Corrective
Traffic Management		Traffic Management					
Capacity Building	Capacity building						
Monitoring	Monitoring and Prediction						
Research	Research						

Engineering:

- Enhance the structural integrity and efficiency of critical facility components
- Construction of storm retention basins for flash flooding

Technology:

- Investment in more climate-resilient technologies and equipment in planned expansion and upgraded programmes

Automation of logistics procedures

- Planning alternative routes, design and future development guidelines
- Internal capacity-building and retraining building of redundancy into critical operations proactive infrastructure and management plan
- Re-examine land use planning in flood prone areas

Insurance: Some risks cannot be avoided; therefore, they must be insured by third parties.

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ANNEXURE I: Survey Format

Impact Assessment of disasters on Coastal area road network and port logistics: A case study of Kakinada			**Goods Terminal Survey**		
Name of Surveyor	Monika Goyal		School of Planning and Architecture Bhopal		
Terminal Name			Terminal Type		
FLEET CHARACTERISTICS					
Fleet type	National permit				
	State permit				
Fleet capacity (tonnage)	HCV (3AXLE)		Regional		
	HCV (TRUCK TRAILER)				
	LCV		City		
	MCV				
Origin		Destination			
Frequency of trips	Daily				
	Monthly				
	Occasional				
COMMODITY DETAILS OF GOODS TRANSPORTED					
COMMODITY TYPE	PLEASE TICK	TOTAL FLEET DEDICATED			
Fruits & Vegetables					
Textile & Readymade Garments					
Iron and Steel					
Chemical & Fertilizers					
Building Construction					
Paper Products					
Plastics					
Bread and Dairy					
Food grains					
CARGO DETAILS					
Total number of Cargo	Arrived				
	Dispatched				

Commodity's Handled	TYPE OF COMMODITY	TONNAGE
Number of days transhipment Delay due to natural disaster	Disaster type	Number of Days
Cost of Per cargo handling		
Monetary Losses due to delay (average)		

Impact Assessment of disasters on Coastal area road network and port logistics: A case study of Kakinada	**Disaster Management Authority**

Name of Surveyor	Monika Goyal	School of Planning and Architecture Bhopal		
Type of Disaster	Date	Mandal's / villages affected	Magnitude of hazard	Infrastructure Losses

Impact Assessment of disasters on Coastal area road network and port logistics: A case study of Kakinada				**Road Inventory Survey**	
Name of Surveyor	Monika Goyal	School of Planning and Architecture Bhopal			
NAME/NO. OF ROAD		TYPE		TOTAL LENGTH	

SN	CHARACTERISTICS	SECTION 1	SECTION 2	SECTION 3
1	RIGHT OF WAY (M.)			
2	CARRIAGEWAY			
	WIDTH (M.)			
	NO. OF LANES			
	ENCROACHMENT (METRES)			
	TYPE OF ENCROACHMENT			
3	SHOULDER			
	WIDTH (M.)			
	TYPE (PAVED/UNPAVED/ABSENT)			
4	FOOTPATH			
	WIDTH (M.)			
	TYPE			
5	MEDIAN (PRESENT / ABSENT)			
	IF PRESENT, WIDTH			
6	ROAD SURFACE TYPE			
	Condition of pavement			
7	DRAINAGE TYPE (OPEN / COVERED / UNDER GROUND)			
	WIDTH (M.)			
8	STREET LIGHTING (PRESENT / ABSENT)			
	SPACING (M.)			

Impact Assessment of disasters on Coastal area road network and port logistics: A case study of Kakinada									**Traffic Volume Count Survey**			
Name of Surveyor	Monika Goyal			School of Planning and Architecture Bhopal								
Location :		Direction:					Road Name :					
TIME	FAST MOVING VEHICLES									SLOW MOVING VEHICLES		
	CAR/ JEEP/TAXI	2-WHEELER	3-WHEELER	LCV/ TEMPO	BUS	MINI BUS	TRUCK	MAV	OTHERS (SPECIFY)	CYCLE	TRACTOR	OTHERS (SPECIFY)
From												
To												
Total												
From												
To												
Total												
From												
To												
Total												
From												
To												
Total												
Hourly Total												