PM GATISHAKTI: EXAMINING THE ROLE OF TELECOMMUNICATIONS IN LOGISTICS SECTOR

Dissertation Submitted to the Panjab University, Chandigarh for the award of degree of **Executive Masters in Public Administration and Public Policy,** in partial fulfilment of the requirement for the Advanced Professional Programme in Public Administration

(2023-24)

Submitted by

Sanjeev Kumar Arya

Roll No 4902

Under the Guidance and Supervision of

Faculty Guide Dr. Sapna Chadah

49th ADVANCED PROFESSIONAL PROGRAMME IN PUBLIC ADMINISTRATION (2023-24)

INDIAN INSTITUTE OF PUBLIC ADMINISTRATION
NEW DELHI

CERTIFICATE

I have the pleasure to certify that **Shri Sanjeev Kumar Arya,** has pursued his research work and prepared the present dissertation titled **'PM GatiShakti: Examining the role of Telecommunications in Logistics Sector'** under my guidance and supervision. The same is the result of research done by him and to the best of my knowledge; no part of the same has been part of any monograph, dissertation or book earlier. This is being submitted to the Panjab University, Chandigarh, for the purpose of **Executive Masters in Public Administration and Public Policy** in partial fulfillment of the requirement for the Advanced Professional Programme in Public Administration (APPPA) of Indian Institute of Public Administration (IIPA), New Delhi.

I recommend that the dissertation of **Shri Sanjeev Kumar Arya** is worthy of consideration for the award of Executive Masters degree of the Panjab University, Chandigarh.

Date : 22nd March,2024
Place : New Delhi

(Dr. Sapna Chadah)
Faculty Guide
Indian Institute of Public Administration,
New Delhi-110002

ACKNOWLEDGEMENT

At the outset, I wish to express my sincere gratitude to my guide and mentor Dr. Sapna Chadah for her guidance, motivation and support at every stage of this study. Her advice was invaluable during the research & writing of this dissertation and helped to complete my study in such a short time.

I would also like to thank the IIPA as an institute for providing the required infrastructural facilities to complete the work. I want to thank library staff of IIPA for their cooperation and making available the resources required for this study A heartfelt thanks to all the experts who enriched my understanding with their constructive feedback during the research proposal presentations. Their perspectives have been immensely beneficial in steering this research toward its objectives.

I am grateful to the officials of DoT, DPIIT, NLDS, TEC, TSPs, and Concor for their valuable inputs. I would like to thank APPPA office staff Shri Anil Sharma, Shri Rajesh and Shri Manish Rawat for their continuous help and support.

Finally, I would like to thank my wife and daughter for their unwavering support and help during the course of this study.

Date: 22nd March, 2024

(**Sanjeev Kumar Arya**)

Indian Institute of Public Administration

New Delhi- 110002

List of Abbreviations

1. **5G**: Fifth Generation of Wireless Technology
2. **AI**: Artificial Intelligence
3. **API**: Application Programming Interface
4. **AWS**: Amazon Web Services
5. **BISAG-N**: Bhaskaracharya National Institute for Space Applications and Geoinformatics
6. **CSCMP**: Council of Supply Chain Management Professionals
7. **DoT**: Department of Telecommunications
8. **DPIIT**: Department for Promotion of Industry and Internal Trade
9. **EDI**: Electronic Data Interchange
10. **ESCAP**: Economic and Social Commission for Asia and the Pacific
11. **EVM**: Ethereum Virtual Machine
12. **EXIM**: Export-Import
13. **GIS**: Geographic Information System
14. **IaaS**: Infrastructure as a Service
15. **IBEF**: India Brand Equity Foundation
16. **ICT**: Information and Communication Technology
17. **IIMM**: Indian Institute of Materials Management
18. **IoT**: Internet of Things
19. **ISRO**: Indian Space Research Organisation
20. **JMVP**: Jal Marg Vikas Project
21. **KPMG**: Klynveld Peat Marwick Goerdeler
22. **LEADS**: Logistics Ease Across Different States
23. **LaaS**: Logistics as a Service

24. **LPBTS**: Low Power Base Transceiver Stations
25. **LPI**: Logistics Performance Index
26. **MeitY**: Ministry of Electronics and Information Technology
27. **mMTC:** Massive Machine Type Communication
28. **MoRTH**: Ministry of Road Transport and Highways
29. **NH**: National Highways
30. **NLDSL**: NICDC Logistics Data Services (NLDS)
31. **NIST**: National Institute of Standards and Technology
32. **NLP**: National Logistics Policy
33. **OCDP**: Organization for Economic Cooperation and Development Committee on Digital Economic Policy
34. **OFC**: Optical Fiber Cable
35. **OLT** :Optical Line Terminal
36. **ONT**: Optical Network Terminal
37. **PaaS**: Platform as a Service
38. **PDOA**: Public Data Office Aggregator
39. **PMGS-NMP**: Prime Minister GatiShakti National Master Plan
40. **PM WANI**: Prime Minister Wi-Fi Access Network Interface
41. **PoS**: Proof of Stake
42. **PoW**: Proof of Work
43. **RFID**: Radio Frequency Identification
44. **SaaS**: Software as a Service
45. **SSID**: Service Set Identifier
46. **TSP**: Telecom Service Providers
47. **UDAN**: Ude Desh ka Aam Naagrik

48. **ULIP**: Unified Logistics Interface Platform

49. **USOF**: Universal Service Obligation Fund

50. **WIPO**: World Intellectual Property Organization

51. **DCIS**: Digital Communication Innovation Square

Table of Figures

Table of Contents

EXECUTIVE SUMMARY

Introduction: PM GatiShakti National Master Plan (NMP) has been launched in October 2021 for providing multimodal connectivity infrastructure to various zones having economic activity. Railways, roads, ports, waterways, airports, Mass transport and logistics infrastructure will work as seven engines to pull forward the economy. Further, IT communication, energy Transmission, and other social infrastructure will play as complimentary roles to support the engines.

The approach of PM GatiShakti NMP is for economic transformation, seamless connectivity and to improve logistics efficiency. This is based upon GIS mapping of infrastructure, developed by BISAG. In order to make the logistics and transportation infrastructure more efficient, PM GatiShakti NMP is offering a comprehensive digital master planning tool which integrates data from sixteen central ministries and uses GIS-based planning tools. Telecom is one of the important layers in PM GatiShakti and logistics eco system. Telecom infrastructure also plays an important role for ease of doing business and minimizing the transaction cost.

Further, Frontier Technologies like 5G, Artificial Intelligence (AI), Big data, Cloud, Block chain, Internet of Things (IoT) are transforming our works and life. These also play a significant role in digital transformation of the Logistic sector.

Statement of Problem: PM GatiShakti has been launched to break the silos working of different government departments, making the concerted approach towards a common goal. Further, to improve logistics efficiency is one of the underlined approaches under PM GatiShakti initiatives. The logistics cost of India was assessed to 14 percent of GDP which is very high as compared to developed nations. Further, as per Logistic Performance Report (LPI) 2018, India was ranked as 44 in the world. Some of the elements for evaluation under LPI are management of customs and border procedures and the capacity to monitor and locate shipments. The ongoing projects to be undertaken under PM GatiShakti will require adequate presence of timely, high speed and reliable telecom connectivity. In some regions, inadequate telecommunications infrastructure can hinder the adoption of advanced logistics technologies, limiting their potential benefits.

Objectives:

The study was driven by four objectives: to study different parameters of Telecom layer in PM GatiShakti platform related to logistics sector; to examine the role of telecommunications and frontier technologies in logistics sector; to study the issues and challenges in use of telecommunications & frontier technologies in logistics sector; to suggest measures to facilitate use of frontiers technologies to improve efficiency in logistics sector.

Methodology:

Methodology used is a mix of descriptive and empirical methods. Both qualitative and quantitative data points have been collected from primary and secondary sources. Secondary data have been taken from open accessible information available in the internet and inter-alia includes PM GatiShakti Portal and related reports, books, journals, periodicals. The primary data has been collected through the questionnaire and meetings/interview with officials/experts from various stakeholders.

Conclusion & Suggestions: Innovation, investment and institution are the keys for economic growth of any country. India is leading in all these fronts by having various initiatives such as PM GatiShakti and National Logistic Policy 2022.

Thus, this study has been under taken to understand the aspect of Telecom layer in PM GatiShakti, the roles & benefits of frontier technologies in the Logistic operations and the issues & challenges and recommendation for their effective utilization.

The study indicates that frontier technologies like 5G, Artificial Intelligence (AI), Big data, Cloud, Block chain, Internet of Things (IoT) help to enhance visibility, improve efficiency, facilitate real-time tracking, predictive maintenance, and support autonomous vehicles and drones. Telecom connectivity is now working as the nervous system for the entire infrastructure including logistics sector. 5G Technology is crucial for real-time tracking, IoT device communication, and remote monitoring. The innovative PM GatiShakti portal has become as an essential planning tool for telecom infrastructure by providing comprehensive GIS-based Infrastructure mapping essential for better decision making catering to the needs of logistics sector.

Chapter 1

Introduction

"Infrastructure has always been important in sustainable development of any country. Those who study the history of infrastructure know this very well. GatiShakti master plan will rejuvenate India's multimodal infrastructure. The results of the PM GatiShakti master plan are becoming visible."

Hon'ble Prime Minister Shri Narendra Modi

1.1 PM GatiShakti: An Introduction

1.1.1 PM GatiShakti National Master Plan (NMP) has received the Prime Minister's Award for Excellence in Public Administration under Innovation (Centre) category in 2022. This is a comprehensive plan launched by the Department for Promotion of Industry & Internal Trade to facilitate the mapping of social and economic infrastructure planning in India using GIS enabled platform and institutional mechanism. PM GatiShakti National Master Plan (PMGS-NMP) has been launched in October 2021 for providing multimodal connectivity infrastructure to various economic zones. PM GatiShakti has been launched having transformative approach for economic growth and sustainable development. The approach is driven by Seven (7) engines, which are: Railways, Roads, Ports, Waterways, Airports Mass Transport and Logistics Infrastructure.

1.1.2 All these seven engines will pull forward the economy in harmony. Sectors like Energy Transmission, IT Communication, and Social Infrastructure will support these engines in complementary roles. The approach unites the efforts of the Central Government, the state governments, and the private sector together which will lead to increase in job and entrepreneurial opportunities for all, especially the youth.

The scope of PM GatiShakti National Master Plan encompass the seven engines for economic transformation, seamless multimodal connectivity and Logistics efficiency

1.1.3 PM Gatishakti National Master Plan (NMP) platform brings together data from 16 central ministries like Telecommunications, Railways, Roadways, Power, and

Tourism etc., to achieve sector specific development goals. This is based upon GIS based integrated planning and coordination tools, by mapping all the available infrastructure across the ministries. Bhaskaracharya National Institute for Space Applications and Geo informatics (BISAG-N) has developed for the departments.

1.1.4 The plan as a Digital Master Planning tool has been developed by BISAG-N and prepared in dynamic Geographic Information System (GIS) platform wherein data on specific action plan pertaining to all the Ministries/Departments have been incorporated within a comprehensive database. Dynamic mapping of all infrastructure projects will be provided by way of a map with real- time updation. The map is built on open-source technologies and hosted on secured MEGHRAJ i.e. cloud of Govt. of India. It uses satellite imagery provided from ISRO and base maps from Survey of India. The comprehensive database of the current & future projects under various Ministries has been integrated with more than 200 GIS layers. This facilitates planning, designing and execution of the infrastructure projects with a common vision.

1.1.5 This is an integrated platform which is called as National Master Plan where all the economic zones and their multimodal connectivity infrastructure in the country are depicted, along with physical linkages. This will promote comprehensive and integrated multimodal national network of transportation and logistics to improve efficiency and create avenues for further developments, value addition and generating employment opportunities.

1.1.6 The PM GatiShakti institutional framework is designed to break inter-departmental silos in the country. This will integrate planning and infrastructure development efforts across multiple agencies, reduce logistics cost, and improve logistics efficiency. The platform is a response to the need for integrating planning and infrastructure development efforts across multiple agencies in order to improve logistics efficiency, reduce logistics cost, break inter-departmental silos in the country. For continuous updation of the master plan, individual ministries are creating APIs with BISAG-N.

1.1.7 While PM Gatishakti National Master Plan is envisaged for development of integrated infrastructure and network, to bring efficiency in services (processes, digital systems, regulatory framework) and human resource, the National logistics Policy is the

follows logically. National Logistics Policy, 2022 has been launched in September, 2022. The NLP, 2022 provide a comprehensive agenda for development of entire logistics ecosystem. The National Logistics Policy envisages "to develop a technologically enabled, integrated, cost efficient, resilient, sustainable and trusted logistics ecosystem in the country for accelerated and inclusive growth."

1.1.8 Development of data driven systems for monitoring various components of the logistics ecosystem to enable higher logistics efficiency , is envisaged through (a) the PM Gatishakti National Master Plan; (b) the Unified Logistics Interface Platform(ULIP); (c) the Logistics Ease Across Different States ' (LEADS) study for monitoring logistics performance across states and ; (d) development of robust standardized methodology for calculating logistics cost and institutionalizing regular national assessment of higher costs in economy.

1.1.9 It is pertinent to mention here that logistics refers to the strategic movement of goods and services from one place to another. Originally, term was used to describe the transportation of military supplies to soldiers deployed on the front line, but with the increase of e-commerce and online shopping, logistics is now essential to the global supply chain process, and it include procurement, storage and distribution of materials. Logistics is characterized by a complex interplay of multiple stakeholder groups, varied nature of infrastructure across different modes of transport, and broad processes / services that enable movement of goods under respective regulations.

1.1.10 India Brand Equity Foundation has mentioned that as per EXIM infrastructure procedure, Telecommunication infrastructure is helpful to keep the transaction cost low and thus, improving export competitiveness. Telecommunications services though wireline, wireless communication, and internet access are critical for the ease of doing business.

1.1.11 KPMG (2022) in its report has mentioned about major initiatives by Indian Government inter-alia include:

(i) The Union Budget in 2021 has allocated INR 2.3 lakh crore for transport infrastructure.

(ii) The dedicated freight corridors for freight movement which are long distance, high-capacity freight rail routes

(iii) The Sagarmala project on developing waterways transport by developing Coastal Economic Zones and improving existing ports and.

(iv) The Bharatmala and Golden Quadrilateral projects for development of road highway infrastructure in the country.

(v) The Jal Marg Vikas Project (JMVP) is developed for operations of National Waterway, which is under progress.

(vi) National infrastructure pipeline includes more than 7,400 infrastructure projects which covers, INR 30 lakh crore for roads, INR 14 lakh crore for railways, INR 1.4 lakh crore for airports and INR 1 lakh for ports and inland waterways.

(vii) UDAN scheme aims to establish more than 100 airports to improve air connectivity.

1.1.12 As per Leads Report (2021), Digital and telecom connectivity is also one of the participants in Logistics ecosystem. Telecom networks, including wired and wireless technologies like fiber optics, 4G, and 5G, provide high-speed data connectivity. This connectivity is essential for transmitting large volumes of data related to infrastructure design, monitoring and management.

1.1.13 Through PM GatiShakti, different parameters of Telecom layer are being geo-mapped such as Optical fiber cable (OFC), Tower, location/address of Base stations etc. This information is beneficial for decision making while executing the new projects in telecom expansion. 5G is the next technological frontier and the implementation of Digital Transformation through 5G will significantly affect other national Mission Mode projects. The integration of 5G technology will add a new dimension to the Digital India, and Smart Cities missions. Furthermore, the incorporation of 5G technology can potentially contribute to the Make in India and Start-Up India initiatives.

1.1.14 The economic benefits from 5G technology are also quite immense. As per Organization for Economic Cooperation and Development (OECD), Committee on Digital Economic Policy, the rollout of 5 G technology will help increase GDP, create employment, and Digitize the economy. The Government of India has recognized this fact and has made major thrust on proliferation of 5G in the country through various interventions like auction of spectrum, test bed for 5G and other policy initiatives.

1.1.15 With the advent of 5G, there will be a requirement to rollout 5G base stations and Low Power Base Transceiver Stations (LPBTS) with 5G radios often called "small cells'' that requires denser network deployments in order to support larger traffic volumes per unit area.

To support 5G deployment, Optical fiber is the preferred medium for existing wireless backhaul networks, and even the wireless backhaul eventually needs to connect ultimately into a fiber backhaul.

1.1.16 Fatas et al. (2009) have mentioned that "*Over a long period of time, the increase in the economic well-being in the world can come only from innovation. Often we associate innovation with new technology or new products, but in reality a significant amount of innovation is also about new ways of producing the same old things, i.e. better management and better organization of production."* It is imperative that innovative ways coupled with emerging technologies can change the paradigm of logistic sector in India.

1.1.17 Durant, I.(2021),acting UNCTAD secretary-general, also said that "It is key that developing countries do not miss the wave of frontier technologies, otherwise it will further deepen inequalities. Hence, societies and productive sectors need to be well prepared and build the required skills."

The Economic and Social Commission for Asia and the Pacific (ESCAP) (2018), a body under United Nations, has also mentioned in their report that improved application of frontier technologies to transportation and logistics could reduce carbon emissions by an estimated 4.5 billion tons by 2020.

1.1.18 This research study focuses on the different parameters of Telecom layer in PM Gati Shakti and examines roles of telecommunications and global frontier technologies in logistic sector which can help to improve efficiency and enhance customer experience.

1.2 Statement of the Problem:

a) Infrastructure projects had been implemented previously in the country but these have been undertaken by different departments in silos leading to disconnect in the vision of the country. This also lead to in-efficient use of resources of the country. For example, road department was not aware of the OFC laying plan by TSPs/ISPs or vice versa. Similarly, Railways connectivity to one city was not planned in consultation with road

department. The outlook of PM GatiShakti is for growth accelerating reliable infrastructure through synchronized, integrated and comprehensive planning on the basis of sharing of knowledge, technology and innovation on a common platform. The PM GatiShakti National Master Plan covers 7 engines for economic growth, as well as seamless multimodal connectivity and logistics efficiency. National Master Plan address the missing gaps to ensure seamless movement of people, goods and services. It aims to enhance ease of living, ease of doing business, minimize disruptions and expedite completion of works with cost efficiencies. High Logistics Cost is one of the few challenges being faced by Logistics sector in India. Presently, the logistics cost is 14 percent of GDP which is very high as compared to developed nations. As per Logistic Performance Report (LPI) 2018, India is ranked as 44 in the world. The Logistics Performance Index (LPI) is an interactive benchmarking tool designed to assist nations in identifying opportunities and difficulties related to their trade logistics performance as well as actions they may take to enhance it. As per PM GatiShakti website, even though the departments serving logistics sector have adopted digitization, but information flow between the systems is limited, making documentation and approval process very complex.

b) Telecom infrastructure plays an important role for ease of doing business and minimizing the transaction cost. New ICT uses in logistic sector like Internet of things, 5G, Cloud computing and Big data are some of the key aspects to improve efficiency and ease in documentation and approval process. Pervasive telecommunications connectivity for such technologies shall be the mandatory requirement to perform to its optimum. The impact of inadequate telecommunications infrastructure in certain regions on the logistics industry can be profound, affecting various aspects of supply chain management, transportation, and warehousing.

c) For ongoing projects to be undertaken under PM GatiShakti objective, will require adequate presence of timely, high speed and reliable telecom connectivity. In some regions, inadequate telecommunications infrastructure can hinder the adoption of advanced logistics technologies, limiting their potential benefits.

In this regard, the recommendations of 5G steering committee formed by Department of Telecommunications (DoT) has set up the vision of India in 5G domain as Deployment

(rolling out expeditiously, efficient and pervasive 5G networks to maximize the value offered by 5G technology), Technology & Manufacturing.

d) The roll out of 5G services requires strong backhaul support. This is one of the challenges to meet the backhaul requirements for 5G, for which fiberisation of tower and use of street furniture is required. Fiber is the favoured option for 5G because of its scalability, security and ability to carry huge amount of backhaul traffic.

e) The use of frontier technologies like Artificial Intelligence (AI), Internet of Things (IoT), Cloud computing, Big Data Analytics and 5G are talked about and started being used in logistic sector. However, the questions remains in the mind whether Indian Logistic sector is geared up to encash this opportunity.

1.3 Research Objectives:

The objectives of the research are as below:

i. To study different parameters of Telecom layer in PM GatiShakti platform related to logistics sector.
ii. To examine the role of telecommunications and frontier technologies in logistics sector.
iii. To study the issues and challenges in use of telecommunications & frontier technologies in logistics sector.
iv. To suggest measures to facilitate use of frontiers technologies to improve efficiency in logistics sector.

1.4 Research Methods -Research Strategy and Research Design:

Both descriptive and exploratory research designs have been used. A mixed research strategy i.e qualitative and quantitative has been employed to complete the study proposed. Both primary and secondary data has been used for study. The data sources used in the research from secondary sources are gathered from:

- Various academic journals, periodicals and reports
- Policy documents and publications of Government of India
- Department of Telecommunications (DoT)
- Department for Promotion of Industry and Internal Trade (DPIIT)

- PM GatiShakti Portal
- International Telecommunications Union (ITU)

The primary data has been collected with the help of questionnaire and interview schedule. The questionnaire was administered to 169 officials from Government Departments, Telecom Service Providers (TSPs), Logistics Companies, industries, associations and subject matter experts, etc. interview was conducted with 12 respondents involved I direct implementation of the programme. The data was collected from the following stakeholders:

- Department of Telecommunications (DoT)
- DPIIT
- Experts from IT Industries/IoT Industries,
- Retired Senior officials from MeitY
- Experts from Logistics Sector
- Telecommunication Engineering Centre (TEC)
- Telecom Service Providers (TSPs)
- CONCOR

1.5 Rationale or Justification:

a) The scope of PM GatiShakti National Master Plan is for economic transformation, as well as seamless multimodal connectivity and logistics efficiency. It will also include the infrastructure developed by the State Governments, under the GatiShakti Master Plan. The focus will be on planning, financing through innovative ways, usage of technology and speedier implementation. The World Bank publishes the Logistics Performance Index (LPI), a composite index and benchmarking tool to analyze how efficiently supply chains in an economy connect firms to international opportunities. India had got rank of 44 out of 160 countries on the LPI in 2018. The Ministry of Commerce and Industry, Government of India, has also crafted the Logistics Ease Across Different States (LEADS) report to analyse the business environment pertaining to infrastructure, policy, and regulatory regime in all State/UTs for improving logistics efficiency in India.

b) According to a recent Ernst & Young report (2023), "India@100: realizing the potential of a US$ 26t economy", in which India is projected to reach US$26T by FY48. Transportation and logistics sector can act as the backbone in India to support this fast-paced growth, which the country is asserted to attain in the next 25 years. As per report, India's freight movement is heavily skewed toward road transportation, which takes 66% of cargo (in ton-km). Share of rail transportation is (31%), followed by shipping (3%) and air (1%). The sector continues to observe disparity in freight mode transportation and is working toward solving this issue.

c) The National Logistics Policy (NLP) 2022 has set a goal to reduce logistics costs by fifty percent by the year 2030. It aims to create a data-driven decision system and establish a technology-enabled, integrated, affordable, self-sufficient, practical, and reliable logistics ecosystem in India. The policy also focuses on process re-engineering, digitization, and multi-modal transport. Launched in September 2022, the NLP aims to transform India's logistics sector by making it more efficient, cost-effective, and sustainable. It complements the PM GatiShakti National Master Plan, which prioritizes infrastructure development.

d) KPMG (2022) in its report has suggested that India can reduce its logistics cost through three measures:

   (i) Transport costs can be reduced by improved modal share, trucking efficiency, and reducing fuel costs.

   (ii) Inventory costs can be reduced by improving warehousing infrastructure, and by enhancing supply chain design and management.

   (iii) Admin costs can be reduced with modern IT and management techniques. By reducing these costs, India can save INR 10 lakh crore in 2022.

e) According to NITI Aayog (2019), Government of India has prioritized IoT, AI, and Big Data to transform business of supply chain and logistics, spending Rs 100 crores in the area, which is igniting the overall demand for digital logistics domain in the country. Globally, it is estimated that 25-30% of logistic carriers travel empty on their return journey & 85 million deliveries are made daily. With growing market demand, Digital logistics solutions can offer environment

friendly practices, such as alternative fuel-powered transportation, optimized fuel-efficient route planning, and packaging optimization.

f) In this regard, Telecom plays a fundamental role in providing the digital backbone and connectivity for various infrastructure projects through its ability to establish and maintain robust communication and data networks. It is well understood that frontier technologies like 5G technologies, IoT, AI and Big data analytics are also expected to play a significant role in digital transformation of the industry, manufacturing and logistics sector.

g) DoT is coordinating to get various telecom assets like optical fiber cable (OFC), Tower/ BTS etc. mapped on the NMP platform. It may be noted that already more than 10 lakh route kilometers of OFC of Government PSUs like BSNL, BBNL, GAIL, POWERGRID, RAILTEL etc. has been mapped on this portal. In addition, 5.72 lakh towers with about 19 lakh BTSs have also been mapped. This GIS mapping not only helps in quick Fiberisation of the unfiberised BTS but also helps in utilization of the unused OFC. This geo tagging will also help state governments to map the street furniture. This will eventually lead to not only proliferation of 5G services utilizing the data of OFC, towers and street furniture available in PM Gatishakti but also for other ICTs. DoT has allocated spectrum for 5G in the 3.3-3.6 GHz and 24.25-25.5 GHz bands. This spectrum will be used by telecom operators to roll out 5G services in India. Street furniture guidelines issued by DoT and circulated to all states to identify the street furniture and mapping in PM GatiShakti portal.

h) DoT has already issued the guidelines to all state governments for use of street furniture in rolling out 5G networks. Therefore it is a high time that the progress on mapping of OFC, street furniture and towers may be assessed, which ultimately help for different use cases of 5G, IoT & AI etc for the tailored application in the different areas of Logistics sector can be made feasible for improvement in logistics efficiency.

i) The application of frontier technologies like AI & machine learning, Block Chain technology, Big data and data analytics, 5G technology, IoT, cloud computing,

Autonomous vehicles , Augmented Reality etc. in the logistics sector has the potential to transform the way goods are transported, stored, and managed. These technologies have potential to enhance efficiency, reduce costs, and improve overall supply chain management. Therefore, the need is apparent to examine such frontier technologies which can play an important role in the logistics sector leading to cost savings, improved efficiency, enhanced customer service.

1.6 Research Questions:

The research questions are as below:

i. What are the different parameters of Telecom layer in PM GatiShakti, related to logistic sector in the country?

ii. What are the roles of telecommunications and frontier technologies in logistic sector?

iii. What are the issues and challenges in use of telecommunications and frontier technologies in logistic sector?

iv. What can be suggestive measures to facilitate use of frontier technologies to improve efficiency in logistic sector?

1.7 Limitations:

Few limitations of the research process are anticipated in the study. These limitations are as follows:-

(i) Owing to paucity of time due to short duration of the course, the study is limited for use of telecommunications and frontier technologies in logistics sector.

(ii) Due to limited time duration, sample size and geographical spread for study is limited.

(iii) Ambit of research is focused on the key areas specified in Research Objectives due to time and resource constraints.

(iv) Limited accessibility to policy makers in Departments/Ministries and key stakeholders in industries for interview.

1.8 Chapterisation : The broad Chapterisation scheme for the research Report is as under:

Chapter 1: Introduction: This Chapter provided a brief description of PM GatiShakti National Mater Plan and National Logistics Policy 2022 and description on background, status and importance of logistic sector in India. In this Chapter, the developments occurring in telecom sector, initiatives by DoT related to Logistic sector is also given.

Chapter 2: Review of Literature: This chapter includes description of literature reviewed.

Chapter 3: Logistics Sector: An Overview: This chapter gives the overview and status of logistics sector in the country.

Chapter 4: Roles of Telecommunications and Frontier technologies in Logistics sector: This chapter has studies and highlights status of Telecom layer in PM GatiShakti Portal. The successful use cases of telecom layer have also been discussed. The roles of telecom and 5G technology in Logistics sector are examined. Roles of frontier technologies (AI, Blockchain, IoT, Big Data, and Cloud) in logistics sector are also examined. This chapter also includes the global trends for adoption in the sector. Further, the initiative taken by the Government in digitalization and automation in the logistics sector is explored.

Chapter 5: Analysis of Data and Research Findings: The content analysis of literatures and the data collected from various stakeholders using the questionnaire, interviews has been brought out in this Chapter. Further the issues and challenges faced in use of telecommunications & frontier technologies in the logistic sector have also been explored.

Chapter 6: Conclusions and Recommendations: This chapter provides the conclusions emerging from the study and enlists recommendations for better implementation of the program.

Chapter 2

Review of Literature

2.1 The website PM GatiShakti has been accessed and the content available on this website has been reviewed.PM GatiShakti National Master Plan has been launched to provide multimodal connectivity infrastructure to various economic zones. This master plan is a transformative approach to enhance economic growth, infrastructure development, and the completion of projects in a time-bound manner.

2.2 Apruzzesse et al. (2023) studied the potential uses of digital technologies, like IoT, Blockchain, AI, and 5G, in optimization of supply chains and port operations. In this study, the common objective observed is that by use of innovative technologies, effectiveness of logistics processes can be improved through continuous monitoring and resource optimization. 5G infrastructures are regarded as the backbone to implement other technologies.

2.3 The National Logistic Policy (2022) envisages “driving the country's economic growth and business competitiveness through an integrated, seamless, efficient, reliable, green, sustainable, and cost-effective logistics network by leveraging best-in-class technology, processes, and skilled manpower”. This will help in reducing logistics costs and improve performance.

2.4 Song et al.(2021) reviewed about application of IoT technologies in smart logistics from the perspectives of logistics transportation, warehousing, loading/unloading carrying, distribution & information processing. It is pointed out that data security, privacy and resource management will be big challenges in future due to enormous data generated by IoT devices.

2.5 Feng et al. (2021) stated in the article that application of IoT, big data analytics, and AI in smart logistics differentiates form those used in traditional logistics with four characteristics namely: intelligence, flexibility, integration of logistics and self-organization.

2.6 Naik L et al. (2022) attempted to identify the barriers to the logistics sector's growth and deliberate the solutions for making unified end-to-end logistics. They have stated to adopt innovative models, latest technical systems, global best practices and a systematic implementation strategy can all assist the strengthen the logistic sector and thus stimulating growth and employment in India.

2.7 Lagorio et al. (2022) in the published paper through systematic literature review (SLR) has attempted to identify the main areas and activities in logistics in which 5G can be implemented. The paper pointed out that currently, industrial applications of 5G technology in logistics are few. The reasons are that integration of 5G with other technologies is complex and require training to the workforce in addition to the high costs required to build a stable network infrastructure.

2.8 Lagorio et al. (2018) has attempted to study about the interest of scholars on the technologies supporting the logistics management most adopted technologies in Logistics field. After the study, it has been brought forward that RFID and IOT are most cited technologies. RFID is most used and IOT is more recent and expanding technology coupled with Big Data.

2.9 Choy et al.(2014) stated that Warehouse management System & Transport Management system are considered as the necessary tools for supporting Warehouse & delivery process in the logistics industry. Logistics process and service performance can be improved by using Business Intelligence and logistics Information systems (LIS), finally giving long term competitive advantage.

2.10 According to Fatas et al. (2009) in their paper '4Is of Economic Growth', over a long period of time, the increase in the economic well-being in the world can come only from innovation. Often innovation is associated with new technology or new products, but in reality a significant amount of innovation is also about new ways of producing the same old things, through better management and better organization of production. We use

the term innovation to signify both technological inventions and managerial or organizational innovations. In our discussion, it is useful to introduce the concept of the world technological frontier. “A country whose production possibilities and organizational structure are located at this frontier uses the most advanced technology, the most advanced capital, the most skilled labor and implements best managerial practices to produce a variety of goods and services.”

2.11 Temjanovski et al. (2021) state that the main issues facing logistics businesses and their end users in day-to-day operations are supply chain visibility, transportation costs, business procedures, and customer service. The majority of these difficulties can be surmounted by implementing cloud computing in supply chain management, which offers two different kinds of chances.

2.12 Cichosz et al.(2020) in their research has analysed that an obstacle that Logistics Service Providers (LSPs) primarily struggle with is complexity of the logistics network and underlying processes. The second identified barrier relates to lack of resources i.e. shortages of human and financial resources. The third barrier pointed out on the top of employees’ resistance to change is technology adoption.

2.13 According to KPMG's research (2022), there is a lack of digitization, standardization, and automation in transportation activities such as load planning and vehicle routing. For instance, real-time visibility into inventory flow is lacking and radio-frequency identification (RFID) tracking is not used to its full potential. The common warehouse operations are not automated. Due to a decrease in the pace at which commodities move through the supply chain, this results in excess inventory holdings and inventory loss because operators lack adequate visibility into the stocks and locations of inventory.

2.14 Santhi et al.(2022), mentioned that Blockchain technology has the potential to the supply chain and logistics infrastructure to bring

significant advantages in many ways such as trust, transparency, traceability, security, and flexibility.

2.15 According to Horvyi et al.(2023), leaders in decision-making positions might be aware of the available options in the market, yet they find it difficult to comprehend how these solutions align with their specific business objectives and needs. This uncertainty leads to apprehension about the financial investment, the time required for implementation, the process of training staff on the new logistics automation system, and the eventual return on investment. As a result, a lot of logistics executives are hesitant to invest in a system that could soon become obsolete or superseded by more recent models. They added that there is a common misperception that using robotic process automation (RPA) in logistics means that human workers must be totally replaced by machines and software, or that automation completely removes the need for human monitoring at every stage of the process.

2.16 According to Tijan,.E. et al.(2019), Blockchain technology is the promising solution for overall improvement in logistics. This technology can assist to reduce or eliminate fraud and errors, minimize costs and delays, improve inventory management and also help to identify issues faster.

2.17 Cil,.A.Y. (2022) have stated that IoT-enabled cold chain logistics systems, have a great deal of promise for managing, monitoring, receiving, and identifying abnormal events connected to temperature-sensitive products in real time.

Chapter 3

Logistics Sector: An overview

"Logistics sector will be a cornerstone in our endeavor to take India to a 10x growth from a USD 3.5 trillion to USD 35 trillion by 2047"

By Shri Piyush Goyal,

Hon'ble Minister of Commerce and Industry

3.1 Logistic Management- Concept & Definition:

3.1.1 As per IIMM (2020), the Council of Supply Chain Management Professionals (CSCMP) defines "logistics management as that *part of supply chain management that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption to meet customers' requirements*. *The CSCMP explains logistics management as the management activities that include inbound and outbound transportation management, fleet management, warehousing, materials handling, order fulfillment, inventory management, demand and supply planning and management of third-party logistics service providers*".

3.1.2 As per IIMM (2020)*, "Logistics management involves storage, distribution, warehousing, goods handling, transportation, monitoring and delivery of goods. It also entails planning, organising, managing, coordinating and controlling the flow of goods to ensure that goods reach the right place, at the right time, for the right cost and in the right condition".*

A pictorial representation of logistics management is shown in Figure 3.1:

Figure 3. 1: Logistics Management

(Source: Book by IIMM)

3.1.3 As per ARAMexpress, the global logistics market was valued at $9.96 trillion in 2022. This is expected to grow at a CAGR of 6.3% between 2023 and 2028 to reach a value of almost $14.37 trillion by 2028.

3.2 Importance of Logistics Management:

The importance of logistics management for an organization are in Quality products, increased transparency, increases revenue, enhances goodwill, customer satisfaction, on-time delivery & communication. The major components of logistics management are storage, warehousing & material handling, packaging, inventory, transportation, Information & control and order processing.

3.3 Transportation is a cornerstone of the logistics sector, serving as the lifeline that facilitates the movement of goods from production facilities to end-users. Its role is pivotal in ensuring the seamless functioning of supply chains and delivery of products on time. The primary function of transportation in logistics is to provide connectivity, linking various points within the supply chain and enabling the flow of goods across different stages of production, distribution, and consumption. On transportation mode, the India logistics market has been divided into roadways, seaways, railways, and airways.

Among these, roadways currently have dominance in the market. This is illustrated in Figure 3.2

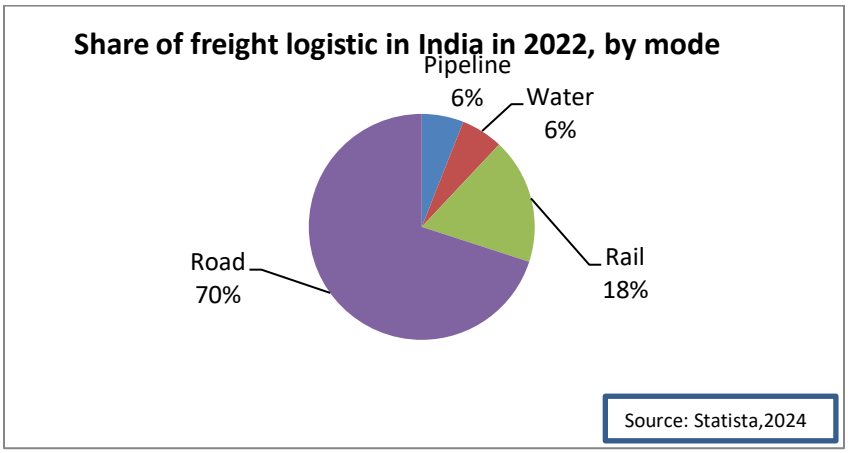

Figure 3. 2: Share in freight logistics in India

(Source: *https://www.statista.com/statistics/1248877/india-share-of-freight-logistics-by-modes/)*

3.4 As per report from Statista, the digital logistics market in transport segment dominates with a revenue share of 55% integrating technology, data analytics, and automation to optimize supply chain operations. Different modes of transportation are:

(i) Road Transport:

According to the India Brand Equity Foundation (IBEF), India has a total road network of nearly 64 lakh km, which is the second largest in the World after the United States of America and the National Highways network alone stood at 145,240 km in 2022-23. The Government of India has allotted Rs. 111 lakh crore under the National Infrastructure Pipeline for FY19-FY25.

As per India Infrastructure research report (2021), technologies such as artificial intelligence and computer vision to improve safety and commuter experience across all expressways and access-controlled corridors will be used. In addition, MoRTH is implementing intelligent transport system applications across various National Highways (NH) to optimise traffic flow and improve road safety.

(ii) Rail Transport:

The Indian railway system is considered as the foundation and lifeblood of the economy. Indian railways network is stretched in thousands of kilometres practically covering the entire nation, and is the fourth largest network in the world after the US, China, and Russia.

IBEF estimates that in 2022–2023, freight will account for 69% of Railways' internal earnings, while passenger traffic will account for 24%. The final 7% will come from other sources of income such as parcel service and sale of platform tickets.

As per Statista, in 2022, around 70 percent of the overall freight transportation in India was carried out by road. As per NITI Aayog, Rails's proportion in freight transportation is on decline since 1951 in the country. As of 2020, Railways accounted for only 18 percent of the total share, while road transportation had a share of 71 percent. This is primarily because the rail capacity is insufficient, especially on high-density routes. However, several factors suggest that Railways could be a cost effective and efficient choice for a significant portion of India's freight transportation needs.

(iii) Inland Waterways:

According to Logistics Skill council, there are 111 officially notified Inland national waterways in India that cover a network of approximately 20,275.5 kilometers. In 2017-18, these waterways handled 55 million tonnes (MT) of cargo, and in 2018-19, they handled 72 MT. It is expected that they will be able to handle 100 MT by 2021-22. In many countries, share of freight mode through waterways has decreased over the last two decades due to various reasons such as limited investments in waterway channelization, dredging, docking facilities, fleet capacity, and efficiency. If transportation by inland waterways is utilized as a single mode of transportation or through multimodal transportation, logistics costs can be reduced to $1/10^{th}$, compared to the logistics cost incurred by road transport. Inland waterway transportation is an ideal option for transporting dangerous goods and less time-sensitive goods. India, with such a large network of inland waterways, can leverage

transportation by inland waterways, which will seamlessly provide connectivity to the ports.

(iv) Seaways:

According to the Ministry of Shipping, India heavily relies on maritime transport for its trading needs, with about 95% of volume and 70% of value being traded through this mode of transport. There are 12 major and more than 200 notified minor and intermediate ports in India. The Sagarmala project aims to develop six new mega ports in India. This programme is the flagship initiative of the Ministry of Ports, Shipping and Waterways. Its objective is to promote port-led development in the country by utilizing India's extensive coastline, which spans over 7,500 km, its 14,500 km of potentially navigable waterways, and its strategic location on major international maritime trade routes.

As per IBEF, India is the 6th largest maritime country in the world having coastline of 7,516.6 kms. In order to bolster the port industry, the Indian government has authorized up to 100% of Foreign Direct Investment (FDI) through the automatic route for port and harbor upkeep and building projects.

(v) Airways:

2023 Logistics Performance Index (LPI) released by the World Bank, around $6 trillion in goods—equivalent to 35% of the global trade value—is shipped annually via air freight. In 2023, the air freight industry in India was valued at approximately $13.08 billion and is expected to increase to $17.22 billion by 2028, with a compound annual growth rate (CAGR) of 5.65%.

Shankaran's (2023) web article reveals that India's air cargo sector handled 2.2 million tonnes of goods, which is one-fifth the volume of China's and one-tenth that of the U.S. market, with domestic flights accounting for 30% of this volume and international flights the remainder. Despite a recent downturn, India's air cargo volume remained at 2.2 million tonnes in 2022, with forecasts suggesting it could reach 10 million tonnes by 2031.

3.5 As per the report of Netscribes (2022), Warehousing is vital for inventory management and meeting rising demand, becoming essential with the growth of e-commerce. Key industry players include Container Corporation of India Ltd., Gati Ltd., Mahindra Logistics Ltd., and Central Warehousing Corporation. In 2021, the logistics and industrial sectors saw a 55% YoY investment increase to USD 1,313 Mn, driven by demand from e-commerce and third-party logistics. The Indian warehousing market is projected to grow at a CAGR of approximately 15.64% from 2022 to 2027, reaching INR 2,872.10 Bn. The expected net absorption of warehouse space in 2022 is a record 42.5 Mn square feet, with major contributions from six metropolitan cities. The growth of the logistics and warehousing business in India is being fueled by the expansion of the e-commerce industry in that nation.

3.6 World Economic Forum (2013) has stated that reduction in supply chain barriers to trade could help to increase global GDP by nearly 5% and trade by 15%. Al Kaabi (2022) in his article "one of the top topics was global logistics trends that are shaping the future of the industry" has stated that the logistics industry is experiencing substantial changes due to the emergence of autonomous delivery, smart logistics, and sustainable logistics, as well as the expansion of cross-border e-commerce. The industry has been evolving continuously, adopting new technologies to meet the changing demands of customers brought on by the growth of e-commerce.

3.7 E-commerce: As per LPI report 2023, released from World Bank, the volume of e-commerce has increased in the last decade. By 2030, it is expected that cross-border e-commerce in goods will grow from its current US$300 billion to US$1– US$2 trillion in merchandise value, resulting in major changes in supply chains. In 2019, E-commerce has a share about 30 percent of global GDP, so its role and significance in economic development cannot be overlooked.

3.8 World Bank LPI report: The World Bank's Logistics Performance Index (LPI) evaluates countries based on six key elements: (a) how efficiently customs and border procedures are managed. (b) The standard of infrastructure related to trade and transport. (c) The simplicity of securing competitively priced international shipping. (d) The skill

level and quality of logistics providers. (e) The capacity to monitor and locate shipments. (f) How often deliveries arrive at their destination on time as scheduled or anticipated.

3.9 Digitalizing supply chain operations generates granular high-frequency datasets by recording data at each step in a supply chain process (as figure 3.3 below).

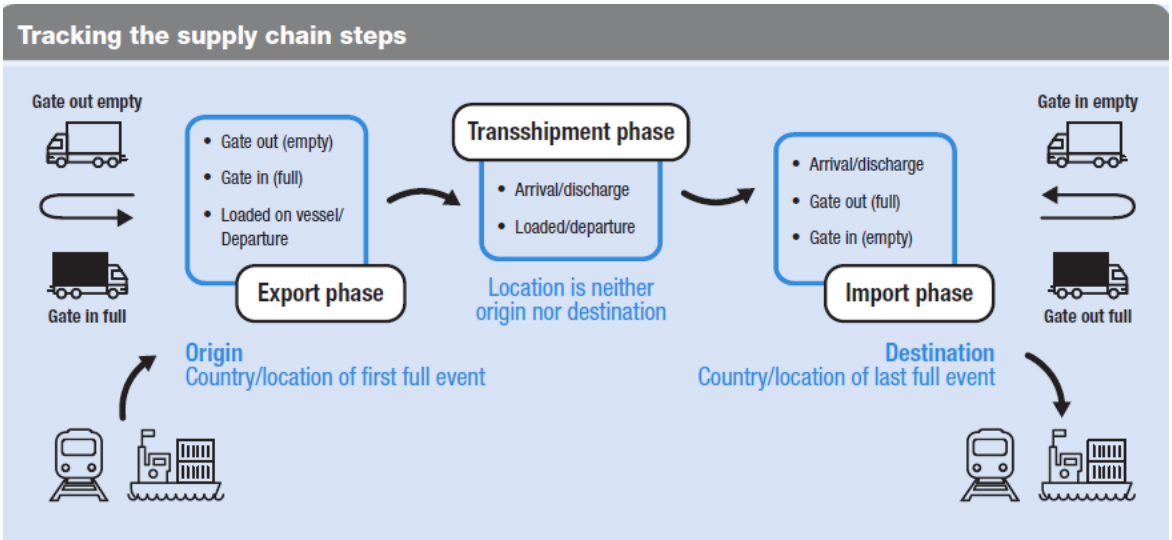

Figure 3. 3: Tracking of supply chain

(Source: LPI report 2023)

3.10 As per KPMG report, transportation holds around 62% of the total Logistics cost. Inventory holds 34% of the total cost. (Figure 3.4)

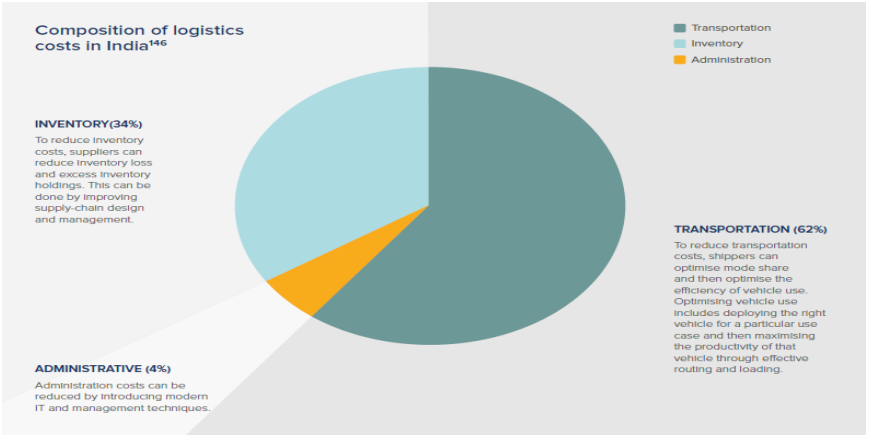

Figure 3.4: composition of costs in Logistics

(Source: KPMG Report, The logistics and warehousing market in India, October 2022)

3.11 KPMG (2022) has observed that around 75 percent of the market is run by small operators who own up to five trucks. Big fleet operators who own more than 20 trucks in the market are only 10 %. Smaller players are less able to invest in larger vehicles, digital equipment and software, and the knowledge needed to run them. They are also unable to optimize their operating patterns. Overloaded trucks and decreased asset utilization are the results of this market structure.

3.12 As per Deloitte (2018), economic advantages of digital technology utilization is not well understood and stakeholder's collaboration is still far from acceptance. Poor asset utilization and operational inefficiencies are so common in the logistics ecosystem. Inadequate technical understanding and outdated technological systems aggravate the problem. The current state of technological infrastructure is still insufficient, as seen by poor network speeds. There are insufficient EDI (Electronic Data Interchange) facilities and IT systems. As a result, it is not always feasible to rely on a standardized system for electronic information transfer, which makes it challenging to find out the current condition of services and operations.

3.13 According to Kumbar et al.(2023), different logistics stakeholders often use disparate data formats for storing and sharing information, which hinders seamless integration between various logistics management systems. This lack of standardization leads to data inconsistencies and impacts the effective implementation of automation and AI solutions in the logistics sector.

Chapter 4

Roles of Telecommunications and Frontier Technologies in Logistics Sector

4.1 Telecommunications layer in PM GatiShakti:

4.1.1 As of September 30, 2023, India's Telecom sector ranks as the world's second largest, has a total of 1181 million users (including both wireless and wireline). India has an overall tele-density of 84.76%, of which, the tele-density of the rural market, stands at 58.05% while the tele-density of the urban market is 133.54%.

By the end of September, 2023, the total number of internet subscribers (narrowband + broadband subscribers), increased to 918.19 million out of which 41.72% are rural internet subscribers.

4.1.2 DoT (2023) has coordinated with BISAG, DPIIT and TSPs and other stakeholder for data management in PM GatiShakti platform. As part of PM GatiShakti NMP, DoT has more than 6 layers having different attributes, Sub-layers, upload methodology, and frequency & meta Data as mentioned below:

(a) Layer1: Mobile Towers: This layer contains mobile towers, along with its base transceivers stations, technologies (4G, 5G etc.), and Telecom Service providers present on that tower.

Attributes: Different attributes in this layers are there such as Tower id, State, Districts, Longitudes, Latitudes, Address, Site Type (Type of towers- Ground based/Roof Top/Wall Mount) Tower Height, Status of Fiberisation, etc.

Upload Methodology: Currently, data verified by TSPs are given to DoT field units and then forwarded to BISAG by DoT via email. Further, in phase-1, TSPs will upload, verify & approve and DOT filed units will publish through data management module being developed by BISAG.

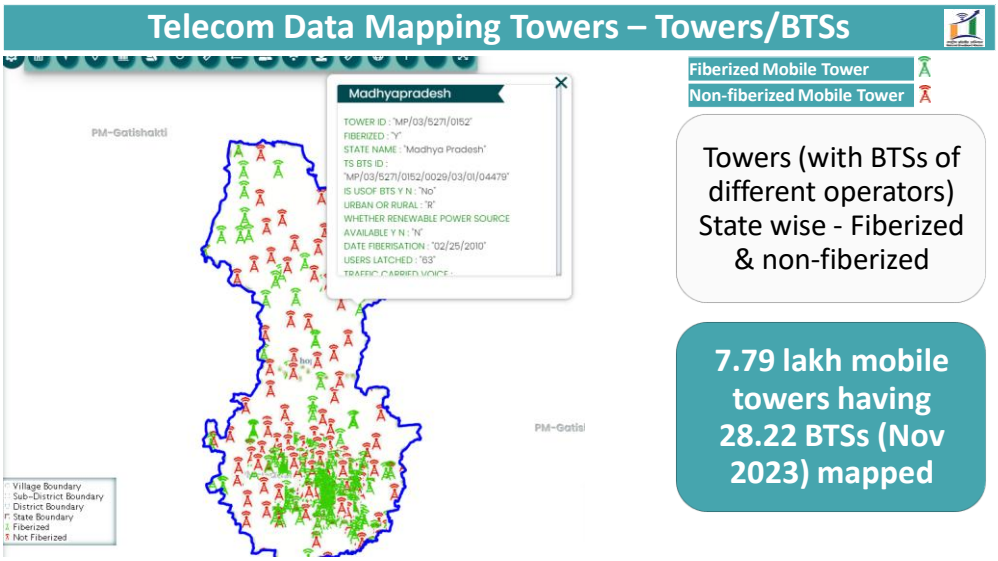

Figure 4. 1: Layer of Mobile Towers

(Source: DoT, National Broadband Mission)

(b) Layer 2: PM WANI Wi-Fi Hotspots: This layer contains PM WANI Wi-Fi access points across India.

Attributes: Different attributes in these layers are there such as PDOA, State, Latitude, Longitude, SSID, etc.

Upload Methodology: Currently, verified data is being provided by CDOT through email and provided to BISAG on email. In next phase, this will be done through API based integration with CDOT.

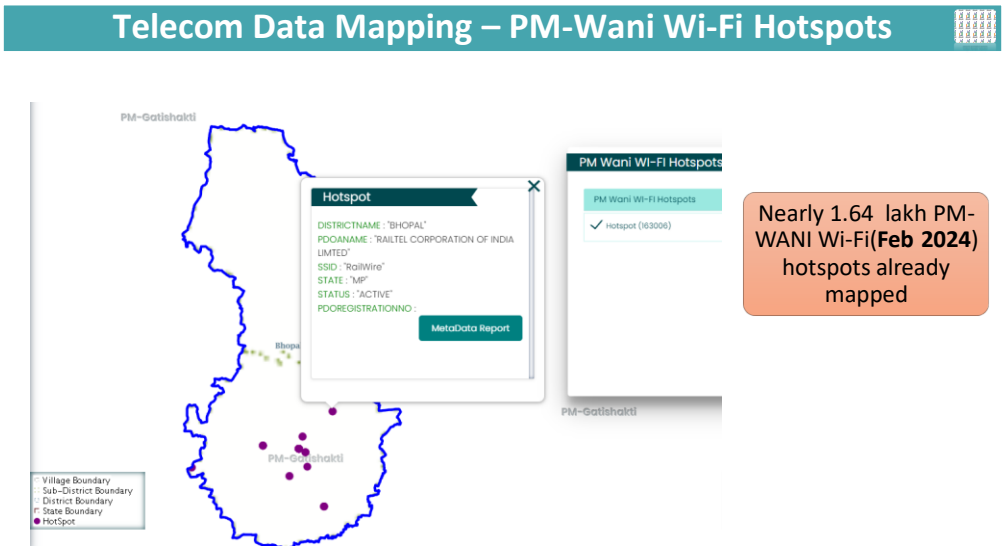

Figure 4. 2: Layer of PM Wani- Hot Spots

(Source: DoT, National Broadband Mission)

(c) Layer 3- Optical Fiber: This layer contains all OFC laid by Class A, B & C Internet Service Providers (ISPs) across Pan India and other PSUs like Railtel, Bharat Sanchar Nigam Limited (BSNL), Bharat Broadband Nigam Limited (BBNL), Mahanagar Telephone Nigam Limited (MTNL), Tata Communications Limited (TCL), Gas Authority of India Limited (GAIL).

Attributes: Different attributes in these layers are there such as PDOA, State, Latitude, Longitude, SSID, etc.

Upload Methodology: Currently, data is given by TSPs to DoT for onward transmission to BISAG through email. Under Phsae-1, TSPs will upload, verify & approve through data management module. Under Phase-II, uploading will be done through API integration with respective operator.

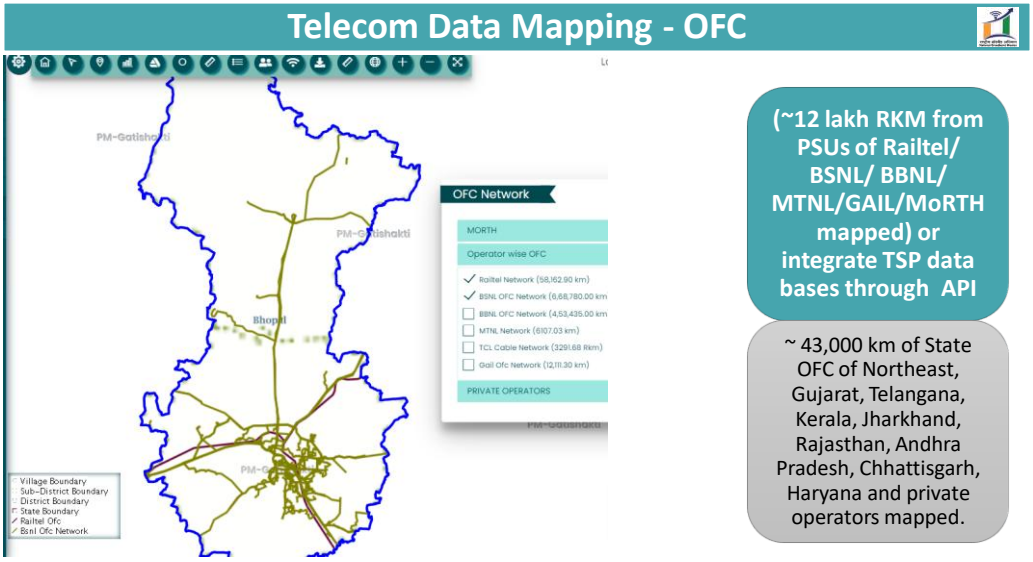

Figure 4. 3: Layer of OFC

(Source: DoT, National Broadband Mission)

Sub layer 3: Network elements:

This is the sub layer of Optical fibre and contains details of elements like Optical Line Terminal (OLT), Optical Network Terminal (ONT) etc.

(d) Layer 4: street Furniture. This layer is to be pulled from State Master Plan (SMP) on PM GatiShakti MNP and consists of telecom related data of street furniture like electic poles, streetlights, Government buildings etc. which can be used by TSPs for planning of 5G.

Attributes: Different attributes in this layers are there such as Street furniture type (like electric poles, streetlights etc.), authority, State, City, Latitudes, Longitudes, Street furniture heights, structure type of street furniture etc. (Roof Top/Wall Mount) Tower Height, Status of Fiberisation, etc.

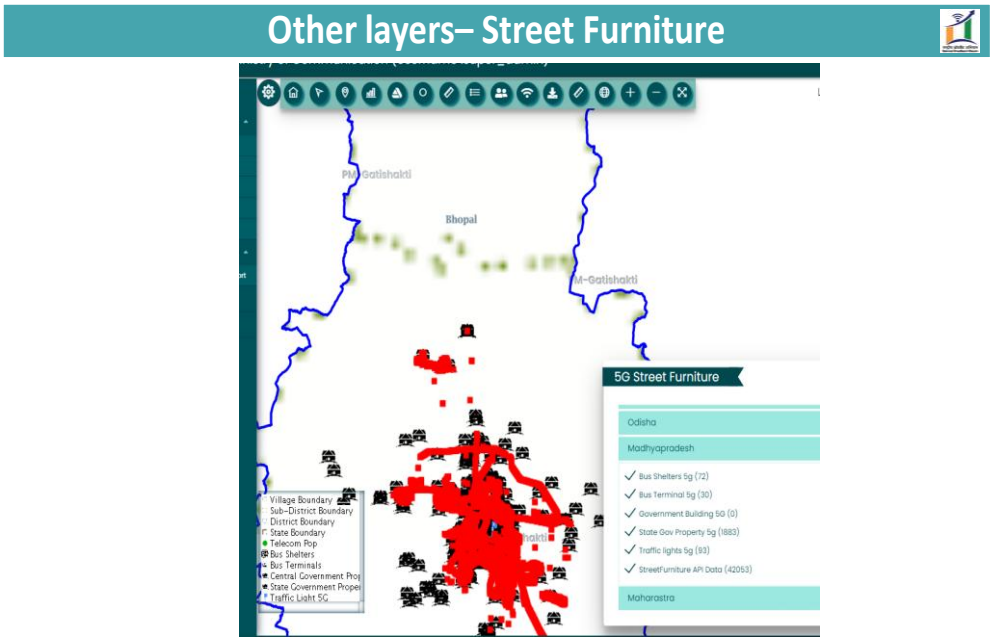

Figure 4. 4: Layer of Street Furniture

(Source: DoT, National Broadband Mission)

Upload Methodology: Currently, data is given by States/UTs to DoT and given to BISAG via email. The, BISAG will pull from State NMP through API integration.

(e) Layer 5: Village connectivity: This layer is derived from the existing layers on NMP. This layer shows what all telecom infrastructure exists in a villages like mobile towers, optical fibers, Wi-Fi hotspots etc.

Attributes: Different attributes in this layers are there such as Villages, code, state/UTs/Wi-Fi, 2G, 4G, 5G , fibre etc.

(f) Layer 6: USOF Mobile Towers: This layer contains all mobile towers under various projects of USOF, DoT, both planned as well as radiating the country. It shows which technologies (4G, 5G etc) and which TSPs are present on the mobile tower.

Attributes: Different attributes in these layers are there such as Site ID, IP name, Latitude, Longitude etc.

4.1.3 Successful uses of Telecom Layer of PM GatiShakti :

(a) 4G Saturation: Portal has been used to assess and provide the coverage in approximately 25000 villages in the country.

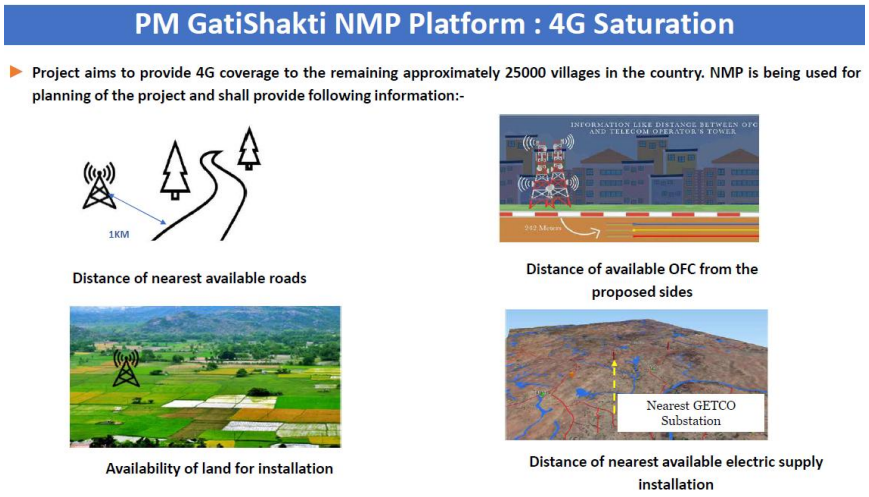

Figure 4. 5: 4G Saturation

(Source: DoT, National Broadband Mission)

(b) Shortest Distance Tool: The tool has been used to determine the shortest distance from the point of interest.

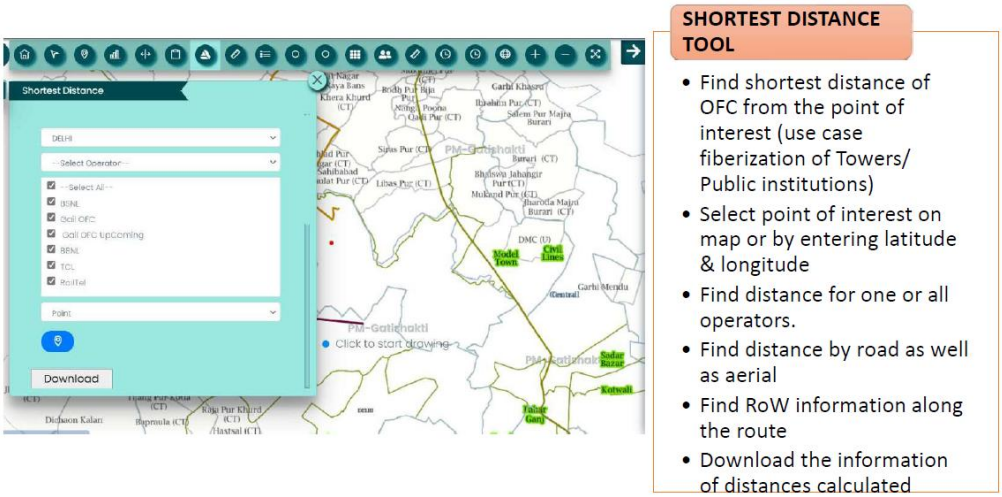

Figure 4. 6: Shortest Distance Tool

(Source: DoT, National Broadband Mission)

(c) Line of Sight Tool: The tools help to determine the height of towers for clear line of sight

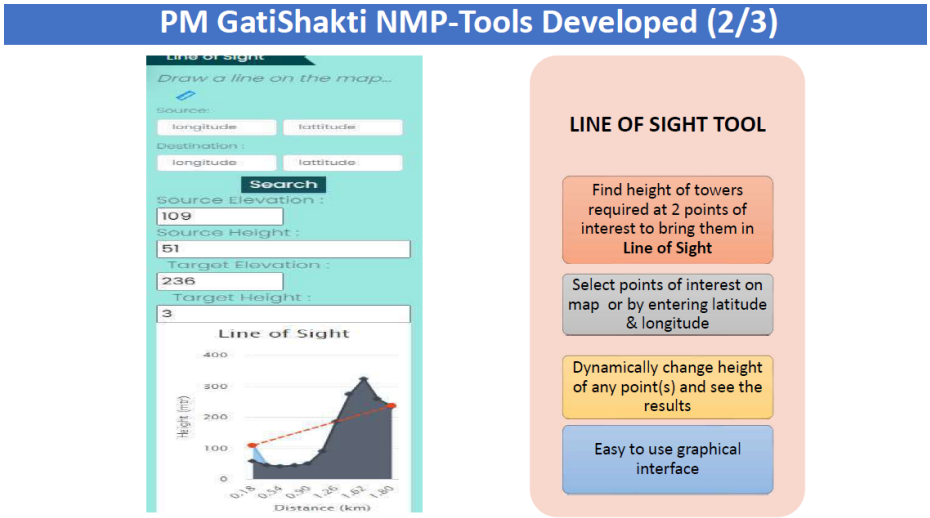

Figure 4. 7: Line of Sight Tool

(Source: DoT, National Broadband Mission)

(d) 5G planning Tool: The tool is being used for 5G planning to check the coverage.

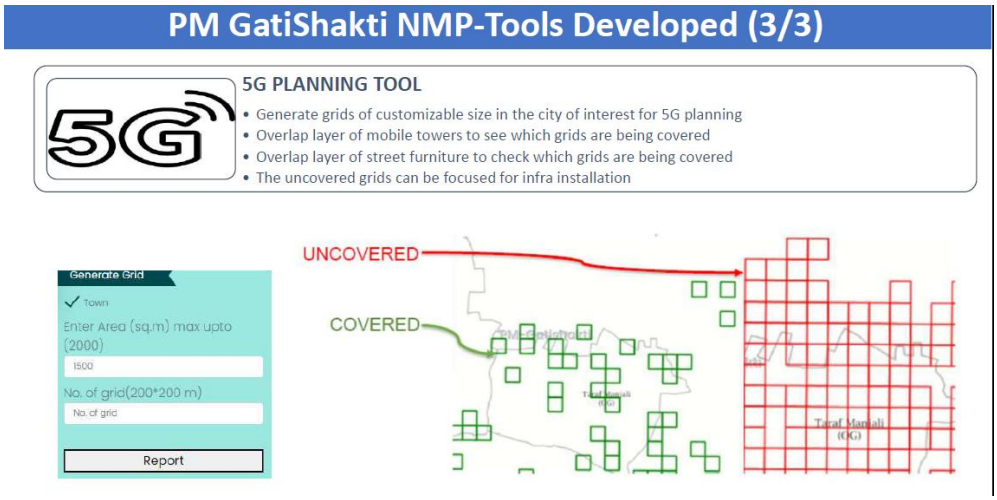

Figure 4. 8: 5G Planning Tool

(Source: DoT, National Broadband Mission)

4.2 Roles & benefits of Telecommunications in Logistics Sector

4.2.1 Telecommunications plays a crucial role in various aspects of the logistics sector, functioning like the nervous system of the entire operation. Here are some key areas where telecommunications contributes significantly:

(i) Enhanced Visibility and Tracking: Moumen et al. (2023) state that the integration of IoT and GPS allows tracking of fuel intake, velocity details as well as the engine's health condition, providing a useful input to increase efficiency, safekeeping and decision-making.

Use of Telecommunications whereby logistic companies trace goods location, status and time expected to them hence reducing losses & thefts while satisfying more customers.

(ii) By telecommunications infrastructure (like internet), logistics management software can be coupled with other solutions such as warehouse management systems, transportation management systems or their centralized system.

(iii) Telecommunications are interfaces through which suppliers, manufacturers, distributors customers communicate thus collaborate and share information together.

(iv) The telecommunication infrastructure is essential for gathering and analyzing real-time data from different points including vehicle sensors, warehouses & infrastructure.

The route optimization can be based on this information as it helps to determine demand of commodities according to customer preference among others; this reduces maintenance costs by managing possible breakdowns before they occur.

(v) E-commerce: Telecommunications is an important part of e-commerce platforms which facilitate online purchases by linking buyers to sellers.

4.2.2 5G technology is ready to revolutionize the logistics sector, by offering significant advantages over previous generations of cellular networks. Here are some key roles 5G plays in the logistics sector:

(i) Enhanced Connectivity and Speed: 5G offers vastly higher data transfer speeds compared to 4G, allowing for the rapid transmission of large datasets, real-time video streaming, and seamless integration with various sensors and devices:

Real-time Tracking: According to Khatib et al.(2021), 5G will improve real-time tracking through Sensors installed on vehicles, containers, and warehouse equipment can transmit data in real-time, providing status about location, condition, and environmental parameters. According to Apruzzese et al.(2023), real-time information access allows for quicker and more informed decisions regarding route optimization, inventory management, and resource allocation.

(ii) Massive Machine Type Communication (mMTC): 5G technology can support the connection of a massive number of devices simultaneously, leading to:

Smart Warehouses: According to Khatib et al.(2021), in smart warehouses, 5G enables the use of IoT and AI for inventory management, streamlining operations and reducing human errors through automation and enhanced connectivity.

(iii) Ultra-Low Latency Communication: 5G boasts significantly lower latency compared to previous generations, meaning minimal delay in data transmission.

According to Gilmore (2020), the fifth generation (5G) of wireless technology allows data to be transmitted with almost no delay. Low latency is critical factor in applications/systems requiring intsant action and, as a result, demand extremely low

latency of 10 milliseconds or less. Examples of such applications include autonomous driving systems and high-speed processes.

Remote Monitoring and Control: The high reliability and low latency of 5G allow for remote monitoring and control of logistics operations, facilitating the management of logistics from distant locations (Cheng, 2022).

(iv) Enhanced Communication with IoT Devices: 5G's ability to support a vast number of connected devices simultaneously revolutionizes logistics operations by ensuring seamless communication among IoT devices throughout the supply chain (Trichias et al., 2021).

(v) According to Hofman(2023), 5G can support technology, improving its speed, accuracy, faster speed and reliability. It offers vastly better connectivity.

(vi) As per Apruzzesse et al. (2023), 5G can have significant effect to improve supply chain visibility, connect and support more smart devices.

4.3 Roles of Frontier Technologies in Logistics Sector:

4.3.1 Fatas et al. (2009) in their paper "The 4 I's of Economic Growth" presented the essence of economic growth theory, which are summarized as below:

(a) "Innovation: The **incentives** to innovate (e.g. respect of intellectual property rights) will drive up the productivity growth in the country. This is the main force behind growth in the developed countries. **Innovation** and **Technology** drive the technological frontier of the world.

(b) Initial conditions: Provides the potential for 'catching up'. Poor economies can grow faster when they set on a convergence path to the rich economies. When underdeveloped nations begin to follow a path toward aligning with wealthier economies, they have the opportunity to accelerate their growth.

(c) Investment: In the process of convergence, accumulating capital stock plays a critical role. This requires high investment rates. It is important to invest in human capital, efficiency, technology what drives investment: stability, institutions.

(d) Institutions: Establishing strong institutions that incentivize stability is the most effective method for maintaining sound macroeconomic policies and political stability: Independent central bank, checks and balances, rule of law, transparency. These institutions facilitate business creation. There is no country that has become rich with poor-quality institutions."

4.3.2 As per WIPO, According to WIPO, there has been a technological explosion in the past 20 years that is changing how we live and work in an increasingly connected digital world. The rise and merging of frontier technologies lies at the core of what is sometimes referred to as Industry 4.0.

According to the OECD, Frontier technologies are those that will "reshape industry and communications and provide urgently needed solutions to global challenges like climate change and have the potential to displace existing processes,"

4.3.3 Frontier technologies are having a significant impact on conduct of business, innovation, and creation of new things and this rate of change is increasing swiftly. Although there is no universally agreed upon definition for this concept, frontier technologies typically operate at the intersection of groundbreaking scientific advancements and their practical applications. They are also transforming the way we communicate, solve problems, provide goods and services, as well as conduct business. Frontier technologies could be considered as advanced technology that can address global issues. Frontier technologies include:

(i) digital technologies, such as the Internet of things (IoT), Blockchain, Artificial intelligence (AI), metaverse, , big data and cloud computing

(ii) physical technologies, such as autonomous driving, 3D printing and hardware innovations and

(iii) Biological technologies, like genetic modification, enhancement of human capabilities, and interfaces between the brain and computers..

4.3.4 Further, as per ESCAP report, OECD identified the following 4 technologies which may have more considerable impacts than others in digital world: AI, big

data analytics, blockchain and the Internet of Things. World Bank has considered 5G as one of the frontier technologies.

4.3.5 While the technologies may be different and have unique functionalities, they are often inextricably linked with increasingly blurred boundaries. For example, big data is an essential component of many other technologies such as blockchains and the Internet of Things, while the development of blockchains and Internet of Things would further strengthen big data.

4.3.6 Santhi et al.(2022) in his paper has dwelled upon this question Can technology enhance supply chain and enhance their profitability? The affirmative answer is supported by three potential areas where it can create value:

(i) Enhance the speed and streamline current practices, particularly among suppliers and vendors situated at the bottom-most tier of the supply chain, often overlooked or challenging to monitor manually.

(ii) Enhance traceability and provenance throughout the entire supply chain to mitigate costs associated with using subpar quality, counterfeit, or grey market parts, facilitate seamless reverse logistics, promote a circular economy, and uphold considerations of reputation, compliance, and ethics.

(iii) Furnish real time information, which is transparent, reliable, and secure to all participants in the supply chain, eliminating errors in inventory records, preventing missing shipments, and avoiding duplicate payments.

4.3.7 World Economic Forum (2016) highlights in its report, "Digital Transformation of Industries: Logistics Industry," five key themes crucial to the logistics sector's digital evolution in the coming decade:

i. Digitally-enabled information services will play a crucial role in the logistics industry by putting data at the center of its operations. This will be achieved through initiatives such as logistics control towers and analytics as a service. These services will help in reducing operating costs while improving operational efficiency.

ii. Digital logistics services will also contribute to trade growth by creating digitally-enhanced cross-border platforms. This will allow logistics companies to meet the growing demand for faster same-day deliveries while

promoting the idea of city logistics, which will enable the firms to operate in megacities.

iii. New delivery capabilities will allow logistics to harness technologies to offer new ways to think of manufacturing and logistics processes.

iv. The concept of a circular economy will foster a more sustainable product life cycle, which will help reduce the logistics industry's environmental footprint by cutting carbon dioxide (CO2) emissions, air pollution, and waste material.

v. In the near future, shared logistics capabilities, such as shared warehouses and shared transport facilities, are expected to increase asset utilization.

4.3.8 As per Horovyi et al.(2023), The logistics automation market is experiencing steady growth, and it is expected to expand by $162.5 billion by 2030. According to a survey by Deloitte and MHI, approximately 75% of warehouses are predicted to adopt automation solutions by the end of 2023. The rise of third-party logistics (3PL) companies is another way that automation is changing the logistics industry. These companies outsource their warehouses, fleet, and supply chain management to businesses that want to transport their goods across regions without investing in equipment and employee training.

For the purpose under this study, 5 technologies, Blockchain, Artificial Intelligence, IoT, Big Data & Cloud are considered for study in the subsequent paragraphs.

4.4 Blockchain:

(i) Blockchain is based on decentralized and distributed digital ledger that records transactions across a network of computers in a secure, transparent, and tamper-resistant manner. In distributed ledger with growing lists of records (blocks) that are securely linked together via cryptographic hashes. A cryptographic hash of the previous block, a timestamp, and transaction data is stored in block. This linkage ensures the integrity and chronological order of transactions. Blockchain technology consists of blocks, each holding transaction data, a unique cryptographic hash, timestamp, and reference to the previous block, along with miner details. Miners validate these blocks in a decentralized network, removing the need for central authorities. This network relies on consensus mechanisms like Proof of Work (PoW) and Proof of Stake (PoS) to agree on transaction

validity. It operates on a peer-to-peer basis, enabling direct node communication without central servers. Additionally, virtual machines on this network execute smart contracts, ensuring secure transactions, with the Ethereum Virtual Machine (EVM) processing contracts on the Ethereum blockchain.

(ii) Dobrovnik et. al(2018) has also made the reference from Iansiti and Lakhani that Blockchain is not a disruptive technology, which threatens traditional business model with a cheap solution and overtake incumbent organization quickly. Rather, it is a foundational technology that has the potential to create new and improved economic and social systems. However, it will take several decades for this technology to become integrated into our economic and social infrastructure. Adoption will occur gradually and steadily, as technological and institutional changes gain momentum.

(iii) **Applications of Blockchain in Logistics Sector:**

(a) According to Amazon (AWS), blockchain technology can be utilized for tracking and tracing purposes. As transactions are always time stamped and up-to-date, businesses can inquire about the status and location of a product at any point in time. This helps to address issues such as counterfeit products, compliance breaches, and delays.

(b) As per DHL (2018), Blockchain technology has the potential to reduce numerous friction points in global trade logistics, such as trade financing, track and trace, customs cooperation, transportation management, and procurement. Everything pertaining to the asset can be safely documented using blockchain technology. Blockchain technology holds great promise for reducing the time and expense of administrative processes and trade documentation for shipments of ocean freight. A tamper-proof repository and safe data exchange are guaranteed by blockchain technology for these documents. The main characteristics of blockchain include asset management, security, data transparency, and smart contracts. Increased productivity, new business models that enable quicker and more efficient global trade logistics, and improved supply chain transparency and traceability are all made possible by this technology. Blockchain enables secure and trusted transactions between pseudo-anonymous parties.

(c) According to Louw. L (2024), blockchain in inventory management increases the degree of precision and security as compared to traditional solution. Application of Blockchain in inventory management also streamlines operations and minimizes the risk of errors and fraud to optimize supply chain's efficiency.

(d) As per Appsiera (2023), Smart contracts on blockchain can also be used to automate payment procedures based on predetermined criteria. Upon confirmation of delivery, the supplier or logistics provider may be paid according to the terms of the contract. As a result, financial transactions are streamlined and lessen the administrative burden of payment processing. Through smart contracts, transactions can be processed and settled with more speed.

(e) WCO/WTO in its study report on disruptive technologies (2022) has mentioned about Blockchain's potential to facilitate Customs processes is multifaceted, from Customs clearance to inter-agency cooperation, certification, identity management, compliance management, revenue collection and post-clearance audit. Through this technology, the same copy of a ledger is instantly available to all parties at different nodes in the most updated, trusted, secure and immutable manner, averting the need to keep separate ledgers by each party as done in current practice.

(f) As per Deloitte (2018), although its primary application was in the banking industry, it can also be used to guarantee that all parties involved in the logistics industry have visibility into every transaction. Without sacrificing the accuracy of the data, it can be utilized to establish shared networks across organizations that are hesitant to exchange information. In the Indian context, this technology becomes especially pertinent because of the fragmented character of the industry and the absence of common platforms for information exchange. It could be applied to multi-party logistics value chain synchronization. Blockchain technology can be utilized to remove the need for redundant documentation processes, allowing processes to be seamlessly aligned throughout the logistics value chain. Consequently, this would lessen the possibility of errors arising from human data entry at various stages throughout the value chain.

(g) According to Ernst & Young report (2023), “India@100: realizing the potential of a US$ 26t economy”, Blockchain is being used by logistics companies and ports globally to improve operations and reduce unwanted costs**.** One such example is Maersk, which collaborated with Department of Homeland Security (US) and Dutch Customs to track cargo movement using blockchain. Blockchain being actively used in the ports of Antwerp, Rotterdam, and Singapore to help in digital documentation and smart contracts and is. Rotterdam port is using blockchain to make administrative and financial streams paperless.

(h) Santhi et al.(2022), from the literature review, have come to the conclusion that the blockchain technology has the prospective to offer substantial advantages to the supply chain and logistics infrastructure of manufacturing firms, encompassing aspects such as trust, transparency, traceability, security, and flexibility.

(i) As per Ernst & Young report (2023), “India@100: realizing the potential of a US$ 26t economy”, the Ministry of Finance, India, has piloted E-Cargo Tracking System (ECTS) for secure documentation and GPS-tracking of containers. Pilot test run of ECTS was carried out at the Inland Container Depot of the Tughlakabad Import Commissionerate, Delhi. Post successful completion of the pilot, the initiative may be launched across India after an assessment of cost, time, and compliance. Also, the launch of Open Network for Digital Commerce may lead the way for increased adoption of blockchain in digital commerce.

(j) As per NITI Aayog(2020), integration with legacy systems needs to be main target of technical design choices. Given the predominance of legacy systems (such as national IDs, payment systems, supply chain information, weather etc.) in current economy, it is important for blockchain systems to develop capability to integrate with legacy systems.

This report also observed that**,** India faced unique challenges because of the scope, diversity, and intricacy of the processes involved in delivering a variety of public services Blockchain presents special opportunities for resolving problems with enhancing governance. By permitting "self-regulation," India can make significant progress in enhancing the "Ease of Doing Business" by enabling

organizations to communicate via a reliable channel and lowering their reliance on cumbersome regulatory scrutiny and compliance. It also has to be "understood separately from government regulation – networks completely regulated by governments can be decentralized and feature peer-to-peer exchange and, totally centralized systems can also be unregulated and operate beyond the bounds of law".

(k) According to Gartner interoperability remains a major roadblock to the widespread application of Blockchain based tools. In fact, Gartner named interoperability as a top technical challenge, particularly with legacy systems.

(l) As per Civati, A.(2023) Nestle and Unilever employing blockchain in their operations to track food from farm to shelf. Maersk employs blockchain to gain visibility and control over cargo movement across international borders.

(m) As per article in website, SUPRA(2022), consortium block chains will provide a potent solution for data sharing and supply chain tracking.

4.5 Artificial Intelligence:

(i) As per ITU, Artificial Intelligence (AI) comprises a rich set of methods and disciplines, including vision, perception, speech and dialogue, decisions and planning, problem solving, robotics and other applications that enable self-learning. AI is best viewed as a set of technologies and techniques used to complement traditional human attributes, such as intelligence, analytical ability and other capabilities.

(ii) Across many sectors, AI offers advantages of new and innovative services, and the potential to improve scale, speed and accuracy. AI extends and combines many of these advantages with insights from statistics and big data. AI felicitates business and policy/regulatory models to shift from descriptive analysis and trend spotting to more sensitive, proactive predictive and evidence-based models.

(iv) According to Mckinsey (2021), implementing AI-enabled supply-chain management can improve logistics costs by 15%, inventory levels by 35%, and service levels by 65%.

(v) According to NITI Aayog, AI has good number of use cases in Transportation and logistics sector as depicted in figure below:

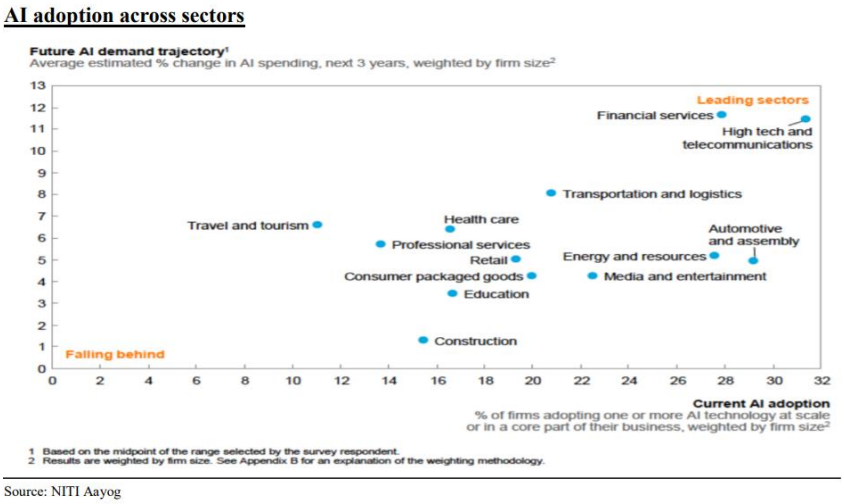

Figure 4. 9: AI adoption across sectors

(Source:*https://www.indiascienceandtechnology.gov.in/sites/default/files/AI%20Trend%20story.pdf*)

(iv) Deloitte (2018) has also suggested that Artificial intelligence (AI) can help automate business processes to reduce/eliminate manual interventions for freight handling, quality improvement, speed up processes and subsequently bring down logistics costs. Almost two-thirds of the logistics costs are hidden, which is attributable to theft and pilferage of cargo, and holding of inventory.

(v) According to Leeway Hertz, Artificial Intelligence (AI) enables supply chain managers to accurately determine the optimal stock levels, identify products that are not moving quickly, and even predict situations of possible stock shortages or surplus inventory. Real-time updates on the progress of orders and shipments can be provided using chatbots. Consumers can find out where their orders are and when they should arrive, which increases transparency and minimizes the need for customer support intervention. Based on the models and algorithms created, AI can also assist with demand forecasts, enhanced resource use, route optimizations, and predictive maintenance. By leveraging AI, operational efficiency, customer satisfaction, and profitability can be enhanced in the businesses.

(vi) According to Muynck,.B.D.(2023), AI's ability to process vast amounts of data, make intelligent decisions and predict outcomes has made it a critical tool in the logistics sector.

(vii) According to Soni's Vision (2024), these technologies like AI and blockchain interplay intricately and there are various implications for intellectual property, algorithmic bias, smart contracts, data privacy, and security. Further, legal framework requires innovative solutions to address the ambiguity surrounding ownership and protection of AI-generated content. Liability and algorithmic bias, data privacy and security, and smart contract enforceability are additional concerns.

(viii) According to Kapoor, et.al (2024), issues such as regulations have not adequately addressed issues like liability for harm caused, AI systems' rights to intellectual property, and privacy and data protection.

(ix) As per an article from India Science, Technology & innovation, some of crucial factors which determining the readiness of large scale AI adoption are viability of technical solution, availability of structured data, Regulatory framework, Privacy & Ethical issues .

4.6 Internet of Things (IoT):

(i) IoT refers to myriad Internet-enabled physical devices that are collecting and sharing data. There is a vast number of potential applications. Typical fields include wearable devices, smart homes, healthcare, smart cities and industrial automation.

Figure 4. 10: Industry evolution

(Source: *https://www.biz4intellia.com/blog/industrial-iot-vs-scada-which-is-more-powerful/*)

(ii) Statista estimates that, by 2025, the Internet of Things (IoT) will be made up of over 30 billion devices worldwide (more than four devices per person).

(iii) According to Nessadora, S, the Internet of Things (IoT) is a big deal. It helps businesses improve their supply chains. Vehicles will use sensors to track shipments. & the platform helps monitor the vehicle's functioning and alerts the system. This will help with route and location management. IoT solutions in warehouses can be helpful in inventory management, storage conditions, and preventative maintenance. Companies can use IoT platform to manage their fleets. IoT devices may be used to monitor the status of assets in real time throughout the value chain which help in Predictive diagnosis and monitoring performance.

(iv) A- team global (2023) has suggested some use cases of IoT in supply chain management and in logistics as below:

a) Through IoT sensors, the mangers can track, monitor & optimize inventory levels of goods in warehouses, distribution centers, retail stores & improve customer service.

b) IoT devices help to track the location, temperature, and other environmental conditions of goods in transit and thus providing real-time visibility & monitoring of the status of shipments.

c) RFID tags attached to the goods/vehicles can be used to track their movement in entire supply chain. IoT-enabled devices can read these tags, which transmit the data to a centralized server for real-time monitoring and further analytics.

d) GPS tracking will be helpful to track the location of goods/vehicles for real-time monitoring.

e) Predictive maintenance of assets: IoT sensors can used to monitor the performance of assets such as trucks, ships, and airplanes, to identify potential maintenance issues before the occurrence of fault and proper maintenance schedule.

f) IoT devices helps to improve safety and security of the assets/ fleets by monitoring and improving driver behavior & prompt responses to emergencies, theft prevention and potential hazards.

g) IoT enables autonomous vehicles and drones to collect and analyze data from their environment, enabling them to navigate and operate autonomously.

(v) As per xChange (2020), smart containers help to track important data like: container geo location, temperature fluctuations, geo-fencing and predictive, shock detection, door open/close status, late in/out site, any unusual activity, etc.

(vi) Reliable Internet connection is essential to IoT. Because of the movement of fleet drivers from one place to another, proper network may not be there all the time. Bandwidth is another issue of concern while implementing IoT in logistics chain.

4.7 Big Data & Data Analytics:

(i) According to EMTEC (2023), 3PL businesses can save costs, increase customer satisfaction, optimize supply chain networks, and improve operational efficiency by utilizing data analytics. Businesses can use data analytics to find patterns and trends in their data, which can improve decision-making, reduce risk, and identify development prospects.

(ii) According to Deloitte (2018), to identify areas for improvement and attain operational efficiencies in the nation's logistics framework, analytics can be applied to the entire logistics value chain. Big Data can be used to organize and carry out intricate data mining, retrieval, and statistical analysis procedures that aid in spotting important patterns and insights. After then, this study can be used to create algorithms, calculate an asset's remaining usable life, spot operational inefficiencies, cut unnecessary expenses, and influence future strategy.

(iii) According to DHL (2023), Big Data analytics ensures operational standards and increases efficiency & Customer Satisfaction. Big data makes it possible to forecast demand and capacity, improve services, reduce costs, and preserve value.

(iv) Lisowski,.H(2021) has mentioned in hig blog that Big data and analytics tools in the logistics sector can use weather data, shipment data, traffic situations, and delivery sequences for route optimization. Through operational optimization, big data offers logistics companies the chance to enhance their consumers' entire experiences. For predictive maintenance, advanced data analytics can be used to

delve further into driving behaviors including speeding, braking, and driving duration, among other things.

4.8 Cloud Technology:

(i) NIST has defined "Cloud Computing is a pay-per-use Model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., Network, Servers, Storage, Applications and Services) that can be rapidly provisioned and released with minimal management effort or service provider interaction". ITU recommendations define "Cloud service as one or more capabilities offered via cloud computing invoked using a defined interface". Cloud service is a broad term that covers all delivery and service models of cloud computing and related solutions.

(ii) The National Institute of Standards and Technology (NIST) outlines three cloud service models: Infrastructure as a Service (IaaS); Platform as a Service (PaaS); Software as a Service (SaaS).

(iii) NIST has prescribed the deployment Models as below:

a) Private Cloud: This type of cloud infrastructure either managed in-house or by a third party, caters to sensitive data and applications requiring secure environments.

b) Public Cloud: Offered by cloud service providers like AWS, this shared infrastructure excels in scalability and affordability, making it a popular choice for many businesses.

c) Hybrid Cloud: Integrating the advantages of both private and public clouds, the hybrid model offers flexibility by enabling the use of both types, ensuring optimal performance and security.

(iv) From 2023 to 2027, the cloud supply chain management market is expected to expand at a compound annual growth rate (CAGR) of 11.09%.Cloud computing has become a disruptive technology in the logistics sector, offering increased flexibility, scalability, and cost reductions. Businesses may access real-time data from anywhere in the globe, simplify procedures, and save money on hardware and infrastructure by utilizing cloud technologies in logistics.

(v) Hung(2019) has stated that at present, a new term “Logistics as a Service (LaaS)” has been coined for Logistics industry.

(vi) Hofman, H. (2023) has said that the ability to scale computing, storage, and network services in the cloud to accommodate changing demand is known as scalability. The fact that cloud computing can be finished quickly and affordably is one of the key reasons it is growing in popularity in the logistics sector.

(vii) As per Oracle (2020), cloud solutions for TMS, WMS & GTM of logistics operations tends to speed up the deployment and reduce IT costs.

(viii) Temjanovski.R (et.al)(2021) : Cloud application is becoming ubiquitous and standardized in the logistics and Supply chain management sector. The logistics industry is characterized by many parties collaboration, where stakeholders must be integrated and synchronized along the supply chain. By applying cloud computing in supply chain management, Logistics companies get huge benefits with saving costs, time, and efforts on establishing their IT infrastructure. It was also noted that Cloud computing can foster collaboration among the parties in a supply chain and can promote innovation.

(ix) Brown et al. (2023) suggest that utilizing Blockchain as a Service (BaaS) can effectively bridge the skills gap. This approach allows organizations to leverage blockchain technology's advantages without the need for substantial investment in specialized technical expertise. IBM, Amazon Web Services, and Oracle are among the notable providers offering BaaS solutions.

(x) Gupta. (2022) has pointed out in his article role of Cloud Computing in Logistics in 2023 - Benefits & Limitations that vendor Lock-In is by far the principal limitation of cloud computing. Once the company has chosen a cloud provider and started using the relevant cloud solutions, it becomes complicated to transfer to another provider.

(xi) It has been observed by Saxena (2023) that when transferring large volumes of information between Cloud data servers, a lack of sufficient internet bandwidth is a common problem. To help prevent business losses from sudden outages, high bandwidth is ensured without sacrificing performance.

4.9 Global Trends in use of Frontier technology in Logistics Sector:

(i) Industry leaders in logistics services, such as DHL Supply Chain, FedEx, UPS, and Samsara, are at the forefront of embracing and integrating various technologies to advance their digital maturity.

(ii) This digital evolution enables these companies to monitor goods delivery in real-time, pinpointing areas for enhancement and boosting efficiency. Moreover, digital tools facilitate the optimization of travel paths, the forecasting of potential delays, and the alerting of stakeholders in case of incidents or asset loss. Implementing technologies for preventative maintenance, route and fuel efficiency, fleet monitoring, and geo fencing significantly reduces expenses and time while optimizing asset usage. Analyzing data through reports, tracking metrics, and evaluating key performance indicators (KPIs) are crucial for maximizing revenue, improving productivity, and refining operational processes. Logistics Service Providers (LSPs) that offer fleet management solutions stand out by incorporating analytics, ensuring fleet security, maintaining thorough maintenance records, and providing comprehensive driver data to oversee fleet operations, thereby promoting vehicle longevity and safe driving practices.

(iii) The Port of Hamburg is the second-busiest container port in Europe. It is an important trade corridor connecting Eastern Europe to Germany and the rest of the world. It has undertaken one of the most comprehensive IoT initiatives ever seen in the logistics industry. The Authority collaborated with a number of companies to develop the 'smartPort Logistics' technology platform, which is being used for predictive and preventive maintenance. Operators receive mobile alerts on a real-time basis regarding any malfunction of an infrastructure facility within the port area, which can be resolved before it causes any damage to life and property.

(iv) Al Kaabi (2022) reports that Bahrain introduced the Global Sea-to-Air Logistics Hub in October 2021 as part of its plan to recover from the COVID-19 pandemic and stimulate economic growth. This hub, the region's fastest with a lead time of two hours and over 60 direct air routes, leverages blockchain technology, notably IBM's TradeLens for efficient and transparent customs processes, enhancing the trade's transparency.

(v) As per Delloitte (2018), in another development, the Qingdao New Qianwan Automatic Container Terminal at the eastern port of Qingdao, China, has become the first fully-automated port of Asia controlled by artificial intelligence. The terminal utilizes laser scanning and positioning to locate the four corners of each container and then accurately pick and load them onto driverless electric-powered trucks, which operate on digitally controlled routes.

(vi) As per Mike Thomas (2024), FOURKITES is a logistics company provides real-time tracking of fleet vehicles on roads, over seas and in the air using AI solutions. Its visibility technology serves shippers, carriers and logistics service providers. Its visibility technology benefits logistics service providers, shippers, and carriers. Over 3 million shipments are tracked daily by the company's Fin AI, a natural language interface that automates laborious activities like forecasting the downstream effects of supply chain issues spanning over 6,000 data points and 18 million ETAs. Some of the examples where these technogies used are :

a. **Amazon**: Pioneering in warehouse automation, Amazon employs robotics and AI through Amazon Robotics (formerly Kiva Systems), enhancing efficiency in picking and packing processes.
b. **DHL**: Utilizes AI for route optimization and predictive analytics, improving delivery efficiency and managing the supply chain more effectively.
c. **FedEx**: Integrates AI-powered robots for sorting and delivering packages, and employs AI for predictive maintenance of delivery vehicles and aircraft.

4.10 Initiatives in India in logistics sector promoting use of technology: In India, a super power in Software Industry, various initiatives have been taken to automate the different processes in the logistics sector. Major initiatives are:

(i) As per Ernst & Young report (2023) following solutions have been developed by the Government of India:

a) E-Way: It facilitates truck movements across states and reduce turnaround time. Companies are integrating e-way bill with RFID tag and GST portal, for faster movement.

b) e-Sanchit: eSanchit (e-Storage and computerized handling of indirect tax documents) supports paperless processing, uploading of support document. It saves time and facilitates international trade

c) E-Logs: Portal was developed by logistics division of DPIIT to facilitate time-bound resolution of issues. Additional functionality of registering, coordinating and monitoring resolution of user issues is being developed. As per lead report, States and UTs may also consider establishing similar digital platform and institutional setup to engage and collaborate with stakeholders to enhance the effectiveness of logistics eco-system

d) GHG calculator: Developed to promote sustainability in freight transportation. It calculates and compares total cost of operation and GHG emissions, thereby promoting a shift to low-carbon modes of transport

(ii) Transecure: Use of Blockchain for secure sharing of commercial invoice of shipments and cargo , IMEI, GPS for tracking of cargo,

(iii) National Logistics Policy (NLP) launched in September 2022, aims to:

a. Reduce logistics costs in India from 13-14% to be on par with developed nations.
b. Improve efficiency and competitiveness of Indian businesses and products.
c. Create a seamless, integrated, and sustainable logistics ecosystem through technology and skilled manpower.

Key aspects of the NLP are:

a) Focus on multi-modal transport: Promoting seamless movement of goods through waterways, railways, and roadways.
b) Digitization and automation: Encouraging use of e-logistics platforms, blockchain, and intelligent transport systems.
c) Regulatory reforms: Simplifying documentation, streamlining clearances, and harmonizing taxes.
d) Skill development: Building a skilled workforce for the logistics sector.
e) Infrastructure development: Modernizing logistics infrastructure like warehouses, cold chains, and multimodal hubs.

(iv) **Logistics Data Bank**

The Government of India, through the National Industrial Corridor Development and Implementation Trust (NICDIT), and the leading Japanese IT company NEC Corporation have formed NICDC Logistics Data Services (NLDS).

The company's groundbreaking "Logistics Data Bank System (LDB System)" initiative offers comparable performance indicators and an export-import container visibility service throughout all of India.

“Logistics Data Bank System (LDB System)” comprehensive solution that combines data from multiple supply chain agencies to deliver comprehensive, real-time information in a single window.The various stakeholders and systems integrated are depicted in below figure:

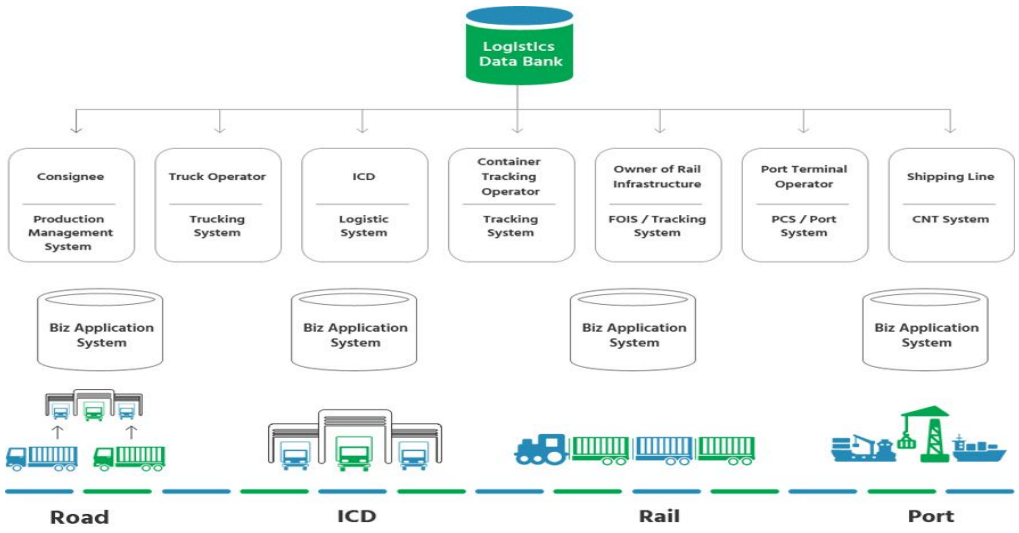

Figure 4. 11: LDB integration

(Source: *https://nldsl.in/our_services.aspx?mpgid=10&pgid1=11&pgidtrail=12*)

- Once the Container is offloaded from the vessel the Container number & in-time is captured and provide to LDB. LDB system records the Port-out information which is visible to the end user. Container is moved to the yard from where it takes one of the below routes:
- Container which is transported by trucks and trains
- Containers which is moved to another yard of different terminal operator.

LDB uses RFID technology through Internet of Things (IoT), Big Data and Cloud-based architecture to provide tracking of EXIM container movement in India. However, GPS based tracking is not incorporated in the system.

(v) **ULIP**

In order to provide real-time information to all stakeholders in the logistics value chain, GOI has developed ULIP. It is positioned to be a unified platform that offers information related to logistics-related services such as cargo/ shipment visibility, authorizations, and certifications seamlessly. Create a nationwide single window logistics platform for end-to-end visibility

Provide visibility for optimal usage of various modes of transportation and offer a platform for data exchange between government and private entities. Offer data which can be utilized by the stakeholders for simplification of complicated processes like compliance, document filing, certifications, and approvals.

ULIP integrates 24 systems, 78 APIs and 1,454 fields across waterways, ports, shipping, civil aviation, railways, DGFT and customs and road transport and highway. The architecture has been shown in the figure 4.10.

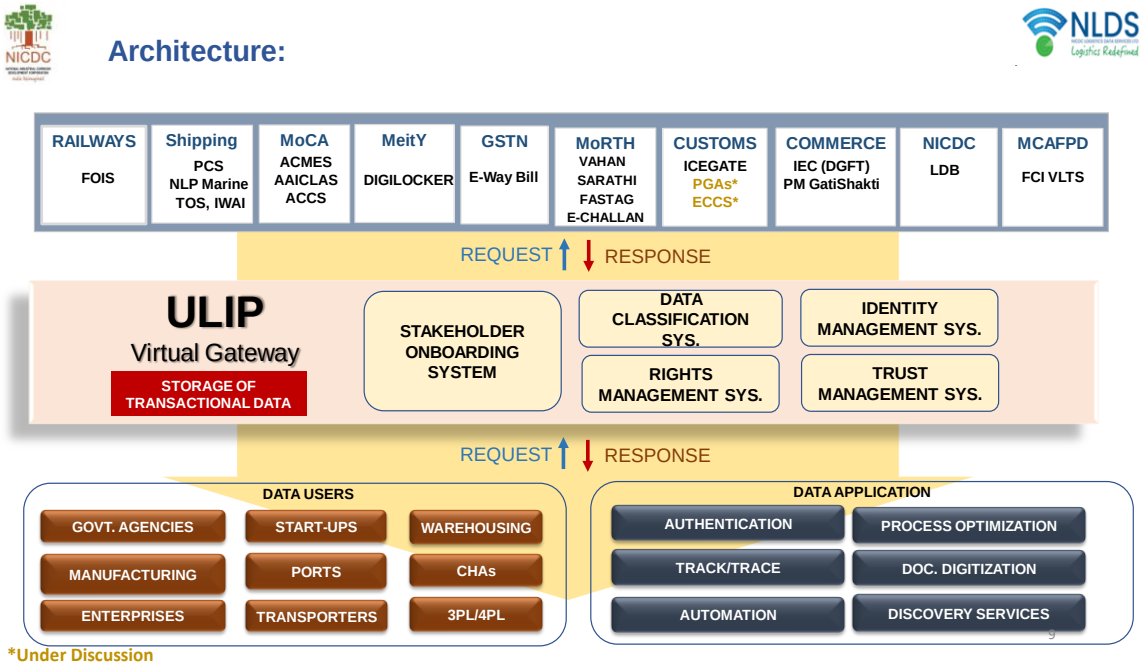

Figure 4. 12: Architecture of ULIP

(source: *https://goulip.in/home#apis-tabs*)

(vi) As per the LEADs report 2023, Positive results of various initiatives have already started to emerge. As per World Bank report, (Logistics Performance Index), India's rank improved from 44 in 2018 to 38 in 2023.

(vii) Karnataka Skill Development Corporation has collaborated for skill development in e-commerce industry with industry champions like Flipkart and ECom Express.

(viii) Sonowal, (2024) has mentioned that the government has announced its plan to transform Jawaharlal Nehru Port into a fully smart port within the next year. This initiative, dubbed SMARTPORT, aims to establish a single-window platform that will deliver real-time information to all stakeholders. The introduction of SMARTPORT is expected to enhance transparency and accountability, create a corruption-free environment within port-related services, and improve overall efficiency.

(ix) In 2023, the various states have their notified its Logistics & Warehousing policy and conferring 'Industry' status on the Logistics and Warehousing Sector.The 'Kaushalya' – The Skill University, Ahmedabad, also offers courses related to the logistics sector. Meanwhile, Gujarat Maritime University provides courses related to Maritime Law and an MBA in Shipping & Logistics.

(x) Kerlala has introduced an Artificial Intelligence (AI)-enabled traffic offense detection system, which has led to the revision of speed limits for vehicles operating in the state, with higher limits being effective from July 1, 2023.

(xi) To unlock the promised economic potential of the North-East, India's first School of Logistics, Waterways, and Communication was inaugurated in January 2023, in Agartala with the aim of delivering exceptional education and training to the skilled individuals of the North-East region. This education will empower them to thrive within the transportation and logistics industry.

(xii) The LEADS 2023 survey highlights the potential for significant improvements in truck transit times and logistics costs through more efficient interstate freight movement. Key strategies include simplifying processes, training officials for fewer physical stoppages, and eliminating barriers at state borders. Technology plays a crucial role, with

recommendations for adopting Advanced Traffic Management Systems, sensors, and automated enforcement tools linked to the GSTN E-waybill and VAHAN databases for smarter checks. Some states are already making progress with these tech-based approaches and administrative reforms, aiming to reduce inspections and improve enforcement quality. This shift towards smart road enforcement could ease congestion at checkpoints and lessen reliance on manual checks, encouraging states to adopt best practices and integrate technology for better freight efficiency.

(xiii) As per the World Bank, LPI report 2023, India's rank has improved to 38 and this has been attributed to various initiatives like PM GatiShakti, infrastructure development, and LDB.

Chapter 5

Analysis of Data and Research Findings

5.1 Introduction:

GIS mapping of Telecom infrastructure in PM GatiShakti is underway and a lot of work has been done. Further, the logistics sector is undergoing change with lot of policy initiatives and technology adoption. The present research study was done to explore the various aspects of Telecom layer's within the PM GatiShakti initiative and the roles of telecom & Frontier technologies 5G, AI, Blockchain, IoT, Cloud, and Big Data in the logistics sector. For the purpose of the study empirical data has been collected from various stakeholders.

5.2 As far as the collection of primary data is concerned, the data has been collected through the questionnaire (169 respondents) and meetings/interview with officials/experts (12 respondents) from:

- Department of Telecommunications (DoT)
- DPIIT
- Experts from IT Industries/IoT Industries,
- Retired Senior officials from MeitY
- Experts from Logistics Sector
- Telecommunication Engineering Centre (TEC)
- Telecom Service Providers (TSPs)
- CONCOR

A questionnaire in the shape of Google form was designed for survey. In addition to the introductory details, the questionnaire contained 19 questions about various aspects related to Telecom layer in PM GatiShakti & use of AI, Blockchain, IOT, Cloud and Big data in Logistics sector. The questionnaire is attached as Appendices.

5.2 Field Survey & Analysis:

The responses of the questionnaire were received from various 169 stakeholders. The analysis of questions is presented in the sections below:

(i) Objectives of PM GatiShakti

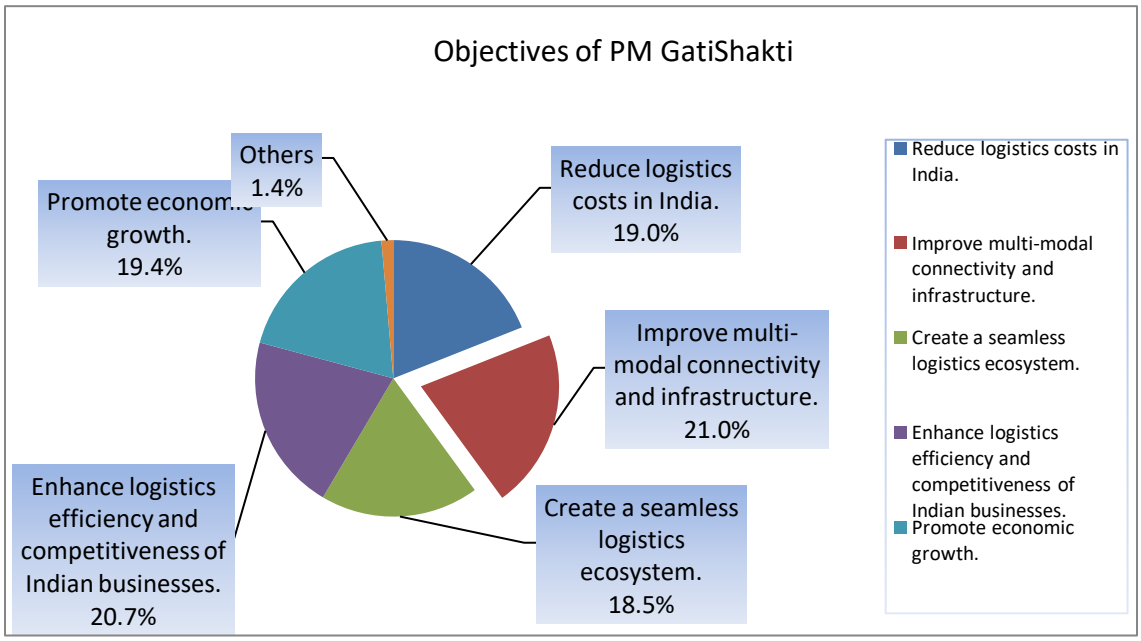

Figure 5. 1: Responses to Question 1.

Analysis of data indicates that 21.0 % of the respondents are of the view that improving multi-modal connectivity and infarstcruture is the prime objective of PM Gatishakti. Around 20.7% respondents opined that objective is to Enhance logistics efficiency and competitiveness of Indian businesses. The emphasis on promoting economic growth (19.4%), reducing logistics costs (19%), and creating a seamless logistics ecosystem (18.5%) also shows significant support, reflecting a strong consensus on the importance of these objectives for PM GatiShakti.

(ii) Usefulness of GIS mapping of telecom infrastructure in PM GatiShakti

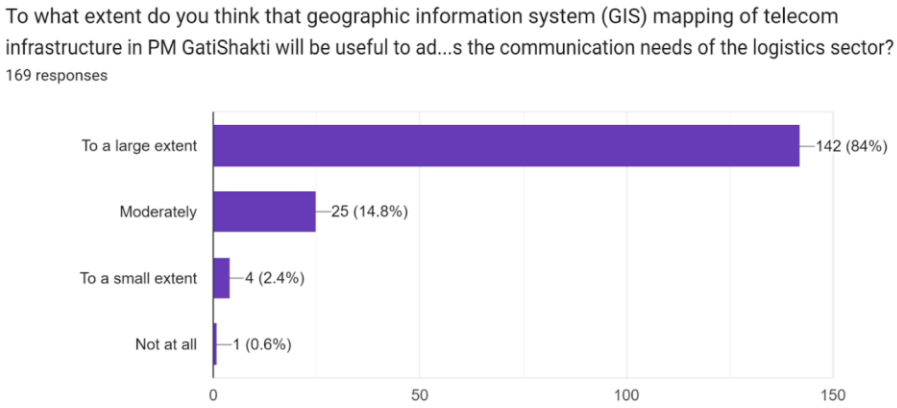

Figure 5. 2: Responses to Question 2.

.

The responses indicate that 84 % of respondents believe GIS mapping will be highly useful to a large extent for addressing the communication needs of the logistics sector. Around 14.8 % of the respondents see moderate usefulness, and very few respondents (2.4%) believe it will be useful to small extent or not useful at all. This suggests a strong consensus on the potential benefits of GIS mapping within the context of PM GatiShakti for the logistics sector.

(iii) Potential benefits of GIS mapping of Telecom infrastructure in PM GatiShakti

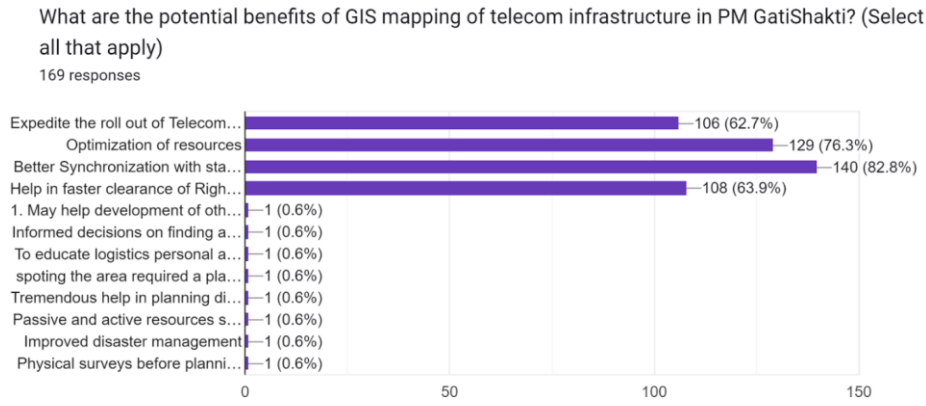

Figure 5. 3: Responses to Question 3

As per the responses, 82.8% are of the opinion that better Synchronization with other stakeholders like Railways, Roads, GAIL, Municipalities, State Governments, and improved decision-making as highest potential of GIS mapping of Telecom infrastructure in PM GatiShakti. Responses also show a strong emphasis on optimization of resources (76.3 %),Help in faster clearance of Right of Way (RoW) permission (63.9 %) and expediting the roll out of Telecom services (62.7 %) as the other mentioned benefits.

(iv) Bottlenecks in GIS mapping of telecom infrastructure in PM GatiShakti

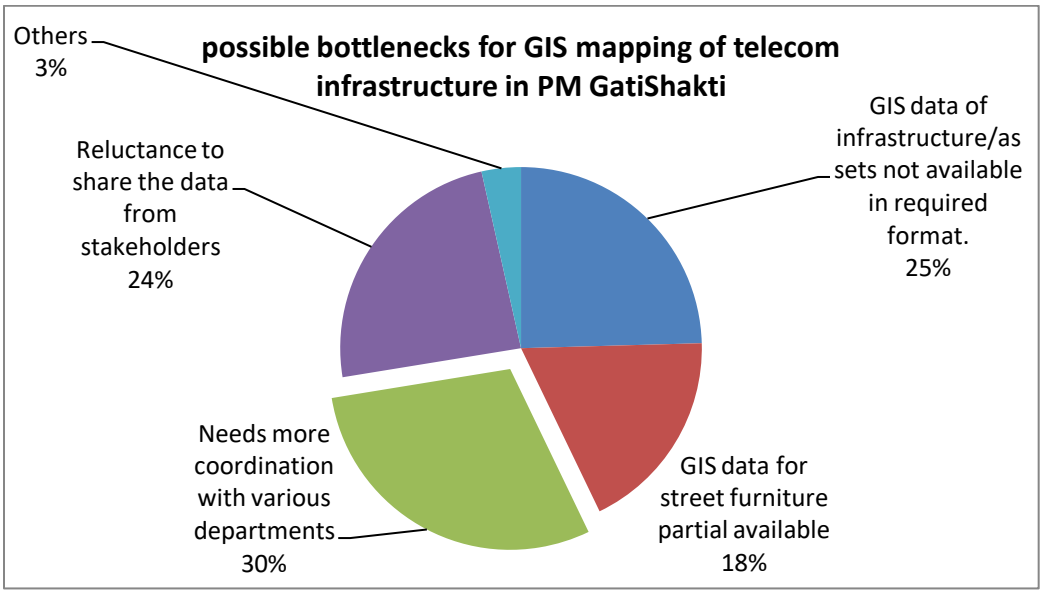

Figure 5. 4 Responses to Question 4

On the question of bottlenecks in GIS mapping, it is observed that 30% are of the opinion that coordination with various departments is the challenge in this process. 25% are of the opinion that GIS data of infrastructure/assets not available in required format. 24 % are of the opinion that there is reluctance from the stakeholders to share data. Further, 18% also mentioned that GIS data for street furniture are available partially.

During **interviews/discussion** with expert, they said that OFC data of private TSPs/ISPs is not mapped in PM GatiShakti which is a major bottleneck. Further, a lack of coordination module for collaboration with stakeholders for Telecom layer in the portal hinders coordination.

(v): Key parameters of the Telecom layer in PM GatiShakti

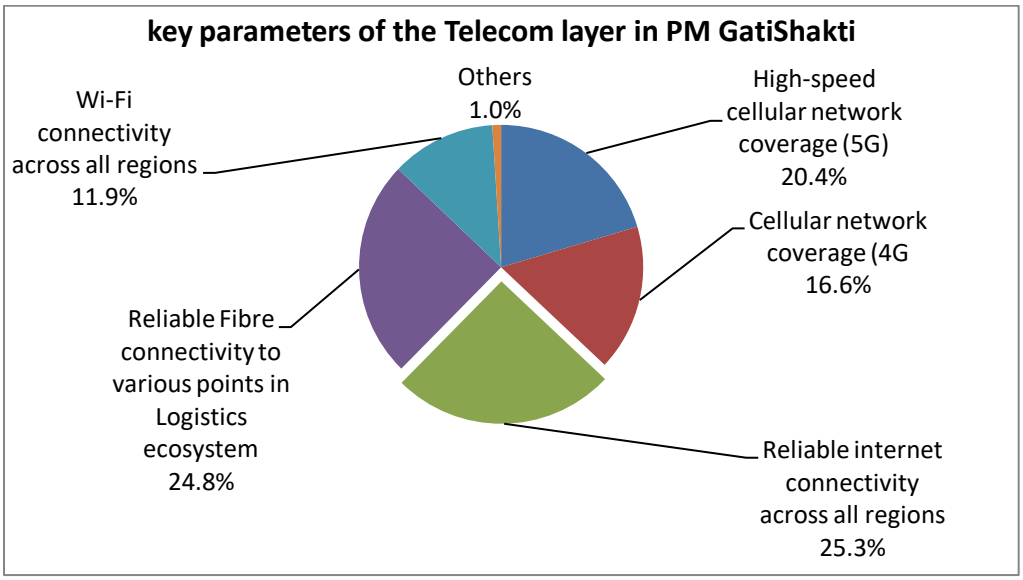

Figure 5. 5: Response to Question 5

On point of key parameters of telecom layers, 25.3% indicate that reliable internet connectivity is the key parameters of Telecom layer related to Logistics.24.8% are also of the opinion that Reliable Fibre connectivity to various points in Logistics ecosystem is very much required. Around 20.4 % has are in favour of High Speed network Coverage (5G). Further 16.6% has indicated for 4G cellular network coverage and 11.9% has indicated Wi-Fi across all regions as one of the key parameters of telecom layer in PM Gatishakti related to improvement in logistics efficiency. The above data shows the importance of reliable internet and fiber connectivity as the most sought parameters in enhancing the logistics sector's efficiency through the PM GatiShakti initiative.

(vi): Areas of integration of 5G technology in logistics process

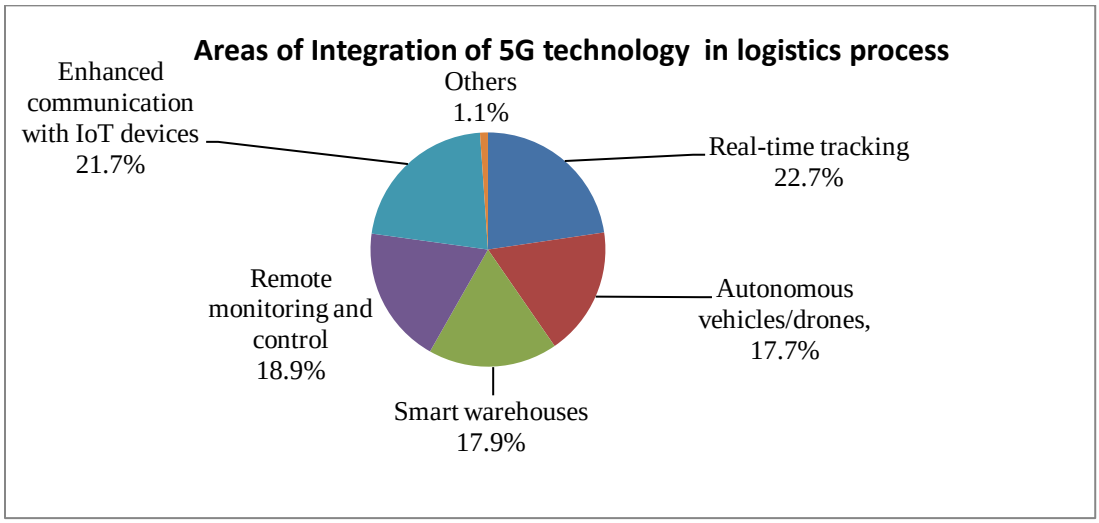

Figure 5. 6: Response to Question 6

Analysis of the data indicates that, 22.7 % are of the opinion that Real Time tracking is the area of maximum utility for use of 5G. Further, 21.7% mentioned that Enhanced communication with IoT devices is also a promising area for 5G use. Around 18.9 % have selected Remote monitoring and control. Around 17.9% see 5G uses in Smart Warehouses followed by 17.7% who have opted for Autonomous vehicles/Drones. These responses are emphasizing the broad spectrum of logistics areas where 5G technology can significantly enhance efficiency and functionality. This suggests a strong consensus among respondents on the critical role of 5G in facilitating real-time tracking, IoT integration, remote operations, and the use of autonomous logistics solutions.

(vii) **Benefits of 5G technology in logistics operations**

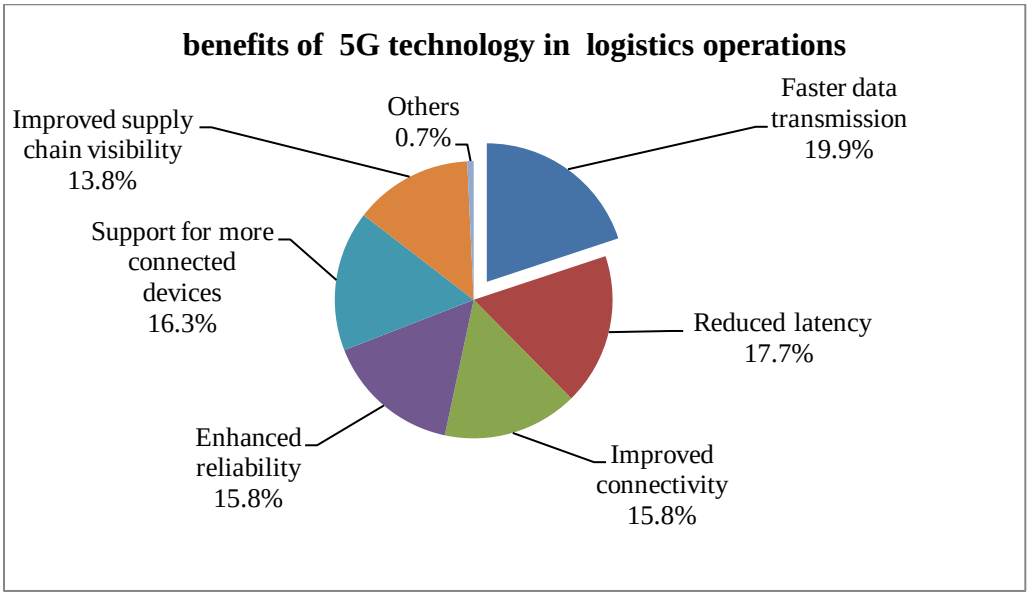

Figure 5. 7: Response to Question 7

Analysis of the data indicates that 19.9% are of the opinion that Faster data transmission is the most beneficial aspect of 5G in logistics operation. Further, 17.7% mentioned that reduced latency is also another benefit of 5G uses. Around 16.3 % see that support for more connected devices is another benefit. Around 15.8 % have selected for Enhanced reliability and equal number (15.8%) for improved connectivity. 13.8 % have selected Improved supply chain visibility as one of the benefits for 5G use in logistics sector. The responses indicate the significant impact of 5G technology is expected to have on logistics operations, particularly in terms of data transmission speed, latency reduction, device connectivity, reliability, and supply chain visibility.

(viii) **Measures to enhance the effectiveness of the Telecom layer in PM GatiShakti**

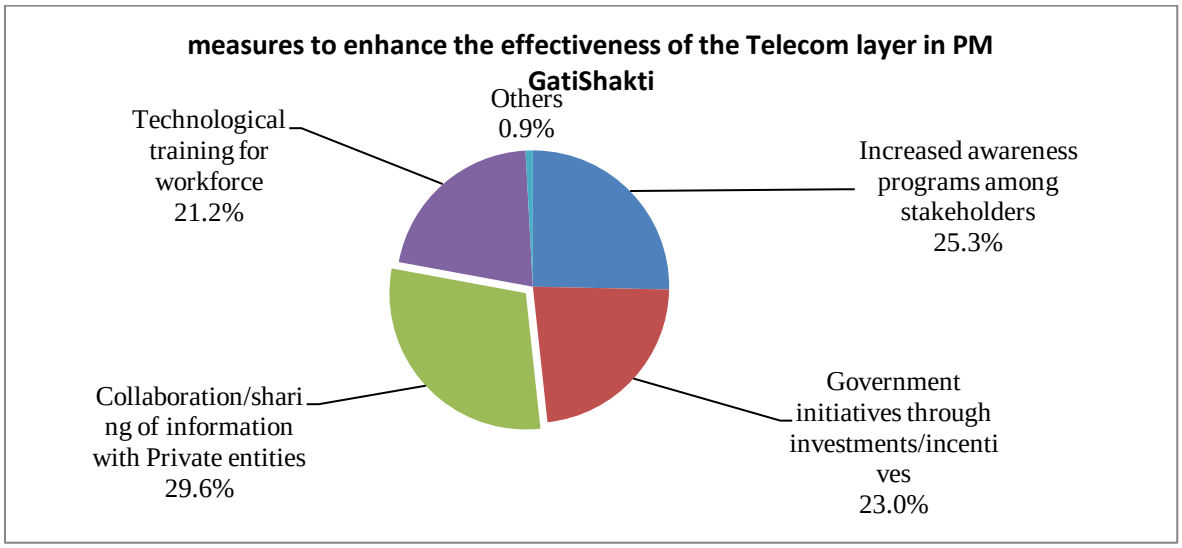

Figure 5. 8: Response to Question 8

Analysis of the data indicates that 29.6 % of the respondents are of the opinion that Collaboration and sharing of information with private entities shall be increased. Around 25.3 say that more awareness/outreach programmes among stakeholders shall be done. Further 23.0% are in favour that Government shall make more initiatives and investment for effectiveness of telecom layer. Around 21.2% are in favour of technological training of workforce for effectiveness of telecom layer in PMGatishakti. The responses affirm the importance of collaboration, awareness, government support, and workforce training as key measures to enhance the effectiveness of the Telecom layer within the PM GatiShakti.

During the discussion /interviews, they said that private TSPs OFC data, which is currently not being mapped, shall be mapped in PM Gatishakti for holistic picture.

(ix) **Potential Areas for Block chain applications in Logistics Sector**

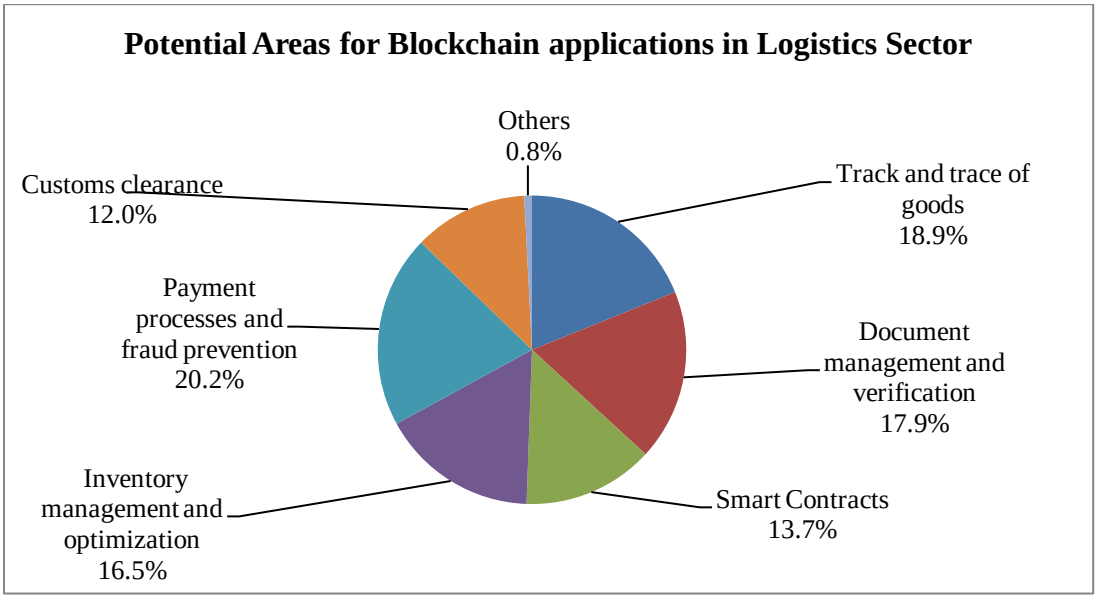

Figure 5. 9: Response to Question 9

Analysis of data indicates that around 20.2% of the respondents have selected Payment processes and fraud prevention as the potential area for use of Block Chain technology. Around 18.9% have selected to use Blockchain for Tracking and tracing of goods. Further, 17.9% are in favour of using for Document management and verification and 16.5% are in favor of Inventory management and optimization. Use of Block chain in Smart Contract has been responded by 13.7%, followed by the area of Customs clearance by 12.0% for use of Block Chain in logistics sector.

(x) **Benefits for adopting Block chain in logistics operations**

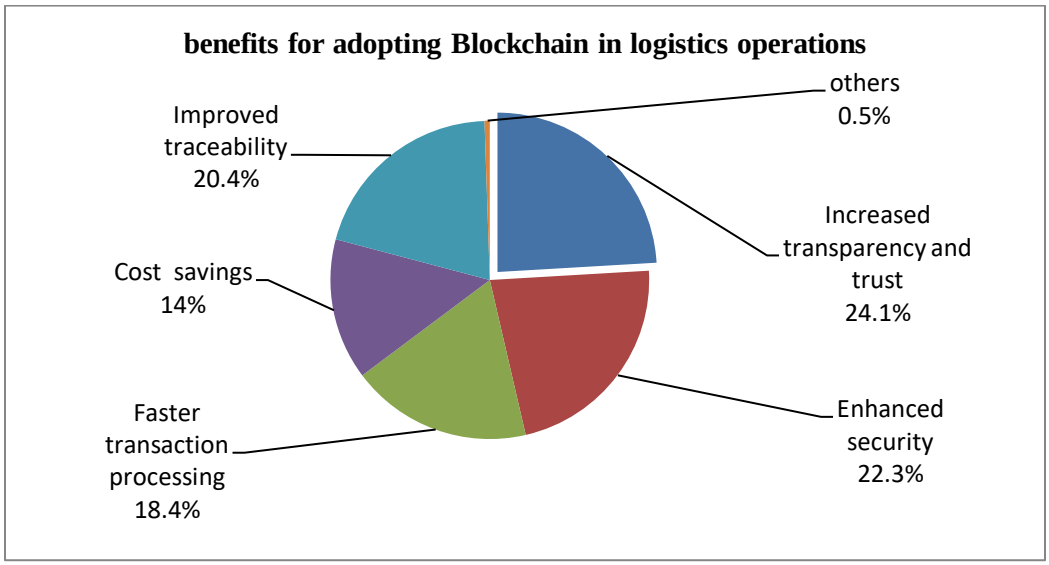

Figure 5. 10: Response to Question 10

Analysis of data indicates that 24.1% of the respondents are of the opinion that Increased transparency and trust is the foremost benefit. Around 22.3% says Enhanced security is another key benefit. Further 20.4% are in favour of Improved traceability. Around 18.4% have selected Faster transaction processing followed by Cost savings by 14%. The above responses show the significant impacts of Blockchain technology, such as increased transparency and trust, enhanced security, improved traceability, faster transaction processing.

(xi) **Areas of the logistics process for integration of AI technologies**

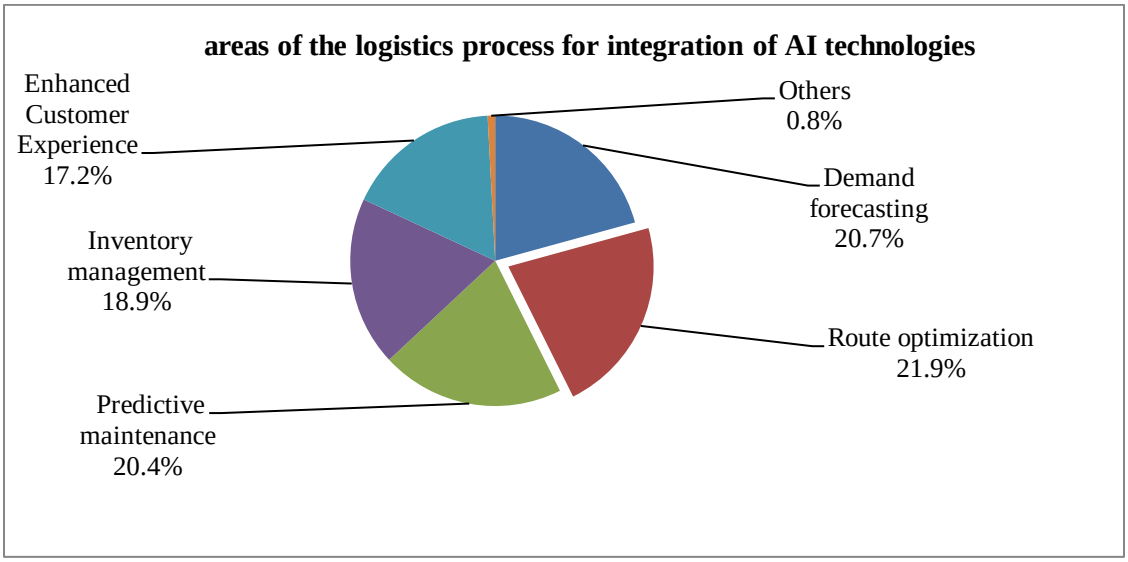

Figure 5. 11: Response to Question 11

As regards the areas of application of AI are concerned, analysis of data indicates that, around 21.9% of respondents have said that route optimization is major area for application of AI. Around 20.7% have selected demand forecasting for using AI followed closely by 20.4% for predictive maintenance. Further, 18.9% of the respondents are in favour of inventory management and 17.2% are in favour of Enhanced Customer Experience for application of AI. This suggests a strong consensus among respondents on the significant potential for AI use in logistics operations.

(xii) **Benefits of Artificial Intelligence (AI) in logistics operations**

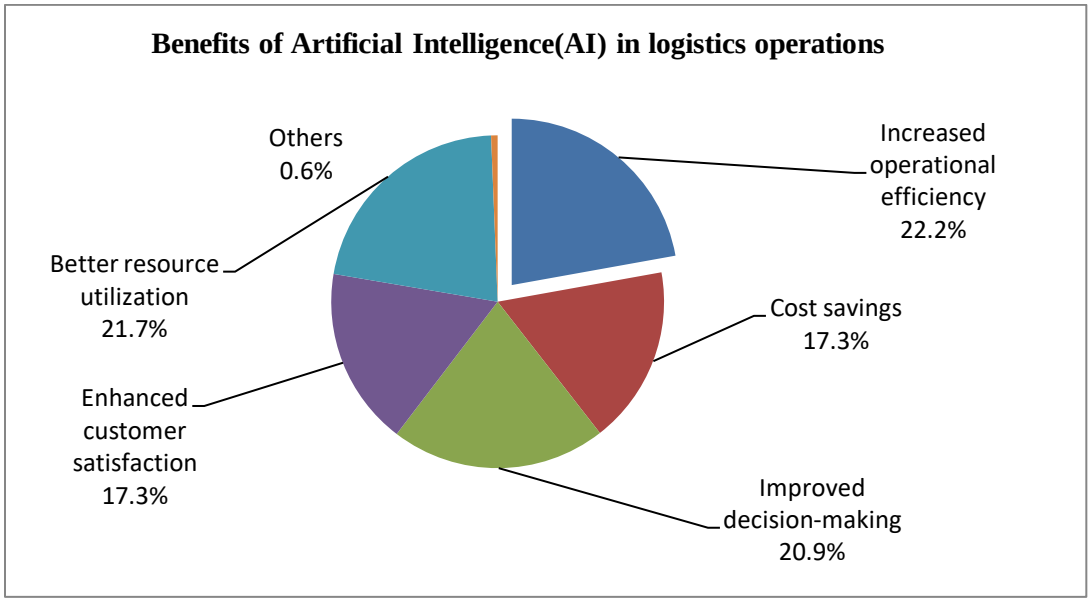

Figure 5. 12: Response to Question 12

Analysis of data indicates that 22.2% of the respondents are of the opinion that increased operational efficiency is the foremost benefit for use of AI in logistics sector. Around 21.7% say that better resource utilization is another key benefit of AI. Further 20.9% are of the opinion that decision-making will be improved by use of AI. Around 17.3% have selected Enhanced customer satisfaction and 17.3% see AI can contribute to cost savings. The above responses show the significant benefits of AI technology are as increased operational efficiency, better resource utilization, & improved decision-making.

(xiii) **Benefits of using Cloud technology in logistics sector**

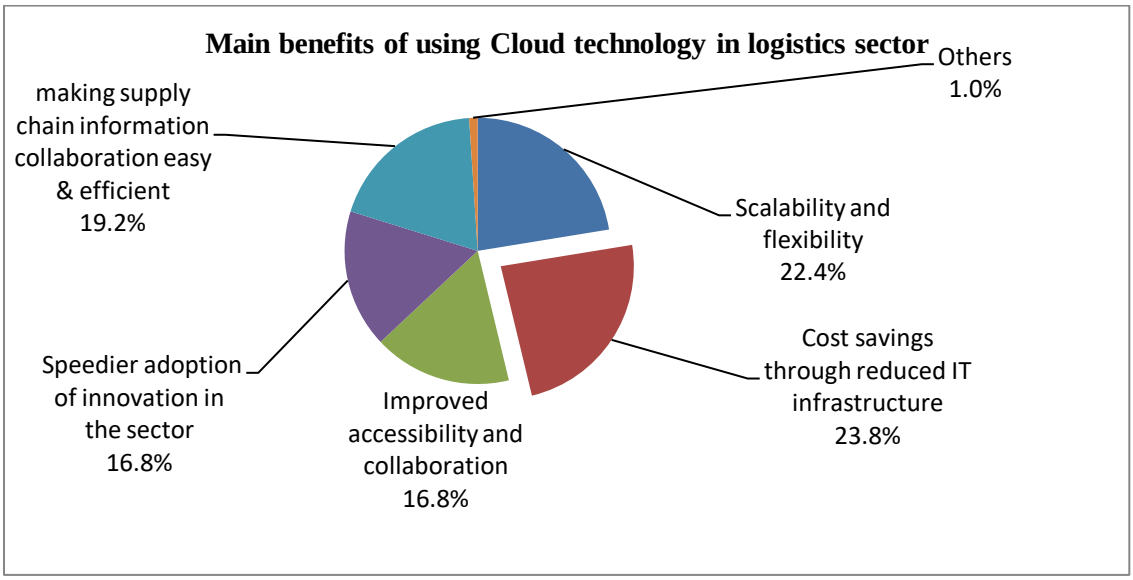

Figure 5. 13: Response to Question 13

Data indicates that 23.8% of the respondents are of the opinion that Cost savings through reduced IT infrastructure is the foremost benefit of Cloud technology. Around 22.4% say that scalability and flexibility is another key benefit. 19.2% are of the opinion that Cloud technology will make supply chain information collaboration easy and efficient. Further, 16.8% have selected speedier adoption of innovation in the sector and equal percentage (16.8%) have selected improved accessibility and collaboration as benefit of cloud technology in logistics sector. This suggests a strong consensus among respondents that use of Cloud technology in the logistics sector will bring scalability, cost saving, flexibility, and collaboration.

(xiv) **Potential Areas of the logistics process for integration of IoT devices**

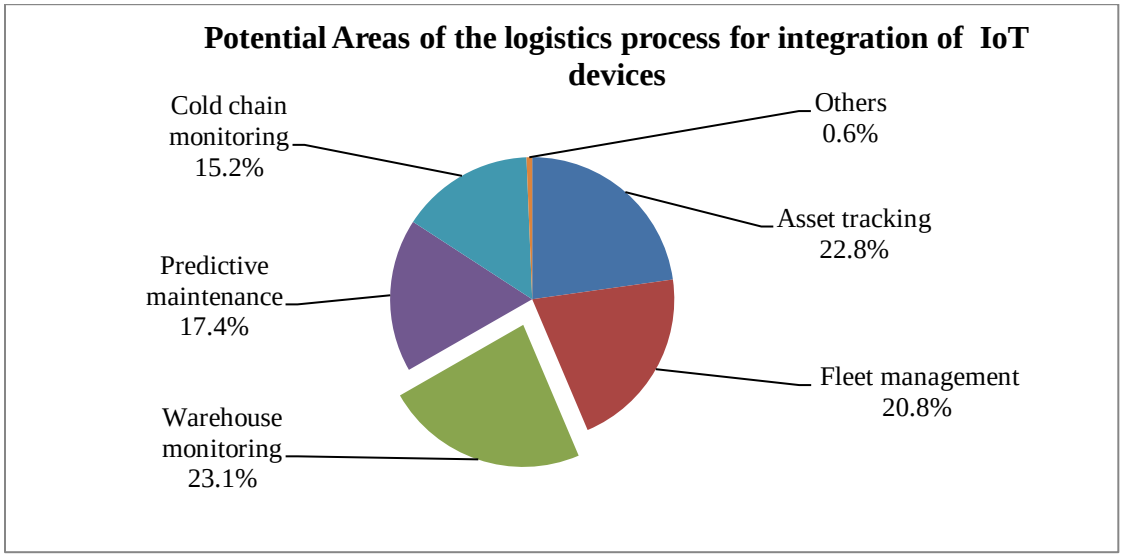

Figure 5. 14: Response to Question 14

Analysis of data indicates that 23.1% of respondents have selected Warehouse monitoring as major area for application of IoT. Around 22.8% have selected asset Tracking for use of IoT and 20.8% of the respondents are of the opinion that Fleet Management can be improved by use of IoT devices. Further, 17.4% are in favour of using IoT for predictive maintenance and 15.2% are in favour of use of IoT for Cold chain monitoring.

(xv) **Benefits of Internet of Things (IoT) in logistics operations**

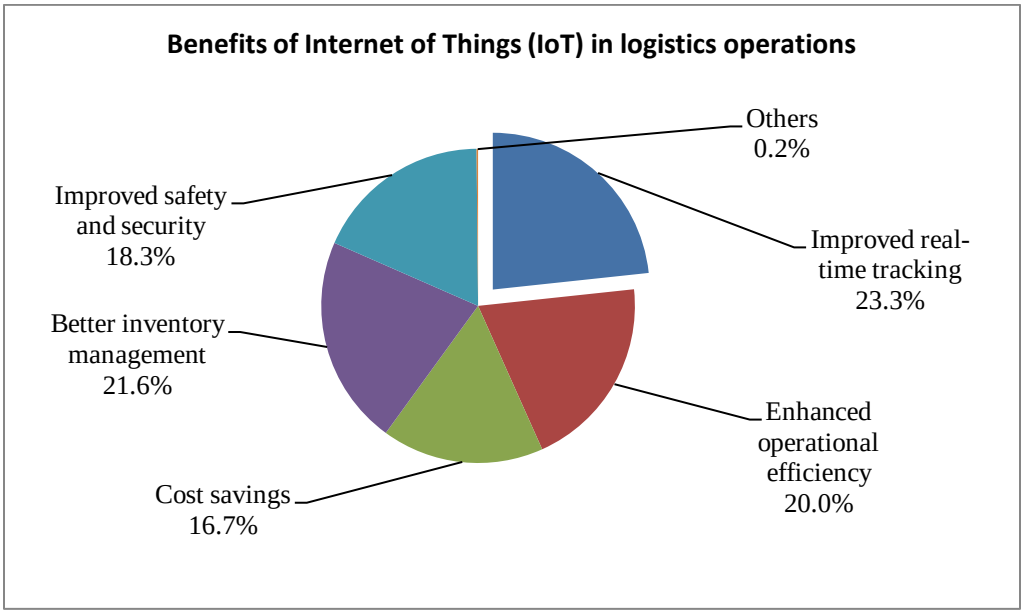

Figure 5. 15: Response to Question 15

On the question of benefits of IoT in Logistics sector, 23.3% are of the opinion that improved real-time tracking is the foremost benefit. Around 21.6% says use of IoT will help in better inventory management. According to 20% of the respondents operational efficiency will be enhanced by using IoT devices. 18.3% of the respondents have selected improved safety and security as the benefit of IoT devices and 16.7% find Cost savings as one of benefits of IoT usage.

(xvi) **Areas of the logistics process for using Big Data**

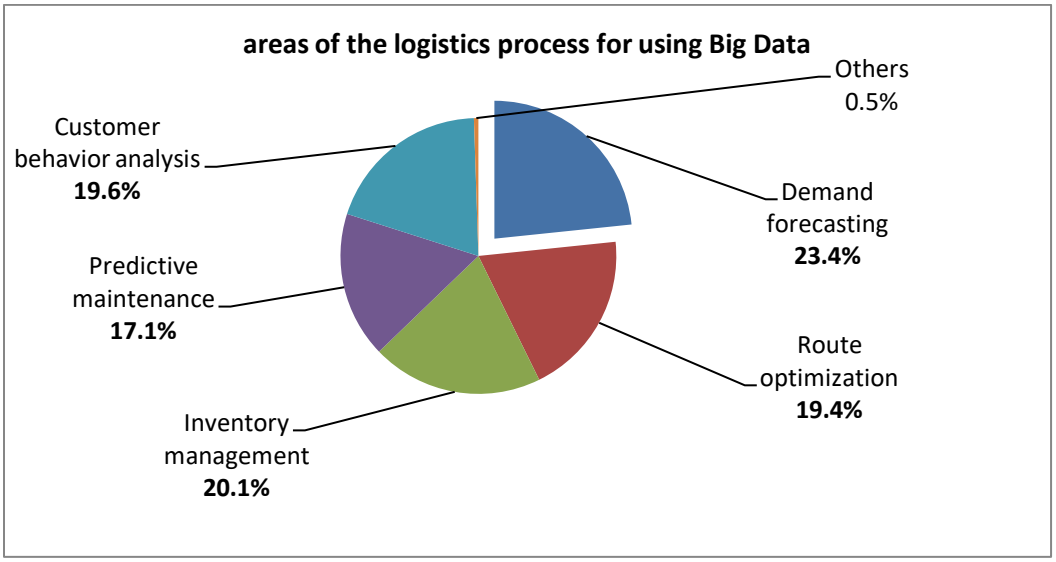

Figure 5. 16: Response to Question 16

On areas o f logistics processes where Big Data can be used, 23.4% have opined that demand forecasting as major area for application of Big Data. Around 20.1% have selected Inventory Management for use of Big Data. Around 19.6% said that Big Data can be useful for customer behavior analysis followed closely by 19.4% of respondents who are in favour of use of Big Data for Route optimization. Further, 17.1% find its use in predictive maintenance.

(xvii) **Benefits of Big Data in logistics operations**

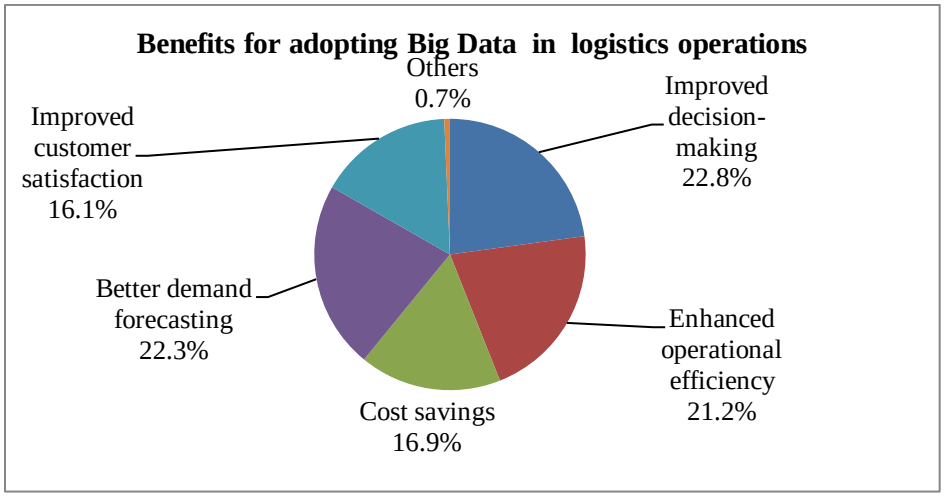

Figure 5. 17: Response to Question 17

Analysis of the data indicates that 22.8% of the respondents are of the opinion that improved decision-making is the foremost benefit. 22.3% said that better demand forecasting is another key benefit by using Big Data. Around 21.2% indicated that enhanced operational efficiency is another key benefit of using Big Data. 16.9% have selected cost savings as benefit and 16.1% view that customer satisfaction will be improved by using Big Data.

(xviii) Main challenges in utilizing telecommunications and frontier technologies in logistics operations

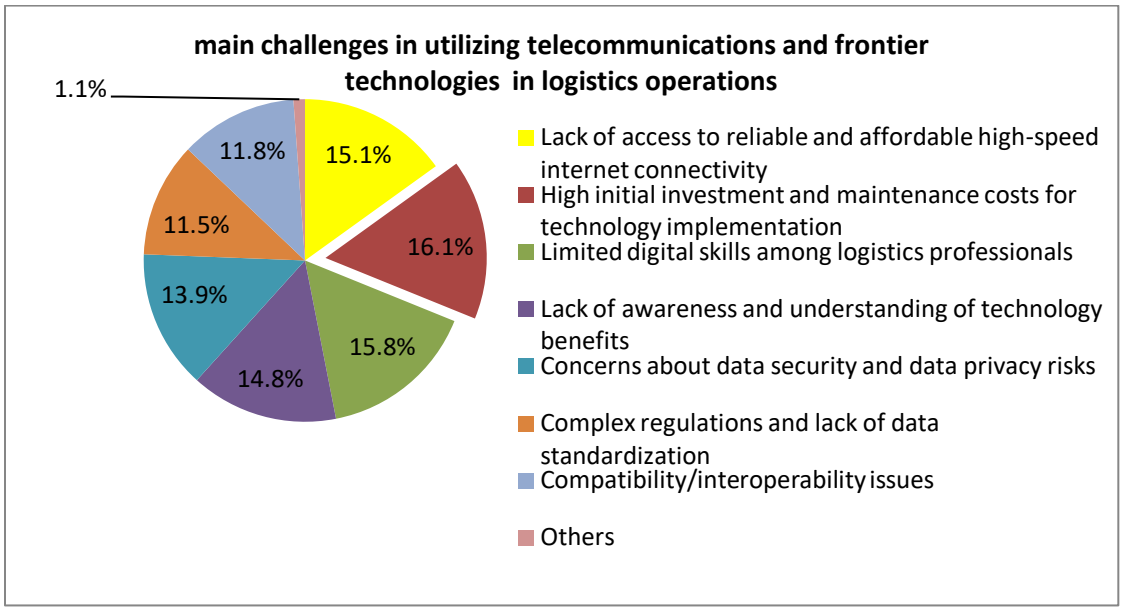

Figure 5. 18: Response to Question 18

When asked to list the main challenges in utilizing telecommunications and frontier technologies in logistics operations, 16.1 % has indicated lack of access to reliable and affordable high-speed internet connectivity as the most substantial one. Around 15.8% are of the opinion that high initial investment and maintenance costs for technology implementation is a major concern. 15.1% opined that limited digital skills among logistics professionals are a barrier. 14.8 % have selected that lack of awareness and understanding of technology benefits is a challenge in understanding how these technologies can be beneficial. Further, a chunk of 13.9 % sees that data security and data privacy risks are a notable challenge. Around 11.5 % also feel complex regulations and lack of data standardization is a challenge.

During the interview, it emerged that with introduction of GSTN, E-way, Icegate in customs clearance, Documentation has become seamless and digitalized. Still standardization of data format is required. Some of the expert opined that that it take longer time to take the data from authorities. Further, one expert mentioned about

bringing the clarity on regulation on blockchain especially on private blockchain. Further, there is a need for awareness program about the related regulations in IT act.

(xix) **Suggestions to facilitate the use of global frontier technologies in the logistics sector**

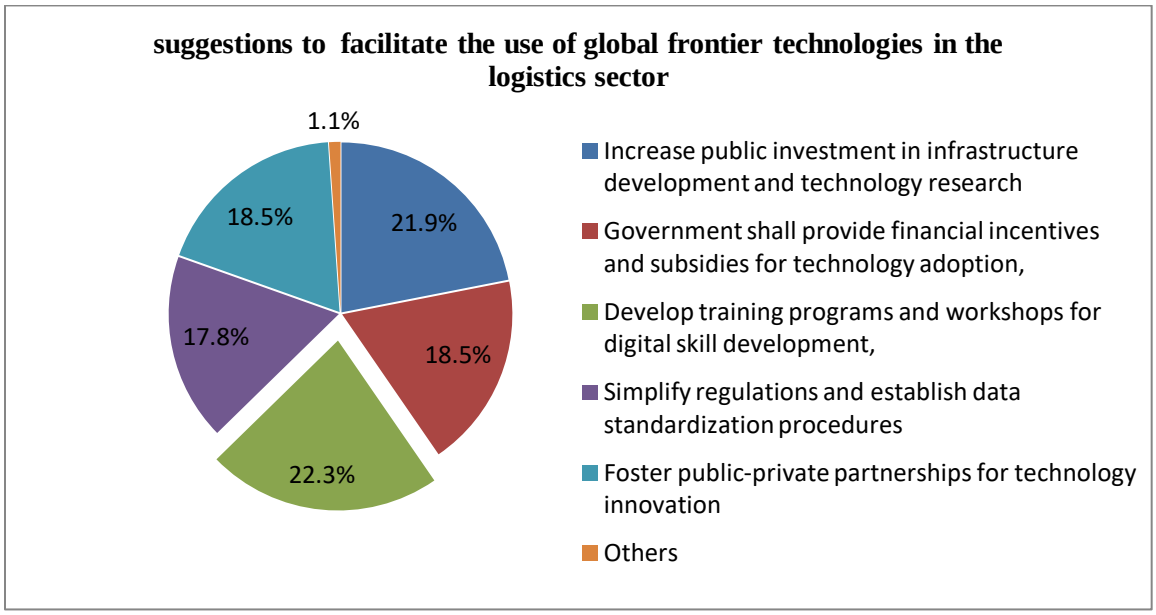

Figure 5. 19: Response to Question 19

When asked about facilitative suggestions for better use of these frontier technologies in the logistics sector, 22.3 % are of the opinion that there is a need for capacity building through training programs and workshops for skill development as the most significant step which highlights the importance of education and skill development for the workforce to leverage new technologies effectively. Further, around 21.9 % have selected Increase public investment in infrastructure development and technology research as another significant step and key to facilitating the use of technology. Further, 18.5 % are of the opinion that Government shall provide financial incentives and subsidies for technology adoption to boost technology adoption which is considered a substantial enabler for adopting new technologies in the sector. Similary 18.5 % are also in favour of

Simplify regulations and establish data standardization procedures. As steps to support the integration of frontier technologies in logistics.

During meeting/**Interviews,** they said standardization on documentation and equipment is required. Containers have already been standardized in India. One expert mentioned that Government need to invest in creation of Blockchain network through Consortium. Some experts were of the view that there shall be guidelines & mechanism to share the logistics data with proper authorization and rights. Synchronization/sensitisation with different stakeholders is the key to mobilize. Affordable & reliable internet shall be made available to the points of logistics operation. Satellite based communication will also be beneficial for the remote and inaccessible areas of the country.

5.3 Findings:

This survey having 19 questions was aimed to explore the various aspects of Telecom layer's role within the PM GatiShakti initiative and the roles of telecom & Frontier technologies 5G, AI, Blockchain, IoT, Cloud, and Big Data in the logistics sector. Following findings emerge from the survey and interviews conducted. A notable consensus emerged among the respondents on several point:

a) PM GatiShakti's Objectives: Majority of the respondents agreed with objectives of PM GatiShakti and can contribute significantly in improving multi-modal connectivity, enhancing logistics efficiency, promoting economic growth, reducing logistics costs, and creating a seamless logistics ecosystem.

b) GIS Mapping of Telecom Infrastructure: Most of the respondents highlighted the importance of geographic information system (GIS) mapping of telecom infrastructure in PM GatiShakti which is useful to address the communication needs of the logistics sector. Participants are agreed that PM GatiShakti will help in synchronization with other stakeholders like Railways, Roads, GAIL, Municipalities. Further, this also came out that the reliable and affordable internet & 5G are the key infrastructure requirements in Logistics Sector.

c) Roles of frontier Technology and Benefits identified by the respondents are as follows:

(i) 5G Technology is crucial for real-time tracking, IoT device communication, and remote monitoring, with benefits including enhanced data speed and reduced latency.

(ii) Blockchain has been beneficial for increasing transparency & trust, enhancing security and improving traceability, mainly for payment processing and fraud prevention.

(iii) AI has many roles & benefits in route optimization, demand forecasting, and decision-making, enhancing operational efficiency, resource utilization and customer satisfaction.

(iv) Cloud Technology has many benefits like cost savings, scalability, flexibility, and improved collaboration.

(v) IoT Devices has many use cases in warehouse monitoring, asset tracking thus improving real-time tracking, inventory management, and operational efficiency.

(vi) Big Data has the potential in areas of demand forecasting, inventory management and improving decision-making.

The survey emphasizes a strong consensus on the significant role of frontier technologies in enhancing the efficiency, tracing and transparency in India's logistics sector. Participants emphasize the importance of overcoming existing barriers through Public investments, skill development and collaborative efforts to fully leverage the potential of telecommunications through PM GatiShakti and frontier technologies within Logistics sector.

5.4 Issues and Challenges:

PM GatiShakti platform is instrumental in integrated planning of many key infrastructure projects in the country. These infrastructure projects are helping to increase the LPI

ranking of India. Telecom layer is keeping pace in mapping all the telecom infrastructure in the country. Further, various initiatives have also been taken in the country like launch of LDB and ULIP projects which are aiding to break the silos and integrating various stakeholder in the Logistics Sector. However, there are certain issues in mapping of Telecom layer in PM GatiShakti and adoption of frontier technologies in Logistics sector. The study identifies the following main bottlenecks and challenges:

5.4.1 Challenges for GIS mapping of telecom infrastructure in PM GatiShakti:

(i) GIS data of infrastructure/assets not available in required format: As PM GatiShakti is a new initiative, State governments are facing challenges to collate and record the data in prescribed GIS format. Further, issues have been raised by agencies that street furniture data from some of State governments/authorities are still to be uploaded in the PM GatiShakti Portal.

(ii) Reluctance to share the data from stakeholders: The OFC data of private TSPs is not shared by them for mapping in PM Gatishakti. Certain stakeholders, such as private companies are hesitant to share their data due to concerns about confidentiality, security and competition. The lack of data sharing can create gaps in the overall infrastructure map.

(iii) Needs more coordination with various departments: At present, ROW policy is issued by some of the states. Further, the charges of electric poles/ clearances for RoW are still high in some states. So more coordination is needed in these aspects. Effective GIS mapping necessitates seamless coordination between various governments departments and private agencies responsible for different aspects of infrastructure, such as transportation, telecom, and street furniture.

(iv) The accuracy of the entire GIS model hinges on the precision of the captured data. Inaccurate data can lead to misleading visualizations, hindering better analytics and decision-making and hindering the project's overall objectives. This requires accurate capturing of GIS data at every level for this model to work efficiently.

5.4.2 High initial investment and maintenance costs for technology implementation:

(i) Adoption of frontier technologies like 5G, IoT sensors, BlockChain and AI platforms requires significant initial investments and maintenance costs. The Indian logistics market consists of numerous small and medium-sized enterprises (SMEs). This can be particularly challenging for smaller logistics players with limited financial resources.

(ii) Limited government subsidies: While the Indian government encourages digitalization, focused subsidies or financing schemes to support technology adoption in the logistics sector are relatively limited, especially for smaller companies.

5.4.3 Skills Gap among logistics professionals:

(i) At present logistics sector is very unorganized. It is perceived that many logistics professionals lack necessary skills to effectively operate and utilize these frontier technologies. Therefore, upskilling and capacity building are crucial. A skilled workforce with expertise in operating, managing, and maintaining these technologies is crucial for successful implementation.

(ii) Rural-urban digital divide: India has a significant digital divide between urban centers and rural areas. Many logistics professionals in smaller towns and rural regions might lack foundational skills needed to use/operate these new technologies effectively.

(iii) To engage and retain the talent of such high skilled workforce is a challenge for smaller players in rural areas in the sector.

5.4.4 Lack of awareness and understanding of technology benefits:

a) Many stakeholders, including logistics players and policymakers, may not fully understand the economic benefits and return on investment (ROI) of these technologies.

b) Many logistics companies, particularly smaller ones, are heavily focused on immediate cost reductions. The potential long-term ROI from technologies like AI-powered route optimization might not be properly understood or communicated.

5.4.5 Lack of access to reliable and affordable high-speed internet connectivity:

a) Large parts of India, especially rural areas, lack access to reliable and affordable high-speed internet connectivity, hindering the smooth operation of data-driven logistics solutions. Still the penetration of the internet subscribers in rural areas is hinged to 41.72%.

b) **Rural connectivity gaps:** Vast areas of rural India still lack consistent 4G/LTE coverage, let alone the readiness for 5G. As per M2CATALYST global mobile insights report, 78% of the location of India is connected on 4G/5G. This significantly can affect the use of real-time tracking, IoT devices, and cloud-based solutions in those areas.

5.4.6 Concerns about data security and data privacy risks:

a. India's data privacy laws are still in their relative infancy. The recent Digital Personal Data Protection Bill, though positive, is yet to be fully implemented. This leaves some ambiguity in the responsibilities of logistics IT companies when it comes to implementing & protecting sensitive data.

b. Logistics companies collect and handle enormous amounts of sensitive data, including: Customer Information, Shipment Information, and Financial Data. In recent years, India has seen a surge in cyber attacks targeting organization across all sectors. Logistics companies are attractive targets due to the valuable data they possess..

c. Logistics sector have involves multiple stakeholders like transporters, warehouses, freight forwarders. Each of these points may become potential security vulnerability. Smaller players might not have robust cyber security systems in place, making the entire chain susceptible to data breaches.

5.4.7 Understanding of regulations and lack of data standardization:

a. The logistics sector in India is governed by a multitude of central and state-level agencies, each with its own regulations and permits. This creates a complex and often overlapping regulatory environment.

b. Obtaining permits for warehousing, transportation, and other logistics activities can be a time-consuming and cumbersome process due to procedural hurdles and variations in requirements across states.

c. Stakeholders are hesitant / reluctant to share the data due to confidentiality or proper mandate from higher authorities. It takes time to get the approval from competent authority to obtain logistics data (API) for on boarding in ULIP platform.
d. Different logistics stakeholders, including transporters, warehouses, and e-commerce platforms, often use different data formats for storing and sharing information. This lack of standardization makes data exchange difficult and inefficient. The lack of standard data formats hinders seamless integration between various logistics management systems, leading to data inconsistencies and hindering data-driven decision-making.
e. The absence of data standardization poses a challenge for implementing automation and AI solutions effectively in the Indian logistics sector, as these technologies rely heavily on consistent data.

5.4.8 Compatibility/interoperability issues:

a. Integrating Legacy systems with new technologies can be expensive and technically complex.
b. Proprietary technologies created by different vendors can lead to a lack of interoperability, pressing companies to rely on a single vendor's solutions, limiting flexibility.

5.4.9 Fragmented ecosystem:

The logistics sector in the country is very fragmented having more numbers of small and medium-sized players. This fragmentation would make it difficult to implement standardized solutions and widespread adoption. On boarding these smaller and unorganized operators in Digital platform is a challenge.

5.4.10 Resistance to change/adopt new technology:

While it looks odd but people be at management level or at workers level shows resistance to adopt new technology/change in the organizational structure/processes.

Chapter 6

Recommendations & Conclusion

6.1 Background:

Frontier technologies such as Artificial Intelligence, Blockchain, Big Data, IoT, Cloud & 5G are leading the way in transforming Human civilization. Indian Logistics Sector is also adopting these frontier technologies, keeping pace with the world. PM GatiShakti, LDB & ULIP are such technology-based innovative initiatives that are changing the face of the Indian logistics sector. Adoption of frontier technologies and adequate telecom infrastructure in the logistics sector will improve the ability to monitor shipments, monitor the timings of deliveries, and ease documentation procedures, thus, in turn will, help in improving LPI of India. Investments, Institutions & Innovations, are the keys to the growth in the sector & economy and shall be the pivots for any policy intervention. India has the advantage of a robust software development industry, and the use and promotion of frontier technologies in the logistics sector can give an edge to the industry and boost the Indian economy.

6.2 Recommendations: Based on the observations and findings of content analysis and field survey, the following recommendations are made:

I. **Need for capacity building of various stakeholders to promote research and training:**

a) Collaboration with educational institutions and industry leaders to develop training programs and workshops equipping the Logistics workforce with the necessary skill sets in the fields of AI, BlockChain, IoT, Cloud & 5G to operate and maintain these technologies.

b) Specific courses shall be undertaken under Skill India Programme on these frontier technologies, keeping in mind the Logistics 4.0

c) Upskilling and Reskilling programmes for existing professionals in the logistics sector shall be formulated.

d) Partner with private sector players to create apprenticeship programs that offer hands-on experience in AI, Blockchain, IoT, Big Data/Cloud, and 5G technologies.

II. Increase public investment in infrastructure development for digital technologies:

a) The Government shall be the role model and lead by investing in infrastructure development and adopting these technologies to develop the ecosystem in the Logistics sector. LDB and ULIP are the best examples.

b) The Government shall create the Logistics Innovation Hub where the use cases of these frontier technologies in Logistics sector can be developed, tested and validated through industry & Government collaboration. ULIP can be utilized to integrate the different players in the logistics ecosystem adopting these frontier technologies.

c) Research and development projects through IITs,NITs focused on innovative logistics solutions based on AI, Blockchain, IoT, Big Data/Cloud, and 5G.

d) Government may form a consortium on Blockchain involving Government bodies, PSUs, private players and other stakeholders. Creating a private Blockchain network by the Government will give a boost for adoption of Blockchain in the country alongwith trust and speed.

e) Special budget allocation for enhancing digital infrastructure in rural and semi-urban areas to enable the widespread use of advanced logistics digital solutions. This will be useful for smaller and unorganized players.

f) Investment in telecom infrastructure development shall be increased in smaller towns and villages, expanding nationwide 5G networks and fiber optic connectivity, prioritizing key logistics hubs, roads/railways, ports, etc. A special drive on coverage and connectivity of logistics route /points may be done in consultation with DoT/State/DPIIT on regular intervals. In case of the requirement of 5G coverage/ in such areas, 5G infrastructure may be developed through USOF scheme. Satellite based communication to inaccessible and hilly areas may also be explored.

g) Central Government/State Government shall invest in updating/upgrading their technical systems related to logistics infrastructure such as railways, roads & highways etc. for further sharing of data on ULIP/PM GatiShakti platform.

h) Allocate special funds for the development of advanced logistics infrastructure, such as smart warehouses, smart containers and efficient transportation networks.

III. Financial Incentives and Subsidies for Technology Adoption:

a) There is a need for Government-funded schemes to support Small and Medium Enterprises (SMEs)/Start-ups in the logistics sector to adopt advanced technologies. This may be followed in the line of I-DEX scheme of defense and Digital Communication Innovation Square (DCIS) scheme of DoT. Targeted subsidies and tax breaks for logistics companies (specifically focusing on SMEs) shall be introduced to encourage adoption of frontier technologies like AI, Blockchain, IoT, Big Data, Cloud, and 5G technologies in logistics sector.

IV. Promote public-private partnerships for technology development and implementation:

a) Establishment of Institution to encourage collaboration between government, industry leaders, and academia to pilot innovative technology solutions addressing specific challenges faced by the Indian logistics sector.

b) This institution will be a platform for sharing knowledge, resources, and best practices among stakeholders to accelerate technology adoption and create a conducive ecosystem for innovation.

c) Encourage collaboration between Indian logistics companies and global technology firms to test cutting-edge solutions in the Indian context.

d) Set up government-supported incubators and accelerators that focus on logistics technology startups, offering mentorship, funding, and business support services. Department may think on the line of IIT Madras Pravartak which is a promising attempt.

V. Need for streamlining regulatory framework and Standardized Procedures:

a) Streamline regulatory processes to facilitate the adoption of new technologies. Government need to issue regulations on use of Private block chain and use of Artificial Intelligence at the earliest.These regulations need to be in accordance with the international norms in the area.

b) Standard setting Bodies like TEC/BIS may be consulted to develop the standards on use of Blockchain related to Logistics sector in the country. These expert bodies can provide assistance in preparing comprehensive standards on IoT devices with certification mechanism. This will help in building market access and trust across the sector.

c) Further, Development and enforcement of industry-wide (Logistics) data standards to ensure interoperability is required. Further, centralized mechanism/guidelines for sharing of data /information across state/PSUs/centre may be built for seamless sharing on ULIP platform.

d) Develop a national framework and collaboration for logistics data interoperability, ensuring compatibility across different states/PSUs/industries and regions within India and secure data exchange across platforms.

VI. For Data privacy and Cyber Security:

a) Data Localization Requirements: Data localization requirements for strategic logistics data may be considered to enhance control over data access, ensuring privacy of data and compliance with Indian laws.

b) Creation of Sectoral-Computer Emergency Response Team (CERT): A dedicated sectoral CERT of Logistics sector shall be established to handle and respond to cyber related issues. This sectoral CERT will share/exchange the data with other sectoral CERT and CERT-In.

c) Comprehensive Data Protection guidelines: Enforcement of comprehensive data protection laws that define the collection, processing,

storage, and sharing of personal and sensitive data within the logistics sector. Specific guidelines tailored to the logistics sector may be issued, addressing data privacy and security challenges associated with logistics operations.

d) **Audits:** Regular security audits and vulnerability assessments of the IT infrastructure across all domain in logistics operations. Further, DoT shall also come for security testing of IoT devices at the earliest.

6.3 Conclusion:

The PMGS-NMP has a potential for transformation in economic growth and sustainable development as well as improving the logistics efficiency. The PMGS-NMP, an initiative full of breakthroughs, is a digital tool used for master planning, in which data from different sectors are merged. This paper shows how the telecom layer can play an important role in accomplishing this purpose. It is observable that incorporation of telecommunication and global frontier technologies has the ability to transform Indian logistics sector. Our research aimed at understanding parameters in the Telecom layer of PMGS-NMP, examing the roles of telecommunications and frontier technologies on logistics, challenges faced by industry practitioners and proposing strategic measures for optimizing its utilization.

From this study it has emerged that telecom connectivity & technologies like 5G,IoT,AI, Block Chain, Big Data, and Cloud Computing are important when it comes to enhancing logistics efficiency. Some benefits provided by these technologies include real-time monitoring, predictive maintenance and data driven decision making leading to significant improvements in operational efficiency, cost reduction and quality within the logistics sector.

In spite of this, there are some issues and challenges for implementation of these technologies. Major concerns to be addressed include high costs; standardizing data and skills gap in logistics staffs. These obstacles prompted various suggestions such as speedy creation of critical telecom infrastructure; cooperation

between public and private sector; training of more logistics workers among others. To cap it all, PM GATISHAKTI initiative and strategic deployment of telecommunications and global frontier technologies offer the way forward for India's logistics sector transformation. By dealing with challenges identified and taking measures based on the concept of Investment, Innovation & Institution, India can unlock vast opportunities for improving its logistic efficiency & minimizing operational costs.

6.4 Scope for Further Research

The research was limited to examining roles of telecommunications and frontier technologies like AI, IoT, Blockchain, 5G, and Cloud Computing in integration in Logistics Sector. Given the vast logistics sector, future studies could delve into the specific technologies within the logistics sector focusing on the operational improvements, cost reductions, and efficiency gains achieved through technological adoption. Further, research could focus on the impacts of the PM GatiShakti Master Plan on seamless multimodal connectivity and logistics efficiency.

Bibliography

1 Apruzzese,M.,Bruni,M.E., Musso,S. & Perboli,G.(2023). 5G and Companion Technologies as a Boost in New Business Models for Logistics and Supply Chain. *MDPI Sustainability, 2023,(15(15), 11846*. https://doi.org/10.3390/su151511846

2 Deloitte.(2014). Indian Logistics Focus on infrastructure creation to sustain and drive growth. Deloitte. Retrieved on August 15, 2023, from https://www2.deloitte.com/content/dam/Deloitte/in/Documents/IMO/in-imo-indian_logistics_focus_on_infrastructure-noexp.pdf

3 Deloitte. (2018). India - On the Cusp of a Logistics Revolution. Deloitte. Retrieved on October 15, 2023 from https://www2.deloitte.com/content/dam/Deloitte/in/Documents/public-sector/in-ps-india-on-cusp-of-a-logistics-revolution-noexp.pdf

4 Feng,Bo. & Ye, Q.(2021).Operations management of smart logistics: A literature review and future research. *Frontier Engineering Management. 8(8):344-345*. https://doi.org/10.1007/s42524-021-0156-2

5 Korczak,J. & Kijeswka,K. (2019). Smart Logistics in the development of Smart Cities. *Transportation Research Procedia, 39, 201-211*. https://doi.org/10.1016/j.trpro.2019.06.022

6 Naik, L.R. & Singh,S.P.(2022).Progression and Opportunity of Logistics Industry in India. International *Journal of Creative Research Thoughts, Volume10 (Issue 7),a427-a432*. Available at https://ijcrt.org/papers/IJCRT2207049.pdf.

7 Lagorio,A., Zenezini, G., Mangano,G. & Pinto,R.(2018). A systematic Review of Innovative Technolgies adopted in Logistics Management. *Politrcnico Di Torino Repository Istituzionale, (2021) 437-443*. 10.1080/13675567.2020.1850661

8 Lagorio,A., Cimini, C., Pinto,R. & Cavalieri,S.(2022). 5G in Logistics 4.0: potential applications and challenges. *Procedia Computer Science, 217(2023) 650-659*. 10.1016/j.procs.2022.12.261

9 Song,Y., Yu, R.F., Zhou,L. & He,Z.(2021), Applications of the Internet of Things (IoT) in Smart Logistics: A Comprehensive Survey. *IEEE Internet of Things Journal, Vol.8, NO. 6,4250-4274.* 10.1109/JIOT.2020.3034385

10 DPIIT.(2022). National Logistic Policy 2022. DoT. Retrived October, 15, 2023 from https://dpiit.gov.in/sites/default/files/NationalLogisticsPolicy_2022_29September2022_0.pdf

11 DPIIT.(2022). Logistics Ease Across Different States(LEADS) Report-2022.DPIIT. Retrieved from https://dpiit.gov.in/sites/default/files/LEADSReports_2022_19April2023.pdf

12 United Nations, Economic and Social Commission for Asia and the Pacific (ESCAP). FRONTIER TECHNOLOGIES for sustainable development in Asia and the Pacific. United Nations. Retrieved from https://repository.unescap.org/bitstream/handle/20.500.12870/295/ESCAP-2018-RP-Frontier-technologies-sustainable-development-Asia-Pacific.pdf?sequence=1&isAllowed=y

13 Durant, I. (2021). *Emerging technologies can foster inclusive COVID-19 recovery.* UNCTAD. Retrieved from https://unctad.org/news/emerging-technologies-can-foster-inclusive-covid-19-recovery

14 Article in Business line. (2021). Developing an efficient logistics ecosystem. Retrieved October 16, 2023 from https://www.thehindubusinessline.com/opinion/developing-an-efficient-logistics-ecosystem/article37992023.ece

15 Ernst & Young report.(2023). Realizing the potential of a US$26 trillion economy. Retrieved October 17, 2023 from https://www.ey.com/en_in/india-at-100

16 Tijan, E., Aksentijevic, S., Ivanić, K., & Jardas, M. (2019). Blockchain Technology Implementation in Logistics. *Sustainability,* 11(4), 1185. https://doi.org/10.3390/su11041185

17 Raja Santhi, A., & Muthuswamy, P. (2022). Influence of Blockchain Technology in Manufacturing Supply Chain and Logistics. *Logistics*, 6(1), 1-22. https://doi.org/10.3390/logistics6010015

18 World Economic Forum. (2013). Enabling Trade Valuing Growth Opportunities. Retrieved January 20, 024 from https://www3.weforum.org/docs/WEF_SCT_EnablingTrade_Report_2013.pdf

19 Puri, K.(2023). 11Logistical Issues and 4 Ways to Solve Them. Accessed on January 23rd, 2024 from https://fareye.com/resources/blogs/logistical-issues

20 Logistics Skill Council. Logistics Industry Overview. Accessed from https://lsc-india.com/logistics-industry-overview

22 Moumen, I., Rafalia, N., Abouchabaka, J., & Aoufi, M. (2023). Real-time GPS tracking system for IoT-enabled connected vehicles. E3S Web of Conferences, 412(1). https://doi.org/10.1051/e3sconf/202341201095

23 Vimal, K.E. K, Sivakumar K, Kandasamy,J., Venkat,V., & Mani,R.S.(2023).Barriers to the adoption of digital technologies in a functional circular economy network. *Operations Management Res*earch **16**, 1541–1561 (2023). https://doi.org/10.1007/s12063-023-00375-y

24 Cichosz, M., Wallenburg, C. M., & Knemeyer, A. M. (2020). Digital transformation at logistics service providers: Barriers, success factors and leading practices. International Journal of Logistics Management, 31(2), 209-238. https://doi.org/10.1108/IJLM-08-2019-0229

25 Horovyi,V., & Ampligove.A.(2023). Automation in Logistics and Warehousing: New Performance Frontier. Accessed on October , 13th 2023 from https://www.trinetix.com/insights/automation-in-logistics-and-warehousing-new-performance-frontier

26 Indian Institute of Materials Management. (2020). *Logistics Management*. Indian Institute of Materials Management.

27 Appsiera.(2023). Blockchain Technology for Logistics | Benefits and Challenges. https://www.appsierra.com/blog/blockchain-technology-for-logistics

28 Civati,.A.(2023). Blockchain For Logistics & Shipment - Use cases and numbers for this fast growing market. Accessed from

https://www.linkedin.com/pulse/blockchain-logistics-shipment-use-cases-numbers-fast-civati/

29 Muynck,.B.D.(2023). The True Role Of AI In Logistics. Accessed January 25th 2024 from https://www.forbes.com/sites/forbestechcouncil/2023/08/17/the-true-role-of-ai-in-logistics/?sh=5e82e6aa51d3

30 Choy, K. L., Gunasekaran, A., Lam, H. Y., Chow, K. H., Tsim, Y. C., Ng, T. W., Tse, Y. K., & Lu, X. A. (2014). Impact of information technology on the performance of logistics industry: The case of Hong Kong and Pearl Delta region. The Journal of the Operational Research Society, 65(6), 904-916. https://www.jstor.org/stable/24503149

31 Leeway Hertz. The role of AI in logistics and supply chain.Accessed from https://www.leewayhertz.com/ai-in-logistics-and-supply-chain/

32 A-teamGlobal.(2023). ADVANTAGES OF IOT IN LOGISTICS AND SUPPLY CHAIN MANAGEMENT (2023). **A**ccessed on January 31,2024 from https://a-team.global/blog/advantages-of-iot-in-logistics-and-supply-chain-management/)

33 Strategic Market Research. Accessed on 05th February, 2024 from https://www.strategicmarketresearch.com/market-report/digital-logistics-market

34 NIST.(2011). Recommendations of the National Institute of Standards and Technology, U.S. Department of Commerce. Accessed from https://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication800-145.pdf

35 Hung, Y.-H. (2019). Cloud Computing: A Study of Logistics as a Service (LaaS). *International Journal of Future Computer and Communication*, 8(3), September, doi: 10.18178/ijfcc.2019.8.3.546.

36 https://indiainfrastructure.com/wp-content/uploads/2020/02/Road-Development-in-India-2021-22_Released_TOC.pdf

37 Louw. L (2024). A complete guide to inventory management with the use of blockchain. Accessed from https://www.bsvblockchain.org/news/a-complete-guide-to-inventory-management-with-the-use-of-blockchain

38 Temjanovski, R., Bezovski, Z., & Jovanov Apasieva, T. (2021). Cloud computing in logistic and Supply Chain Management environment. *ISSN 1857-9973*, UDC004.75:004.455]:658.86/.87.

39 WEF. (2016). Digital Transformation of Industries Logistics Industry (2016). Accessed on 15.10.2023, from https://www.weforum.org/publications/digital-transformation-of-industries/

40 WCO/WTO. (2022). Study Report on Disruptive Technologies (2022). Accessed on February 15th 2024 from https://www.wto.org/english/res_e/publications_e/wco-wto22_e.htm

41 WEF. (2022). This is what the future of logistics looks like. accessed on 22.01.2024 from https://www.weforum.org/agenda/2022/10/this-is-what-the-future-of-logistics-looks-like/

42 Al Kaabi, M. B. T. (2022, October 12). This is what the future of logistics looks like. World Economic Forum. https://www.weforum.org/agenda/2022/10/this-is-what-the-future-of-logistics-looks-like/

43 Cil, A. Y., Abdurahman, D., & Cil, I. (2022). Internet of Things enabled real time cold chain monitoring in a container port. *Journal of Shipping and Trade*, 7, Article 9. https://doi.org/10.1186/s41072-022-00110-z

44 Thomas.M.(2024). 17 examples of AI in supply chain. Accessed from https://builtin.com/artificial-intelligence/ai-in-supply-chain

45 Horovy, V. & Ampilogova, A. (2023).Automation in Logistics and Warehousing;New Performance Frontier. accessed February 15th 2024 from https://www.trinetix.com/insights/automation-in-logistics-and-warehousing-new-performance-frontier

46 IBEF.(2024). Road and Infrastructure Industry Analysis. Accessed from https://www.ibef.org/industry/roads-presentation

47 M2Catalyst.(2023). M2CATALYST GLOBAL MOBILE INSIGHTS REPORT. Accessed from https://www.m2catalyst.com/_files/ugd/6ef073_02d12bb07bb2404fb5538e30ebb7e2ef.pdf

48 KPMG. (2022). The logistics and warehousing market in India. Accessed on January 25th, 2024 from https://kpmg.com/in/en/home/insights/2022/10/logistics-and-warehousing-market-in-india.html

49 NITI Ayog. https://www.strategicmarketresearch.com/market-report/digital-logistics-market

50 Logistics Skill Council. LIST OF SUB-SECTORS UNDER LSC. Accessed from https://lsc-india.com/sub-sectors

51 ITU. Artificial Intelligence for Good. Retrived from https://www.itu.int/en/mediacentre/backgrounders/Pages/artificial-intelligence-for-good.aspx#:~:text=Artificial%20Intelligence%20(AI)%20comprises%20a,applications%20that%20enable%20self%2Dlearning)

52 Mckinsey & Company. (2021). Succeeding in the AI supply-chain revolution. Accessed from https://www.mckinsey.com/industries/metals-and-mining/our-insights/succeeding-in-the-ai-supply-chain-revolution

53 Emtec.(2023). Transforming Logistics: How Digital Technologies are Reshaping the Industry. Accessed October 15th, 2023 from https://www.emtec.digital/think-hub/blogs/digital-technologies-empowering-logistics-with-innovations/)

54 ITU.(2024). Y.3500 : Information technology - Cloud computing - Overview and vocabulary. Accessed from https://www.itu.int/rec/T-REC-Y.3500-201408-I.

55 NIST.(2011). Recommendations of the National Institute of Standards and Technology, U.S. Department of Commerce. https://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication800-145.pdf)

56 Ernst & Young (2023). Envisioning the future of Indian logistics@2047. Accessed on January 25th, 2023 from https://www.ey.com/en_in/consulting/transforming-the-future-of-indian-logistics-sector#:~:text=Envisioning%20the%20future%20of%20Indian%20logistics%402047&text=Logistics%20is%20of%20critical,fast%2Dpaced%20growth%20in%20economy

57 OECD. (2022). Frontier Technology. Retrieved from https://unfccc.int/news/frontier-technology#:~:text=Technology%20can%20sometimes%20seem%20overwhelming,the%20potential%20to%20displace%20existing

58 Silitonga, N. (2023). 14 Logistics Innovations and Industry Trends In 2023. Retrieved from https://www.dropoff.com/blog/logistics-innovations-and-industry-trends/

59 Web Article (2023), Top 4 Logistics Trends at the 2023 World Economic Forum. Accessed on 22.01.2024 from https://aramexpress.aramex.com/top-4-logistics-trends-at-the-2023-world-economic-forum/

60 NITI Aayog(2020). BlockChain the India Strategy. Accessed from https://www.niti.gov.in/sites/default/files/2020-01/Blockchain_The_India_Strategy_Part_I.pdf

61 Brown.M & Melchionna, M.(2023).7 challenges with blockchain adoption and how to avoid them (2023). Accessed from https://www.techtarget.com/searchcio/tip/5-challenges-with-blockchain-adoption-and-how-to-avoid-them

62 Soni's Vision.(2024).AI and Blockchain Reimagine the Legal Landscape for Indian Startups(2024). Accessed from https://www.sonisvision.in/blogs/ai-and-blockchain-reimagine-the-legal-landscape-for-indian-startups

63 Saxena, A.(2023). Navigating the Challenges of Cloud Computing (2023). https://sprinto.com/blog/challenges-in-cloud-computing/#:~:text=Multi%2Dcloud%20environments%20present%20issues,security%20requirements%20of%20multi%2Dclouds.

64 LEADS report (2023). Logistics Ease Across Different States Report. Accessed from https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1987132

65 AWS(Amazon). Blockchain for Supply Chain: Track and Trace. Accessed from https://aws.amazon.com/blockchain/blockchain-for-supply-chain-track-and-trace/#:~:text=Track%20and%20Trace%20with%20Blockchain&text=Because%20transactions%20are%20always%20time,violations%2C%20delays%2C%20and%20waste.

66 DHL(2018). Blockchain in Logistics. Accessed January 25th ,2024 from https://www.dhl.com/content/dam/dhl/global/core/documents/pdf/glo-core-blockchain-trend-report.pdf

67 Dobrovnik, M., Herold, D. M., Fürst, E., & Kummer, S. (2018). Blockchain for and in Logistics: What to Adopt and Where to Start. *Logistics*, 2(3), 18. https://doi.org/10.3390/logistics2030018

68 Hofman, H.(2023). How cloud computing is shaping the future of logistics. Accessed January 31st 2024 from https://www.maersk.com/insights/digitalisation/2023/02/06/cloud-computing-logistics

69 Oracle(2020). Is Logistics at a Tipping Point for Cloud and Emerging Technology Adoption?. Accessed from https://www.oracle.com/a/ocom/docs/is-logistics-at-a-tipping-point-for-cloud-and-emerging-technology-adoption.pdf

70 xChange.(2020). Smart Container | Advantages, Use Cases and Impact on Container Logistics. Accessed from https://www.container-xchange.com/blog/smart-containers/

71 xChange. (2023). The benefits of digitalizing container operations. https://www.container-xchange.com/wp-content/uploads/reports/2023-04-Benefits_of_Digi_Conops.pdf

72 DHL(2023). Big Data in Logistics: What Is the True Value of Data?. Accessed from https://dhl-freight-connections.com/en/trends/big-data-in-logistics-what-is-the-true-value-of-data/

73 DoT (2023), "Implementation of SoP for Data Management on DoT PM GatiShakti National Master Plan Platform" dated 15.05.2023, issued by the National Broadband Mission, Department of Telecommunications.

74 NITI Aayog.(2021). FAST TRACKING FREIGHT IN INDIA. Accessed on 25.01.2024: https://www.niti.gov.in/sites/default/files/2021-06/FreightReportNationalLevel.pdf

75 IBEF.(2024). Railways Industry Report. Accessed from https://www.ibef.org/industry/indian-railways

76 IBEF.(2023). Ports Industry Report. Accessed from https://www.ibef.org/industry/ports-india-shipping

77 KPMG (2022). The logistics and warehousing market in India, October 2022 accessed on 25.01.2024. Accessed from from

https://kpmg.com/in/en/home/insights/2022/10/logistics-and-warehousing-market-in-india.html

78 Shankaran, J. (2023). Indian cargo market touches 2.2mn tonnes: Trade And Transport Group. Accessed from **https://www.stattimes.com/air-cargo/indian-cargo-market-touches-22mn-tonnes-trade-and-transport-group-1348150?infinitescroll=1**

79 Gupta, A. (2022). A Role of Cloud Computing in Logistics in 2023 - Benefits & Limitations. Accessed from https://closeloop.com/blog/role-of-cloud-computing-in-logistics-2022-benefits-limitations/

80 Sonowal. (2024).Govt plans to develop Jawaharlal Nehru Port as smart port within a year: *The Economic Times*. Retrieved from https://economictimes.indiatimes.com/industry/transportation/shipping-/-transport/govt-plans-to-develop-jawaharlal-nehru-port-as-smart-port-within-a-year-sonowal/articleshow/100510011.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst.

81 Khatib, E. J., & Barco, R. (2021). Optimization of 5G Networks for Smart Logistics. *Energies*, 14(6), 1758. https://doi.org/10.3390/EN14061758

82 Gilmore,M.(2020). 5G'S IMPACT ON TRANSPORT AND LOGISTICS: $280BN OF BENEFITS IN 2030. Accessed February, 01st, 2024 from https://smarttransportpub.blob.core.windows.net/web/1/root/5gs-impact-on-transport-and-logistics-280bn-of-benefits-in-2030-september-2020.pdf

83 Hofman,H.(2023). The game-changing potential of 5G in logistics. Accessed from https://www.maersk.com/insights/growth/2023/01/17/the-potential-of-5g-in-logistics#:~:text=5G%20in%20logistics%20can%20benefit,or%20thousands%20of%20square%20metres.

84 Kapoor, R.,Yaghoubi,S.H.&Kalathi,T.T.(2024). AI Regulation in India: Current State and Future Perspectives. Accessed from https://www.morganlewis.com/blogs/sourcingatmorganlewis/2024/01/ai-regulation-in-india-current-state-and-future-perspectives#:~:text=Issues%20such%20as%20liability%20for,best%20legal%20and%20contractual%20protections

85 Kumbar,V. & Hiremath,S.M.(2023). Envisioning the Future of Indian Logistics. *International Journal For Multidisciplinary Research*. https://doi.org/10.36948/ijfmr.2023.v05i02.2756

86 India Science, Technology & innovation. Artificial Intelligence in India. Accessed from https://www.indiascienceandtechnology.gov.in/sites/default/files/AI%20Trend%20story.pdf

87 SUPRA. (2022). *What is a Consortium Blockchain?* Accessed from https://supra.com/academy/what-is-a-consortium-blockchain/

88 Netscribes (India) Pvt. Ltd. (2022). *Warehousing Market in India 2022-2027*. https://www.marketresearch.com/Netscribes-India-Pvt-Ltd-v3676/Warehousing-India-32528958/

Appendices

Questionnaire for PM GatiShakti: Examining the role of Telecommunications in Logistics sector

Dear Sir/Madam,
Greetings!

My name is Sanjeev Kumar Arya, working as Director at Department of Telecom (DoT). I am presently pursuing my public policy course from Indian Institute of Public Administration. This questionnaire is part of my dissertation work, examining the role of Telecommunications & Frontier Technologies in Logistics sector for the course. I can be contacted at 9868131555 and sanjeevarya1@gmail.com for any clarification on the same.
The information provided by you will be kept strictly confidential and will be used only for academic purpose at Indian Institute of Public Administration, New Delhi.
I, therefore, request your cooperation and participation in responding questionnaire. The questionnaire will take about few minutes to respond.
Thanks.
* Indicates Required Question

* Indicates required question

1. Name *

2. Email

3. What is your profession? *

Mark only one oval.

- ◯ Government/PSUs
- ◯ Private Sector(ICT/Logistics/etc.)
- ◯ Academia/Student
- ◯ Other: _____

4. Gender *

Mark only one oval.

- ◯ Male
- ◯ Female
- ◯ Other

Skip to question 5

PM GatiShakti

5. Do you agree with the following objectives of PM GatiShakti? (select all that may apply) *

Check all that apply.

- ☐ Reduce logistics costs in India.
- ☐ Improve multi-modal connectivity and infrastructure.
- ☐ Create a seamless logistics ecosystem.
- ☐ Enhance logistics efficiency and competitiveness of Indian businesses.
- ☐ Promote economic growth.
- ☐ Other: _____

6. To what extent do you think that geographic information system (GIS) mapping of telecom infrastructure in PM GatiShakti will be useful to addresses the communication needs of the logistics sector? *

Check all that apply.

- ☐ To a large extent
- ☐ Moderately
- ☐ To a small extent
- ☐ Not at all

7. What are the potential benefits of GIS mapping of telecom infrastructure in PM GatiShakti? (Select all that apply) *

Check all that apply.

- [ ] Expedite the roll out of Telecom services
- [ ] Optimization of resources
- [ ] Better Synchronization with stakeholders like Railways, State Governments, Roads, GAIL, Municipalities and improved decision making
- [ ] Help in faster clearance of Right of Way(RoW) permission
- [ ] Other: _____

8. What are the possible bottlenecks for GIS mapping of telecom infrastructure in PM GatiShakti?(Select all that may apply) *

Check all that apply.

- [ ] GIS data of infrastructure/assets not available in required format.
- [ ] Needs more coordination with various departments
- [ ] GIS data for street furniture partial available
- [ ] Reluctance to share the data from stakeholders
- [ ] Other: _____

9. In your opinion, what are the key parameters of the Telecom layer in PM GatiShakti that are relevant to improving logistics efficiency in India? (Select all that apply) *

Check all that apply.

- [ ] High-speed cellular network coverage (5G)
- [ ] Cellular network coverage (4G)
- [ ] Reliable internet connectivity across all regions
- [ ] Reliable Fibre connectivity to various points in Logistics ecosystem
- [ ] Wi-Fi connectivity across all regions
- [ ] Other: _____

10. *

In which specific areas of the logistics process would the integration of 5G technology offer significant advantages? (Select all that apply)

Check all that apply.

- [ ] Real-time tracking
- [ ] Autonomous vehicles/drones
- [ ] Smart warehouses
- [ ] Remote monitoring and control
- [ ] Enhanced communication with IoT devices
- [ ] Other: _____

11. What benefits or improvements are considered for adopting 5G technology in logistics operations? (Select all that apply) *

Check all that apply.

- [ ] Faster data transmission
- [ ] Reduced latency
- [ ] Improved connectivity
- [ ] Enhanced reliability
- [ ] Support for more connected devices
- [ ] Improved supply chain visibility
- [ ] Other: _____

12. *

What measures do you think could enhance the effectiveness of the Telecom layer in PM GatiShakti ?(Select all that apply)

Check all that apply.

- [ ] Increased awareness programs among stakeholders
- [ ] Government initiatives through investments/incentives
- [ ] Collaboration/sharing of information with Private entities
- [ ] Technological training for workforce
- [ ] Other: _____

Roles of Frontier Technologies {Artificial Intelligence(AI), Big Data, Block Chain, Cloud, Internet of Thing(IoT)} in Logistics Sector

13. According to you, which areas of logistics sector have the potential for Blockchain applications? (Select all that apply) *

Check all that apply.

- [ ] Track and trace of goods
- [ ] Document management and verification
- [ ] Smart Contracts
- [ ] Inventory management and optimization
- [ ] Payment processes and fraud prevention
- [ ] Customs clearance
- [ ] Other: _____

14. What benefits or improvements have you perceived for adopting Blockchain in logistics operations? (Select all that apply) *

Check all that apply.

- [ ] Increased transparency and trust
- [ ] Enhanced security
- [ ] Faster transaction processing
- [ ] Cost savings
- [ ] Improved traceability
- [ ] Other: _____

15. In which specific areas of the logistics process would you like to integrate AI technologies ? (Select all that apply) *

Check all that apply.

- [ ] Demand forecasting
- [ ] Route optimization
- [ ] Predictive maintenance
- [ ] Inventory management
- [ ] Enhanced Customer Experience
- [ ] Other: _____

16. What benefits or improvements are expected by using Artificial Intelligence(AI) in logistics operations? (Select all that apply) *

Check all that apply.

- [ ] Increased operational efficiency
- [ ] Cost savings
- [ ] Improved decision-making
- [ ] Enhanced customer satisfaction
- [ ] Better resource utilization
- [ ] Other: _____

17. What do you consider as the main benefits of using Cloud technology in logistics sector? (Select all that apply) *

Check all that apply.

- [ ] Scalability and flexibility
- [ ] Cost savings through reduced IT infrastructure
- [ ] Improved accessibility and collaboration
- [ ] Speedier adoption of innovation in the sector
- [ ] making supply chain information collaboration easy & efficient
- [ ] Other: _____

18. In which specific areas of the logistics process, integration of IoT devices have potential? (Select all that apply) *

Check all that apply.

- [ ] Asset tracking
- [ ] Fleet management
- [ ] Warehouse monitoring
- [ ] Predictive maintenance
- [ ] Cold chain monitoring
- [ ] Other: _____

19. What benefits or improvements are considered for adopting Internet of Things (IoT) in logistics operations? (Select all that apply) *

Check all that apply.

- [ ] Improved real-time tracking
- [ ] Enhanced operational efficiency
- [ ] Cost savings
- [ ] Better inventory management
- [ ] Improved safety and security
- [ ] Other: _____

20. What specific areas of the logistics process have the potential benefits for integration of Big Data ? (Select all that apply) *

Check all that apply.

- [ ] Demand forecasting
- [ ] Route optimization
- [ ] Inventory management
- [ ] Predictive maintenance
- [ ] Customer behavior analysis
- [ ] Other: _____

21. What benefits or improvements have you perceived for adopting Big Data analytics in logistics operations? (Select all that apply) *

Check all that apply.

- [ ] Improved decision-making
- [ ] Enhanced operational efficiency
- [ ] Cost savings
- [ ] Better demand forecasting
- [ ] Improved customer satisfaction
- [ ] Other: _____

22. What are the main challenges being faced in utilizing telecommunications and frontier technologies(Big Data analytics, IoT, Artificial Intelligence(AI), blockchain & cloud technologies) in logistics operations ? (Select all that apply) *

Check all that apply.

- [ ] Lack of access to reliable and affordable high-speed internet connectivity
- [ ] High initial investment and maintenance costs for technology implementation
- [ ] Limited digital literacy and skills among logistics professionals
- [ ] Lack of awareness and understanding of technology benefits
- [ ] Concerns about data security and data privacy risks
- [ ] Complex regulations and lack of data standardization
- [ ] Compatibility/interoperability issues
- [ ] Other: _____

23. What specific measures do you suggest the government or industry stakeholders can take to facilitate the use of global frontier technologies to improve efficiency in the logistics sector? (Select all that may apply) *

Check all that apply.

- [ ] Increase public investment in infrastructure development and technology research
- [ ] Government shall provide financial incentives and subsidies for technology adoption
- [ ] Develop training programs and workshops for digital skill development
- [ ] Simplify regulations and establish data standardization procedures
- [ ] Foster public-private partnerships for technology innovation
- [ ] Other: _____

24. Any other remarks (for issues/challenges/recommendations)

_____

_____

_____

_____

_____

भारतीय लोक प्रशासन संस्थान
Indian Institute of Public Administration
Indraprastha Estate, Ring Road, New Delhi -110002
www.iipa.org.in

Surendra Nath Tripathi, IAS (Retd.)
Director General
(Former Secretary, M/o Parliamentary Affairs, GoI)

14/XLIX-APPPA/13/2023-24
5th January, 2024

Sub: Request for Assistance in Data Collection for Research on "PM GATISHAKTI: Examining the role of Telecommunications in Logistics Sector".

Shri Sanjeev Kumar Arya from Department of Telecommunications, is undergoing ten months Advanced Professional Programme in Public Administration at this Institute, which is sponsored by Department of Personnel & Training, Govt. of India (3rd July, 2023 to 30th April, 2024).

As part of the course, Shri Sanjeev Kumar Arya, has to submit a dissertation on " **PM GATISHAKTI: Examining the role of Telecommunications in Logistics Sector** " as in the Year 2022, PM GatiShakti National Master Plan (PMGS-NMP) by Department for Promotion of Industry and Internal Trade(DPIIT) was recognized for Innovations (Centre) Category under PRIME MINISTER'S AWARDS 2022. He is examining the role of Telecommunications & frontier technologies in Logistics sector in the country.

In order to make the study meaningful, it is imperative that the research process be facilitated in the form of answering questionnaires/ granting interviews and sharing relevant data. In light of the above, we kindly request your office to issue directives to all relevant government officials and stakeholders.

The objective of the research is to study issues and challenges and suggest recommendations to facilitate use of frontier technologies in Logistics sector. It is earnestly requested to facilitate the officer anyways in furtherance of a meaningful dissertation.

Yours sincerely,
Sd/-
(Surendra Nath Tripathi)

Shri Rajesh Kumar Singh, IAS
Secretary
Department for Promotion of Industry and Internal Trade
Udyog Bhawan, New Delhi 110011

Copy to:

1. Smt. Sumita Dawra, Special Secretary(Logistics), DPIIT, Email: dawras@ias.nic.in
2. Shri. Dr. Surendra Ahirwar, Joint Secretary , DPIIT, Email: surendra.ahirwar@nic.in

(Surendra Nath Tripathi)

Coordinates: 91-11-23702434 • Fax: +91-11-23702440 • email: sntripathi@iipa.education | directoriipa9@gmail.com

भारतीय लोक प्रशासन संस्थान
Indian Institute of Public Administration
Indraprastha Estate, Ring Road, New Delhi -110002
www.iipa.org.in

Surendra Nath Tripathi, IAS (Retd.)
Director General
(Former Secretary, M/o Parliamentary Affairs, GoI)

14/XLIX-APPPA/13/2023-24
5th January, 2024

Sub: Request for Assistance in Data Collection for Research on "PM GATISHAKTI: Examining the role of Telecommunications in Logistics Sector".

Shri Sanjeev Kumar Arya from Department of Telecommunications, is undergoing ten months Advanced Professional Programme in Public Administration at this Institute, which is sponsored by Department of Personnel & Training, Govt. of India (3rd July, 2023 to 30th April, 2024).

As part of the course, Shri Sanjeev Kumar Arya, has to submit a dissertation on " **PM GATISHAKTI: Examining the role of Telecommunications in Logistics Sector** " as in the Year 2022, PM GatiShakti National Master Plan (PMGS-NMP) by Department for Promotion of Industry and Internal Trade(DPIIT) was recognized for Innovations (Centre) Category under PRIME MINISTER'S AWARDS 2022. He is examining the role of Telecommunications & frontier technologies in Logistics sector in the country.

In order to make the study meaningful, it is imperative that the research process be facilitated in the form of answering questionnaires/ granting interviews and sharing relevant data. In light of the above, we kindly request your office to issue directives to all relevant government officials and stakeholders.

The objective of the research is to study issues and challenges and suggest recommendations to facilitate use of frontier technologies in Logistics sector. It is earnestly requested to facilitate the officer anyways in furtherance of a meaningful dissertation.

Yours sincerely,
Sd/-
(Surendra Nath Tripathi)

Shri Rajat Kumar Saini, IAS
CEO & MD, NICDC and Chairman NLDSL
Flat No. 302 C, 03rd Floor,
World Trade Centre, Babar Road,
New Delhi - 110001

Copy to:
Shri Girish Kumar Surpur, Chief Executive Officer (CEO) and Director-NICDC Logistics Data Services Limited (NLDSL)

(Surendra Nath Tripathi)

Coordinates: 91-11-23702434 • Fax: +91-11-23702440 • email: sntripathi@iipa.education | directoriipa9@gmail.com

Gmail Sanjeev Arya <sanjeevarya1@gmail.com>

Interview of DDG(NMB), DOT regarding .

Sanjeev Arya <sanjeevarya1@gmail.com> Mon, Feb 12, 2024 at 10:08 AM
To: neeraj@gov.in
Cc: sanjeevk.arya@nic.in

Respected Sir,

My name is Sanjeev Kumar Arya, working as Director at Department of Telecom (DoT). I am presently pursuing my public policy course from Indian Institute of Public Administration. This interview is part of my dissertation work PM GatiShakti: examining the role of Telecommunications in Logistics sector for the course. Apart from this I am examining the roles of frontier technologies like AI, Big Data, Blockchain, Cloud & IoT in the logistics sector.

As it is learnt that you are the key person in implementing the National Broadband Mission & GIS mapping for Telecom layers on behalf of Department of Telecommunications.

So, It will be good insights on the subject and leanings for me while interviewing you and this will help me in my dissertation.

The information provided by you will be used only for academic purpose at Indian Institute of Public Administration, New Delhi.

I also wish to seek some data to be provided from your office as per attached.

I, therefore, request you giving me the appropriate date and time for Interview.

Yours Sincerely,

Sanjeev Kumar Arya,

Director(TEC)

ITS-99 Batch.

Questions data from NBM.docx
12K

Annexure to email(DoT); Questions & data required from Department of Telecom (NBM):

1. What are the different layers/sub layers and parameters of Telecom layer with their names?
2. Who are different stakeholders involved in it for different layer/sublayer?
3. What is the current status of Tower mapped in PMGATISHAKTI, State wise and operator wise along with the total figure?
4. What is the current status of OFC mapping in PMGATISHAKTI, State wise and operator wise along with the total figure?
5. What is the current status of street furniture mapping, state wise along with total figure?
6. Kindly share the use cases, wherein PMGATISHAKTI has been useful in roll out of Telecom services?
7. Whether Private TSPs can access this portal can for their expansion of telecom services especially in case of 5G services?
8. Any other inputs/remarks.