



शिक्षा मंत्रालय
MINISTRY OF
EDUCATION



A Report on **FUTURE TALENT REQUIREMENTS IN LOGISTICS**

Vision 2047 document



The vision aims to transform India into a developed nation by 2047, the 100th year of independence. It encompasses various aspects of development

A Report on

FUTURE TALENT REQUIREMENTS IN LOGISTICS

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Executive Summary

Logistics plays a pivotal role in a country's economy by facilitating the efficient movement of goods, services, and information throughout the supply chain. Essential logistics components in economic development include trade facilitation, supply chain efficiency, job creation, infrastructure development, cost reduction, market access and globalization, innovation and technological advancements, etc.

The logistics sector in India is one of the largest in the world and is expected to reach INR 47.12 lakh crore by 2030. It is undergoing significant transformation due to various factors such as technological advancements, policy reforms, and increasing demand for efficient supply chain solutions. For example, India remarkably improved its logistics performance in the World Bank's latest report by ranking 38 (from 42) out of 139 countries in the 2023 edition of the Logistics Performance Index (LPI). In addition, to enhance logistics performance and infrastructure nationwide, the Indian government has undertaken initiatives like the National Logistics Policy (NLP), PM Gati Shakti National Master Plan, Sagarmala Programme, Bharatmala Pariyojana, Dedicated Freight Corridors, e-Way Bill System, Infrastructure Investments, Logistics Data Bank (LDB) and the Single Window Interface for Facilitating Trade (SWIFT).

The logistics industry creates employment opportunities across a wide range of sectors, including transportation, warehousing, distribution, and freight forwarding. By employing a diverse workforce, logistics contributes to reducing unemployment rates and improving living standards in communities. As the global and Indian landscape continues to evolve with rapid technological advancements and changing market dynamics, the logistics, supply chain management, and manufacturing sectors are undergoing significant disruptions.

In this dynamic environment, the role of workforce talent has become increasingly crucial, with organizations seeking skilled professionals who can navigate the complexities of modern supply chains, harness emerging technologies, and drive innovation.

The percentage of employable talent in India was estimated to be just over 51 percent in 2024, showing a slight improvement from the previous year's figure of around 50 percent. Despite this increase, less than half of the available talent in the country is considered suitable for employment, underscoring ongoing challenges in aligning skills with market demands. The logistics, supply chain, manufacturing sectors are facing significant challenges related to talent shortages, driven by various factors including evolving technology, changing skill requirements, and demographic shifts. About 77% of the employers in transportation, logistics & automotive industries across India stated that they had talent shortages in 2023.

However, the future job market in logistics and supply chain management is on the brink of significant transformations fuelled by technological advancements, evolving consumer behaviours, and global economic trends. The National Logistics Policy 2022 signifies a transformative phase for India's logistics sector, aiming to shift from fragmentation to cohesion and growth. By emphasizing human resource development and embracing cutting-edge technological advancements, the policy addresses skill shortages and aims for a sustainable logistics environment. With expectations of adding 10 million jobs by 2027, integrating next-generation technologies is crucial for efficient operations, as highlighted by sources like Gartner. However, to attract skilled workers, the sector must also enhance training programs and working conditions.

Executive Summary

The convergence of growth, technology, and skill development underscores the importance of a well-trained workforce and advanced technologies for streamlined operations. Overall, emerging technologies are revolutionizing the industry, enabling real-time monitoring, seamless data exchange, and agile decision-making across the value chain.

We envisage that the linchpin in this transformation will be driven by adoption of a range of technologies, including Big Data Analytics, Digital Twin, Blockchain Technology, Cloud Logistics, Internet of Things (IoT), Transportation Management System (TMS), Self-driving Vehicles, Augmented and Virtual Reality (AR/VR), Real-Time Supply Chain Visibility, Robotics, and Automation in Warehouses, as well as Drones. Currently, the industry operates at a digitization level of around 43%, with potential for substantial growth. According to McKinsey, increased digitization can lead to a 3.2% increase in annual growth of EBIT and a 2.3% increase in annual revenue growth. As the industry embraces digital transformation and innovation, professionals must continually upgrade their skill sets to remain competitive and adaptable. Supply chain visibility stands out as a top strategic priority among industry professionals. Meanwhile, skills such as manual data entry, traditional procurement practices, narrow specialization, static supply chain strategies, hierarchical decision-making, and manual material handling may become obsolete. Looking ahead, key aspects of the future job market in logistics governed by several factors including technology integration, data analytics, problem-solving, supply chain digitization, e-commerce expansion, sustainability and green logistics, globalization and trade, supply chain resilience, cross-functional collaboration, and adaptability.

The report provides some recommendations for shaping the future of the logistics workforce in India:

- **Curriculum redesign/upgradation:**

The report recommends making changes on the curriculum to ensure that it aligns with the evolving needs of the logistics industry. This includes incorporating courses and training programs that focus on emerging technologies, supply chain management, data analytics, problem-solving, and sustainability. This shall ensure a pipeline of skilled graduates.

- **Vocational Training:**

A study by KPMG highlights the efficacy of vocational training programs in augmenting employability, with over 80% of graduates from certified vocational courses securing gainful employment in the logistics sector within six months of completion. Leveraging digital platforms and immersive learning technologies further enhances accessibility and scalability of training initiatives, empowering aspiring professionals to acquire industry-relevant competencies irrespective of geographical constraints.

- **Faculty Training:**

The report suggests providing faculty training to enhance their knowledge and skills in the field of logistics. This includes organizing workshops, seminars, and training programs for faculty members to keep them updated with the latest industry trends and practices.

- **Training and Development of current and future workers:**

Invest in training programs to equip current logistics workers with the skills needed for emerging technologies like AI, ML, Big Data, and automation. Companies must embrace new technologies like AI, ML, Blockchain, IoT, Robotics, and Drones to improve efficiency and productivity. They must provide opportunities for reskilling and upskilling the existing workforce to adapt to the changing technological landscape.

Executive Summary

- **Training on Soft Skills:**

Soft skills are crucial for logistics workers. Adaptability, critical thinking, and collaboration are key to solving problems and working in a fast-changing environment. Communication, cultural awareness, and negotiation skills are also important for building strong relationships with a global network of clients, suppliers, and colleagues. Companies that promote continuous learning can empower their workforce to stay ahead of the curve.

- **Training of Aging Workforce:**

India's workforce is getting older. While the working-age population is growing and will be a major source of global labor, the number of young workers entering the workforce is shrinking. This is especially true in the logistics sector, where 40% of workers are already 45 or older. To address this challenge, policymakers and businesses need to focus on skilling and upskilling the workforce, particularly with digital skills. This will help workers stay competitive in a job market that is increasingly reliant on technology.

- **Diversity in Recruitment:**

Attract talent from diverse backgrounds with targeted recruitment campaigns highlighting the evolving and dynamic nature of the logistics industry. To be successful, the industry needs to embrace diversity and technology to address the changing workforce demographics and drive innovation.

- **Women in Logistics:**

Logistics companies can revamp themselves to attract more women by embracing digitization and highlighting the value of soft skills where women often excel. By prioritizing diversity and inclusion, logistics companies can benefit from a wider range of talent and perspectives, ultimately improving their competitiveness.

- **Industry Involvement:**

The chapter emphasizes the importance of industry involvement in shaping the future of the logistics workforce. It recommends establishing partnerships and collaborations between educational institutes and industry players to bridge the gap between academia and industry. This can be done through internships, industry visits, guest lectures, and industry-sponsored research projects.

- **Creation of a World Class Research and Innovation Ecosystem in Logistics:**

The chapter recommends creating a world-class research and innovation ecosystem in logistics to foster innovation and drive advancements in the field. This includes promoting research and development activities, encouraging collaboration between academia and industry, and providing funding and support for research projects in logistics.

- **Improved working conditions:**

Investments in improving working conditions in warehouses and throughout the supply chain to ensure worker safety and well-being can also attract skilled talent. Benefit packages, competitive salaries and career development opportunities will result in attraction and retention of skilled and qualified talent.

Future Talent Requirements in Logistics

1. Introduction

India is experiencing significant economic growth, with GDP increasing steadily. Gross domestic product (GDP) in India was 4112 billion USD (INR 342 lakh crore) till 8th March 2024^{1,1} with growth rate of 6.8%^{1,2} and expected to reach 5 trillion USD (INR 417 lakh crore) in next 5 years [See Fig. 1.1 and Fig. 1.2].

A country's GDP growth is shaped by various critical factors that drive economic expansion and development. Key drivers of GDP growth encompass investment, consumption, exports, innovation and technology, political stability, policy environment, and natural resource utilization. These drivers interact synergistically to impact overall economic performance and the pace of GDP expansion within a nation.

“Tomorrow's Bharat

Implementing policies and strategies that prioritize these drivers can foster sustained and accelerated economic growth over the long term.

Logistics plays a pivotal role in a country's economy by facilitating the efficient movement of goods, services, and information throughout the supply chain. Essential logistics components that contribute to economic development include trade facilitation, supply chain efficiency, job creation, infrastructure development, cost reduction, market access and globalization, innovation and technological advancements.

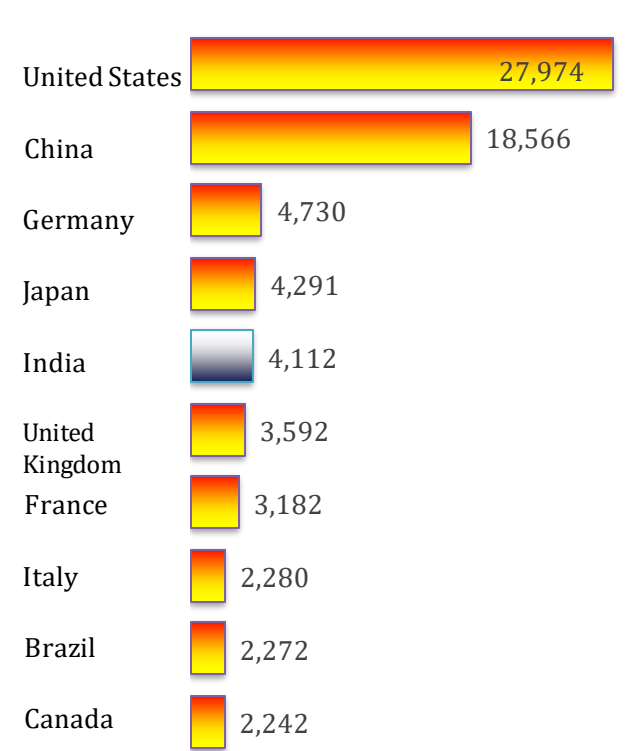


Figure 1.1: GDP of top 10 Countries in 2024 (in USD Billion)

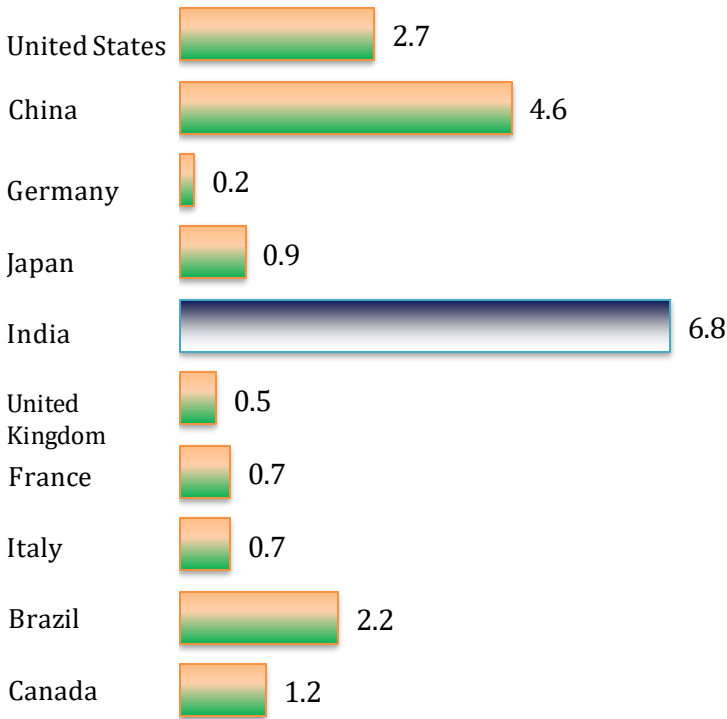


Figure 1.2: GDP growth rate (Annual percent change)

^{1,1} Source: <https://cleartax.in/s/world-gdp-ranking-list>
^{1,2} Source: https://www.imf.org/external/datamapper/NGDP_RPCH@WEO/ADVEC/OEMDC/WEOWORLD

The logistics industry creates employment opportunities across a wide range of sectors, including transportation, warehousing, distribution, and freight forwarding. By employing a diverse workforce, logistics contributes to reducing unemployment rates and improving living standards in communities.

1.1. Global Logistics Scenario

The COVID-19 pandemic had a profound and multifaceted impact on the global logistics industry. However, the global logistics industry has continued to recover from the COVID-19 pandemic. The global logistics market size was approximately 10.71 trillion USD (INR 892 lakh crore) in 2023^{1.3} and is expected to reach 14.08 trillion USD (INR 1173 lakh crore) by 2028. Approximately 45% of the worldwide logistics market is centered in the Asia-Pacific region.

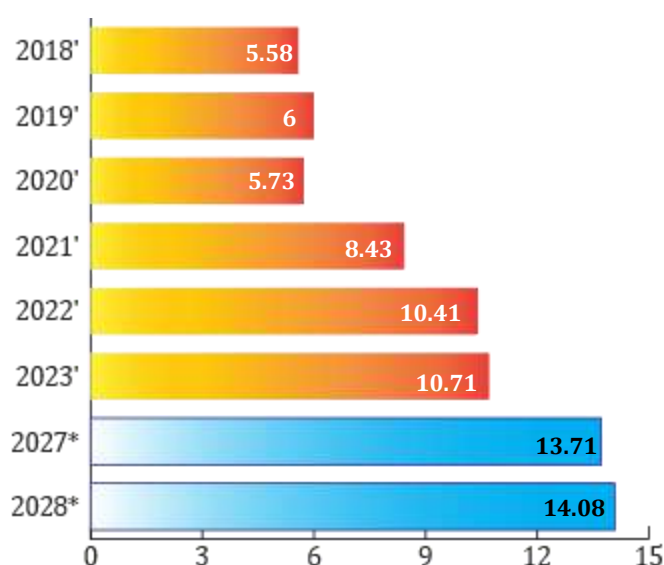


Figure 1.3: Size of the logistics industry worldwide 2018-2028 (in trillion USD)

As the global landscape continues to evolve with rapid technological advancements and changing market dynamics, the logistics, supply chain management, and manufacturing sectors are undergoing significant transformations.

In this dynamic environment, the role of talent has become increasingly crucial, with organizations seeking skilled professionals who can navigate the complexities of modern supply chains, harness emerging technologies, and drive innovation.

Disruption is one of the critical challenges for the logistics sector, and resilient transportation and logistics companies play a crucial role in it. They ensure the smooth functioning of supply chains and the movement of goods, especially during challenging times such as natural disasters, economic disruptions, or pandemics. Total Return to Shareholder (TRS) of resilient transportation and logistics companies on US market is better than non-resilient companies as well as NIFTY 50 and S&P500 [See Fig. 1.4]. This shows the importance of developing a resilient logistics sector.

The major players operating in the global logistics market are DHL, UPS (United Parcel Service), FedEx, Maersk, ECU Worldwide, DB Schenker, C.H. Robinson, Kuehne + Nagel, JD Logistics, XPO Logistics, Amazon Logistics. It is imperative for these firms to enhance the resilience of their logistics operations and implement strategic plans to minimize the talent demand-supply gap. Otherwise, it will impose significant constraints on other industries that depend on the logistics sector.

1.2. Indian Logistics Scenario

The logistics sector in India is one of the largest in the world. This sector in India is vital for the country's economic progress. Logistics contributes around 13% of India's GDP and is rapidly increasing. The logistics market size in India was INR 22.95 lakh crore in 2022^{1.4} and expected to reach INR 47.12 lakh crore by 2030.

Indian logistics sector is undergoing significant transformation due to various factors such as technological advancements, policy reforms, and increasing demand for efficient supply chain solutions.

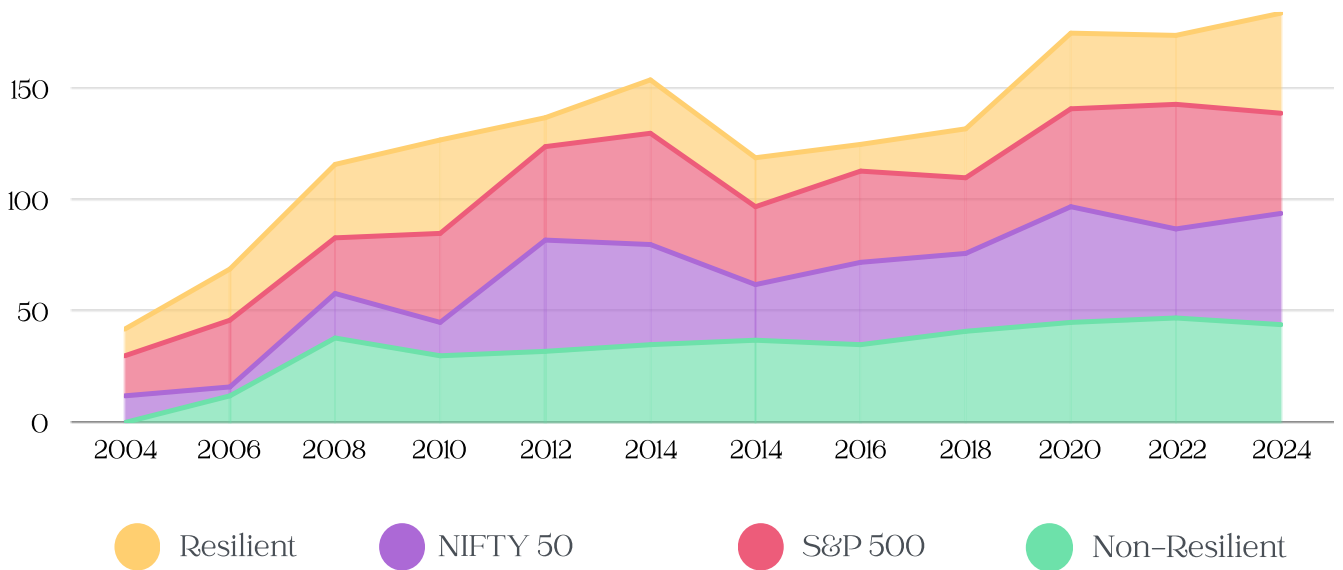


Figure 1.4: Resilient transportation and logistics players in United States outperform throughout the last economic cycle

The transportation industry contributed around 3.75% of the GDP, and the road sector dominates. More than 50% of freight and 90% of passenger traffic are handled by road. The e-commerce sector grew at 3.76% YoY, with the food and beverages sub-segment capturing 18.39% YoY growth and the personal and household sub-segment having 10.69% YoY growth. The transportation costs ratio in India is higher than the inventory and

administration costs concerning total logistics costs. The Department for Promotion of Industry and Internal Trade (DPIIT) estimated the logistics cost in India is 7.8% to 8.9% of the GDP. The most expensive mode of logistics in India was air with around 18 INR per metric ton kilometer, more than tenfold the cost of rail transport. It was followed by road transport with 3.6 rupees per metric kilometer. Road shared around 64% of the overall freight logistics.

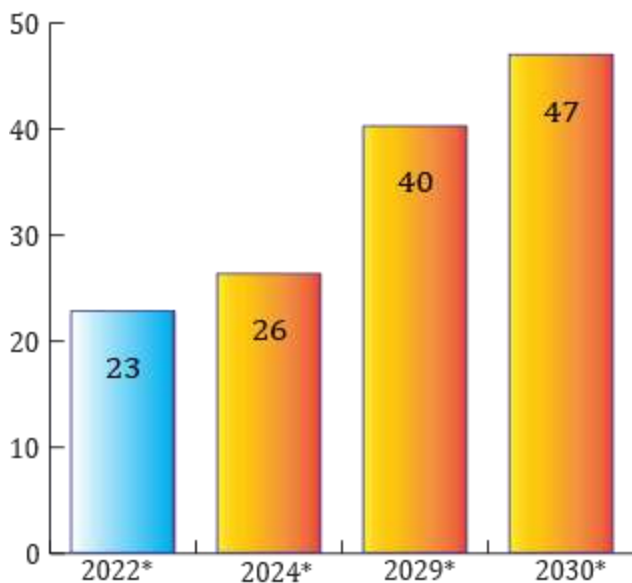


Figure 1.5: Size of logistics market in India (in INR Lakh Crore)

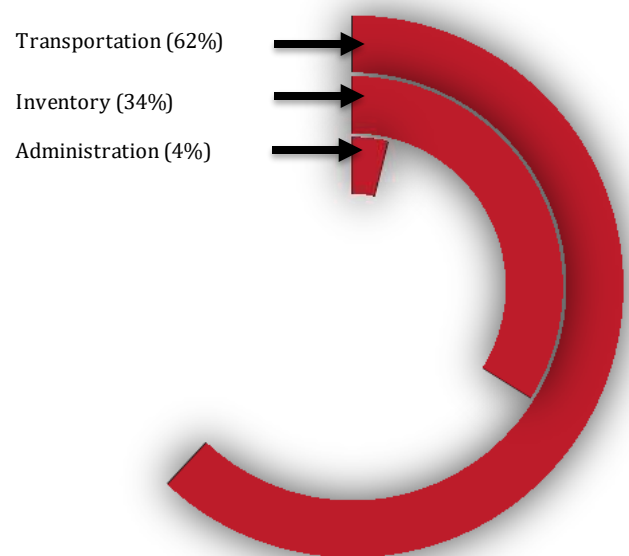


Figure 1.6: Distribution of total logistics costs in India by type

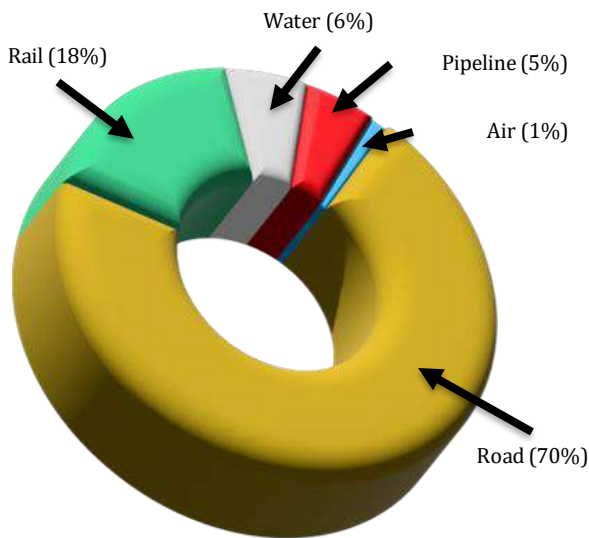


Figure 1.7: Share of freight logistic in India

For freight transporting beyond 300 km, railway's modal share decreased to around 32%. The Indian logistics market is diverse and includes a mix of domestic and international players across various segments. Some of the prominent companies operating in the Indian logistics sector are Blue Dart Express Ltd, Gati Ltd., DTDC Express Limited, Mahindra Logistics, DHL Express India, Reliance Logistics, Allcargo Logistics, Safexpress, FedEx Express India, India Post and many more.

1.2.1. Logistics Performance

India remarkably improved its logistics performance in the World Bank's latest report by ranking 38^{1.5} (from 42) out of 139 countries in the 2023 edition of the Logistics Performance Index (LPI). This LPI score depends on six parameters: customs, infrastructure, ease of arranging shipments, quality of logistics services, tracking and tracing, and timeliness. Notably, India has shown remarkable progress on four out of these six indicators, reflecting the impact of several strategic initiatives implemented over recent years

To enhance logistics performance and infrastructure nationwide, the Indian government has undertaken initiatives like the National Logistics Policy (NLP), PM Gati Shakti National Master Plan, Sagarmala Programme, Bharatmala Pariyojana, Dedicated Freight Corridors, e-Way Bill System, Infrastructure Investments, Logistics Data Bank (LDB) and the Single Window Interface for Facilitating Trade (SWIFT). These initiatives are focused on improving efficiency, reducing costs, and promoting the seamless movement of goods.

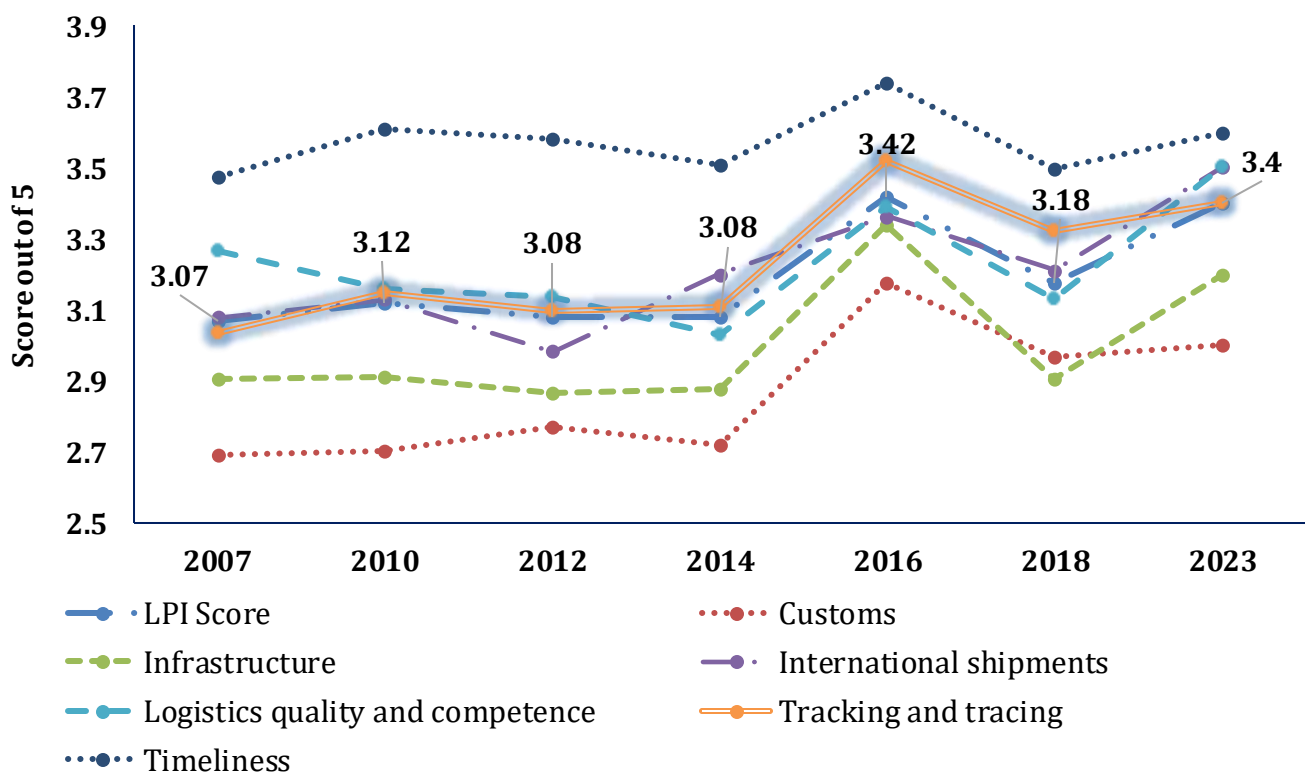


Figure 1.8: Logistics performance index

In the financial year 2023-24 (FY24), INR 27,482 crore budget was allocated to the Dedicated Freight Corridor Corporation of India (DFCC), marking a substantial 75% increase from the allocation of INR 15,710.44 crore in FY23. As per the budget announcement, the DFCC will finance INR 15,241 crore through internal accruals, demonstrating a significant commitment to the development and expansion of dedicated freight corridors across the country. The Ministry of Road Transport and Highways has planned 35 multi-modal logistics parks and 108 port connectivity.

Thus, it is evident that the logistics infrastructure in India, encompassing both physical and IT components, is experiencing promising growth due to policy reforms and the prioritization of the logistics sector by the Government of India.

1.3. Workforce in Logistics, Supply Chain and Manufacturing Sector

The supply chain involves multiple functions and components like procurement, production, marketing, and customer service. On the other hand, logistics concentrates on transportation, warehousing, and inventory management. The logistics, supply chain, and manufacturing sectors offer a wide range of job roles for operational, managerial, and strategic levels. Each of these roles is critical in ensuring efficient operations, seamless coordination, and effective management of goods and services.

Based on the responsibilities and scope of work, some job roles within the Logistics, Supply Chain and Manufacturing sectors include:

- Entry-Level/Operational Roles:
 - Warehouse Associate
 - Forklift Operator
 - Order Picker/Packer
 - Shipping and Receiving Clerk
 - Inventory Control Assistant
 - Production Team Leader
- Mid-Level Management Roles:
 - Logistics Manager
 - Supply Chain Analyst
 - Operations Manager
 - Procurement Manager
 - Manufacturing Supervisor
 - Warehouse Supervisor
 - Quality Control Inspector
 - Shipping Supervisor
- Senior Management/Strategic Roles:
 - Supply Chain Director
 - Operations Director
 - Plant Manager
 - Head of Logistics
 - Vice President of Supply Chain

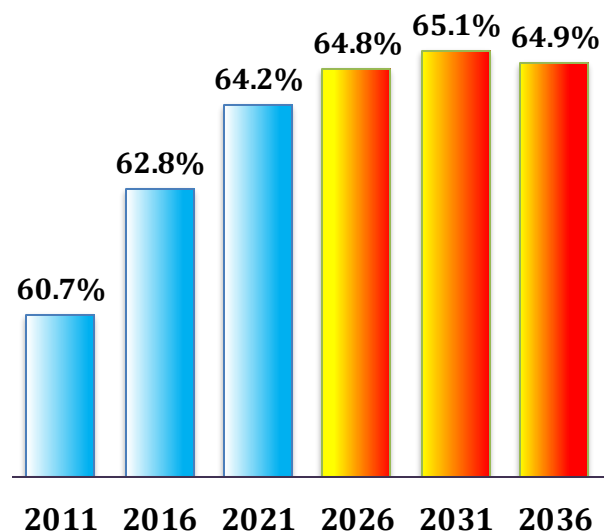


Figure 1.9.: Share of working age population India 2011-2036

India's working-age population (between 15 to 60 years) constituted over 64% (approx. 92.16 crore) of its total population in 2021 and was expected to grow until 2031^{1.6} to 65% (approx. 93.6 crore) . According to the Economic Survey, the logistics industry employs over 22 million people in India and expected to add 10 million jobs by 2027 with growth rate 12%.

The percentage of employable talent in India was estimated to be just over 51 percent in 2024, showing a slight improvement from the previous year's figure of around 50 percent. Despite this increase, less than half of the available talent in the country is considered suitable for employment, underscoring ongoing challenges in aligning skills with market demands.

The logistics, supply chain, manufacturing sectors are facing significant challenges related to talent shortages, driven by various factors including evolving technology, changing skill requirements, and demographic shifts. About 77% of the employers in transportation, logistics & automotive industries across India stated that they had talent shortages in 2023^{1.7}.

The Team Global Logistics Private Limited survey underlines a concerning trend, with 55% of supply chain and logistics leaders saying that recruiting knowledgeable workers or employees is the most challenging. According to ManpowerGroup 77% of employers are not able to fill job vacancies in U.S.

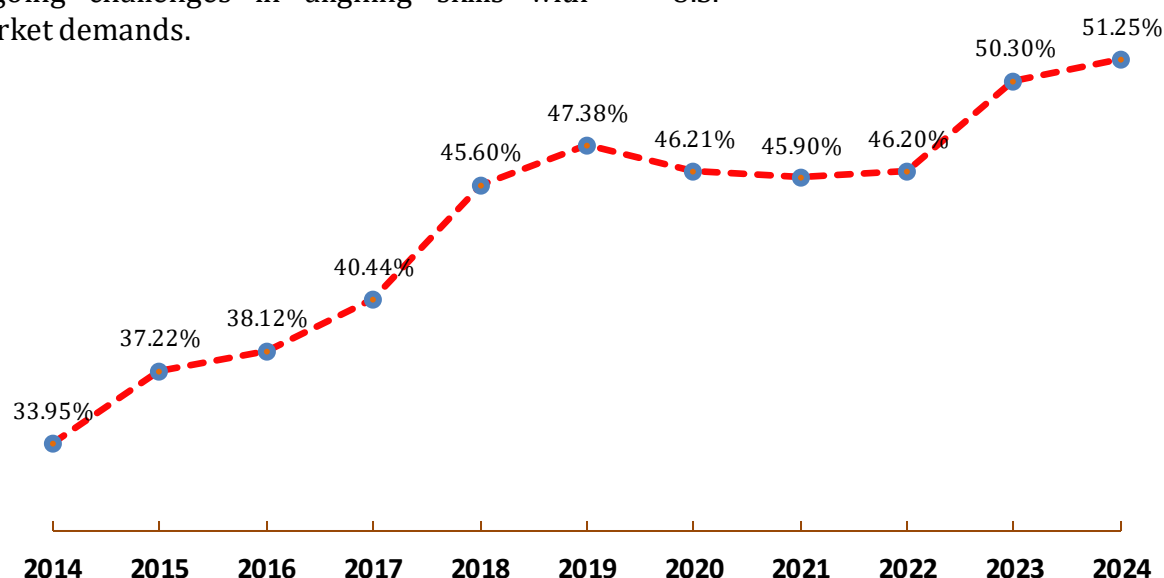


Figure 1.10: Availability of employable talent India 2014-2024

According to projections from Deloitte and the Manufacturing Institute, the manufacturing sector will require an additional 3.8 million employees in the U.S. between 2024 and 2033^{1.8} due to retirements, career changes, and the creation of new roles within the industry.

As the demand for higher-skilled workers in U.S. manufacturing intensifies, the report suggests that up to half of these positions, around 1.9 million jobs, could remain vacant if manufacturers do not address the skills gap and recruitment challenges.

1.4. Emerging skillset in Logistics Workforce

The future job market in logistics and supply chain management is expected to undergo significant transformations driven by technological advancements, changing consumer behaviors, and global economic trends. technologies driving this transformation include:

^{1.6} Source: <https://www.statista.com/statistics/1454430/india-share-of-working-age-population/>

^{1.7} Source: <https://www.statista.com/statistics/1320128/india-share-of-talent-shortage-by-industry/>

^{1.8} Source: <https://www.foxbusiness.com/economy/us-has-shortage-manufacturing-workers-threatens-global-competitiveness>

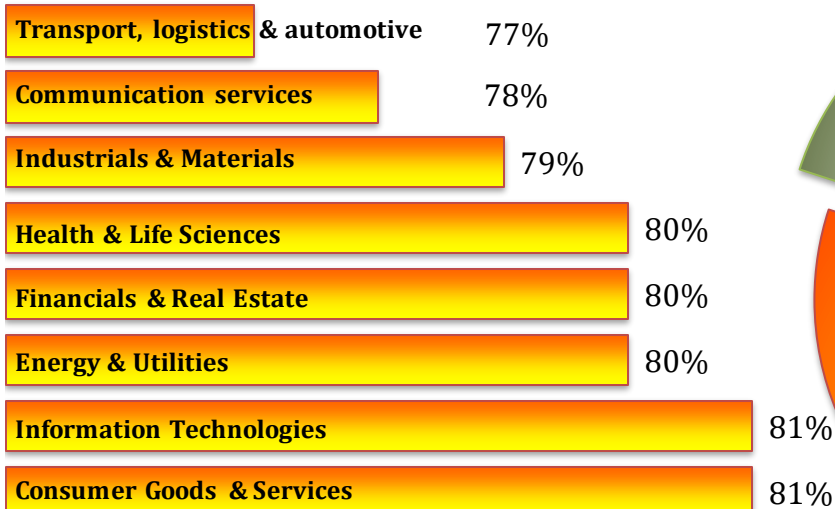
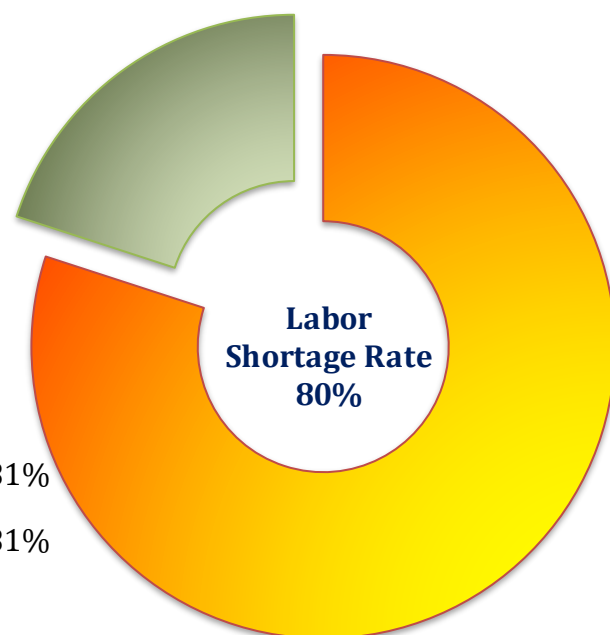


Figure 1.11: Share of talent shortage India 2023, by industry

- Big Data Analytics
- Digital Twin
- Blockchain Technology
- Cloud Logistics
- Internet of Things (IoT)
- Transportation Management System (TMS)
- Self-driving Vehicles and Drones
- Augmented and Virtual Reality (AR/VR)
- Real-Time Supply Chain Visibility
- Robotics and Automation in Warehouses
- Drones

According to McKinsey study, supply chain currently operates at a digitization level of around 43%. Digitization in supply chain management can lead to a 3.2% increase in annual growth of EBIT (earnings before interest and taxes) and a 2.3%^{1.9} increase in annual revenue growth.

As the logistics and supply chain sector continues to embrace digital transformation and innovation, professionals will need to continuously update their skill sets to remain competitive and adaptable in the evolving industry landscape. Currently Supply chain visibility is one of the most important strategic priorities among the industry professionals.



The AI logistics market is expected to reach USD 12 billion by 2027^{1.10} with CAGR 24%. Global cargo drone market size is expected to reach USD 1,285 million in 2024 from USD 828 million in 2023 with CAGR 54%.

Skills becoming obsolete or less essential:

- Manual Data Entry & Basic Spreadsheet Skills
- Traditional Procurement Practices
- Narrow Specialization
- Static Supply Chain Strategies
- Silos and Hierarchical Decision-Making
- Manual Material Handling

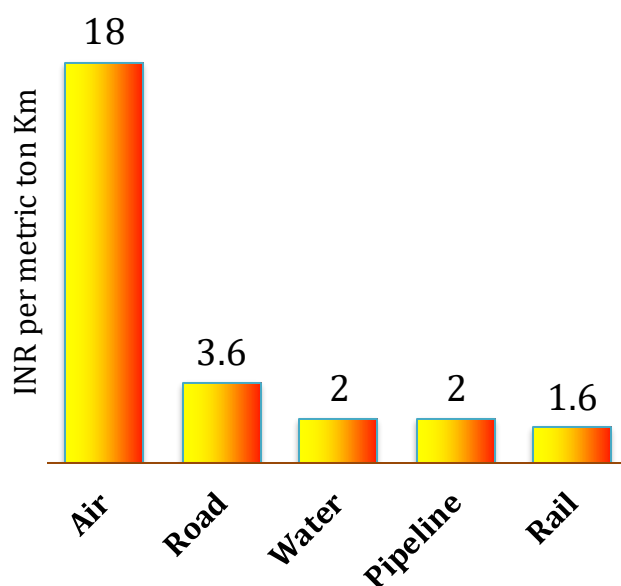


Figure 1.12: Per metric ton kilometer cost of different modes of logistics in India (in Indian rupees)

Some key aspects of the future job market in logistics market include:

- Technology Integration
- Data Analytics and Business Intelligence
- Problem-Solving and Critical Thinking
- Supply Chain Digitalization
- E-commerce Expansion
- Sustainability and Green Logistics
- Globalization and Trade
- Supply Chain Resilience
- Cross-functional Collaboration
- Adaptability and Lifelong Learning

The following sections will explore key trends, challenges, and opportunities in the future talent landscape of logistics and supply chain management, emphasizing the importance of strategic workforce planning and investment in education and training to meet the evolving demands of the industry.



2

Sectors Related to Logistics and Supply Chain Management

2. Sectors Related to Logistics and Supply Chain Management

Future talent skill requirements in logistics and supply chain management vary across industry sectors due to unique challenges and opportunities. Developing a diverse skill set encompassing technical expertise and industry-specific knowledge will be crucial for professionals seeking to thrive in these dynamic sectors. Organizations must invest in talent development and strategic workforce planning to address evolving demands and drive sustainable growth.

2.1 Multimodal Logistics

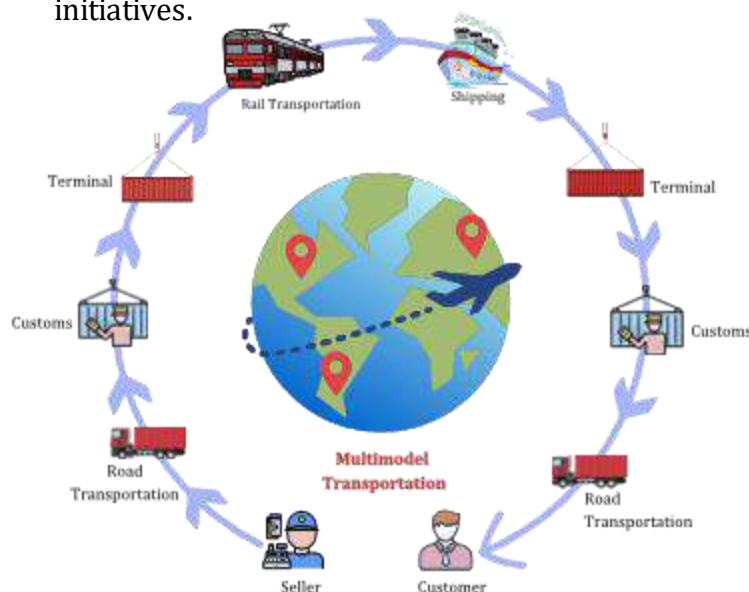
Multimodal logistics refers to the transportation and movement of goods using multiple modes of transportation within a single supply chain journey. This approach combines different transport modes such as road, rail, air, sea, and inland waterways in a coordinated manner to optimize efficiency, reduce costs, and enhance reliability. Key aspects and benefits of multimodal logistics are:

- Integration of Transport Modes
- Enhanced Flexibility and Reliability
- Cost Optimization
- Environmental Sustainability
- Improved Supply Chain Efficiency
- Regulatory Compliance and Customs Clearance
- Technology Integration

Driven by booming global trade, e-commerce, and intricate supply chains, the multimodal logistics market, valued at over INR 500 lakh crore (USD 6 trillion). The global multimodal logistics market is projected to reach INR 767 lakh crore (USD 9.2 trillion) by 2032 indicating a significant growth trajectory. Combining road, sea, and air transportation, this sector offers optimized delivery solutions, but faces hurdles like infrastructure limitations and varying regulations.

However, with investments in infrastructure, standardized regulations, and adoption of AI and automation, the future of multimodal logistics looks bright, promising to streamline global trade and contribute substantially to economic prosperity.

In 2022, the Global Transportation Industry Market achieved a value of USD 7.31 trillion, with projections indicating a growth to USD 11.1 trillion by 2030, accompanied by a Compound Annual Growth Rate (CAGR) of 5.4% during the forecast period spanning from 2023 to 2030. The expansion of the global transportation industry is fueled by various factors, including urbanization, population growth, increasing reliance on e-commerce platforms for online shopping, and ongoing infrastructure development initiatives.



Additionally, substantial investments in transportation infrastructure, encompassing roads, railways, ports, and airports, are pivotal in driving the expansion of the transportation sector. Both governmental bodies and private entities are investing in infrastructure projects to enhance connectivity, alleviate congestion issues, and improve transportation system efficiency. Within the global landscape, the Asia-Pacific region holds a significant share of the transportation industry market, with countries such as China and India collectively accounting for over two-thirds of the regional market.

Notably, China stands out with a substantial transportation industry market, attributable to its vast population, robust manufacturing sector, and thriving export-driven economy. The nation has made substantial investments in establishing an extensive network comprising roads, railways, airports, and ports, geared towards supporting both domestic and international trade activities.

The Transportation sector is divided into three main categories. First, the Land Transportation sector, which includes road transport utilizing trucks, rail transport for long-distance goods movement, and pipeline transport for the transfer of liquids and gases. Second, the Water Transportation sector, which handles goods shipped via oceans, rivers, and canals. Third, the Air Transportation sector, which focuses on fast cargo delivery services. Important metrics for this sector include port and airport rankings, CO2 emissions, contributions to GDP, freight volume, and transportation intensity. This sector exclusively represents B2B values.

Value added in the Transportation market is projected to amount to INR 338.9 lakh crore (USD 4.06 trillion) in 2023. Volume of goods transported in Transportation market is projected to amount to 45.55 trillion Tonne-kilometre (TKM) in 2023. Transportation intensity in the world is projected to amount to 0.43 TKM/GDP.

2.1.1. Key Drivers of Multimodal Logistics in India

Overdependence on road transport, a congested network, and fragmented infrastructure inflate logistics costs. Multimodal transportation utilizes a combination of road, rail, water, and air, selecting the most efficient mode for each leg of the journey, thereby bringing down expenses.

Government Initiatives: The Indian government recognizes the importance of multimodal logistics and has introduced policies like the National Logistics Policy and projects like Dedicated Freight Corridor, Bharatmala and Sagarmala to develop a more integrated transport network, including inland waterways and coastal shipping. The government of India has introduced various initiatives to enhance the logistics industry in India and optimize freight transportation. In 2023, India allocated a remarkable 1.7% of its GDP to transportation infrastructure, which can be pivotal in paving the way for INR 417.4 lakh crore (USD 5 trillion) economy and benefitting every logistics company in India.

Growth in E-commerce and Retail: The e-commerce boom in India necessitates faster and more reliable deliveries. Multimodal logistics offers flexibility and cost-effectiveness for businesses catering to this growing demand.

India - Middle East - Europe Economic Corridor (IMEC): IMEC is a significant planned economic corridor aimed at fostering economic development and connectivity between Asia, the Persian Gulf, and Europe. It was planned during the G20 summit, and the MoU was signed by the governments of India, US, UAE, Saudi Arabia, France, Germany, Italy, and the European Union. This will increase trade and investment, create new job opportunities, and require a skilled workforce in international trade, logistics, and diplomacy.



2.1.2. Workforce related to Multimodal Logistics

The logistics industry in India faces a significant challenge in terms of skilled workforce, especially in the context of multimodal logistics. Some key roles related to multimodal logistics are:

- Logistics Managers and Planners
- Transportation Coordinators
- Warehouse Supervisors and Workers
- Customs Brokers and Clearance Agents
- Fleet Managers and Drivers
- Supply Chain Analysts
- Safety and Compliance Officers
- Customer Service Representatives
- Technology Specialists
- Trainers and Educators

As government transportation agencies shift from being primarily infrastructure builders to becoming more balanced operations organizations with an emphasis on transportation systems management and operations, there is a growing need to not only attract, retain, and develop traditional roles like traffic engineers but also to recruit a more technically diverse workforce. This workforce must possess expertise in emerging technologies such as connected and automated vehicles, big data analytics, and advanced decision support systems.

Highest-Priority Issues: The key challenges faced by transportation agencies are:

- 1) Gap between current training programs and the evolving requirements in the field, as well as an absence of a defined career development pathway for professionals in transportation systems.
- 2) Many agencies still face staffing limitations. While big data can optimize transit schedules by analyzing factors such as road work delays, accidents, and congestion, there is a need for skilled personnel to interpret this data. The ability to manage infrastructure efficiently and disseminate information promptly has become increasingly attractive.

- 3) While nearly half of new hires are civil engineers, trends indicate the need for professionals from other disciplines to provide high-quality transportation services.
- 4) Many states struggle to fill critical technical roles, particularly in systems engineering, information technology, and the maintenance of intelligent transportation systems (ITS) devices, with about half relying heavily on consultants.
- 5) Current transport staff typically have specialized expertise in one or more areas, but few possess a wide-ranging, diverse skill set.

New and Emerging Positions:

- Data Analyst/Statistician
- Software Engineer
- AI Specialist
- Telecom Engineer
- Data Visualization Expert
- Connected and Automated Vehicle (CAV) Program Manager
- Traffic Incident Management Program Manager
- Cybersecurity Engineer
- Weather Specialist
- Systems Integration Engineer
- Transport Simulation Modelling Specialist
- Emerging Technologies Coordinator
- Transportation Systems Performance Manager
- Integrated Corridor Operations Manager

Multimodal transport integrates various modes of transportation into a cohesive logistics chain. These modes include:

- Road Transport
- Rail Transport
- Sea Transport
- Air Transport
- Inland Waterway Transport
- Pipeline Transport

2.1.3. Road Transport

Road transportation involves the movement of goods via road networks. Primarily focused on commercial cargo, this form of transportation plays a key role in supporting logistics and supply chain operations. This market involves transporting goods from manufacturers or distributors to wholesalers, retailers, or other businesses within the supply chain. It contributes significantly to the flow of goods within the broader business ecosystem. As businesses increasingly operate within expansive global supply chains, efficient and reliable transportation services to move goods across various points in these supply chains have become vital.

Intermodal connections further enhance its reach, seamlessly integrating with trucks, ships, and airplanes to create a comprehensive transportation network. Despite facing challenges like infrastructure maintenance and regulatory hurdles, ongoing modernization efforts aim to bolster its reliability and efficiency.

As the industry embraces digital technologies and emphasizes sustainability, global rail freight transport remains indispensable for facilitating trade and driving economic growth across continents. In 2020, the rail freight market was worth some 247.4 billion U.S. dollars worldwide. Projections estimate that the market will grow to almost 280 billion U.S. dollars in 2026, at a compound annual growth rate of about two percent per year.

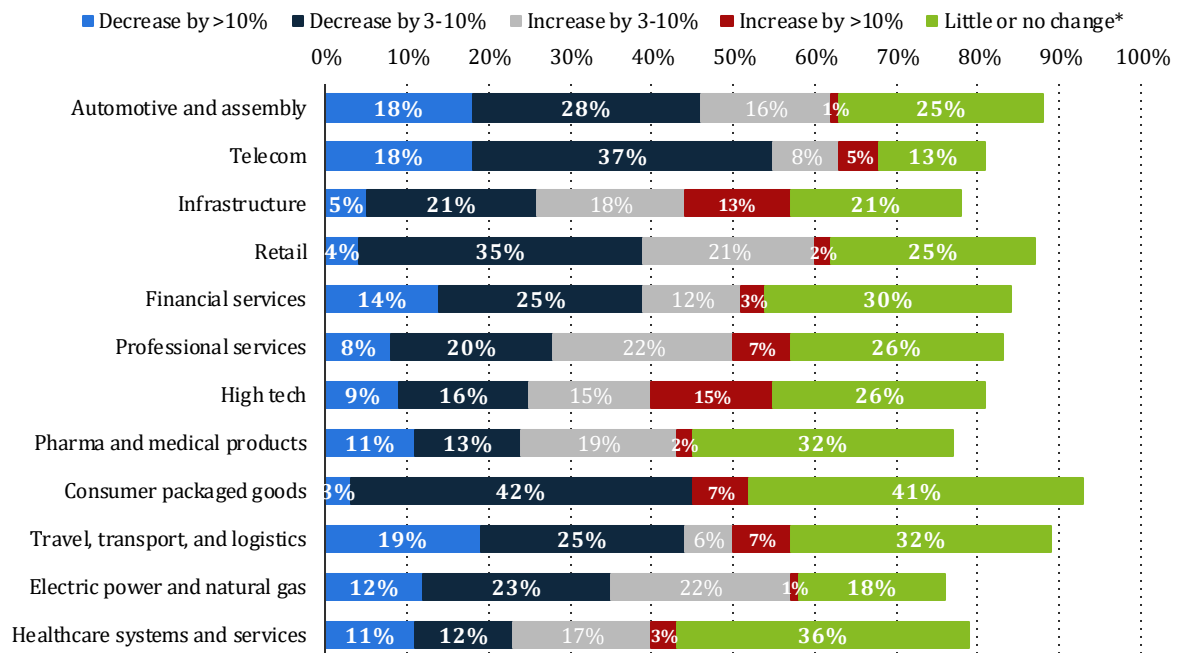
Positions	Required Skill Set
Entry Level	• Understanding of logistics terminology, transportation modes, and route planning. • Familiarity with logistics software and basic documentation (e.g., invoices, bills of lading). • Ability to work effectively in a team and coordinate with drivers, warehouse staff, and customers. • Strong written and verbal communication skills. • Basic analytical skills to address and resolve issues such as delivery delays and routing problems.
Mid-Level	• In-depth understanding of road logistics operations, including fleet management, route optimization, and compliance with transportation regulations. • Proficiency in using advanced logistics software and systems. • Experience in project management, including planning and execution of logistics projects. • Strong analytical skills to assess logistics challenges and develop effective solutions. • Expertise in maintaining and improving customer relationships, ensuring high levels of client satisfaction.
Senior-Level	• Expertise in developing and executing strategic plans for road logistics operations. • Ability to lead large teams and manage complex projects with a focus on long-term objectives. • Comprehensive understanding of road logistics, including industry trends, best practices, and regulatory frameworks. • Experience in ensuring compliance with local, national, and international transportation laws. • High-level analytical skills to tackle complex logistical challenges and implement innovative solutions. • Strategic decision-making capabilities to enhance efficiency, reduce costs, and drive profitability. • Skilled in negotiation, conflict resolution, and representing the organization at industry events and forums.

2.1.4. Rail Freight Transport

Global rail freight transport serves as a cornerstone of the logistics landscape, offering unparalleled efficiency and cost-effectiveness, particularly for long-distance hauls and heavy cargo. With its environmental benefits, including lower emissions per ton-mile compared to other modes of transportation.

It stands as a sustainable solution in an increasingly eco-conscious world. In 2020, the rail freight market was worth some INR 20.55 lakh crore (USD 247.4 billion) worldwide. Projections estimate that the market will grow to almost INR 23.26 lakh crore (USD 280 billion) in 2026, at a compound annual growth rate of about two percent per year.

Figure 3.1: Predicted workforce changes from AI adoption in organizations by industry from 2020-2023



Despite facing challenges like infrastructure maintenance and regulatory hurdles, ongoing modernization efforts aim to bolster its reliability and efficiency. As the industry embraces digital technologies and emphasizes sustainability, global rail freight transport remains indispensable for facilitating trade and

driving economic growth across continents. According to a global AI survey, the automotive and assembly, as well as the telecom industries, are expected to experience the largest workforce reductions over the next three years due to the implementation of artificial intelligence (AI) technologies.

Positions	Required Skill Set
Entry Level	- Understanding of railway logistics operations, including cargo types, train schedules, and basic safety regulations. - Familiarity with logistics software and documentation (e.g., waybills). - Strong written and verbal communication skills for coordinating with colleagues, train crews, and customers. - Basic analytical skills to address and resolve operational issues, such as delays and routing problems. - Precision in handling cargo details and adhering to safety regulations.
Mid-Level	- In-depth understanding of railway logistics operations, including freight management, route optimization, and compliance with transportation regulations. - Proficiency in using advanced logistics software and railway management systems. - Experience in project management, including planning and execution of logistics projects. - Strong analytical skills to assess logistics challenges and develop effective solutions. - Expertise in maintaining and improving customer relationships, ensuring high levels of client satisfaction.
Senior-Level	- Expertise in developing and executing strategic plans for railway logistics operations. - Ability to lead large teams and manage complex projects with a focus on long-term objectives. - Comprehensive understanding of railway logistics, including industry trends, best practices, and regulatory frameworks. - Experience in ensuring compliance with national and international transportation laws. - High-level analytical skills to tackle complex logistical challenges and implement innovative solutions. - Strategic decision-making capabilities to enhance efficiency, reduce costs, and drive profitability. - Skilled in negotiation, conflict resolution, and representing the organization at industry events and forums.

2.1.5. Maritime Logistics

Maritime logistics involves a network of stakeholders, including Shipping Companies, Port Authorities, Customs and Regulatory Bodies, Freight Forwarders, Ship Brokers, Maritime Insurance Providers, Maritime Technology Providers.

Global dry bulk shipping market size was INR 13.5 lakh crore (USD 162.6 billion) in 2023 and expected to reach INR 20 lakh crore (USD 239.5 billion) in 2032 with CAGR 4%. International seaborne trade carried by container ships in 2023 was 2.2 billion tons.

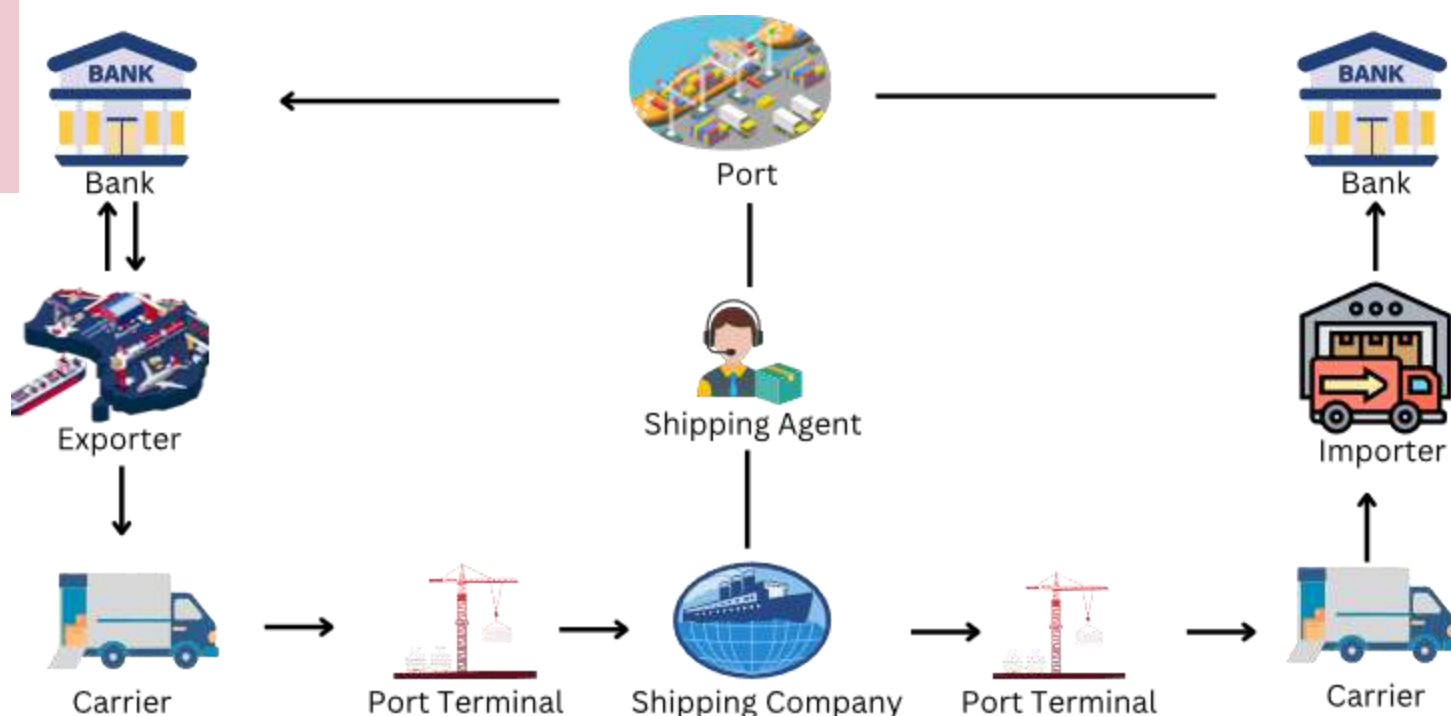


Figure 2.2: The Maritime Transporter Ecosystem

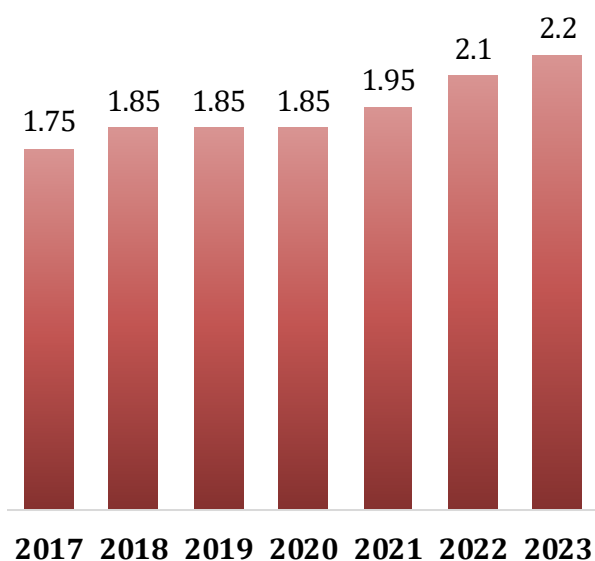


Figure 2.3: International seaborne trade carried by container ships (in billion tons loaded)

Maritime logistics plays a crucial role in India's economy by facilitating international trade. It enables the transportation of goods to and from India's ports, connecting the country to global markets. India's maritime sector contributes significantly to the Gross Domestic Product (GDP) and employment generation. Container volume handled at major ports across India in 2022 was 167.38 million metric tons. Key contributions of Maritime Logistics to the Indian Economy are

- **Trade Facilitation:** Over 90% of India's trade by volume and 70% by value travels by sea. Efficient ports and shipping infrastructure are essential for seamless import and export operations, keeping international trade flowing.

- **Boosting Exports:** The "Make in India" initiative hinges on efficient maritime logistics to deliver Indian-made goods globally. Faster and cost-effective shipping allows businesses to compete better in the international market.
- **Energy Security:** India relies on maritime imports for over 80% of its oil and 50% of its gas. Smooth maritime logistics ensure a steady supply of energy resources, vital for powering the economy.
- **Job Creation:** The sector generates significant employment opportunities in shipping, ports, shipbuilding, and related services. Government initiatives aim to create millions of jobs through further development.
- **Development of Coastal Communities:** Port activities and ancillary industries stimulate economic growth in coastal areas, leading to better infrastructure and livelihood opportunities.
- **Future Potential:** India has a vast coastline and strategic location. Upgrading infrastructure and promoting inland waterways can unlock further economic potential.
- **Government Initiatives:** Recognizing the importance, the Indian government is investing heavily in port modernization, coastal shipping, and skill development in the maritime sector.

Machinery and Equipment in Maritime Logistics

Maritime logistics operations involve a range of machinery and equipment, including:

- **Ships and Vessels:** Varied types and sizes for transporting cargo.
- **Container Handling Equipment:** Cranes, forklifts, and container handlers for loading and unloading containers at ports.
- **Navigational Equipment:** GPS systems, radar, and sonar for safe navigation.
- **Cargo Handling Machinery:** Conveyor belts, pallet jacks, and hoists for moving cargo within ports
- **Safety Equipment:** Lifeboats, life jackets, and firefighting equipment for ensuring safety at sea.

The level of automation in maritime logistics is increasing, with the adoption of technologies such as autonomous ships, robotic container handling, and digitalization of operations.

International Logistics Policies

International logistics policies govern various aspects of maritime transportation, including trade agreements, customs procedures, port regulations, and environmental standards. These policies impact the efficiency, cost, and reliability of maritime logistics operations.

Sustainability in Maritime Logistics

Sustainability is an increasingly important aspect of maritime logistics. Efforts are being made to reduce emissions, minimize environmental impact, and promote eco-friendly practices. Initiatives include the use of alternative fuels, energy-efficient technologies, and measures to prevent marine pollution. Regulatory bodies and industry stakeholders are working together to develop and implement sustainable practices in maritime logistics.

Upcoming/Proposed Advancements:

- **Automation and Robotics:** Autonomous ships, remotely operated container terminals, and cargo handling robots will enhance efficiency and safety while reducing human error.
- **Artificial Intelligence (AI) and Big Data Analytics:** AI-powered route optimization, predictive maintenance, and real-time cargo tracking will improve decision-making, reduce costs, and minimize delays..

- Internet of Things (IoT) and Blockchain: Real-time condition monitoring of ships and cargo, along with secure and transparent documentation through blockchain, will improve transparency and streamline processes.
- Electric and Alternative Fuels: Transitioning to cleaner fuels like LNG, biofuels, and wind-assisted propulsion will significantly reduce emissions and enhance sustainability.

Manpower in Maritime Logistics: The maritime industry employs a diverse workforce, including:

- Seafarers
- Port Workers
- Logistics Managers
- Maritime Engineers
- Customs Officers
- Maritime Lawyers

These professionals come from various educational backgrounds, including maritime academies, engineering schools, business schools, and law colleges.

Projected Manpower and Job Opportunities:

Automation may displace some traditional jobs and create new opportunities in areas of AI and data analytics, robotics engineering, and cybersecurity.

The focus will shift towards a more skilled workforce with expertise in operating and maintaining advanced technologies.

Academic curriculums will need to adapt to include these emerging skill sets to prepare the workforce for the future of maritime logistics.

Sustainability Improvement:

- Stringent regulations and incentives for adopting cleaner fuels and technologies.
- Investment in shore-side power infrastructure for reducing ship emissions at ports.
- Collaborative efforts between stakeholders to develop and implement best practices for sustainable maritime operations.

Positions	Required Skill Set
Entry Level	• Basic understanding of shipping routes, cargo types, and port operations. • Familiarity with logistics software and maritime regulations. • Strong written and verbal communication skills. • Ability to work effectively in a team environment and coordinate with various stakeholders. • Analytical skills to identify and resolve logistics issues quickly.
Mid-Level	• In-depth understanding of maritime logistics operations, including supply chain management, cargo handling, and port operations. • Proficiency in using advanced logistics software and familiarity with international maritime regulations and compliance. • Experience in project management, including planning, execution, and monitoring of logistics projects. • Strong analytical skills to assess complex logistics challenges and implement effective solutions. • Expertise in maintaining and enhancing customer relationships, ensuring high levels of client satisfaction.
Senior-Level	• Expertise in developing and executing strategic plans for logistics operations. • Ability to lead large teams and manage complex projects with a focus on long-term goals. • Comprehensive understanding of global maritime logistics, including industry trends and regulatory frameworks. • Experience in compliance with international maritime laws and standards. • High-level analytical skills to address intricate logistical challenges and implement innovative solutions. • Strategic decision-making capabilities to enhance operational efficiency and profitability.

- By embracing these advancements, India's maritime logistics sector can become a global leader in efficiency, sustainability, and economic growth. Collaboration amongst stakeholders and a focus on skill development will be crucial to ensure a smooth transition and unlock the immense potential of this vital sector.

2.2. Air Cargo Shipment

Air cargo shipment refers to the transportation of goods via aircraft. It involves the movement of various types of cargo, including perishable items, electronics, pharmaceuticals, and machinery, among others, from one location to another. Air cargo shipment is known for its speed, reliability, and efficiency, making it a preferred choice for time-sensitive and high-value goods. Air cargo shipment plays a crucial role in global trade and supply chains, facilitating international commerce and contributing significantly to the movement of goods across borders. Some of the top air freight corporations in the world, based on their market influence, operational scale, and global presence, include FedEx Express, UPS (United Parcel Service) Airlines, DHL Aviation, Cathay Pacific Cargo (air freight carrier based in Hong Kong), Singapore Airlines Cargo, Lufthansa Cargo, Emirates SkyCargo, Korean Air Cargo

2.2.1. Key Stakeholder of Air Cargo in supply chain

Shippers handle your products with care to guarantee they arrive intact. Double-check all paperwork, like invoices and customs declarations, for accuracy and completeness.

Ground handlers are responsible for overseeing the acceptance, inspection, and preparation of goods at airports.

Warehouse operators ensure the proper handling and storage of incoming products. They meticulously manage inventory and promptly process orders.

Customs agents ensure the efficiency of your paperwork by verifying its accuracy. They collect all applicable taxes and customs charges and implement security measures to prevent illegal movements of goods.

Airlines or carriers are responsible for the prompt and secure delivery of your cargo. They manage the loading and unloading of cargo at terminals as well

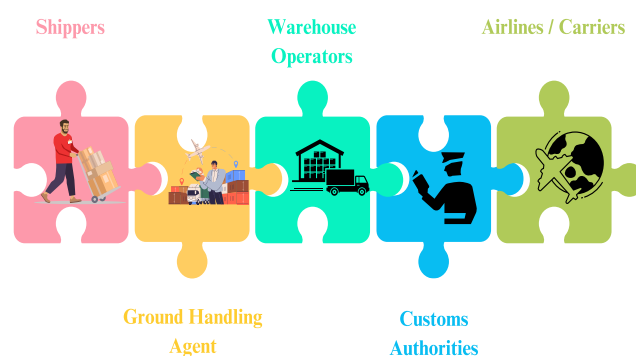


Figure 2.4: Key Stakeholder of Air Cargo in Supply Chain

2.2.2. Contribution of Air Cargo to Indian Economy

Air cargo consistently expanded from 1.55 million tonnes in 2006-07 to 4.27 million tonnes in 2022-23. Indian air freight market was USD 13.08 billion (INR 10.91 lakh crore) and expected to reach at USD 17.02 billion (INR 14.36 lakh crore) by 2028 with a CAGR of 5.7%.

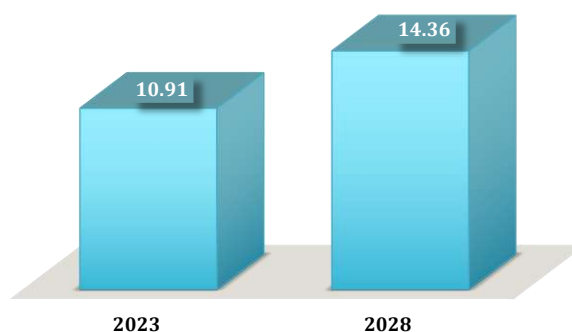


Figure 2.5: Indian Air Freight Market in INR lakh crore

Several Indian businesses specialize in air freight services, facilitating efficient cargo transportation across domestic and international routes. Some of the top air freight companies operating in India are Blue Dart Aviation, Air India Cargo, SpiceXpress, IndiGo Cargo, GMR Air Cargo and Aerospace Engineering Limited (GACAEL), FedEx India, DHL Express India, Quikjet Cargo Airlines.

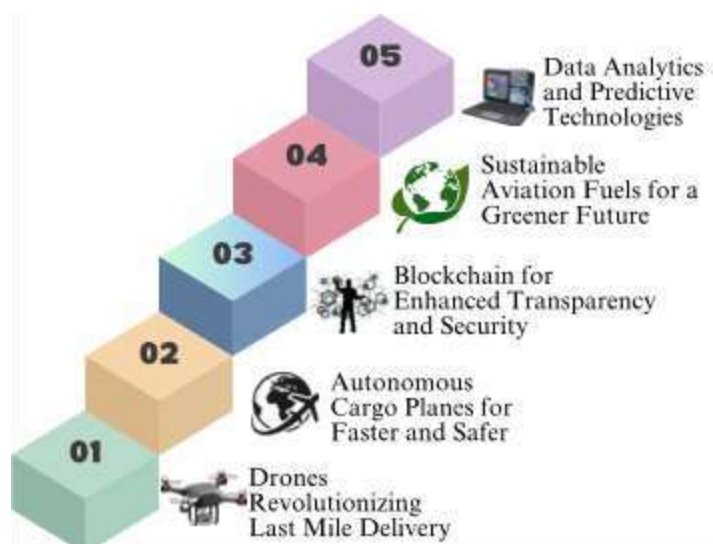


Figure 2.6: Critical Challenges Faced by Air Cargo Industry

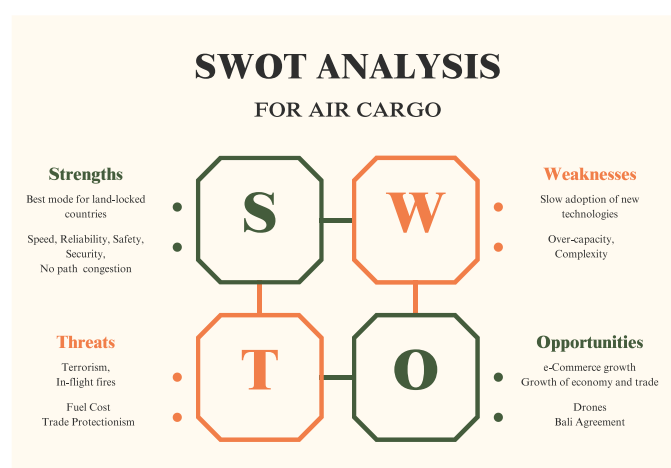
2.2.3. Trends and Innovations in Air Cargo Industry

The air cargo industry is experiencing a transformative phase, characterized by increased emphasis on innovation, digitalization, and sustainability. These strategic shifts are aimed at boosting operational efficiency, minimizing environmental footprint, and sustaining competitiveness in a dynamic market shaped by the rapid expansion of e-commerce and evolving consumer demands.

- **Drones for last-mile delivery:** Companies like Amazon and UPS are using drones to quickly deliver, reducing delivery times and carbon emissions.
- **Autonomous cargo planes:** Advancements in autonomous technology enable cargo planes to operate without human pilots, improving speed and safety.



- **Blockchain for transparency:** Blockchain technology enhances security and traceability in supply chain management, minimizing fraud and delays.
- **Sustainable aviation fuels:** Airlines are adopting sustainable fuels to reduce carbon emissions and mitigate environmental impact.
- **Data analytics and predictive technologies:** Leveraging big data and predictive analytics optimizes operations, improves efficiency, and enhances customer satisfaction.
- **Electronic Airway Bill (eAWB):** Enhances security and transparency in shipping by eliminating paper-based documents prone to errors and fraud. It provides real-time tracking, reduces costs, ensures compliance with regulations, and integrates with other technologies for a streamlined supply chain.



Positions	Required Skill Set
Entry Level (Cargo Handlers, Documentation Clerks)	- Physical fitness, attention to detail, basic understanding of cargo handling and safety procedures - Data entry, documentation accuracy, basic IT skills, communication
Mid-Level (Air Freight Agent, Operations Supervisors)	- Customer service, logistics knowledge, problem-solving, coordination with airlines and clients - Supervisory skills, operational management, compliance knowledge, team coordination
Senior-Level (Air Cargo Managers, Logistics Directors)	- Strategic planning, risk management, advanced logistics and supply chain management, leadership, decision-making - Strategic oversight, cross-functional collaboration, budget management, policy development, crisis management

2.3. Healthcare Logistics & Supply Chain Management

The Indian healthcare logistics sector is a critical component of the nation's healthcare system, ensuring the timely delivery of medical supplies and pharmaceuticals. With the advent of technology, there are opportunities to enhance efficiency, reduce costs, and improve patient care. Adopting technology in supply chain can reduce the lengthy inventory holding times and cut the higher costs seen in Indian healthcare logistics.

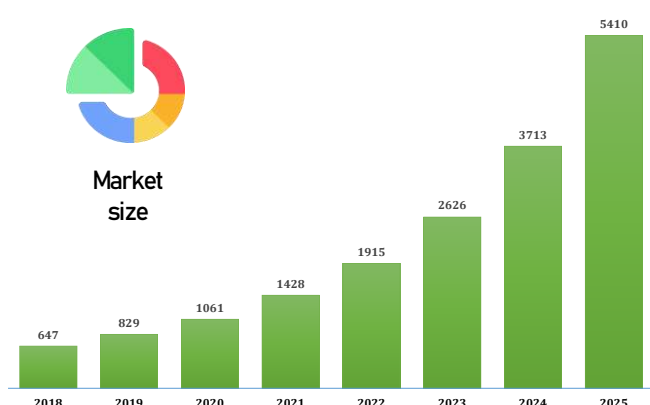


Figure 2.7: Indian Telemedicine Market (in USD Billion)

The current market size of the Indian pharmaceutical industry is more than INR 4 lakh crore (USD 50 billion). The pharma sector, including IT services and domestic production is a significant contributor to this growth.

This step towards modernization is crucial for delivering timely healthcare services and for strengthening India's healthcare system.

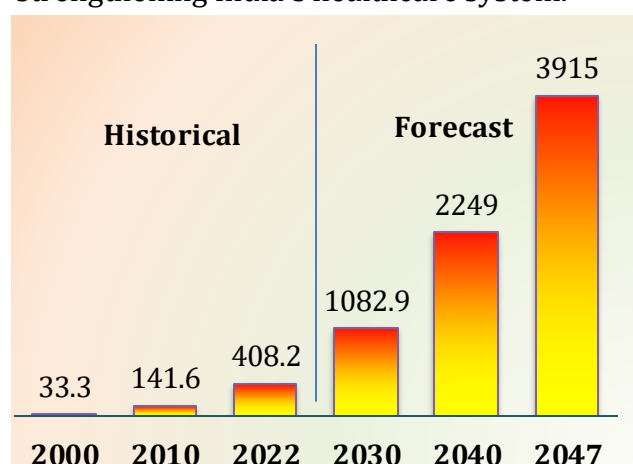


Figure 2.8: Indian Pharmaceutical Market (INR thousand crore)

The Indian healthcare market was valued at approximately INR 15 lakh crore (USD 180 billion) in fiscal year 2023, with hospitals, diagnostics, and retail pharmacies constituting the largest segments. It is projected to grow to around INR 26.6 lakh crore (USD 320 billion) by 2028, with an annual growth rate of 10-12%.

Annual investments in healthcare innovation usually fluctuate between INR 12.5 thousand crore and INR 16.7 thousand crore. However, fiscal year 2022 saw an atypical spike in deal value to about INR 35 thousand crore, primarily due to the significant investment in PharmEasy of roughly INR 12.5 thousand crore.

Enhancing the healthcare logistics supply chain is thus integral to support the growing market and catering to the increasing healthcare needs of the population – to ensure timely delivery of healthcare products and services.

The pharmaceutical supply chain faces several challenges, including supply chain visibility, drug counterfeiting, cold-chain shipping, and rising prescription drug prices, which can significantly increase out-of-pocket patient costs

2.3.1. Workforce in Healthcare Supply Chain Management

In healthcare and pharmaceutical supply chain management, the workforce consists of various roles that ensure the efficient procurement, storage, distribution, and delivery of medical products and pharmaceuticals. Here are some key roles and their responsibilities:

Supply Chain Managers

Skills Required: Strategic planning, leadership, analytical skills, and a deep understanding of supply chain processes and technologies.

Procurement Specialists

Skills Required: Negotiation, analytical thinking, understanding of regulatory requirements, and supplier relationship management.

Inventory Managers

Skills Required: Inventory management, forecasting, analytical skills, and proficiency in inventory management software.

Warehouse Managers

Skills Required: Warehouse management, leadership, attention to detail, and knowledge of storage requirements for different medical products.

Quality Assurance Specialists

Skills Required: Attention to detail, understanding of quality control processes, regulatory knowledge, and analytical skills.

Logistics Coordinators

Skills Required: Logistics management, problem-solving, organizational skills, and knowledge of transportation regulations.

Pharmacists

Skills Required: Pharmaceutical knowledge, patient care, attention to detail, and regulatory compliance.

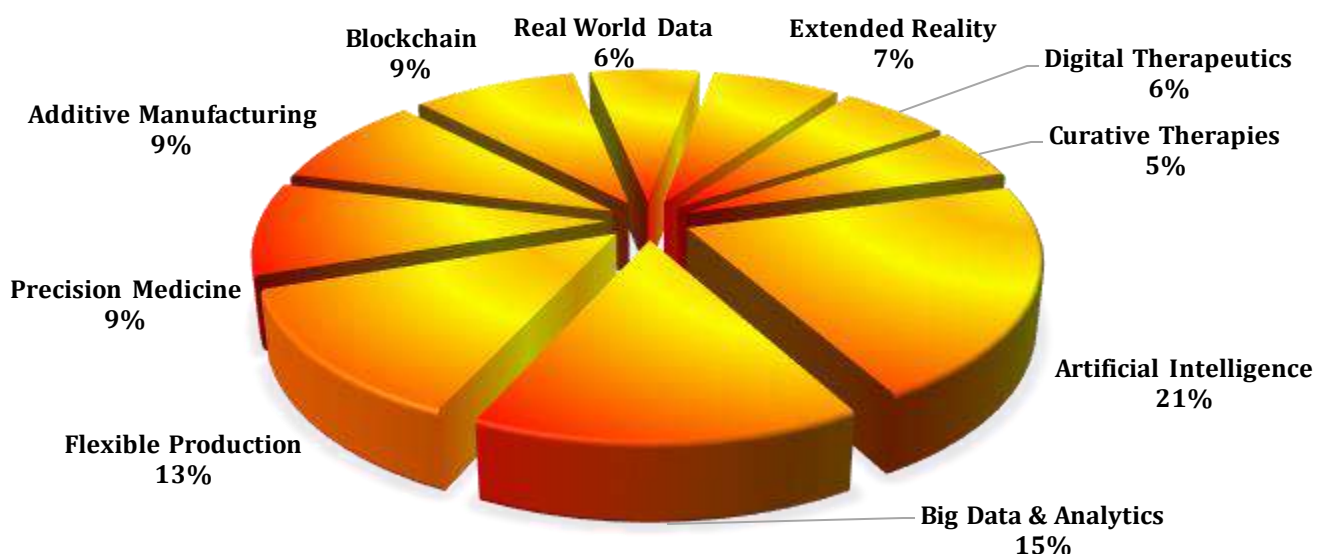
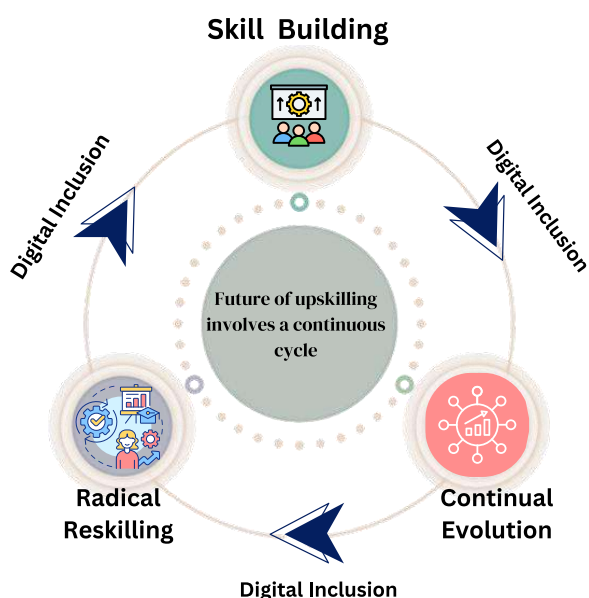


Figure 2.9: Pharma Industry Trends and Innovation in 2024

IT Specialists

Skills Required: IT knowledge, problem-solving, understanding of supply chain technologies, and cybersecurity



Regulatory Affairs Specialists

Skills Required: Logistics management, problem-solving, organizational skills, and knowledge of transportation regulations.



Figure 2.10: Pharma Industry trends and innovation in 2024

Customer Service Representatives

Skills Required: Communication skills, problem-solving, customer service, and knowledge of supply chain processes.

These roles collectively ensure that the healthcare and pharmaceutical supply chain operates smoothly, providing essential medical supplies and medications to patients and healthcare providers efficiently and safely.

Positions	Required Skill Set
Entry Level	- Basic understanding of healthcare supply chain concepts - Knowledge of healthcare regulations and standards - Data entry and inventory management skills - Proficiency in Microsoft Office and healthcare-specific software - Basic communication skills - Understanding of medical terminology and healthcare products
Mid-Level	- Experience with healthcare supply chain software (e.g., ERP systems, GHX (Global Healthcare Exchange), McKesson Supply Chain Solutions, Oracle Healthcare, etc.) - Project management skills in a healthcare context - Knowledge of procurement and logistics processes - Understanding of quality control and assurance in healthcare - Analytical and problem-solving skills - Effective communication and negotiation skills
Senior-Level	- Strategic planning and execution in healthcare supply chain - Leadership and team management in healthcare settings - In-depth knowledge of global healthcare supply chain operations - Expertise in regulatory compliance and risk management - Advanced data analysis and decision-making skills - Ability to drive innovation and process improvements in healthcare

2.4. Agri-Food Supply Chain Management

The Agri-Food Supply Chain entails a sequence of activities from farming to the final consumer touching on key different links including suppliers, processors, retailers and the final consumer. The integration of cutting-edge digital technologies, blockchain, IoT, and AI is revolutionizing supply chain management, boosting traceability, sustainability, and efficiency.

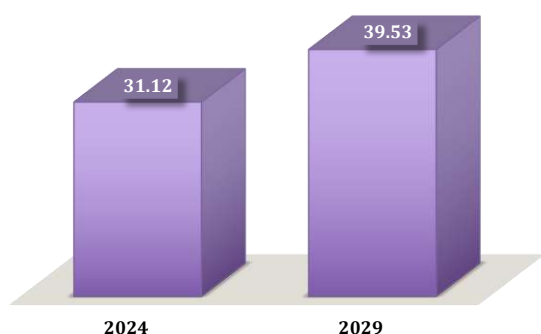


Figure 2.11: Indian Agriculture Market in INR lakh crore

Indian agriculture market is estimated at INR 31.12 lakh crore (USD 372.94 billion) in 2024 and expected to reach INR 39.53 lakh crore (USD 473.72 billion) by 2029 at a CAGR of 4.9 %^{2.1}. The expected export value of the Indian agriculture market in 2024 is INR 96.66 thousand crore (USD 11.58 billion) with a CAGR of 8.62 %^{2.2}.

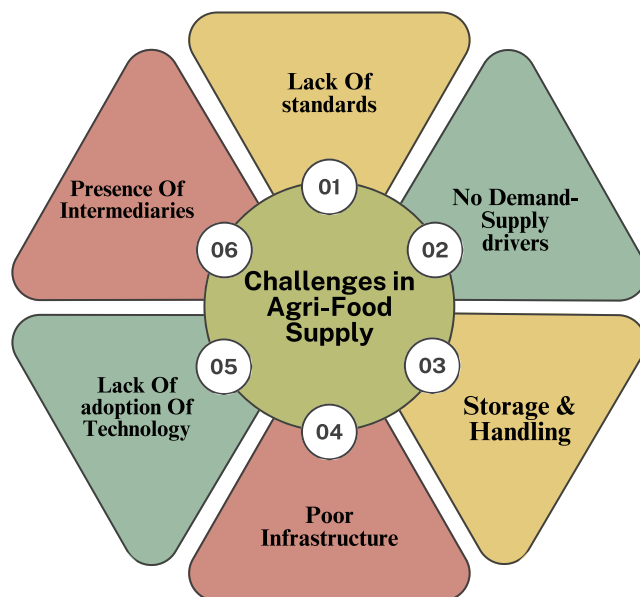
2.4.1. Stakeholders of the Agri-food supply chain

Farmers: Cultivating crops and rearing livestock, farmers are the backbone of the food production process.

Food processors: Businesses that convert unprocessed agricultural goods into processed foods. They can be of several kinds and operate on a business-to-business basis.

Retailers and distributors: who help convey food goods from producers to consumers make up the food traders' category.

Consumers: Consumers who buy and eat food goods are known as consumers.



Transporters: Responsible for moving goods from one point to another.

Warehouses: These facilities store goods until they're ready for distribution.

Procurement Professionals: They source and purchase the necessary materials.

Quality and Analytics Professionals: They ensure the quality of products and analyze data for decision-making.

2.4.2. Role of Logistics in Agriculture and Horticulture

The entire supply chain from farm to consumer is managed by logistics, which plays a crucial role in India's agriculture industries.

Global problems: The distance between producers and markets, conventional manufacturing methods, and acquisition prices are only a few of the global problems that logistics management must overcome. It aims to lower these through machinery, efficient networks, and specialization.

In addition to minimizing waste, increasing farmers' revenue, and guaranteeing food security, efficient logistics also assure the timely and safe conveyance of agricultural products.

Minimizing Waste: Effective logistics helps reduce food waste by ensuring timely delivery and proper handling. It prevents spoilage and ensures that fresh produce reaches consumers promptly.

Reduced Costs: Costs can be reduced by effective logistics management. One way to cut expenses is to optimize transportation routes, minimize empty haulage, and improve load capacity utilization.

Supply Chain Integration: Logistics serves as a bridge between the many supply chain participants, such as farmers, suppliers, distributors, and retailers. Supply chains that are integrated increase productivity and decrease inefficiencies.

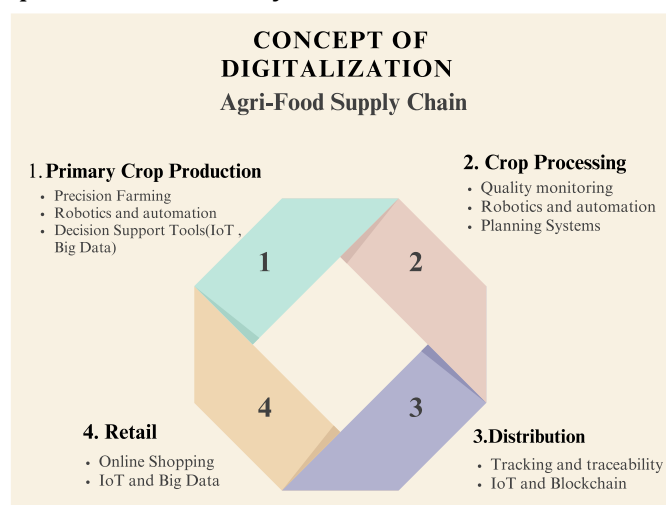
Safety and Quality of Food: Logistics has an impact on the safety and quality of food. Proper handling, storage, and transportation are crucial to preserve product quality and avoid contamination.

Environmental Impact: The sustainability of the environment is impacted by logistics decisions. A greener supply chain is facilitated by optimizing vehicle usage and reducing petrol emissions.

Animal welfare: Logistics choices have an impact on environmental sustainability. Optimizing vehicle usage and cutting petrol emissions help create a greener supply chain.

2.4.3. Digitization in Agri-Food Supply Chain

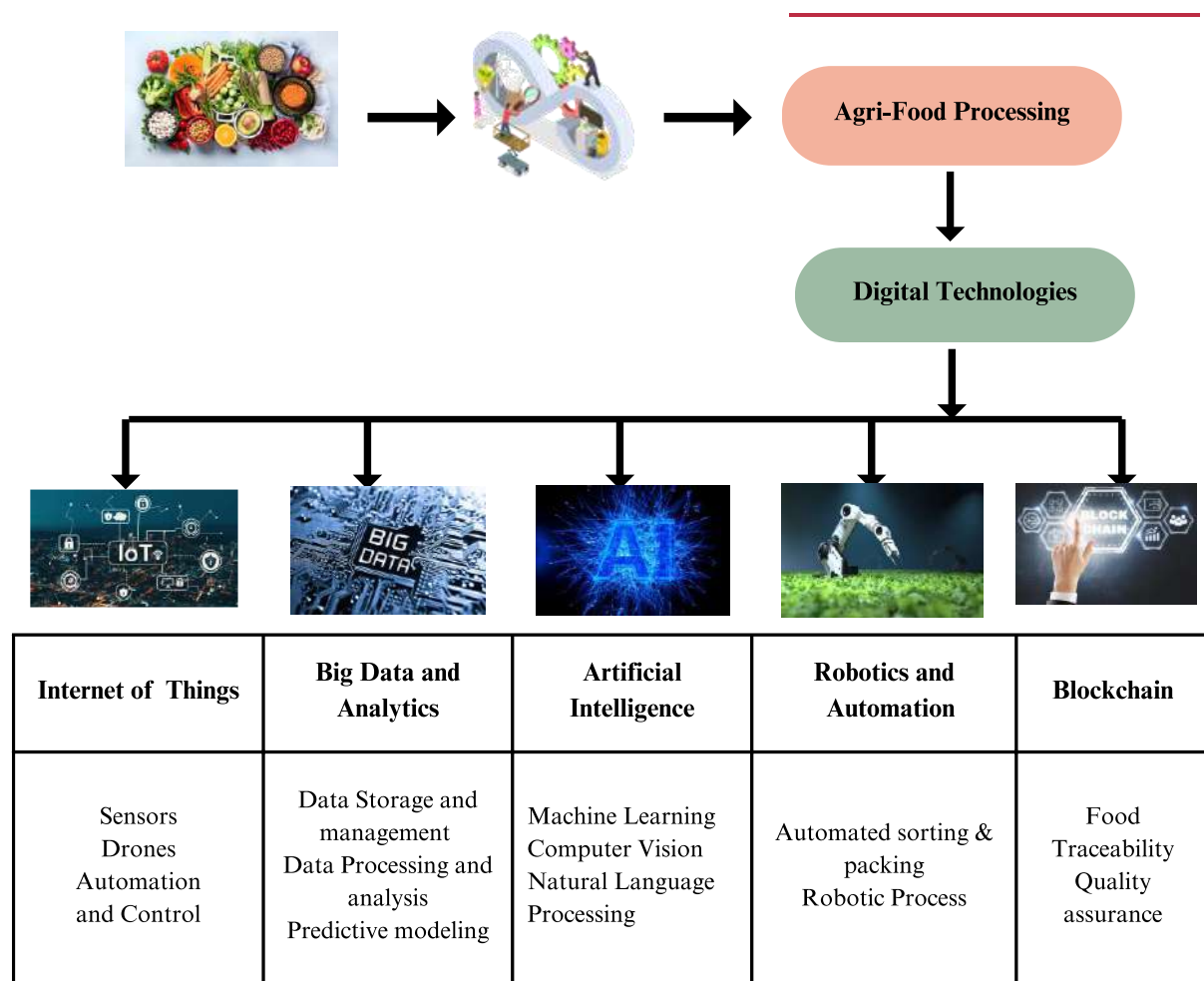
Automating manual processes such as fertilization and watering is made possible by IoT, permits data sharing using RFID and Wireless Sensor Networks (WSN). RFID is used for livestock management, supply chain management, quality control, temperature monitoring, shelf-life estimate, and food product traceability.



IoT Application In SC Management

- **Data Gathering:** Climate, soil, and crop health data are gathered using sensors.
- **Reducing waste:** Crop losses are avoided by early identification.
- **Resource Efficiency:** IoT makes the best use of energy and water.
- **Supply Chain Efficiency:** Demand forecasting and traceability are enhanced by IoT.
- **Integrating Internet of Things (IoT) technology** in tracking products' location and conditions is revolutionizing the agri-food logistics industry.
- By leveraging IoT, businesses can streamline operations, enhance efficiency, and address critical challenges.

It is anticipated that by 2030^{2,3}, the worldwide smart farming industry will grow to INR 5.5 lakh crore (USD 66 billion).



2.4.4. GIS in an Agri-Food Supply Chain

Geographical Information System (GIS) helps with crop suitability analysis on particular types of land. Enhancing supply chain transparency with blockchain technology and maximizing site selection and transit routes. Stakeholders in the agriculture industry can make well-informed decisions about asset management, supplier selection, cost minimization, and facility location by integrating.

Integrating GIS with blockchain and IoT technologies can resolve supply chain problems with transparency and communication, resulting in effective data sharing for all parties.

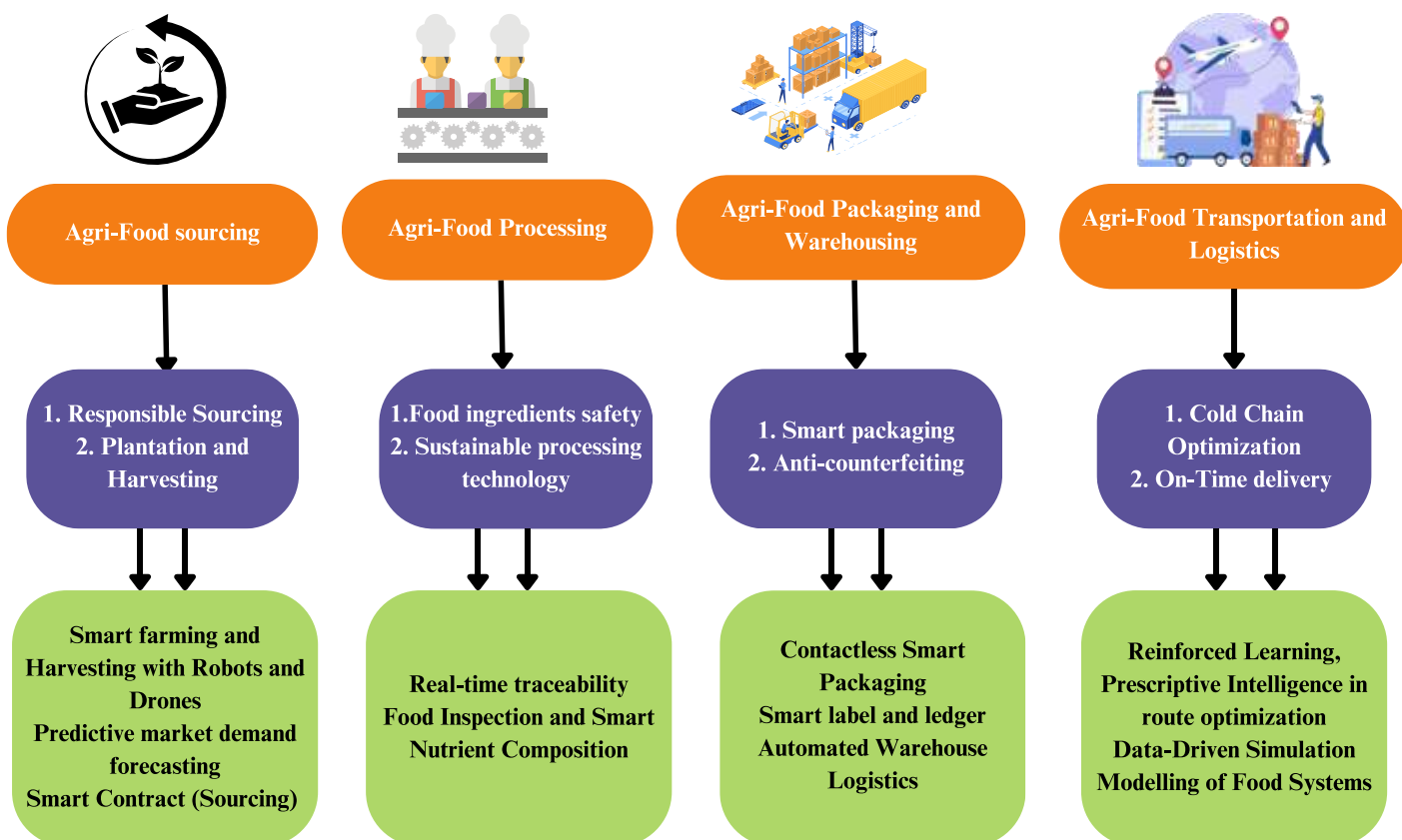
Overall, the productivity, sustainability, and general efficiency of the food supply chain are all greatly improved by GIS applications in agriculture supply chain management.

GIS Integration

Using satellite imagery and geographic data, an integrated strategy of remote sensing and geospatial analysis is used to simulate and anticipate the effects of climate change on food security. This allows researchers to determine how variations in the climate affect agricultural productivity and food supply.

When it comes to environmental variables like temperature, precipitation, soil moisture, and vegetation health, remote sensing offers invaluable information. Additionally, this data can be analyzed and understood in the context of geographical locations with the aid of geospatial analysis.

Combine these methods to create models that predict how crop yields, agricultural practices, and food production will be affected by climate change in particular areas. These models will help stakeholders and policymakers put plans in place to reduce the risks to food security.



2.4.5. Fertilizer Supply Chain

The fertilizer supply chain in 2047 will undergo significant transformations due to advancements in technology, regulatory changes, and evolving market dynamics. This report explores the anticipated developments in manpower, statistical data, and technologies involved in the future fertilizer market.

The global fertilizer market reached USD 210.5 billion (approximately INR 17.23 trillion) in 2022 and is projected to grow to USD 308.6 billion (approximately INR 25.28 trillion) by 2030, at a CAGR of 4.9% during the forecast period of 2023-2030. This substantial growth is driven by increasing global population and food demand, necessitating improved agricultural productivity and enhanced crop yields. The global fertilizer market is expected to grow modestly, with an annual growth rate of 1% to 1.5% over the next few decades.

Key Market Dynamics

- Advanced Farming Techniques
- Balanced Nutrient Management
- Impact of COVID-19
- Artificial Intelligence

Latest Technologies in Fertilizer Supply Chain

- Digital Twins
- Automation and Robotics
- Precision Agriculture
- Green and Blue Ammonia

Manpower in the Fertilizer Sector

The future fertilizer industry will require a workforce with advanced skills in technology, sustainability, and supply chain management. Key roles will include:

- Supply Chain Analysts
- Automation Specialists
- Sustainability Officers
- Digital Twin Technicians

Positions	Required Skill Set
Entry Level	- Fundamental understanding of agricultural product characteristics and processing methods. - Basic knowledge of food safety standards and quality assurance practices. - Fundamental analytical and problem-solving abilities. - Awareness of sustainability practices in agri-food supply chains. - Basic knowledge of regulatory requirements and compliance in the agri-food sector. - Basic understanding of fertilizer types and applications
Mid-Level	- In-depth knowledge of agricultural products, production procedures, and quality assurance. - Comprehensive knowledge of managing agri-food logistics and optimizing supply chain strategies. - Proficiency in using supply chain management software (such as SAP, Oracle, Agriware, and Croptracker) tailored to the agri-food industry. - Competence in data analytics software for supply chain insights (e.g., Tableau, Power BI, ERP). - Ability to analyze data and generate actionable insights for supply chain improvements. - Familiarity with food safety regulations and compliance requirements.
Senior-Level	- Expertise in developing and implementing long-term supply chain strategies to enhance efficiency and competitiveness. - Strong leadership skills to manage and mentor teams, and drive performance improvements. - Ability to identify potential risks in the supply chain and develop strategies to mitigate them effectively. - Understanding of financial principles to manage budgets, cost control, and financial planning within the supply chain. - Capability to drive innovation in fertilizer production and distribution

The fertilizer supply chain in 2047 will undergo significant transformations due to advancements in technology, regulatory changes, and evolving market dynamics. This report explores the anticipated developments in manpower, statistical data, and technologies involved in the future fertilizer market.

2.5. Humanitarian Supply chain Management

Humanitarian supply chains play a critical role in addressing the multifaceted challenges of complex emergencies. The Joint Logistics Enterprise defines a “complex emergency” as the wide array of “international conflict, humanitarian, and domestic disaster relief scenarios, involving combinations of warfare, food insecurity, epidemics, and social conflict”. These scenarios are characterized by some combination of displaced people; widespread damage; hindrance of intervention or prevention due to political, security, or infrastructure constraints; threat of loss of life; or need for large scale assistance.

Humanitarian supply chains are primarily composed of two domains: networks constructed to support military expeditions and chains intended to support nongovernmental disaster relief organizations. As these two domains share some characteristics and tend to intersect, I would propose that together, they comprise the emergency supply chain framework that supports the Joint Logistics Enterprise’s definition of a complex emergency.

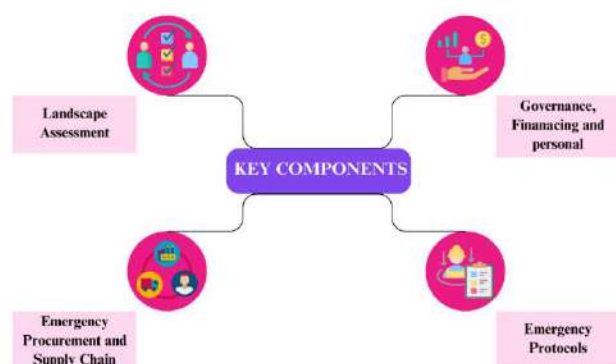


The figure above visually depicts the composition of emergency supply chains, as well as the relationship of the two domains to each other.

2.5.1. Key Components of Humanitarian Supply Chain

Landscape Assessment: A stakeholder assessment is a thorough mapping of all local and international organizations that could play a role in a country's ESC in the event of an outbreak.

The assessment should not only identify the stakeholders but also determine their capacity to provide supply chain support, and what their roles could be



Governance, Financing and Personal: Emergency Supply Chain (ESC) organizational structure encompasses roles and responsibilities for developing and sustaining the supply chain during both regular and crisis situations. It facilitates efficient coordination among Ministries, Emergency Operations Centers, and partners. ESC financing involves determining ongoing and emergency response funding needs, funding sources, and procedures for accessing and disbursing funds.

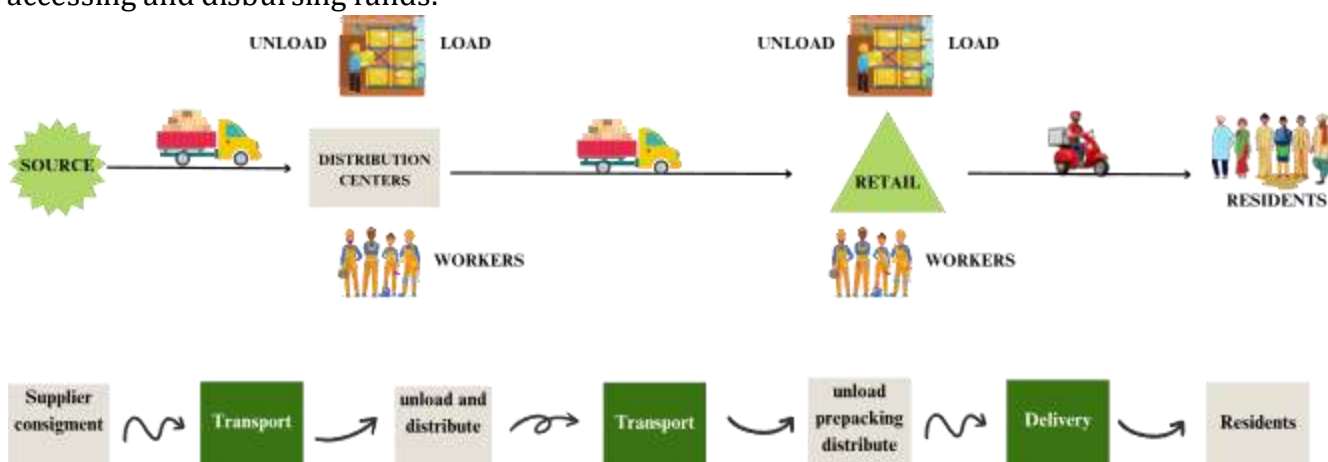
Personnel training and readiness focus on enhancing the capabilities of key staff and stakeholders involved in ESC operations through simulations and training exercises to identify and address weaknesses.

Emergency Protocols: Protocols are rules that describe how processes should function under an emergency, and who should run those processes. They should be incorporated into a government's Emergency Preparedness and Response Plan.

Emergency Procurement and Supply Chain: Procurement and sourcing involve obtaining essential commodities from local and international suppliers in preparation for and during an emergency response.

2.5.2. Food supply chain: COVID-19 pandemic disruption

The figure below describes the scenario and focuses on supply chain management with the optimum labour allocation for relocating goods from Distribution Centers to retailers and residents. The DCs receive goods from outside, distribute them based on the downstream retailers' demand, and arrange vehicles or engage third-party logistics to transport them to each retailer. The retailers receive shipments from DCs, sort and pack the food according to customer requirements, and hand them over to riders or carriers for delivery to residents.



The World Food Programme (WFP) operates at the forefront of hunger relief, mobilizing staff and resources, including trucks, planes, ships, and more to deliver essential aid to those in need. With decades of experience, WFP collaborates with governments, NGOs, businesses, and local communities to achieve sustainable development goals, prioritizing local economies and resilience-building efforts.

Through strategic partnerships and supply chain optimization, WFP maximizes impact, boosts economic growth, and enhances food security for vulnerable populations worldwide. In 2022^{2,4}, the World Food Programme delivered 4.2 million MT of food and procured USD 3.3 billion (INR 50.14 thousand crore).

2.5.3. Crisis Reaction Phases for Supply Chains

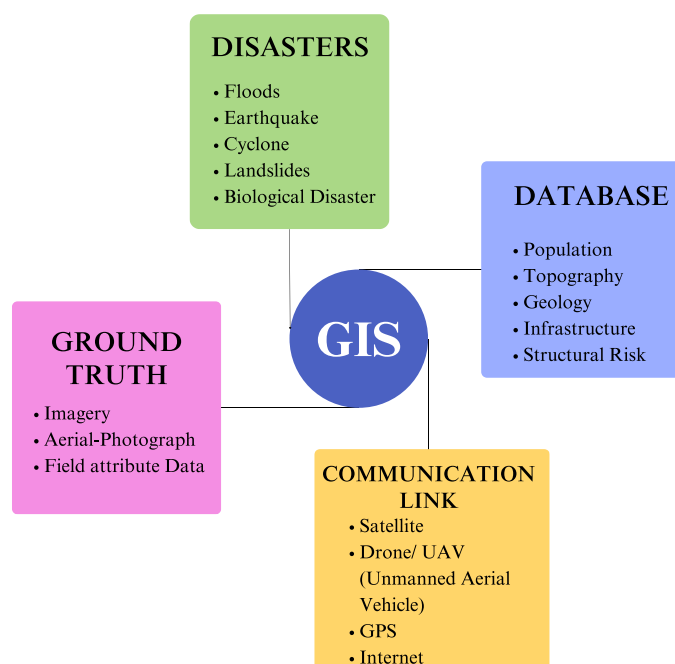
Supply chain crisis invariably has a negative connotation – demanding reaction cycles during pre-crisis phases of supply chain preparation and preparedness, intra-crisis phases of supply chain response and relief, and post-crisis phases of supply chain recovery and restoration. Within these cycles, SCM complexities stem from fragilities and vulnerabilities of complex networks and systems for resource distribution and coordination mechanisms. Potentials for damages, destruction, or disruptions also create uncertainty among supply chain partners in global business environments.

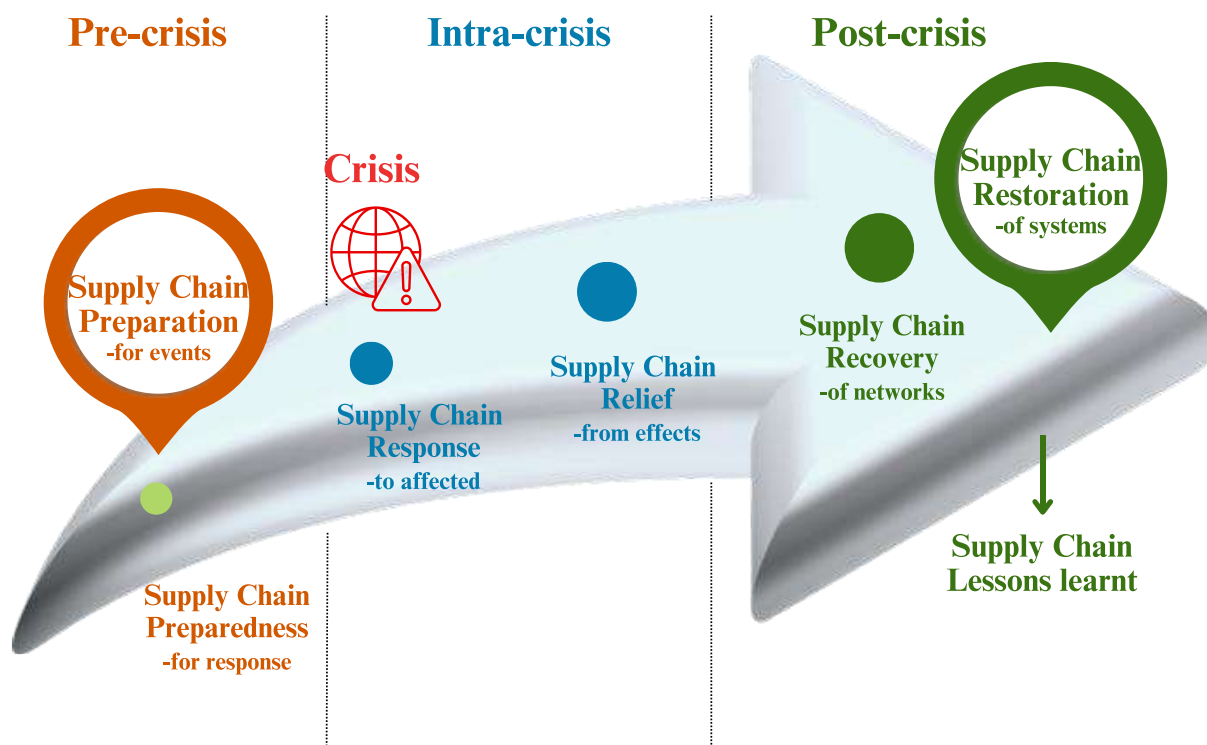
These insecurities underscore the need for supply chain crisis signals to ease recognition. These signals aid partners in enacting collective, holistic, inclusive, resilient, or diversified SCM strategies. The cycle of the Figure also reflects various constructs from the SCM literature related to general crisis management, humanitarian logistics management, and disaster management



2.5.4. Disaster Management

Disaster management is typically divided into four stages: prevention, preparedness, response, and recovery. Managing and responding to disasters effectively requires paying careful attention to each stage. Despite being separated into different stages, each with its own goals, the cycle is designed to be holistic, as each stage is interdependent and builds on the previous one to achieve better outcomes.





Positions	Required Skill Set
Entry Level (Supply Chain Coordinator, Inventory Control Specialist)	- Basic logistics and supply chain knowledge, communication, data entry, attention to detail - Inventory management, data analysis, basic forecasting skills
Mid-Level (Supply Chain Manager, Procurement Manager)	- Advanced logistics knowledge, supplier management, crisis management, leadership, problem-solving - Negotiation skills, vendor management, strategic sourcing, budgeting
Senior-Level (Supply Chain Director, Emergency Response Manager)	- Strategic planning, risk management, advanced problem-solving, leadership, cross-functional collaboration, - Crisis response planning, stakeholder coordination, advanced decision-making, communication.

2.6. Warehouse Automation

Warehouse automation streamlines inventory movement from storage to customers while minimizing human intervention. By implementing automation, businesses can reduce labour-intensive tasks that involve repetitive physical labour and manual data entry and analysis.

The India Warehouse Automation Market is projected to grow from INR 28.37 hundred crore (USD 0.34 billion) in 2024 to INR 93.47 hundred crore (USD 1.12 billion) by 2029^{2.5}, indicating a robust CAGR of 26.96% during the forecast period (2024-2029). The market analysis encompasses various solution types such as conveyor and sortation systems, palletizers, mobile robots (AGV/AMR), vision inspection equipment, and labelling equipment, predominantly utilized in the FMCG industry.

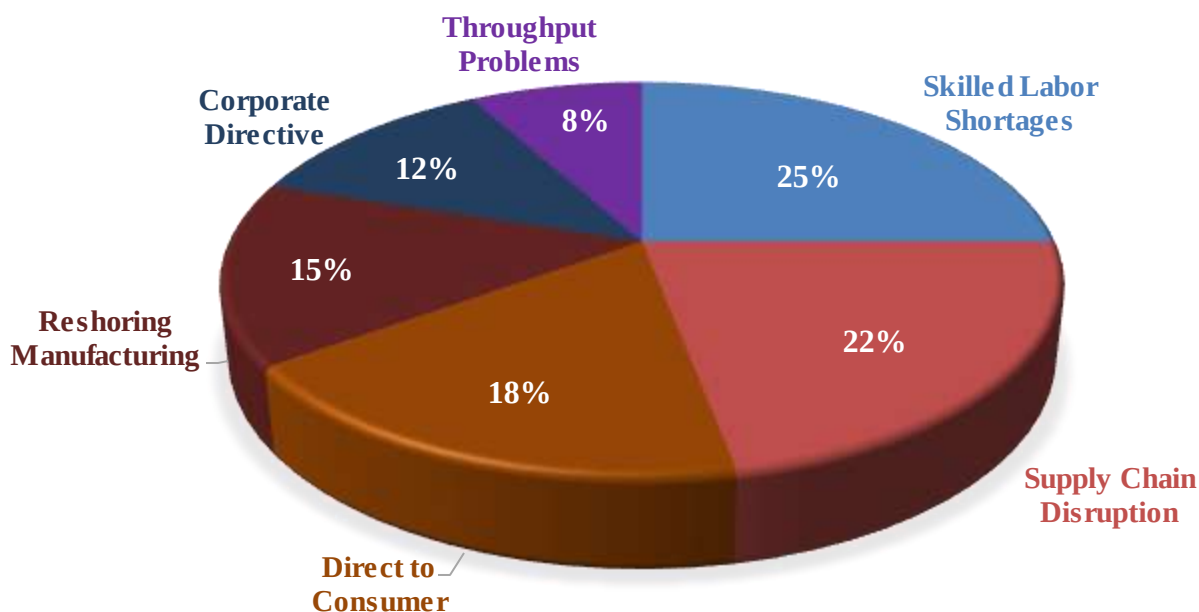
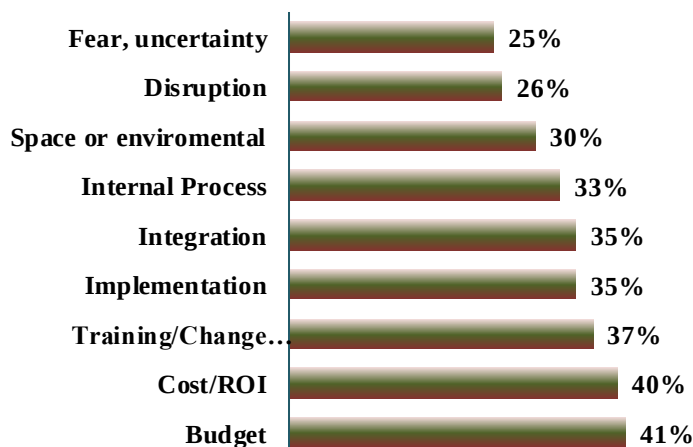
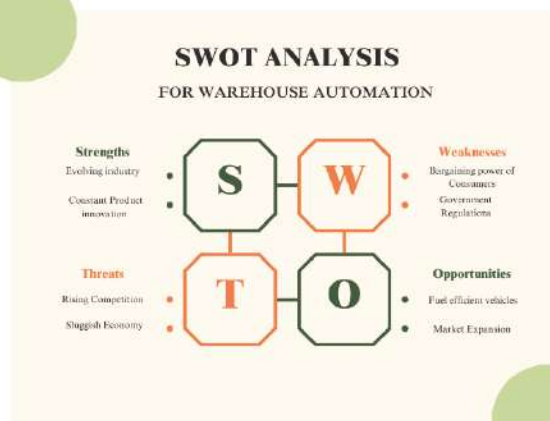


Figure 2.12: Challenges in Indian Warehouse Management

Unsurprisingly, the primary drivers for this adoption are the skilled labor shortage (25%) and supply chain disruption (22%). Smaller facilities are particularly impacted by the labor shortage, while larger facilities are driven to automation due to supply chain disruption.

Among industries, retail and e-commerce are most affected by the labor shortage and supply chain disruptions. Warehouse automation involves leveraging technology to enhance the efficiency of warehouse operations, encompassing tasks like movement and assembly. These processes utilize mechanical aids for product transportation within facilities and database systems for meticulous inventory tracking.

Particularly crucial for FMCG players managing large volumes of goods, warehouse automation necessitates continuous advancement and attention across inbound, storage, and outbound transit processes to ensure seamlessness.



2.13: Barriers in Adopting Warehouse Automation

2.6.1. Indian Warehouse Automation Market Trends

The explosive growth of e-commerce in India has sparked a wave of transformations across various industries, notably in the supply chain and logistics sectors. Data science applications are increasingly prevalent, particularly in shipment tracking, as companies strive to meet the evolving demands of online shoppers for swift and accurate deliveries.

The retail landscape is undergoing a profound shift as e-commerce giants fiercely compete to expedite order fulfillment processes. Warehouse automation and advanced control systems are pivotal in this evolution, enhancing operational efficiency and enabling faster order processing. Key players in India's e-commerce arena, including Amazon, Flipkart, and Bigbasket, rely heavily on warehouse automation to streamline their operations.

Leading e-commerce industries are the prime example of a company offering automated solutions tailored for e-commerce warehouses. Meanwhile, industry leaders like Amazon are not only leasing large automated warehouses but also expanding their footprint through acquisitions of robotic warehousing companies on a global scale.

2.6.2. Warehouse Automation and Sustainable Growth

As we approach 2024, sustainable growth has transcended mere rhetoric, becoming a tangible imperative for companies worldwide. Many global enterprises now prioritize identifying emerging markets that align with their industry strengths while enhancing their Environmental, Social, and Governance (ESG) ratings. This strategic shift is grounded in the proven correlation between high ESG ratings and sustained market outperformance over the medium and long terms.

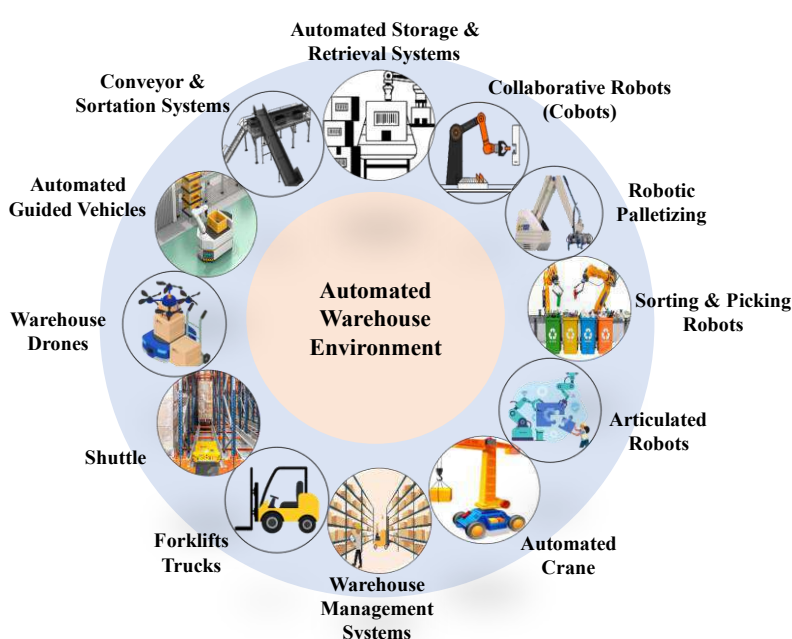
In numerous industries, the pursuit of profitability and operational expansion harmonizes seamlessly with a commitment to fostering positive ESG impacts, a synergy readily achievable through the adoption of advanced warehouse automation solutions.

Beyond the confines of warehouse walls, automation technologies exert far-reaching influence across supply chains and broader business operations, catalyzing efficiency enhancements and sustainability gains.

Beyond the confines of warehouse walls, automation technologies exert far-reaching influence across supply chains and broader business operations, catalyzing efficiency enhancements and sustainability gains.

Outlined below are three pivotal factors underscoring the transformative benefits of replacing traditional manual warehouses with cutting-edge automation solutions.

- Long Term Sustainability
- Higher Operational Resilience
- Fast Scale Up



2.6.3. Warehouse Automation and impact on employee job retention

As more companies embrace automation, the role of the warehouse worker is bound to evolve. However, change can be beneficial. Automation may present new opportunities for existing employees and help companies attract modern job seekers.

Improved Working Conditions with Safety as a Priority

As more companies embrace automation, the role of the warehouse worker is bound to evolve. However, change can be beneficial. Automation may present new opportunities for existing employees and help companies attract modern job seekers.

Tech-Focused Roles with On-the-Job Training

Gen Z (second-youngest generation) people are now entering the workforce and moving toward tech-oriented positions because they have grown up with modern technology. Companies are offering updated software- and technology-based warehouse jobs, like operations supervision, order release, performance data review, and transport planning, with minimum need for manual labor. Maintenance staff and robotics system operators are examples of emerging roles. Tech driven skills needed for these roles mean that smart people expect on-the-job training. Automation suppliers frequently provide ongoing training programs for new employees and practical training during installing new systems.

Sustainability Alignment

When selecting an employer, younger generations prioritize social responsibility and sustainability. In particular, Gen Z highly values these characteristics and frequently looks for employers who share their values.

Investing in warehouse automation can help businesses become more attractive to prospective employees by supporting sustainability initiatives. Automation can enhance sustainability through waste reduction, reusable packaging, and energy-efficient operations. Reusable packaging, such as plastic crates and totes, is handled by automated systems, which also distribute perishables optimally to reduce spoilage and increase shelf life.

Warehouse automation is expanding across the board, from retail and e-commerce to food production and grocery delivery. Companies that make automation investments now will benefit from a more robust workforce later on and will be better equipped to manage labor disputes.

Automation eliminates the need for an all-or-nothing approach. Robotic solutions can automate specific areas of a facility or the entire building to suit a variety of needs. Businesses, present workers, and future workforces all gain from this strategy

Positions	Required Skill Set
Entry Level	- Fundamental understanding of warehouse operations - Basic Computer Skills (e.g., Excel, Power BI, SQL) - Familiarity with basic robotics functions - Basic Inventory Management - Understanding of safety protocols - Basic Data entry and Analysis - Understanding of KPIs (Key Performance Indicators)
Mid-Level	- Proficiency in automation software and tools. - Intermediate programming skills (e.g., Python, Java) - Knowledge of PLCs and HMI systems - Experience with WMS (Warehouse Management Systems) - Data Analysis and Reporting - Performance Metrics Management
Senior-Level	- Systems Integration and architecture design - Strategic Planning and process optimization - Leadership in large scale automation projects - Decision making and innovations - Data driven and decision making - Advanced Analytics and predictive modelling - Strategic Analysis and insights

2.7. Metal and Mineral Supply Chain Management

India continues to shine in the global steel industry, with the country's steel demand projected to grow robustly by 7.7% in 2024^{2,6}, far outpacing the global growth rate of 1.9%, as per the World Steel Association's Short-Range Outlook. This growth is fueled by increased government infrastructure spending and a resurgence in private sector investment, which bolster the construction sector in India.

The Purchasing Managers' Index (PMI) is an essential economic measure based on monthly surveys of private sector firms. It is generated by three key organizations: the Institute for Supply Management (ISM), the Singapore Institute of Purchasing and Materials Management (SIPMM), and the IHS Markit Group. The PMI values range from 0 to 100, with values above 50 signifying expansion, below 50 indicating contraction, and a value of 50 representing no change.

The PMI for JP Morgan Global Manufacturing increased to 50.3 in February 2024 from 50.0 in January 2024, marking the first time the index has been over the neutral 50.0 threshold in 18 months since August 2022.



Figure 2.14: Example of steel supply chain

Growth in new business intakes and attempts to finish backlog of work boosted the increase in global manufacturing production.

Manufacturers of consumer products experienced strong growth, but the rates of expansion in the intermediate and investment goods categories were minimal. China, the USA, India, and Brazil were among the countries that witnessed an increase in manufacturing production. World Steel Association reported preliminary data that showed a 19.7% year-over-year increase in the output of DRI (Direct Reduced Iron) to 9.66 million tonnes (mt) in January 2024. India continued to lead the world in DRI production in January 2024, producing 4.50 mt (up 19% year over year).

Throughout the reviewed period, the nation produced 46.5% of the DRIs produced worldwide. Also, they reported, global crude steel production was 148.11 mt in January 2024, showing a 1.6% year-on-year decrease.

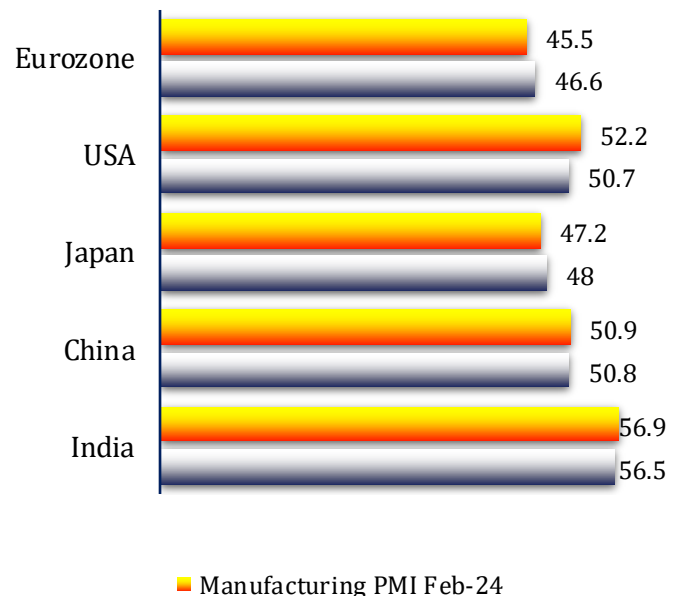


Figure 2.15: Manufacturing Purchasing Managers' Index

2.7.1. Performance of Indian Steel Industry

The total production of finished steel in India increased by 13.2%^{2.7} to reach 114.424 mt in the given period. The non-alloy steel segment accounted for the majority of this production, contributing 106.69 mt (93% share), which represents a 14.5% increase compared to the previous period. The remaining portion was

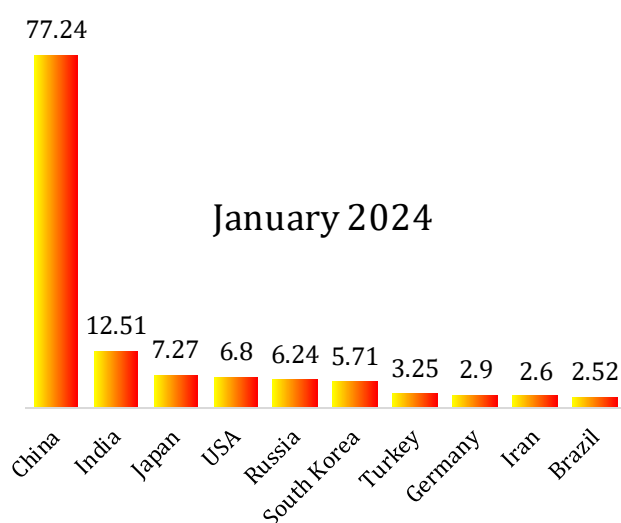


Figure 2.16: Top 10 Countries in World Crude Steel Production (in million tonnes)

In summary, there was a 3.6% rise in total finished steel exports, reaching 5.521 mt. The most significant exported product by volume was HR Coil/Strip at 2.058 mt, representing 37% of all finished steel exports. Italy was the primary export market for India, receiving 1.186 mt of finished steel. Imports of finished steel surged by 34.8% to 6.739 mt overall.

The most imported item by volume was HR Coil/Strip at 2.896 mt, marking a 71.4% increase and accounting for a 43% share of total finished steel imports. Total finished steel consumption rose by 14.5% to 112.515 mt. The non-alloy steel segment contributed 103.659 mt (92% share, up by 14.3%), while the remaining amount came from the alloy steel category, which includes stainless steel.

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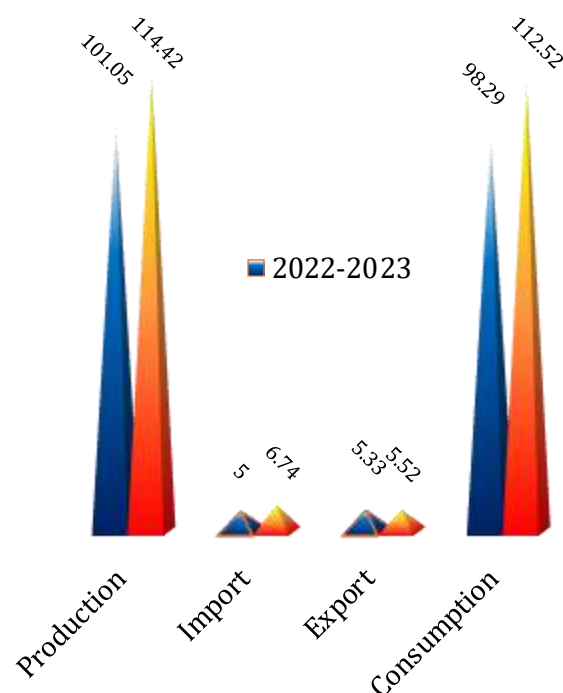
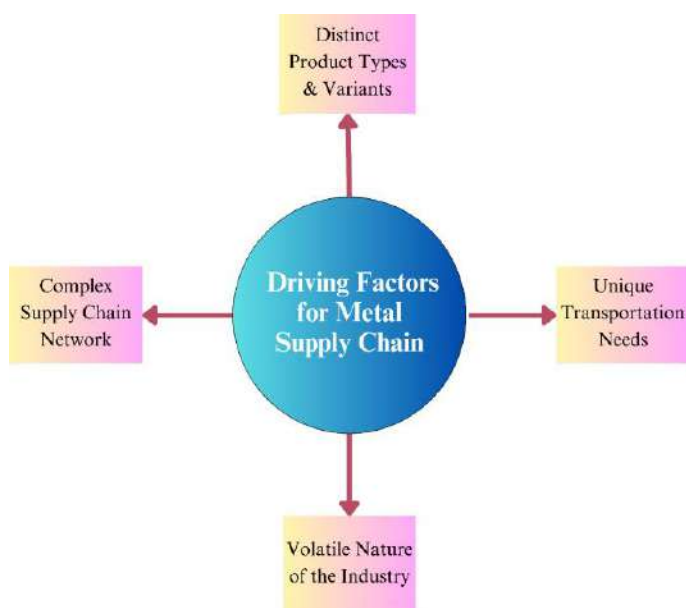


Figure 2.17: Manufacturing Purchasing Managers' Index

2.7.2. The current state of logistics in the steel and mineral industries

The supply chain in the steel industry is unstable, thus companies need to have an agile, responsive workflow in order to be prepared for the future. According to reports, India wants to produce 300 million tonnes of steel by 2030, and a smooth logistics module will be essential to achieving this goal. The following characteristics can be used to identify the contemporary industrial space:

- A diverse range of products
- Specific transport requirements
- Complex stakeholder network
- Industrial Fluctuations



2.7.3. Mineral Supply Chain

To promote industries like advanced electronics, telecommunications, transportation, defence, and green energy technologies, the Ministry of Mines has selected 30 essential minerals that are important for both economic growth and national security. A committee including seven experts was established to ascertain the minerals via a tripartite evaluation process encompassing global approaches, inter-ministerial discussions, and an empirical algorithm predicated on economic significance and supply volatility. Some of the most important minerals were found: platinum group elements (PGE), phosphorous, potash, rhenium, silicon, strontium, tantalum, tellurium, tin, titanium, tungsten, vanadium, zirconium, selenium, and cadmium; antimony, beryllium, bismuth, copper, gallium, germanium, hafnium, indium, molybdenum, niobium, nickel, and rare earth elements, among others.

The committee suggests creating a Centre of Excellence for key Minerals to create a value chain plan and update the key mineral list. Every country categorizes raw materials and vital minerals in distinct ways, based on factors such as economic growth, industry demands, national security concerns and interests, technology, market shifts, and the endowment of natural resources.



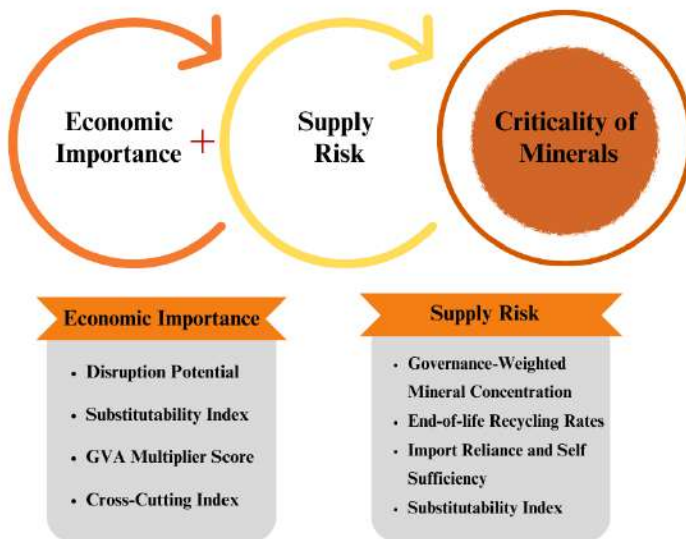
Figure 2.18: Core Objectives in the Indian Mineral Supply Chain

Studies differ in their approach, particularly when it comes to criticality assessment, but the general idea is always similar. The two primary factors considered to assess criticality in the majority of countries are supply risk and economic relevance. The same two criteria were applied in the Indian context as well.

Economic Importance (EI) quantifies the effects of minerals being unavailable in the supply chain on that industry by closely examining how raw materials are allocated to end uses concerning industrial applications. Supply Risk (SR) examines various factors including the concentration of global primary raw material production at the country level, environmental aspects of supplier country governance, the role of recycling, substitution, reliance on imports, and trade restrictions in third countries.

Gold supply chain

There are eight essential phases in the contemporary gold supply chain including miner/recycler, refinery, mint, transport, wholesaler, brokerage, depository/bank, retail investor. Every corporation gets a share of your investment when you buy gold. Due to its intricate supply chain, gold is an asset type that carries a very high premium. Cutting out as much of the supply chain as feasible should be the aim of the budget-conscious investor.



That is just what Vaulted has accomplished. Investors can purchase tangible, deliverable gold through Vaulted directly from the Royal Canadian Mint. Vaulted sliced out 70% of the supply chain, creating the most affordable cost structure in the industry. Blockchain ensures efficiency, transparency, and trust, which improves the gold supply chain.

Block chain-Integrated Gold Supply Chain

- **Transparency and Traceability:** Verifies ethical sourcing and authenticity by following gold from the mine to the consumer.
- **Fraud Prevention:** Authenticity is confirmed, prohibiting the sale of fake goods.
- **Efficiency:** Lowers expenses by automating transactions and streamlining procedures.
- **Overview of the Process**
- **Mining:** Documents information about extraction.
- **Transport and Refining:** Records every stage to ensure ethical procurement.
- **Manufacturing and Retail:** Monitors gold until it is sold.
- **Purchase by Consumer:** Offers the entire history of the gold.

Examples: Tradewinds Markets and IBM, Perth Mint, Emerging Technology

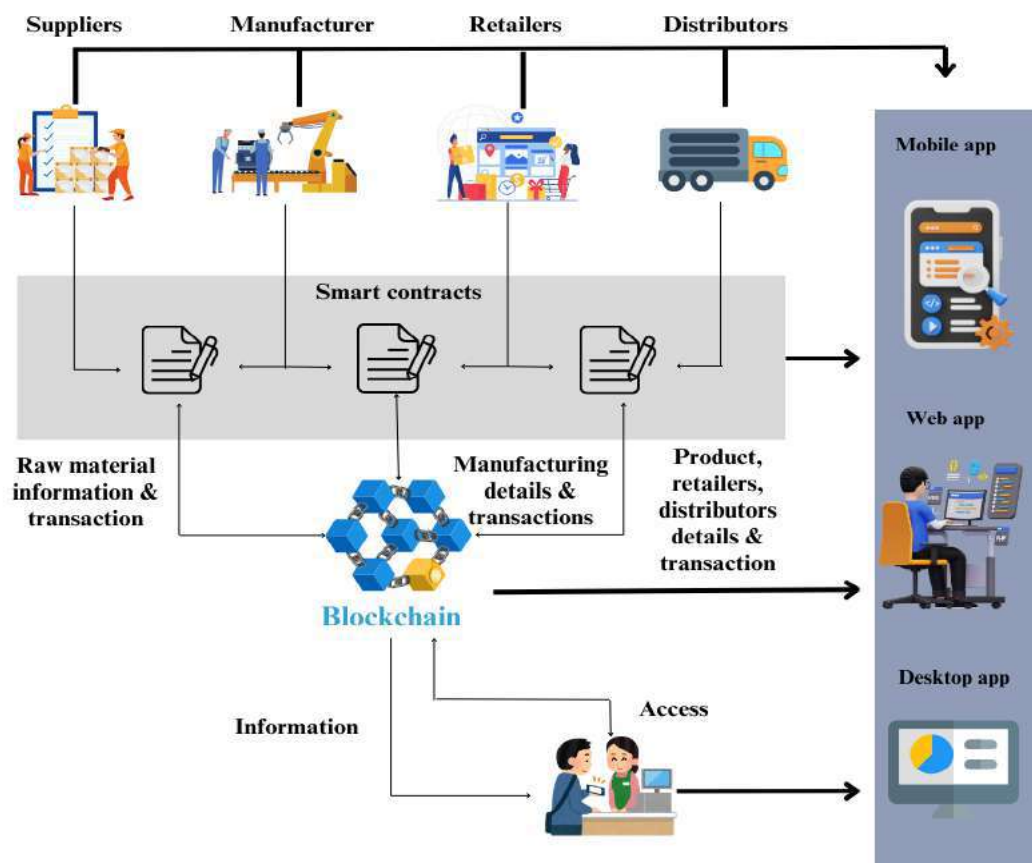


Figure 2.19: Block chain-Integrated Gold Supply Chain

Positions	Required Skill Set
Entry Level	- Fundamental understanding of metal characteristics and processing methods. - Comprehension of logistics and supply chain principles. - Proficiency with inventory management software and data entry. - Fundamental analytical and problem-solving abilities.
Mid-Level	- Metal characteristics, production procedures, and quality assurance. - Solid knowledge of logistics management and supply chain optimization strategies. - Expertise with supply chain management software (SAP, Oracle, etc.). - Project management skills and experience with lean manufacturing practices. - Ability to analyse data and generate actionable insights.
Senior-Level	- Organizing and carrying out supply chain projects strategically. - Thorough understanding of legal requirements and international metal markets. - Proficiency with sustainability principles and supply chain risk management. - Abilities in team management and leadership. - Advanced knowledge of data analytics technologies and analytical abilities.

2.7.4. Skill Level Requirement for Metal Supply Chain in India

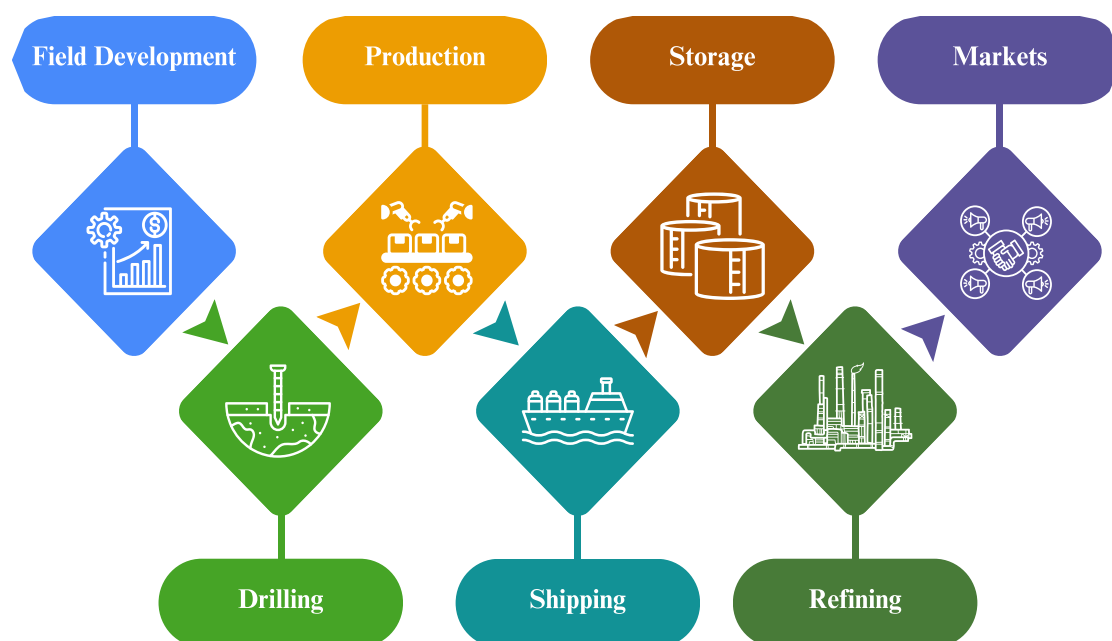
India's metal supply chain is divided into several phases, such as distribution, manufacturing, processing, and mining.

To guarantee effective operations and adherence to quality and regulatory standards, each stage calls for a different set of skills.

2.8. Oil and Gas Industry

The oil and gas industry operates through a global supply chain that includes domestic and international transport, trading, shipping, ordering, and inventory visibility and control.

Other supply chain elements include material handling, import/export facilities, and the distribution of refined energy products from points of origin to market.



Typically, the supply chain is divided into three segments. The upstream segment finds and produces crude oil and natural gas. The midstream segment handles the processing, storing and transporting of energy commodities. And the downstream segment encompasses oil refineries, retail outlets and natural gas distribution companies

Given the many steps involved in energy processing, transportation and logistics, the oil and gas supply chain are understandably complex. Yet with global competition on the rise, industry professionals find that supply chain improvements are both necessary and cost effective.

Leveraging the cloud, Internet of Things (IoT), team collaboration and blockchain digital technologies, among others, enhanced value chains can reduce costs and enhance operations at every stream of oil and gas production. For example, digital systems can help mitigate risk, optimize warehouse inventory strategy, monitor the logistics of transportation, enhance the customer experience, and help ensure the best procurement strategies are in place.

2.8.1. The Technological Impact: Transforming the Oil and Gas Landscape

The digital transformation of the oil and gas industry is significantly driven by emerging technologies, enhancing efficiency, sustainability, and competitiveness. Here's a compressed overview of the key technologies and strategies enabling this transformation

- Data Analytics and AI
- Robotics and Automation
- Internet of Things (IoT)
- Augmented Reality (AR) and Virtual Reality (VR)
- Blockchain
- Cloud and Edge Computing
- Industrial 5G

Strategies for Accelerating Digital Transformation

- Embrace Cloud-Native Solutions: These solutions support scalable resources and improved data integration.
- Foster a Culture of Innovation: Promoting technological adoption and continuous learning within the workforce.
- Strengthen Cybersecurity Measures: Essential to protect against evolving digital threats.

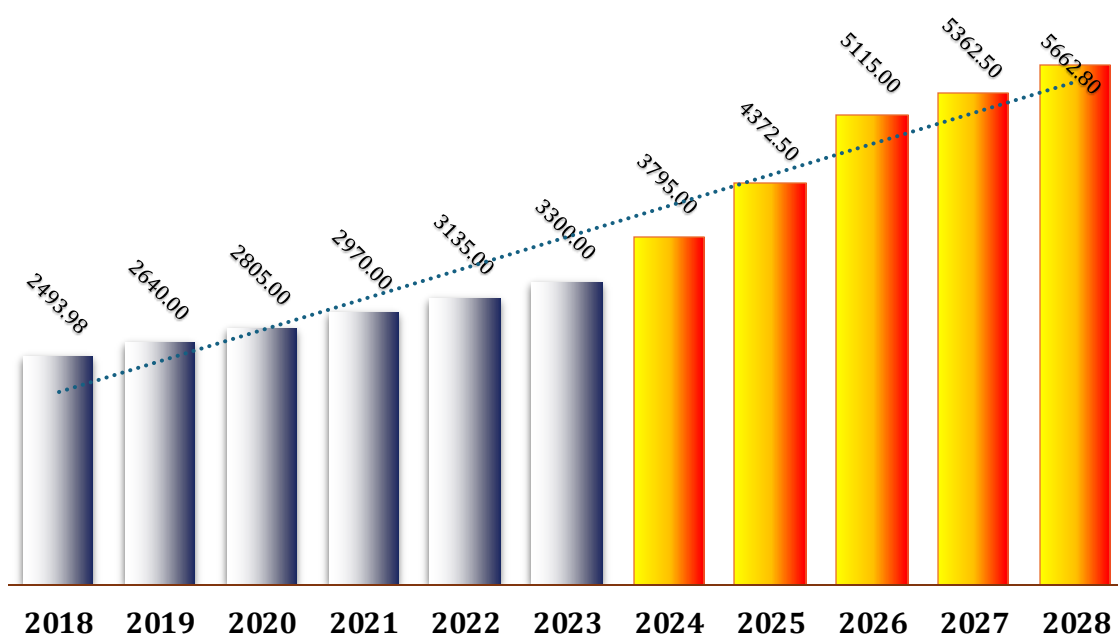


Figure 2.20: Valuation of oil and gas industry (in hundred crore)

- **Leverage Digital Twins for Asset Management:** Allows for real-time monitoring and predictive maintenance.
- **Collaborate with Technology Partners:** Engages expertise for faster implementation of digital solutions

These elements collectively propel the oil and gas industry towards a more digital and efficient future, addressing current challenges and preparing for emerging market dynamics.

Stakeholders in oil and gas supply chain management:

- **Employees and workers:** Those directly employed by the companies, including field workers, engineers, administrative staff, and executives.
- **Investors and shareholders:** Individuals or entities that invest in oil and gas companies expecting a return on investment.

- **Government and regulators:** Entities that oversee operations, provide licenses, levy taxes, and enact regulations to ensure environmental and safety compliance
- **Suppliers and contractors:** Businesses that provide equipment, services, or consultancy to oil and gas companies

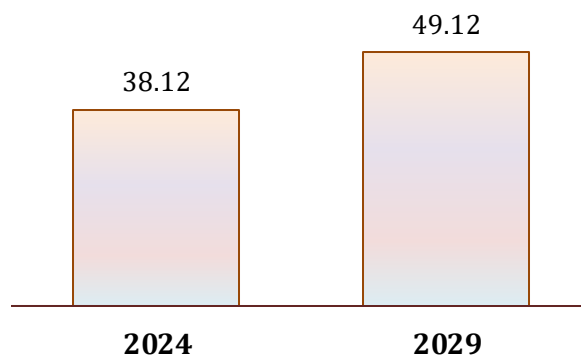


Figure 2.21: Oil and Gas Market Size in India (billion cubic meter)

Positions	Required Skill Set
Entry Level	• Understanding of supply chain principles, and procurement processes specific to oil and gas industry. • Familiarity with industry safety standards, environmental regulations, and compliance requirements. • Ensuring accuracy in documentation, tracking materials, and maintaining records. • Ability to address and resolve issues promptly to maintain smooth supply chain operations.
Mid-Level	• Proficiency in managing procurement, negotiating contracts, and ensuring compliance with contractual terms. • Ability to manage inventory effectively, optimize stock levels, and ensure timely availability of materials. • Proficiency in using supply chain software like SAP Oil and Gas, Oracle SCM, and IBM Maximo. • Competence in analyzing supply chain data, generating reports, and using insights to improve efficiency and performance.
Senior-Level	• Organizing and carrying out supply chain projects strategically. • Thorough understanding of legal requirements and international metal markets. • Proficiency with sustainability principles and supply chain risk management. • Abilities in team management and leadership. • Advanced knowledge of data analytics technologies and analytical abilities.

2.9. Automotive Industry

The automotive supply chain is a vast, intricate global network of manufacturers, suppliers, and service providers that work together to bring vehicles to the market. Think of it as a giant, well-coordinated machine, with millions of moving parts that must work together perfectly to produce the finished product.

2.9.1. Automotive Industry in Indian Economy

The Union Budget for 2023–2024, presented in the parliament, has paved the way for the expansion of India's automotive sector. The Government's intent to boost the Indian automobile sector by emphasizing domestic manufacturing and increasing value addition is prudent.

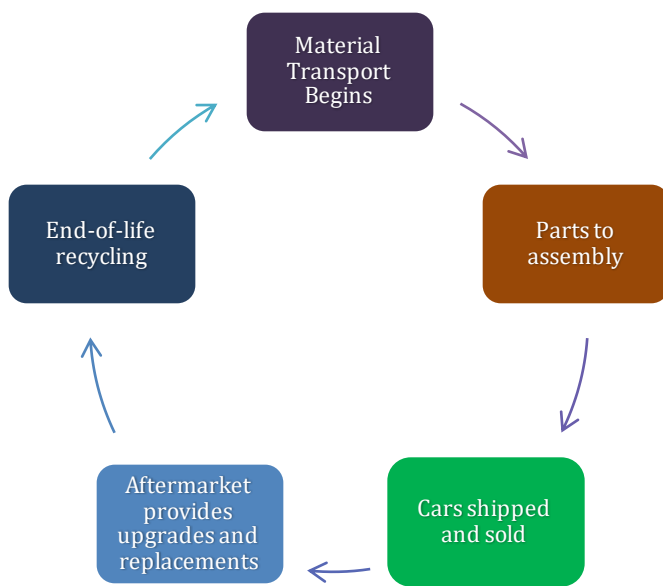


Figure 2.22: Representation of Various Steps Involved in Automotive Supply Chain

Measures such as lowered direct taxes, increased infrastructure spending, and support for start-ups and MSMEs are demand-side policies for the economy and the automotive industry's expansion.

The Indian automotive industry is poised for significant growth in the coming years. India, now the fastest-growing economy, has jumped to the number three spot in the automobile sector, surpassing Japan. Notably, India aims to double the auto industry size to INR 15 lakh crore by 2024 from the current INR 7.5 lakh crore.

The automobile industry significantly contributes to the country's GDP growth, exports, and employment potential, providing 4.5 crore jobs and generating substantial revenue through GST. The sector contributes 7.1% of India's GDP and 49% of its manufacturing GDP.

Increasing capital infusion by 33% to INR 10 lakh crore to bolster infrastructure development, the Government aims to transform the country's road infrastructure to match that of developed economies by 2024. The recent launch of the New Green Express Highway, connecting Delhi, Mumbai, Chennai, and Bangalore, has received an overwhelmingly positive response from the capital market.

The Government of India's policy pushes in the Union Budget on Biofuels - Ethanol Blending Program, Biogas, and National Green Hydrogen Mission will fuel the Indian economy towards its target of a 5 trillion-dollar economy and realizing Net Zero by 2070. The Biofuel policy supports the agriculture industry, thereby empowering the farmers of India not only as 'anna data' but also as 'urjadata' is visionary

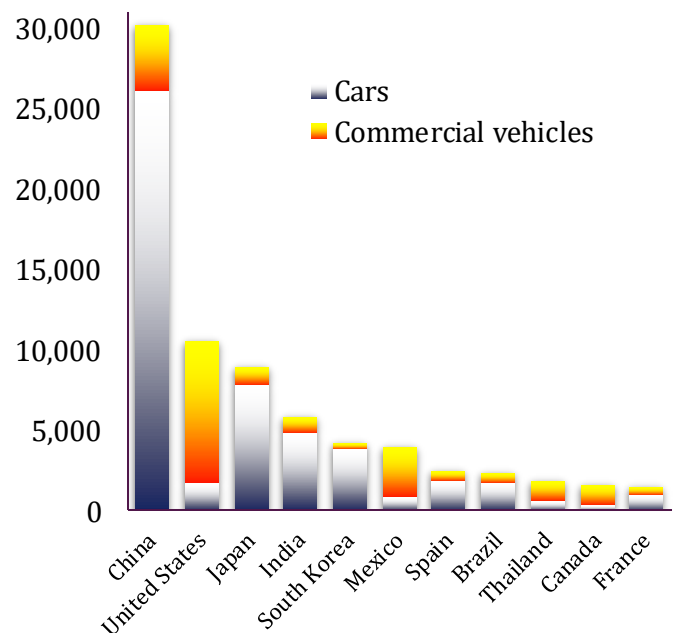


Figure 2.23: Motor Vehicle Production Volume Worldwide in 2023 (in 1000 units)

The reduced cost of lithium-ion batteries, favorable GST policies for electric vehicles, and no custom taxes on machinery and capital items necessary for producing lithium-ion batteries for EVs make this an exciting time for the EV industry.

Lower tax rates will likely lead to increased domestic spending, putting more money in the hands of consumers and boosting sales across the automotive sector. This will relieve the lower end of the vehicle market, where sales of entry-level vehicles and two-wheelers have lagged since customers at the base of the pyramid cannot afford them. The increased disposable incomes will fuel the demand for personal mobility, benefiting the used car segment in India, which is poised to grow at a CAGR of 17.50% during 2021–2030.

The Indian government's recent scrapping program, which incentivizes individuals, businesses, and ordinary people to change their old vehicles with new ones, is expected to increase significantly the country's automotive sector. With this codification, customers are expected to replace their older automobiles with more powerful, fuel-efficient, and environment-friendly vehicles, with a substantial increase in demand for new cars. This will open a wider area for automakers, dealers, and component and accessory providers.

The scrapping program is expected to bolster the economy by creating renewed employment opportunities and different revenue streams, reducing environmental pollution, and improving traffic safety by eliminating older, less dependable cars from the road. This scrapping policy is estimated to be a substantial driver of growth in the Indian Vehicle sector in the upcoming years.

The recycled parts obtained after destroying the old automobiles are estimated to benefit the automotive sector greatly. Recycled components could cut the cost of inputs used in new car manufacture by up to 30%^{2.8}, making the new vehicles less expensive and accessible to customers. This greater convenience will increase the demand for new cars, providing the industry with a long-term source of growth.

Furthermore, recycled parts will conserve natural resources and eliminate waste, making the automotive sector more environmentally friendly. The benefits of recycling extend beyond the automotive sector, potentially creating jobs and encouraging economic growth in related industries like metal and plastic recycling. Promoting recycling and sustainability, the Indian Government's scrapping policy sets the stage for a more prosperous and sustainable future for the country's automobile industry.

It is an exciting period for the Indian automotive industry, and the excitement is palpable. With the Government's commitment to developing world-class road infrastructure, green mobility, reducing dependence on fossil fuels, creating employment opportunities, and improving road safety, the future looks bright for the Indian automotive industry. The Government's growth-oriented policies will significantly impact the automotive sector and boost automobile demand.

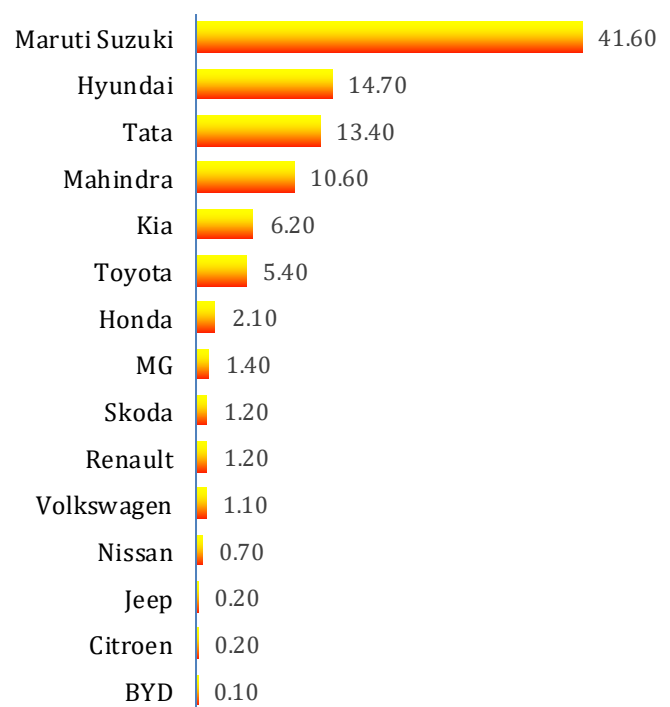


Figure 2.24: Passenger Car Market Share by Vendor across India in 2023 (in %)

SWOT ANALYSIS

FOR AUTOMOTIVE INDUSTRY

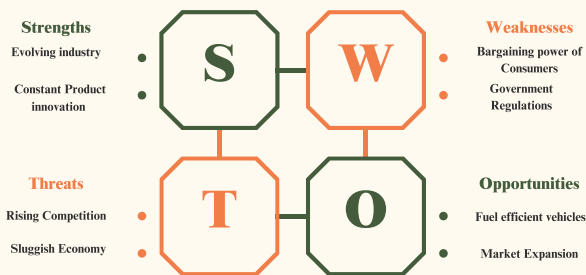


Figure 2.25: Representation of SWOT Analysis of Automotive Industry

Challenges Faced by Automotive Supply Chain

- A lack of Visibility
 - Centralized communication views
 - Tracking of all parts throughout the supply chain
 - Streamlined processes
 - Real-time communication of predictive analytics findings
- Productive Partnerships
- Environmental Concerns
- The Impact of Covid -19

2.9.2. Empowering Sustainable Growth

As we move into 2024, the automotive industry stands at a pivotal crossroads. Sustainability is no longer just an option; it is a necessity. Automotive manufacturers are realigning their strategies to focus on three key priorities: reducing carbon emissions, enabling AI-powered sustainability, and advancing sustainable innovation

- Reducing Carbon Emissions
- Enabling AI-Powered Sustainability
- Advancing Sustainable Innovation
- Intelligent Urban Exchange for Smart Enterprises

Maintaining a Sustainable Automotive Supply Chain

The automobile sector is in a precarious state. The company is under pressure to decrease its environmental effect and embrace sustainable practices, while simultaneously facing problems including the advent of electric cars, semiconductor chip scarcity, economic instability, and high capital expenses.

- Optimize Inventory using AI-Powered Forecasting Tools
- Improve visibility and risk management with AI and data analytics.
- Streamline tasks via robotic process automation (RPA)
- Foster Collaboration and Transparency

2.9.3. Workforce in Automotive industry

India's structural transformation directly from agriculture to the services sector without going through the intermediate step of agriculture to manufacturing to services has opened up policy challenges. While manufacturing can potentially create low-skilled labor-intensive jobs, it is the services sector that has proved to be the most dynamic. The debate between manufacturing and services has been going for long in India.

We illustrate here that both manufacturing and services are inter-dependent on each other. The auto sector, one of the largest sub-sectors in the manufacturing sector, is a case in point. The automobile industry has a significant presence in India with the sector making a major contribution to the manufacturing sector and the overall economy, in general.

India is the largest manufacturer of two-wheelers & three-wheelers and the fourth largest manufacturer of passenger vehicles in the world.

Apart from its direct contribution to the economy, the sector also contributes significantly to the economy through its linkages with other sectors, be it through use of inputs from other sectors (backward linkages) and supply of its output to other sectors (forward linkages). The Input-Output analysis best captures the overall contribution of a sector through economic activities within the sector and in other sectors through backward and forward linkages.

In this way, the sector contributes to the national GVO, which percolates into the creation of jobs. The total number of direct jobs created in the auto sector went up from 3.5 million to 4.2 million between 2015–16 and 2019–20. Out of that more than 60% of jobs are generated from vehicle ‘parc’ (registered vehicles within a defined geographic region). However, the total number of jobs (direct and indirect) created through activities in this sector went up from 24.3 million to 30.7 million

Positions	Required Skill Set
Entry Level	- Fundamental understanding of metal characteristics and processing methods. - Comprehension of logistics and supply chain principles - Proficiency with inventory management software and data entry - Fundamental analytical and problem-solving abilities
Mid-Level	- Deep knowledge of metal characteristics, production procedures, and quality assurance - Solid understanding of logistics management and supply chain optimization strategies. - Expertise with supply chain management software (SAP, Oracle, etc.). - Project management skills and experience with lean manufacturing practices - Ability to analyse data and generate actionable insights.
Senior-Level	- Organizing and carrying out supply chain projects strategically leadership. - Thorough understanding of legal requirements and international metal markets. - Proficiency with sustainability principles and supply chain risk management - Strong abilities in team management and leadership. - Advanced knowledge of data analytics technologies and analytical abilities.

2.10. E-commerce and Q-commerce

E-commerce, or electronic commerce, refers to the buying and selling of goods and services over the internet, involving a broad range of transactions from various sectors such as retail, wholesale, and consumer-to-consumer. Q-commerce, or quick commerce, is a subset of e-commerce characterized by the promise of rapid delivery, typically within an hour of placing an order.

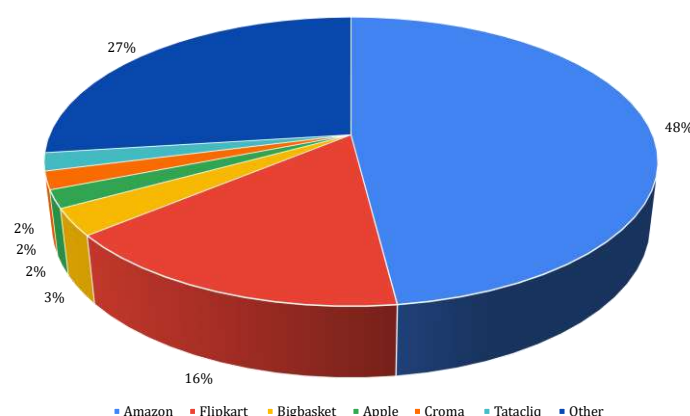


Figure 2.26: Key Players in E-commerce (%^{2.9}) Share

Key Modifications

Expectations of consumer have increased over a period of time evolving from e-commerce to q-commerce with key modifications in areas such as Delivery time, Product Selection, Operational Infrastructure and Consumer Expectations

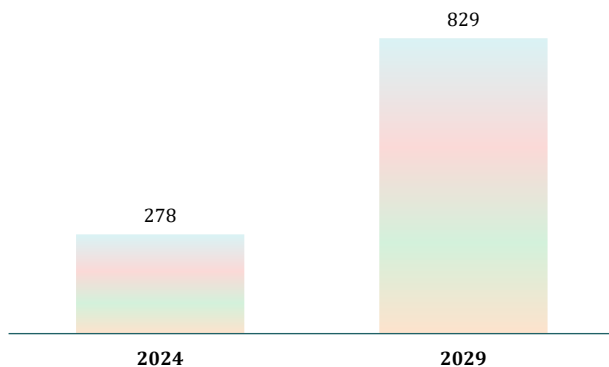


Figure 2.27: Q-Commerce Industry in India (in hundred crore^{2.10})



2.10.1 Logistics and Transportation in E-commerce

E-commerce has revolutionized modern supply chain dynamics by making goods movement faster, more efficient, and convenient for customers. This transformation demands logistics and transportation industries to adapt and keep pace. E-commerce businesses rely on efficient logistics for timely, cost-effective deliveries and inventory management to avoid stockouts or overstocks. Concurrently, logistics companies must embrace new technologies and optimize routes for same-day or next-day delivery, with a particular focus on overcoming the challenges of last-mile delivery.

Inventory Management in E-commerce Supply Chain

Effective inventory management is crucial for the e-commerce supply chain, ensuring products are available at the right place, time, and quantity. As e-commerce has transformed, the demand for efficient inventory management has surged. Accurate inventory management prevents stockouts, reducing lost sales and customer dissatisfaction, which are vital for maintaining customer loyalty and revenue. Proper inventory management minimizes carrying costs and enhances customer satisfaction, making it indispensable for e-commerce success.

3.10.2 Supply Chain Dynamics in Q-commerce

Grade A Warehousing: The Next Big Demand-Driver

Grade A warehousing is essential for Q-commerce due to its proximity to urban centers and transportation hubs, enabling rapid deliveries.

These warehouses support high order volumes with advanced technologies like WMS and automation, enhancing inventory visibility and operational efficiency. They offer scalable storage and flexibility for fluctuating inventory levels, crucial for handling order spikes. Additionally, robust security measures in Grade A warehouses protect high-value or time-sensitive products from theft, damage, and spoilage.

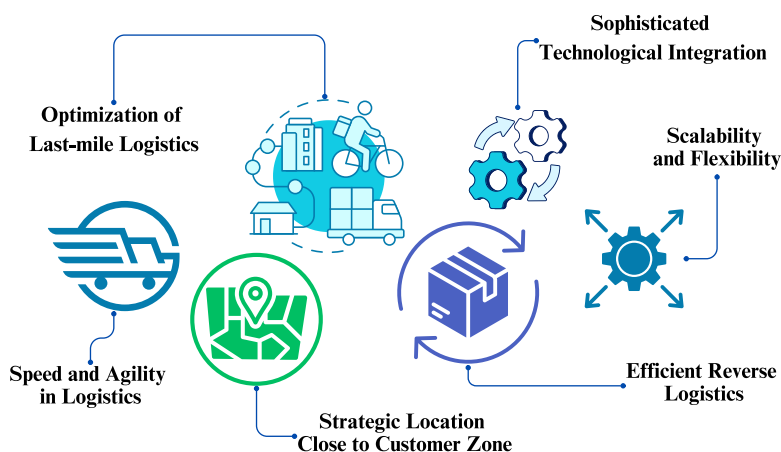


Figure 2.28 Key Features of Grade A Warehouse in Q-commerce

Infrastructure requirements for rapid delivery

Quick commerce (Q-commerce) requires a well-designed infrastructure to ensure rapid order processing and delivery. The essential elements include:

- **Order Management System (OMS):** A backend system for managing and processing consumer orders. It handles order routing, processing, tracking, and inventory management.
- **Throughput of Fulfillment Centers:** Fulfillment centers need to store, replenish, pick, pack, and dispatch orders efficiently.
- **Layout of Fulfillment Centers:** The design of dark stores, including the placement of storage racks, is crucial for minimizing time delays and ensuring efficient order processing.

- **Smart Racking Systems:** These systems should be designed based on SKU characteristics, storage density, and retrieval requirements to maximize space utilization.
- **Packaging and Last Mile Delivery:** Efficient packaging designs and the use of agile transportation methods like bicycles and electric scooters are critical for quick last-mile delivery.

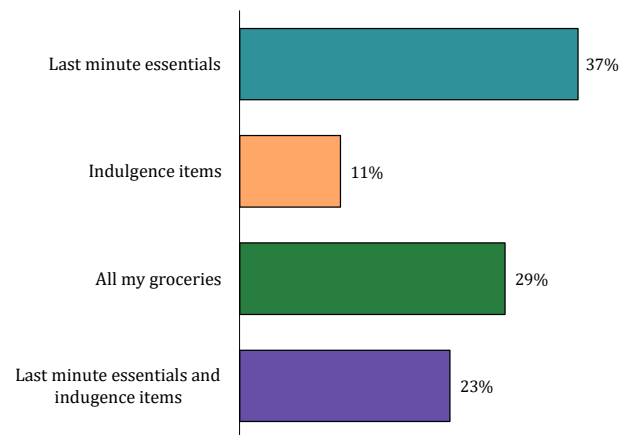
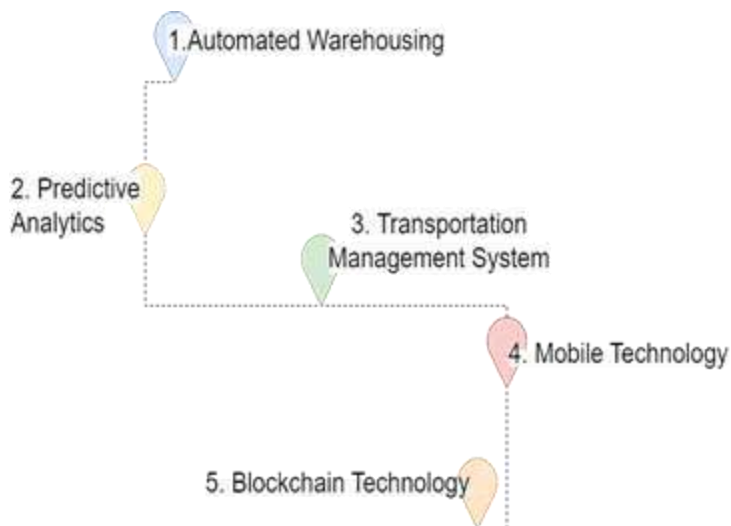


Figure 2.29 Grocery Products Purchased in India as of Feb 2022^{2.11}

2.10.3 Technological Innovations in E-commerce and Q-commerce

Technology has been pivotal in advancing e-commerce by enhancing logistics, transportation, and inventory management. Integrating technology into the e-commerce supply chain has streamlined processes, boosted efficiency, and reduced costs. Innovations such as warehouse management systems and automated picking and packing have transformed e-commerce operations. The influence of e-commerce on advanced tech-driven supply chain dynamics is profound, with technology driving this evolution. AI plays a crucial role in demand forecasting for e-commerce companies.



By leveraging the power of AI, companies can accurately predict customer demand, optimize inventory management, and enhance their overall operational efficiency.

Data Analysis: E-commerce companies collect and analyze vast amounts of data, including customer behavior, sales history, website traffic, and product attributes. By understanding historical sales data and external factors, AI can make more accurate predictions about future demand.

Just-in-Time Inventory: By analyzing demand patterns and supply chain data, AI algorithms can determine the optimal timing for inventory replenishment, ensuring that products arrive precisely when needed.

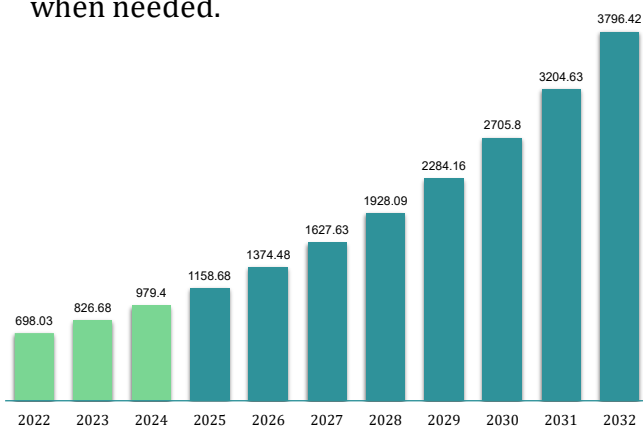


Figure 2.30 Artificial Intelligence in Retail Market Size (in INR thousand crore^{2.12})

Demand Sensing: E-commerce companies use AI to sense changes in customer demand in real time. AI algorithms analyze various sources of data, such as social media, search trends, customer reviews, and competitor activities, to detect shifts in customer preferences and market dynamics.

Dynamic Pricing: AI algorithms analyze market conditions, competitor pricing, and customer demand to recommend optimal prices in real-time.

Lead Time Optimization: AI helps optimize lead times enabling e-commerce companies to plan inventory replenishment based on reliable lead times, reducing the risk of stock outs or overstocking.

Open Network for Digital Commerce (ONDC): ONDC platform aims to create a unified digital commerce ecosystem in India. This will lead to increased digital adoption and a shift towards e-commerce, which will require workers to be tech-savvy and adaptable to new digital tools and platforms.

Robots-as-a-Service and Automation solution for Warehouse in Q-commerce

Warehouse operations can be optimized using a Warehouse Management System (WMS) with barcode readers, ERP, and data analysis tools to reduce time, manual effort, errors, and predict demand. Automation can be fully or partially implemented with Automated Storage and Retrieval Systems (AS/RS), Automated Guided Vehicles (AGVs), Autonomous Mobile Vehicles (AMVs), robotic shuttle systems, and automatic sorting and packaging solutions, enhancing capacity and speed. Additionally, Pick to Light and Put to Light systems are effective for medium-sized dark stores.

2.10.4 Sustainability Challenges and Return Management



The rapid growth of Q-commerce, driven by consumer demand for instant deliveries, presents several sustainability challenges. Key concerns include increased carbon emissions from frequent, small-scale deliveries and strain on delivery personnel.

Return Management

Returns management is a process in retail or e-commerce that works with customers who want to return a product after purchase. The returns management process involves interfacing with customers, collecting the returned items, and restocking them as inventory that has been returned..

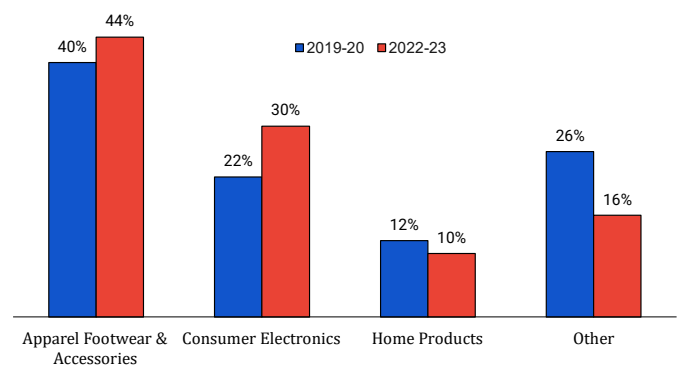


Figure 2.31: Different Products Share in Return Policy by Customers^{2.13}

Use Returns For Customer Retention

Returns impact customer experience and future purchases, influencing their lifetime value. The cost of a return is minor compared to losing a customer. If a product is returned due to size, the customer likely wants to exchange it.

Positions	Required Skill Set
Entry Level	• Basic understanding of e-commerce and q-commerce operations. • Familiarity with inventory management and order fulfillment processes. • Proficiency in using CRM and inventory management software. • Strong communication and customer service skills. • Fundamental data analysis and problem-solving abilities.
Mid-Level	• In-depth knowledge of logistics and supply chain management. • Experience with e-commerce platforms and technologies (Shopify, Magento, etc.). • Proficiency in data analytics and demand forecasting. • Strong project management skills and ability to optimize operational processes. • Experience in managing teams and collaborating across departments.
Senior-Level	• Strategic planning and execution of supply chain and logistics projects. • Comprehensive understanding of market trends and consumer behavior in e-commerce and q-commerce. • Expertise in sustainability practices and risk management. • Strong leadership and decision-making skills. • Ability to drive innovation and continuous improvement in operations.

2.11. Semiconductor Supply Chain

The semiconductor supply chain encompasses several pivotal phases, each with distinct specifications and contributions to the industry's innovation. At the forefront stands research and development an initial phase characterized by its reliance on both labor and capital-intensive endeavors. The Design step, which also necessitates a large human capital investment, comes next. Here, engineers and designers organize the transistors in the system. There are two substages within this stage: the development of blueprints and Electronic Design Automation (EDA), which employs specialized software copyrighted by three major US corporations. The design instructions are converted into actual silicon wafers filled with transistors during the third stage, manufacturing. The requirement for extremely precise and contaminant-free conditions makes this stage capital-intensive. The final stage is Outsourced Assembly, a labor-intensive process that has migrated to capitalize on lower labor costs.

Domestic demand for displays in India is growing at a CAGR of 13.3%. It is predicted that 365 million units would be needed by 2025. This increasing demand requires fab support in order to be met. Therefore, throughout the next ten years, two new fabs must be added every two years. It is crucial to remember that, even though displays are a component of the semiconductor ecosystem, some aspects of their fabrication demand special consideration beyond what is necessary for the semiconductor industry

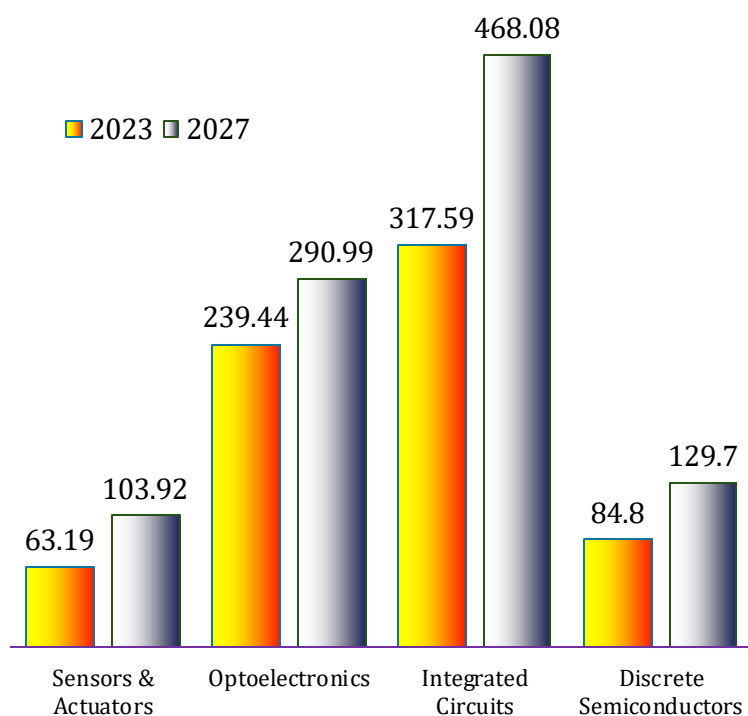


Figure 2.32: India's semiconductor market segmentation (in INR hundred crore)

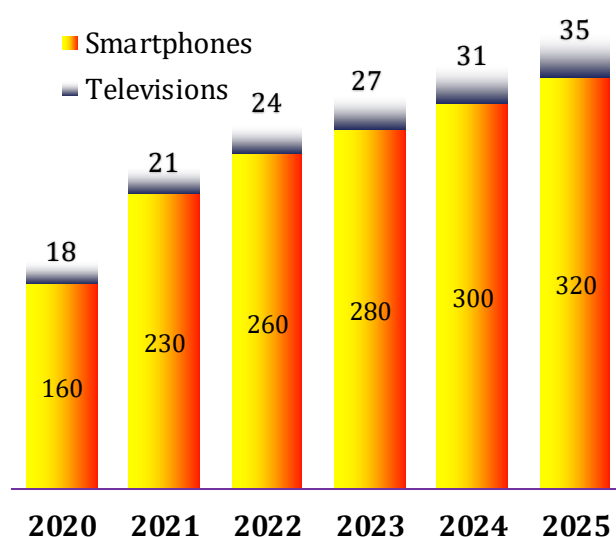


Figure 2.33: India's domestic demand for displays (in million units)

The semiconductor market in India has been divided into four main segments:

- Discrete Semiconductors:** The components that execute important electrical tasks such as signal modulation, switching, and amplification, such as transistors, diodes, and thyristors.
- Integrated Circuits (ICs)** are complicated constructions of interlinked electronic elements used in communication, computing, and various other fields. Some of these components include memory chips, microcontrollers, and microprocessors.

- **Optoelectronics:** Light-interacting electronic components, which consist of photodiodes, solar power cells, and LEDs, that have been utilized in solar power, shows, and applications involving lighting.
- **Sensors and actuators** are essential parts of automated processes, the Internet of Things, and smart devices. They refer to devices that sense physical changes (such as temperature, pressure, or motion) and translate them into electrical signals or actions based on electrical inputs.

2.11.1. Technology in Semiconductor Supply Chain

Collaborative Planning Using Cloud:

Objective: Enhance collaboration and coordination in the supply chain.

Benefits: By dynamically handling the supply network, volatility is reduced, customer happiness improves, and revenue is increased

The outcome: Quick time-to-market, better customer service, reduced levels of inventory, and actual time global visibility

Advanced Planning and Signal Tracking Using Predictive Analytics:

Objective: Handle fluctuations in demand throughout the multiple levels of semiconductor value chain.

Benefits: Gives insights into the plans for capacity for manufacturing, development of products, and innovation.

The outcome: More effective handling of supply-demand shocks and cooperating supply balance throughout marketplaces and goods

Robust Supplier Risk Management Using AI:

Objective: Enhance decision-making and visibility in the management of suppliers.

Benefits: Promoting active risk administration and capacity optimization

The outcome: Improved resilience and management of business cycles via multi-tier supplier sensing powered by intelligent machines.

Faster Time to Market Using Automation, IIoT, and Immersive Technologies:

Objective: Reduce semiconductor manufacturing cycle times.

Benefits include a significant reduction in time for shipping and better product delivery management.

The outcome: Improved competitiveness and reduced shipment delay losses.

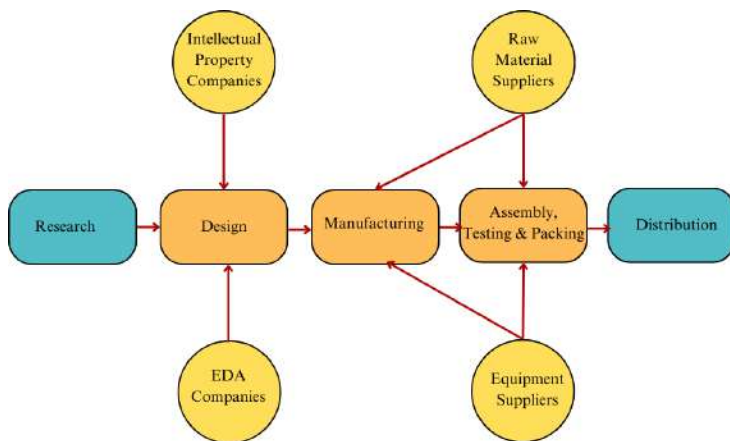
CHALLENGES IN SEMICONDUCTOR SUPPLY CHAIN

DIFFICULTIES WITH CUSTOMS CLEARANCE

- DOCUMENTATION AND COMPLIANCE
- PRE-ARRIVAL CLEARANCE
- BOTTLENECKS IN THE INFRASTRUCTURE

DOMESTIC MANUFACTURING CHALLENGES

- TECHNOLOGY TRANSFER AND EXPERTISE
- THE CAPITAL INTENSIVE NATURE
- SUPPLY OF RAW MATERIALS



Improved Supply Chain Visibility Using IoT, Mobility, and AI:

Objective: to improve supply chain management and logistics.

Benefits Improved control over interruptions quicker supply origin and crucial component identification.

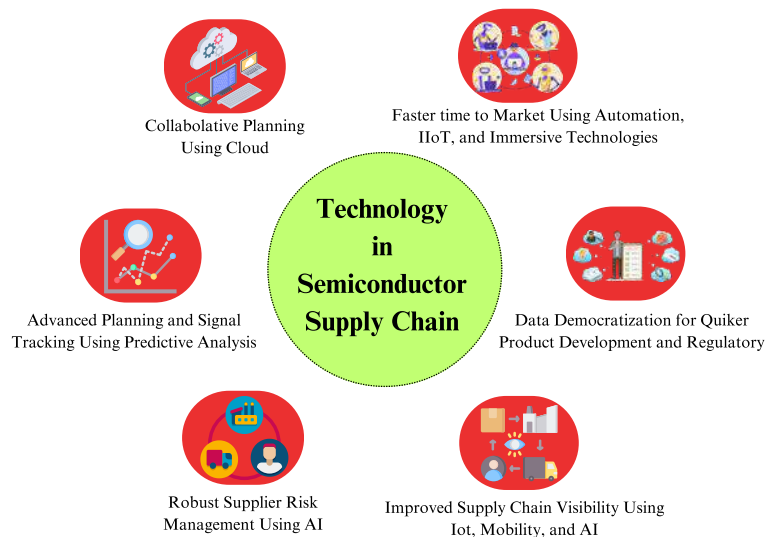
The outcome: More efficient part movement and an overall more efficient supply chain

Data Democratization for Quicker Product Development and Regulatory Compliance:

Objective: : Provide workers with thorough data so they may make better decisions.

Benefits: Utilizing the analysis of big data to boost production, yield, and quality

The outcome: Improved manufacturing and adherence to regulations



Positions	Required Skill Set
Entry Level (Technician/Operator, Junior Process Technician, Production Assistant)	• Tool operation, standard process execution • Data collection, basic analysis, engineering support • MES systems, real-time troubleshooting, • data security Equipment maintenance and support
Mid-Level (Shift Supervisor, Production Team Lead, Maintenance Supervisor)	• Managing shift output and operators • Troubleshooting, SPC review • Equipment troubleshooting, maintenance
Senior-Level (Operations Manager, Process Engineering Manager, Senior Reliability Engineer)	• Capacity planning, cycle time management • Balancing line load, output management • Demand-based planning, cycle time management • Device physics, modelling, integration • Reliability physics, quality assurance • Tool operation (TEM, SEM), analysis, unit process understanding

2.12. Cold Supply Chain

The 2024 Cold Chain news illustrates a promising outlook for international trade, driven by recent upgrades to enhance opportunities among participating nations. Cold chains not only significantly contribute to the opportunities for trade but also dominate the investment processes and the policy-making activities on the global level for the further development of worldwide trends.

The difference between cold storage and the cold supply chain lies in their dynamics, but they collaborate in an overall understanding, as shown in the cold chain Diagram. The standard temperatures identified in the US are also presented, supported by their storage temperature to avoid perishability.

2.12.1 Refrigerated Warehouse and Cold Storage Market

These markets contribute to over \$800 billion in total U.S. goods and services exports, supporting the bottom lines of U.S. companies and increasing the demand for the domestic workforce.

Cold chains primarily support distribution services in the retail and franchise sectors, offering opportunities for small and medium-sized farmers and businesses to enter international supply chains. These chains also enhance consumer access to fresher, safer products, raising the quality of life while driving retail and franchise sales growth.

However, barriers to cold chain growth persist, including government protectionist measures, non-tariff barriers, and customs delays, hindering efficient distribution services and international trade. The International Trade Administration is actively engaged in reducing these barriers through policy development, trade negotiations, and industry advisory committees to promote fair competition and facilitate global trade.

2.12.2 Storage and Distribution growth

Cold storage and the cold supply chain play a crucial role in ensuring the availability of fresh and safe food products throughout the year.

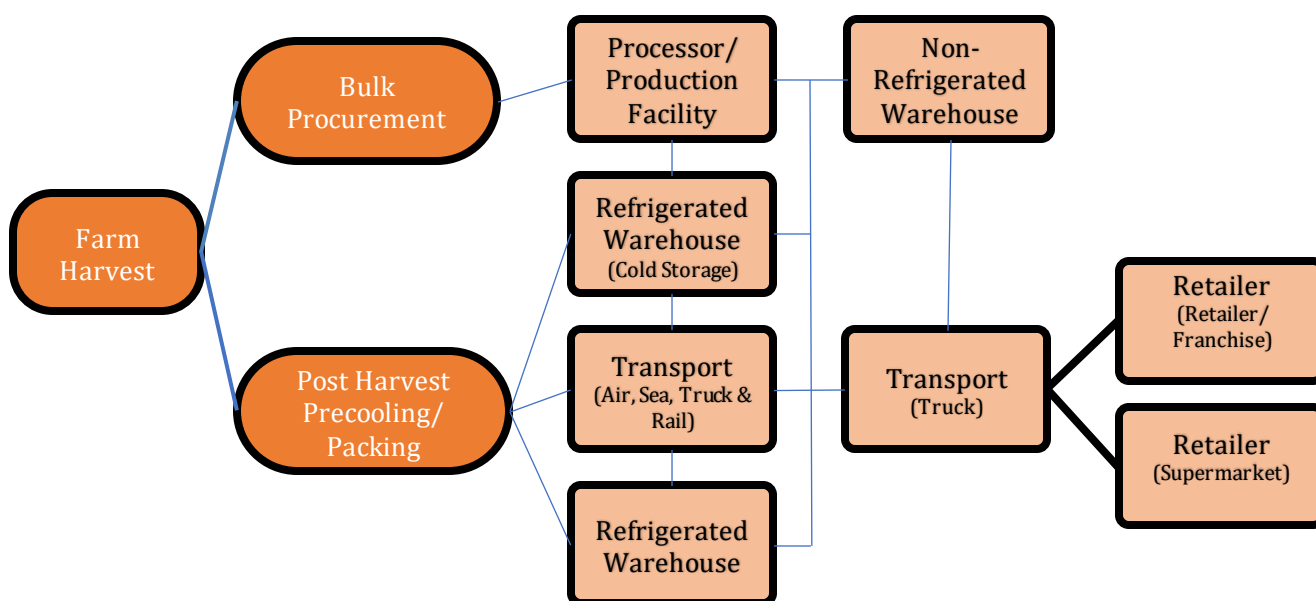


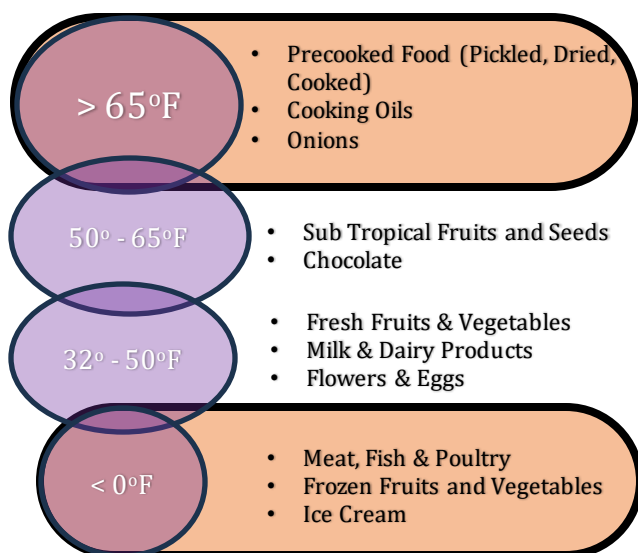
Figure 2.34: Cold Chain Diagram (Perishable Storage and Distribution)

With the U.S. being one of the top GDP contributors globally, the cold chain infrastructure is highly advanced, comprising a vast network of refrigerated warehouses, temperature-controlled transportation, and distribution centers.

This infrastructure supports various industries, including agriculture, pharmaceuticals, and biotechnology, by maintaining optimal storage conditions for perishable goods.

2.12.3 Temperature Regulations

International standards dictate specific temperature requirements for storing various perishable items.



For example, fresh produce such as fruits and vegetables typically require temperatures between 32 to 50°F. At the same time, frozen products like meat and seafood need to be kept at temperatures below -27°F, to maintain their quality and safety. Pharmaceuticals and vaccines often require even stricter temperature control, with storage temperatures ranging from -12°F to -13°C (-2°C to 8°C) for most vaccines.

2.12.4 Cold Storage Infrastructure

When comparing cold storage capacity to population size, developed nations like the United States have significantly higher cold storage capacities per capita than developing countries.

This surplus capacity allows for better preservation of perishable goods and reduces food wastage. Moreover, the cold supply chain infrastructure in developed nations is more robust, with advanced technologies and stringent quality control measures ensuring the safety and integrity of temperature-sensitive products throughout the distribution process.

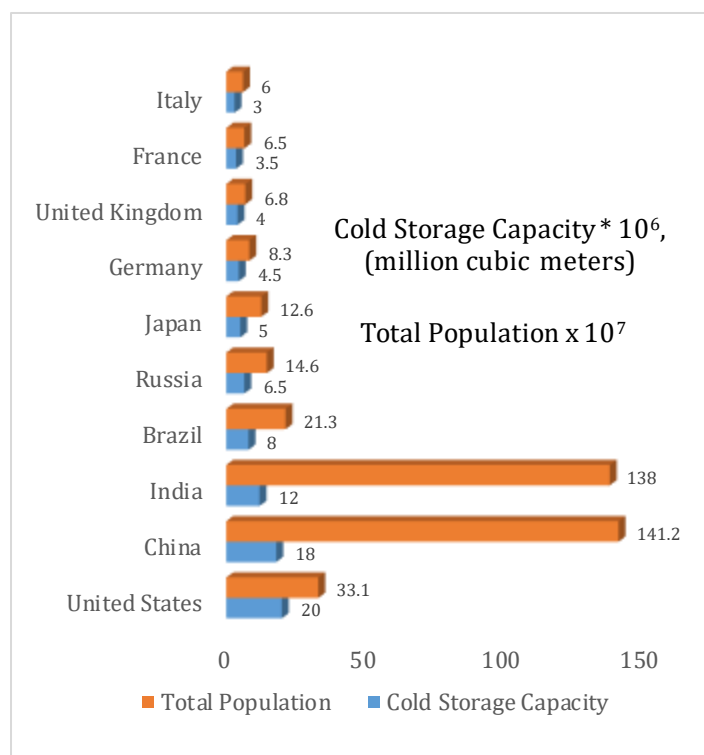


Figure 2.35: Cold Storage versus Total Population

2.13. Unorganized Sector

As of 2024, a significant portion of India's working population is engaged in the unorganized sector. According to the latest data, approximately 29.68 crore workers are registered in the eShram database, representing a substantial segment of the labor force. The number still remains less than actual values but this comprises an estimate of about 90% of the total workforce in India. Workers belonging to this sector have less job security, poorer chances for growth, vulnerable to diseases and no leave or paid holidays.

Health Hazard in Unorganized Sector

The unorganized sector in India faces significant health hazards and occupational safety challenges due to various factors inherent to its nature (see figure 2.36).

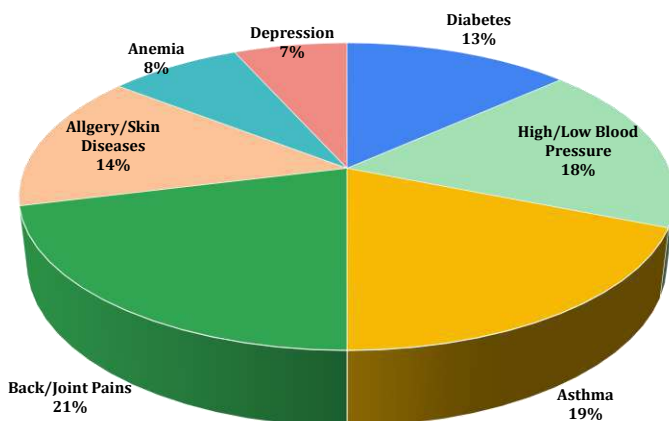


Figure 2.36: Health Hazard in Unorganized Sector

2.13.1. Logistics in Unorganized Sector

The unorganized sector in India comprises a significant portion of the workforce, contributing substantially to the economy but often lacking formal structures and efficient logistics systems. Improving logistics in this sector can enhance productivity, reduce costs, and improve working conditions.



This framework outlines a strategic approach to integrate logistics in the unorganized sector, considering the unique challenges and opportunities.

Supply Chain Integration

Identify key stakeholders, processes, and flow of goods and services. Establish cooperative networks among small-scale producers, suppliers, and distributors. Develop and promote digital platforms for better communication and coordination.

Infrastructure Development

Improve road connectivity and access to transportation services. Establish small, decentralized warehousing facilities to reduce storage costs and improve inventory management. Implement technologies such as GPS, RFID, and IoT for tracking and managing goods.

Skill Development

Design and implement training programs in logistics, supply chain management, and technology. Collaborate with educational institutions to offer certification courses for workers in the unorganized sector. Conduct awareness campaigns to highlight the importance of logistics and supply chain efficiency.

^{3.10} Source: <https://pib.gov.in/PressReleaseframePage.aspx?PRID=1942079>

^{3.11} Source: Rameshkumar, N. (2023). STUDY ON PROBLEMS AND PROSPECTS OF UNORGANIZED SECTOR WORKERS IN COIMBATORE DISTRICT. International Journal of Research and Analytical Reviews, 10(1), 474-480.

Health and Safety

Develop and enforce health and safety standards specific to the unorganized sector. Provide access to affordable protective equipment and safety gear. Organize regular health camps and check-ups for workers.

Policy Advocacy

Advocate for the simplification of regulations to ease the entry and operation of logistics providers in the unorganized sector. Lobby for incentives such as tax benefits and subsidies for logistics improvements. Promote public-private partnerships to leverage resources and expertise in logistics development.

2.13.2. Monitoring and Evaluation

Define key performance indicators (KPIs) to monitor progress, such as delivery times, cost reduction, and worker safety improvements. Conduct regular audits and assessments to ensure compliance with standards and identify areas for improvement. Establish feedback mechanisms for workers and stakeholders to provide input and suggestions.

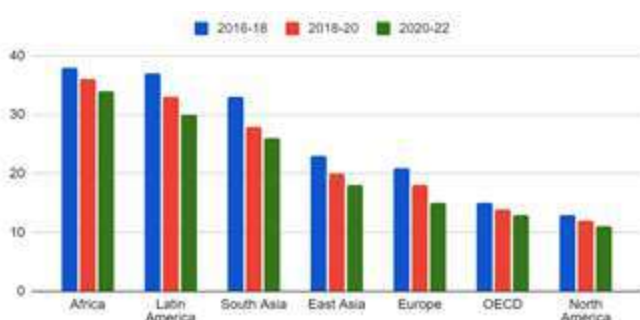


Figure. 2.37: Average informal Economy Contribution in GDP (%)

2.13.3. Formalizing the Unorganized Sector



Informality encompasses the market-based and legal production of goods and services that remains concealed from public authorities due to monetary, regulatory, institutional factors or sanitation. Monetary reasons include the avoidance of taxes and social security contributions, regulatory reasons include the avoidance of government bureaucracy or regulatory burdens, and institutional reasons include corruption, related often to the poor quality of political institutions and weak rule of law.

Unorganized Sector in India with High potential

Several key unorganized sectors in India's economy have significant potential to transition into the organized sector with appropriate interventions and support. These include:

- Retail
- Construction
- Wage Workers
- Food Processing
- Tourism and Roadside Dhabas

By improving regulations, enhancing infrastructure, providing access to finance and technology, and encouraging standardization these sectors can become more organized contributing effectively to India's economic growth.

2.13.4. Enhancing the Skillset to Upgrade Unorganized Sector

Training Programs

Integrating vocational training courses with advanced technologies can significantly enhance the skills of employees in the informal sector.

- **Introduction to Digital Logistics:** Basics of logistics, introduction to digital tools used in logistics (e.g., mobile apps, GPS), Digital Inventory Management: Principles of inventory management, using digital tools like Excel, Google Sheets, RFID, inventory scanning, and specialized inventory software.
- **Digital Navigation and Route Planning:** Basics of GPS technology, using GPS for route planning and optimization, AR navigation tools, VR training modules.
- **E-commerce and Logistics Integration:** Basics of e-commerce, picking-packing, integration of logistics with e-commerce platforms, handling digital orders and returns.
- **Q-commerce Operations:** Picking operations, dark store management, material handling.
- **Eco-Driving and Fuel Efficiency:** Techniques for fuel-efficient driving, vehicle maintenance, and performance monitoring.
- **Basic Driving Skills and Road Safety:** Fundamental driving skills, road signs, traffic rules, and basic vehicle maintenance; AR/VR integration.
- **Advanced Driving Techniques:** Defensive driving, night driving, driving in adverse weather conditions, and advanced maneuvering.
- **Behavioural Skills of Vehicle Drivers:** Customer service, stress management, communication skills.
- **Basic Drone Maintenance:** Drone Flight Mechanics and Controls, Safety and Regulatory Compliance.
- **Cold Storage Operations:** Temperature control and Monitoring, Inventory Management in Cold Storage, Safety and Hygiene Standards, Equipment Maintenance and Operation.
- **Bulk Material Handling:** Loading and Unloading Procedures, Equipment Used in Bulk Material Handling.
- **Basic Port Terminology and Safety:** Port Operations and Logistics, Port Safety Protocols, Port Security Measures.
- **Cargo Handling:** Types of Cargo and Handling Techniques, Loading and Unloading Procedures, Use of Cargo Handling Equipment, Safety Measures in Cargo Handling.
- **Health & Safety in Ship Operations:** Safety protocols, emergency procedures.
- **Shipbuilding and Ship Repair:** Construction techniques, repair procedures.
- **Technical Ship Management:** Maintenance, compliance.



2.14. Supply Chain for National Importance

Supply chains are of national importance as they contribute to the safety, security, and well-being of the population. They play a vital role in responding to emergencies, upholding democratic principles, ensuring energy security, and protecting public health. Improving the efficiency, resilience, and transparency of these supply chains is essential for enhancing national preparedness and resilience in the face of various challenges and threats. Each of the mentioned supply chains plays a crucial role in national security, safety, and public welfare.

- Electoral Ballot Supply Chain
- Election Duty for Paramilitary Supply Chain
- Emergency Utilities Supply Chain
- Nuclear Power Plant Supply Chain
- Improving Vaccine Healthcare Supply Chain
- Humanitarian Supply Chain

2.14.1. Supply Chain for the Energy Sector

The supply chain for the energy sector encompasses the complex network of activities involved in sourcing, producing, transporting, and distributing energy resources such as oil, natural gas, coal, renewable energy sources (solar, wind, hydro), and electricity. Nuclear power plants play a significant role in diversifying energy sources and reducing dependence on fossil fuels. The procurement of uranium ensures a reliable and continuous supply of fuel for these plants, contributing to long-term energy security.

By reducing reliance on finite fossil fuel reserves, nuclear power helps mitigate the risk of energy shortages and price volatility. The Energy Sector covering the following technology sectors:

- Nuclear energy
- Hydropower including pumped storage hydropower (PSH)
- Energy storage
- Fuel cells and electrolyzers
- Semiconductors
- Carbon capture materials
- Neodymium magnets
- Electric grid including transformers and high voltage direct current (HVDC)
- Platinum group metals and other catalysts,
- Solar photovoltaics (PV)

Manpower plays a crucial role in the Energy Sector Supply Chain by providing the talent needed for various operations, from upstream discovery to production and distribution. Manpower offers staffing solutions for a wide range of roles, including Operations & Logistics Technicians, Solar Electrical Engineers, and Installation Technicians. The energy sector's supply chain involves a significant workforce across various sectors.

2.14.2. Nuclear Power Plant Supply Chain

The nuclear power plant supply chain is a complex network of roles and responsibilities that ensure the safe and reliable operation of nuclear facilities. Key roles in the supply chain include:

- Suppliers and Regulators
- Quality Assurance and Quality Control Professionals
- Nuclear Engineers and Technicians
- Health and Safety Professionals
- Supply Chain Managers
- Procurement Specialists
- Waste Management Specialists
- Research and Development Professionals
- Training and Education Professionals

The comprehensive workforce engaged in supporting a 100 GWe nuclear fleet includes 50,000 individuals dedicated to operations and maintenance, 274,000 professionals involved in the ongoing supply chain, and an additional 20,000 workers focused on construction activities, culminating in a total of 344,000 personnel.

The majority of supply chain employees are employed in fuel services, reflecting the self-sufficiency of the nuclear sector in fuel processing and reprocessing.

2.14.3. Electoral Ballot Supply Chain

The electoral ballot supply chain in India involves intricate logistics to ensure the smooth conduct of elections. The technology involved in the electoral ballot supply chain in India includes:

- Electronic Voting Machines (EVMs)
- Voter Verifiable Paper Audit Trail (VVPAT) Machines
- Digital Technology and Social Media
- Digital Library
- Braille Enabled EVMs
- Results Website and Results Trends TV
- GPS Tracking and Monitoring Systems
- Web Radio and Web TV
- Online Modules for Electoral Literacy Clubs in Schools
- Cybersecurity Measures

2.14.4. Space Industry Supply Chain

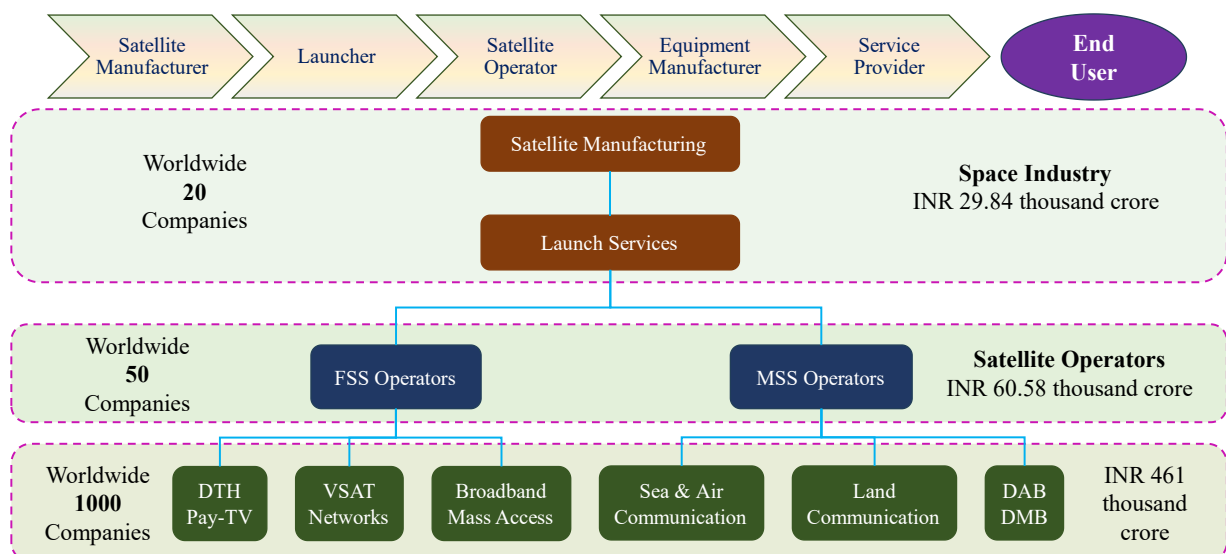
The space industry supply chain (SISC) is transforming significantly, driven by a shift towards more standardized and cost-effective solutions.

Today's space supply chain includes satellite manufacturers, instrument specialists, and rocket companies, moving from bespoke to more plug-and-play approaches.

Companies are adapting their operations to meet the increasing demand from both government and private sectors by offering more generic products like standardized satellite bodies that can accommodate various instruments. Additionally, companies are forming partnerships to build satellite constellations, enabling space industrialization, and focusing on the mass production of smaller satellites

The space industry is experiencing a shift towards industrialization, where the production of satellites has become more efficient and cost-effective. This evolution is triggered by advancements in satellite technology, making it more affordable to build and launch satellites. As the industry diversifies, new entrants challenge traditional aerospace contractors, fostering competition and innovation. Companies like Rocket Lab are expanding their services beyond rocket launches to encompass a wide range of space-related needs, contributing to a more dynamic and competitive space industry supply chain.

Fig. 2.38: Technology involved in Space Industry Supply Chain



Space Industry Supply Chain encompasses a wide range of innovations and advancements in various fields, including logistics, manufacturing, and materials science. Some key technologies that are transforming the space industry supply chain are

- Re-usable Launch Technology
- Additive Manufacturing
- Digital Engineering
- Location-Based Supply Chain Mapping
- Standardization and Modularization
- SmallSat Technology
- Industrialization of Space
- Partnerships and Collaborations
- Supply Chain Management Software

Positions	Required Skill Set
Entry Level	• Supply Chain Management Fundamentals: Understanding of SCM principles, including planning, sourcing, production planning, inventory management, logistics, and distribution. • Basic Technical Skills: Familiarity with space-related technologies, such as spacecraft operations, electronics design, and materials selection. • Soft Skills: Creativity and innovation, resilience and adaptability to uncertainty, effective communication, collaboration and teamwork, adaptability, and flexibility, and creative problem-solving. • Specialized Technical Skills: Knowledge of software and data analytics, AI and machine learning, systems engineering, spacecraft operations, and telecommunications. • Supply Chain Analytics: Ability to analyze and interpret data to optimize supply chain operations, including demand forecasting, inventory management, and logistics optimization
Mid-Level	• Leadership and Strategic Thinking: Ability to develop and implement strategic plans, lead cross-functional teams, and make data-driven decisions. • Complex Problem-Solving: Capability to tackle complex, unprecedented challenges in the space industry, including risk assessment and mitigation. • Specialized Domain Expertise: In-depth knowledge of specific areas, such as space logistics, interplanetary supply chain management, and space technology development
Senior-Level	• Visionary Leadership: Ability to drive innovation, set strategic direction, and make high-level decisions that impact the organization and the industry. • Industry Insights: Deep understanding of the space industry, including market trends, regulatory environments, and emerging technologies. • Change Management: Capability to lead organizational change, drive cultural transformation, and manage complex stakeholder relationships. • Interdisciplinary Collaboration: Ability to work across disciplines, collaborate with experts from various fields, and develop innovative solutions



3

Next-generation Technologies for Efficient Logistics Operations

3. Next-generation Technologies for Efficient Logistics Operations

The National Logistics Policy 2022 marks a pivotal moment for India's logistics sector, transitioning from fragmentation to unity and growth. Emphasizing human resource development, the policy aims to address skill shortages through expanded education and targeted training, aligning with cutting-edge technological advancements. By prioritizing workforce development and technological innovation, the policy aims to overcome traditional challenges and create a more sustainable logistics environment, contributing to India's economic growth. Additionally, the sector must improve training programs, working conditions, and wages to attract skilled workers and ensure a competent workforce for the future. The convergence of growth, technology, and skill development in India's logistics landscape, highlights the integration of advanced technologies and the importance of a well-trained workforce for efficient operations.

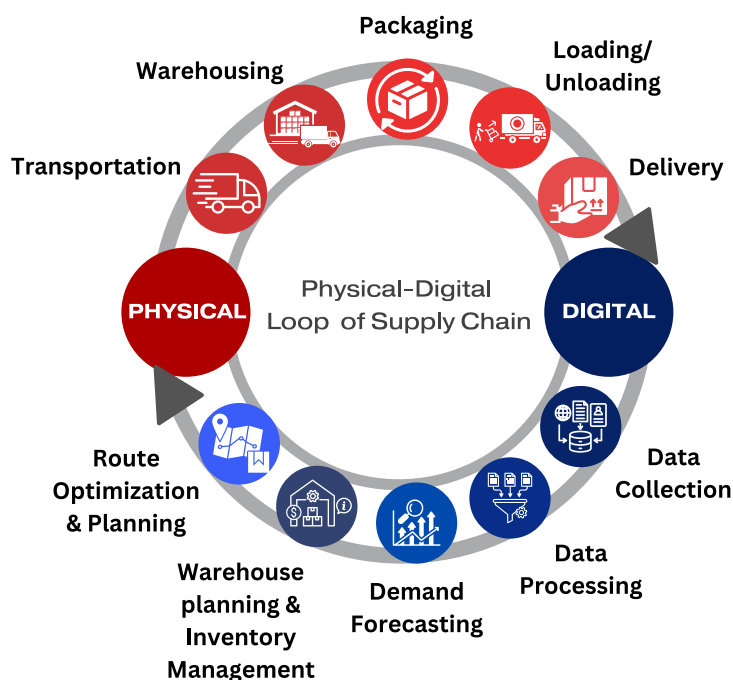


Figure 3.1: Visualizing the Symbiosis of Physical-Digital Loop Merge to Enhance Supply Chain Dynamics

Emerging technologies are changing the Indian logistics functions like warehousing, packaging, loading/unloading, delivery, route optimization and planning, data collection, warehouse planning and inventory management, data processing, and demand forecasting.

Storage and retrieval systems (AS/RS) and warehouse management systems (WMS) improve inventory management and warehouse efficiency. Automation and smart packaging with RFID and QR codes improve tracking. Robotic arms and conveyors make loading and unloading safer and faster. Advanced algorithms optimize and design routes, lowering transportation costs and accelerating deliveries. In last-mile deliveries, drones and driverless vehicles are altering the game. IoT and data analytics transform data collection and processing, improve warehouse planning and inventory management. AI and machine learning make demand forecasting efficient, thereby helping logistics companies follow market trends.

Artificial Intelligence (AI), Generative AI, and the Internet of Things (IoT) allow for sophisticated data analysis, automation, and real-time tracking, resulting in more efficient supply chain operations. Augmented Reality (AR) and Autonomous Vehicles help to increase training and transportation efficiency, and Cloud Computing enables safe data storage and collaboration. 3D printing enables on-demand production, lowering inventory requirements, while blockchain assures supply chain transparency and security.

Visualizing the symbiosis and integration of the physical-digital loop is crucial for enhancing supply chain dynamics across sub-sectors (see Figure 3.1).

^{3.1} Source: <https://www.statista.com/statistics/1288177/india-size-of-logistics-market/>

^{3.2} Source: <https://economictimes.indiatimes.com>

^{3.3} Source: <https://www.gartner.com/en/newsroom/press-releases/2020-02-26-gartner-survey-shows-70--of-supply-chain-leaders-plan>

The following emerging technologies are instrumental in boosting the productivity of logistics and supply chain operations:

- **Artificial Intelligence (AI) and Machine Learning (ML):** Empowers predictive analytics, demand forecasting, optimization, and automation in logistics operations.
- **Generative AI:** Delivers proactive customer service, streamlines documentation, and generates valuable insights within the logistics industry.
- **Big Data Analytics:** Enables analysis of large volumes of data to optimize logistics processes.
- **Cloud Computing:** Offers scalable and flexible logistics solutions, allowing easy access to data.
- **Blockchain Technology:** Ensures data security & enhances supply chain transparency and traceability.
- **Internet of Things (IoT):** Sensors, Quick Response (QR) codes, Radio Frequency Identification (RFID) provide real-time tracking, monitoring, and data collection in warehouses and during transportation.
- **Digital Twin:** Allows for virtual modelling and simulation of logistics processes, enabling effective predictive maintenance and operational optimization.
- **Augmented Reality (AR) and Virtual Reality (VR):** Useful in warehouse operations, training, and remote collaboration in logistics.
- **Control Tower:** Provides centralized monitoring and coordination for logistics operations, improving visibility and decision-making.
- **Robotics and Automation:** Automates warehouse operations and enhances transportation and inventory management efficiency.
- **Autonomous Vehicles and Drones:** Revolutionizes transportation and delivery through automated and efficient logistics solutions, driving superior performance.
- **Advanced Manufacturing:** Enables on-demand production and customization with advanced materials and manufacturing.

In subsequent subsections, each of these technologies and their applications in the Logistics sector are discussed.

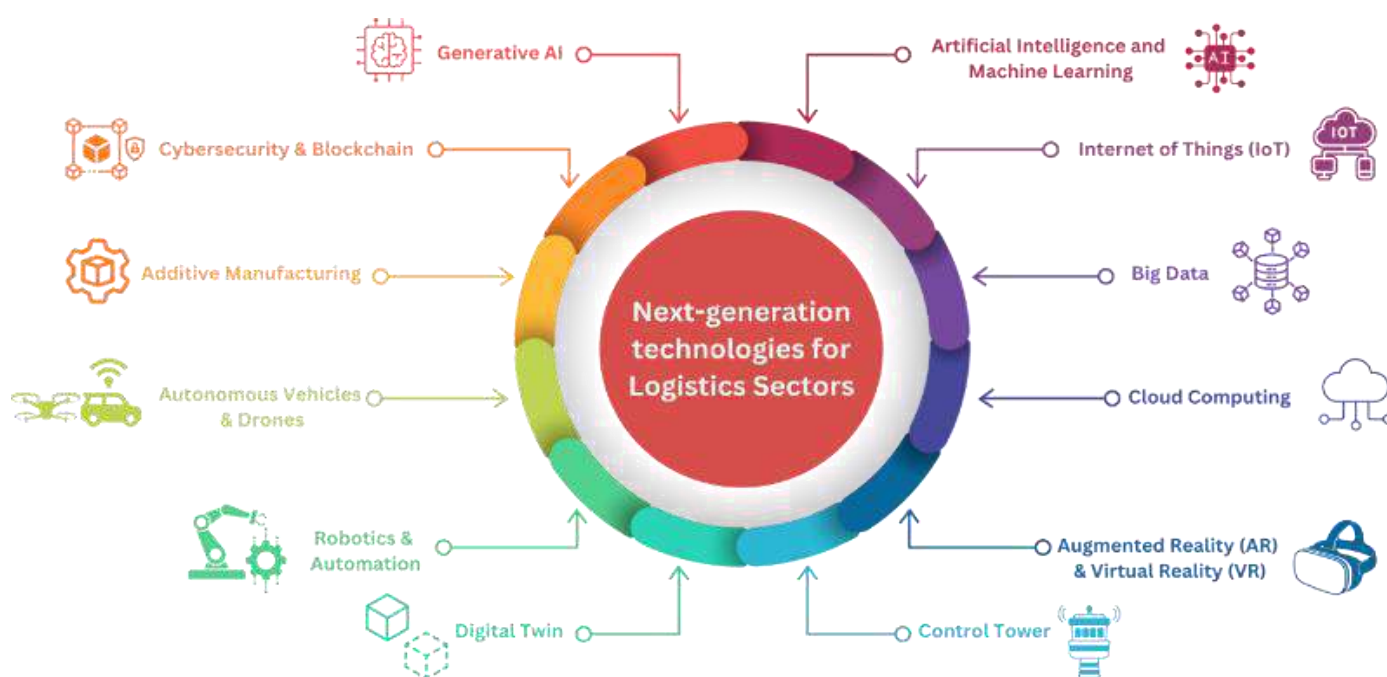


Figure 3.2: Emerging Technologies for Enhancing Productivity in the Indian Logistics Sector

3.1 Artificial Intelligence (AI) & Machine Learning (ML)

Artificial Intelligence (AI) and Machine Learning (ML) offer transformative potential for logistics, automating tasks and enhancing efficiency. AI-ML is reducing manual labour in logistics by automating repetitive operations such as report preparation, invoice creation, and transportation scheduling. This could free up to 80% of the staff, allowing them to focus on more strategic responsibilities. High-performing organizations are clearly adopting AI-ML systems for operational tasks more frequently than low-performing ones (See Figure 3.3).

In warehouses, AI-powered automation accelerates operations like picking and shipping, while in transportation management, especially in last-mile delivery, they optimize routes by lowering fuel costs and delivery times. These technologies also enhance inventory management, by reducing stockouts and overstocking. AI systems excel at analyzing data trends and identifying anomalies, enabling businesses to take swift action and prevent financial losses (See Figure 3.4).

AI-ML Systems adoption in supply chain organizations



Figure 3.3: Differential Adoption of AI-ML Systems in Operations Among the High- vs. Low-Performing Organizations

Prominent Indian logistics firms in the e-commerce industry are incorporating AI-ML into last-mile delivery operations to address the surging demands. Leveraging key data analytics from AI systems, they optimize delivery routes and times, minimizing costs and failures. AI-driven chatbots enhance customer service efficiency by handling inquiries. Furthermore, factories are integrating computer vision techniques into assembly lines to automate sorting, enhancing speed and precision, and enabling swift and reliable package processing.



Figure 3.4: Benefits of Implementing AI-ML Systems in Managing Logistics Operations



Figure 3.5: Emerging Jobs and Skillsets for the Future Workforce for an AI-ML-driven Logistics Industry

A major concern remains the labor skills gap for efficiently applying these systems. AI and ML necessitate a workforce proficient in data science and related subjects, but many logistics employees lack this expertise. This underscores the need for specialized training programs to cultivate these essential skills (see Figure 3.5). Consequently, as the demand for evolving jobs rises, corresponding skillsets become imperative for the future workforce in the logistics sector to effectively utilize AI-ML technologies.

3.2 Generative AI

Generative Artificial Intelligence (GenAI) is rapidly advancing and captivating the imagination of supply chain professionals, heralding a paradigm shift in logistics and supply chain management. Approximately 40% of supply chain organizations have already invested in GenAI (see Figure 3.6). There is immense potential for businesses to employ GenAI solutions using large language models (LLMs) in supply chain management.

This technology, epitomized by ChatGPT, Gemini, and Claude, empowers organizations to forecast demand through vast data, automate decision-making processes, derive actionable insights, and streamline communication in real-time. Integrating novel architectures and methodologies such as Transformers, Knowledge Graphs, Federated Learning, and Explainable AI within LSCM bolsters the industry tool's intelligence and adaptability. Its application across various domains like customer support, demand forecasting, vendor negotiations, production planning, logistics, inventory management, and last-mile delivery enhances its operations with greater accuracy, speed, and agility (see Figure 3.7). One of the fundamental capabilities of GenAI lies in its use of AI-driven "agents" to perform tasks. These agents, namely atomic and composite agents, excel at handling data analysis, report writing, and other tasks quickly and efficiently. Atomic agents focus on specific tasks, such as data retrieval, while composite agents integrate these tasks to achieve more complex goals, like analyzing forecast changes or running supply chain simulations.



Figure 3.6: Current Status of Gen AI Adoption

In India, NITI Aayog is at the forefront of integrating generative AI into various sectors, driving innovation and addressing key socio-economic challenges. By leveraging generative AI, NITI Aayog aims to revolutionize agriculture through predictive crop models, enhance healthcare with advanced medical imaging analysis, and personalize education

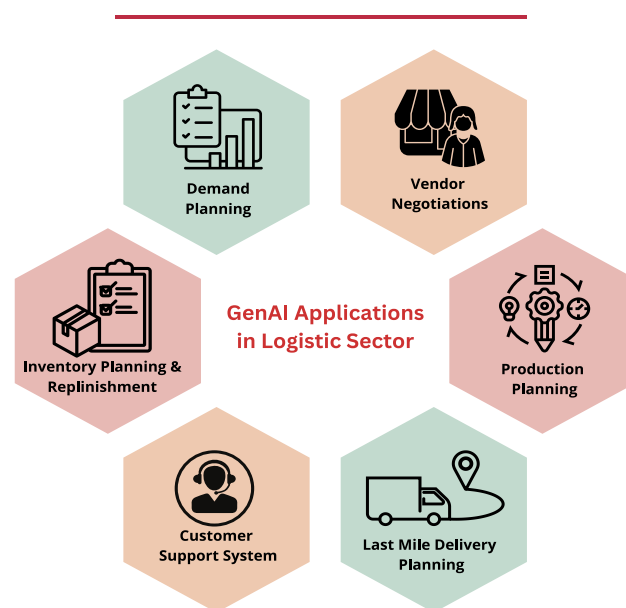


Figure 3.7: Application of Generative AI in Supply Chain

with tailored learning resources. Moreover, NITI Aayog is leveraging generative AI for predictive maintenance of transportation assets such as vehicles and machinery. By analyzing sensor data and maintenance records, AI models can predict potential equipment failures before they occur, enabling proactive maintenance and minimizing downtime. Additionally, generative AI is being utilized for urban planning, language processing, environmental conservation, disaster management, and economic forecasting.

While GenAI offers significant opportunities for productivity gains and digitizing tribal knowledge, there are also certain risks that needs to be addressed. These include the probabilistic nature of LLMs leading to potential inaccuracies, biases inherited from training data, and concerns around data privacy and leakage. Implementing guardrails, managing knowledge hierarchies, and ensuring data privacy are crucial to mitigating these risks. By diligently implementing robust guardrails, fostering transparent knowledge hierarchies, and prioritizing stringent data privacy measures, organizations can effectively navigate the complexities of GenAI.

3.3 Big Data Analytics

In today's rapidly evolving logistics and supply chain landscape, integrating big data analytics has become a pivotal for improving logistics efficiency. Businesses can make informed decisions and drive innovation by harnessing massive amounts of data (see Figure 3.8) This approach innovatively broadens the scope of analysis beyond conventional internal data housed in Enterprise Resource Planning (ERP) and supply chain management (SCM) systems. Using advanced statistical methods on diverse data sources, it unveils new insights that improve decision-making, from day-to-day operations to choosing the best supply chain model.

Big data shapes demand and supply in planning, improves sourcing with real-time risk management, and informs strategic decisions. It optimizes manufacturing processes and identifies waste in warehousing while enhancing transportation efficiency. Retailers utilize it for shelf-space optimization and out-of-stock prevention.

According to a survey conducted by Deloitte, a staggering 76% of organizations view the development of big data analytics capabilities as crucial for their supply chain strategies. Despite this recognition, only 44% invest a minimum of \$5 million annually in these capabilities. Cost reduction is the primary driver behind big data analytics investment for 81% of respondents.

Big Data Analytics benefiting Logistic Businesses

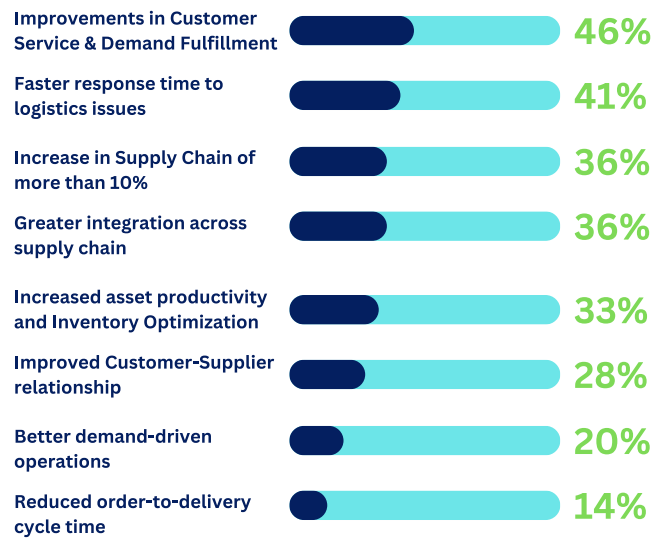


Figure 3.8: Empowering Businesses with the Benefits of Big Data Analytics

It is pertinent to note that usage of big data analytics in supply chain must be exercised with compliance to data privacy and security regulations. Additionally, biases in data procurement and analysis need to be addressed to prevent skewed insights and unfair decision-making. When implementing big data analytics in the supply chain, it's crucial to train employees not only on security concerns but also on technical aspects to ensure responsible data usage and effective utilization of tools.

Big data analytics offers immense potential for optimizing supply chain operations, careful attention to privacy, bias, data quality, and ethics are crucial to mitigate risks and ensure responsible and effective implementation (see Figure 3.9).

Figure 3.9: Big Data Applications for enhancing the performance of Supply Chain

Big Data Analytics for Supply Chain					
Sales, Inventory Planning	Sourcing	Production	Warehousing	Transportation	Consumer
- Supplier risk management - Inventory Projection - Sales Forecasting	- Cost Modeling - Automatic contract analysis - Demand-Supply Balancing	- Scheduling of energy intensive production - Statistical Quality Control - Lot sizing scheduling	- Warehouse space allocation - Automatic stock relocation - Workload optimization	- Real-time routing - Delivery scheduling in line with consumer patterns - Dynamic Routing	- Credit Rating - Return projection - Product recommendations - Fraud Detection - Profiling of Consumers

3.4 Cloud Computing

Cloud computing, alongside emerging technologies like Quantum Computing and Software as a Service (SaaS), is revolutionizing supply chain management by providing scalable and flexible IT infrastructure solutions. Cloud computing improves supply chain operations by gathering and analyzing data to accurately forecast demand and plan production. It also enhances logistics by providing tools for tracking, managing inventory, and optimizing routes. Businesses can reduce downtime and enhance customer satisfaction by centralizing tasks like ordering spare parts and scheduling services on cloud-based systems.

The global public cloud services market size was valued at approximately \$400 billion in 2021 and is projected to surpass \$1062 billion by 2028. Similarly, the Indian public cloud market is forecasted to grow significantly up to INR 1.42 lakh crores (USD 17.01 billion) by 2028 with a CAGR of 16.54% (see Figure 3.11). Key factors contributing to the growth of the cloud market in India include the government's Digital India initiative, the proliferation of e-commerce, the rise of fintech and edtech sectors, and increasing adoption by small and medium-sized enterprises (SMEs).

50% reduction in logistics costs



70% improvement in delivery performance

Figure 3.10: Logistics Cost Reductions and Delivery Performance Improvements With The Integration Of Cloud Computing

Additionally, cloud computing automates procurement processes and simplifies contract management, resulting in cost savings. This technology offers benefits such as actionable insights, real-time visibility, scalability, and cost efficiency. To successfully implement cloud computing in supply chain management, businesses must plan carefully and consider factors like implementation strategy, process suitability, deployment approach, and staff readiness. By doing so, they can maximize the benefits of cloud technology and improve competitiveness in the business landscape.

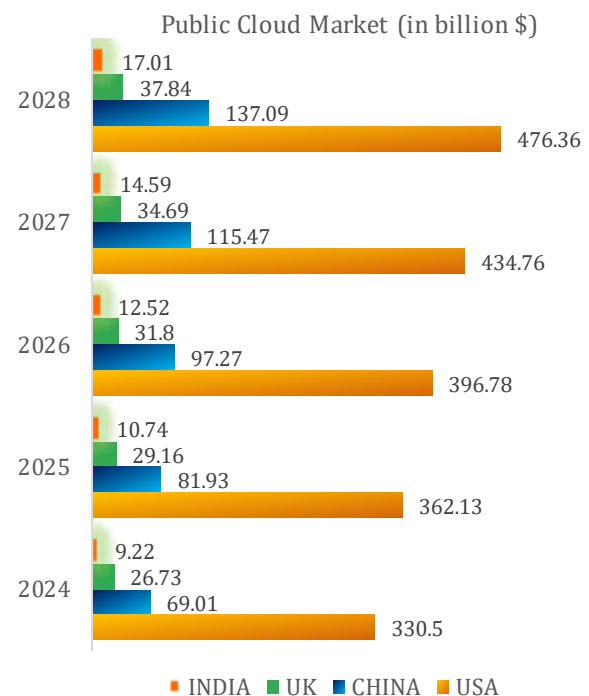
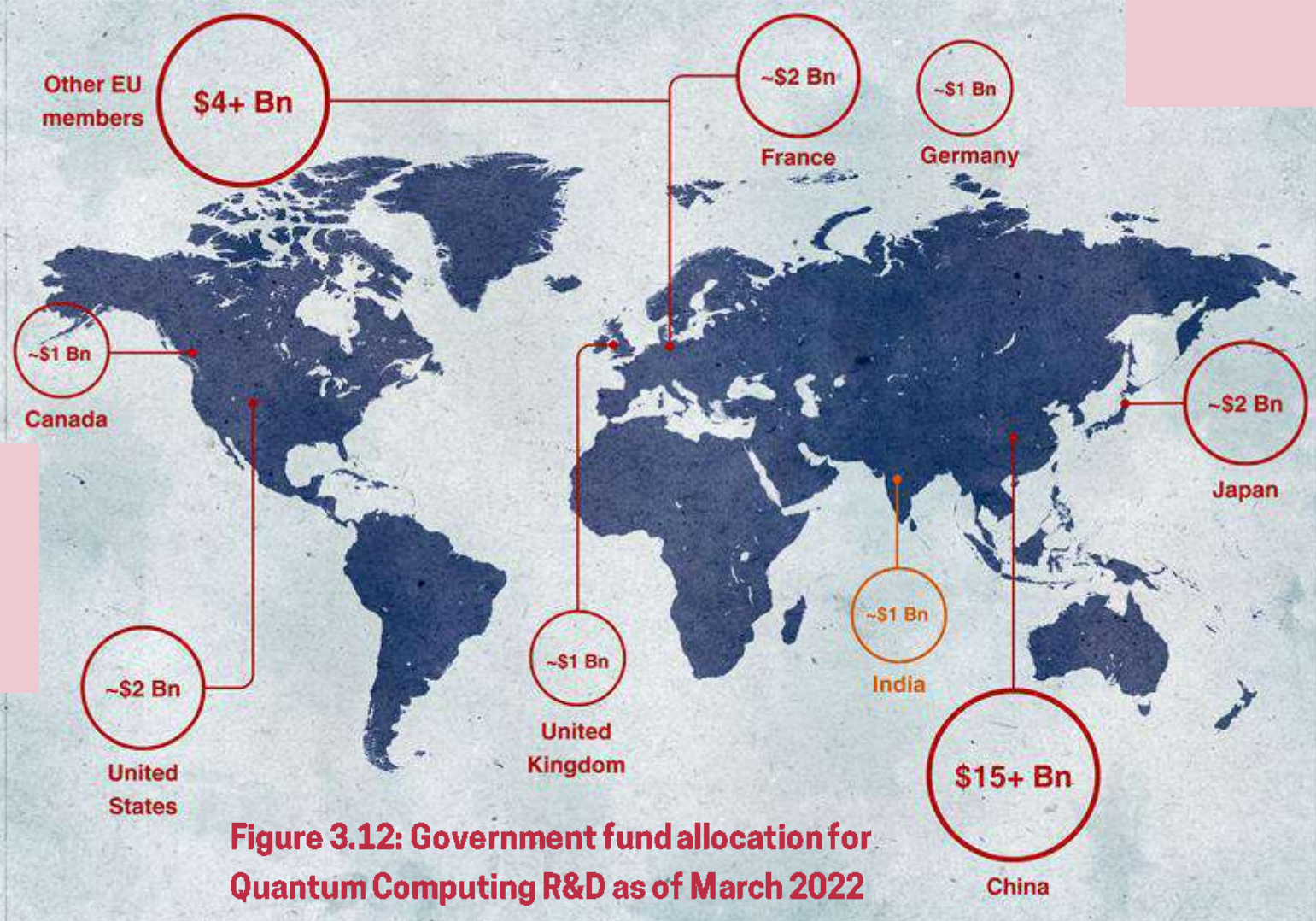


Figure 3.11: Charting India's Public Cloud Market Surge Alongside Global Leaders

3.4.1. Quantum Computing

Quantum computing can help optimize supply chain networks by solving complex optimization problems that classical computers cannot handle. For example, it can aid in optimizing supply chain routing, inventory management, and production planning. Government of India (GOI) is actively investing in Quantum computing technologies; as of March 2022, GOI had invested INR 834.8K crores for deployment of quantum computing systems (see Figure 3.12).



Quantum computing holds profound importance in Military supply chains due to its capacity to tackle complex optimization problems inherent in logistics operations. Military logistics, characterized by challenges like vehicle routing and deployment scheduling, demands swift and precise decision-making amidst dynamic and high-stakes environments. Traditional computing methods often fall short in efficiently solving these problems, requiring significant time and computational resources. However, quantum computing offers a paradigm shift, promising faster and more accurate solutions.

Applications of Quantum Computing include various stages of supply chain such as Planning (Network design planning and resource management), Sourcing (Supplier and order management), Building (Product designing and quality control) and Delivery (Route optimization) (See Figure 3.13).

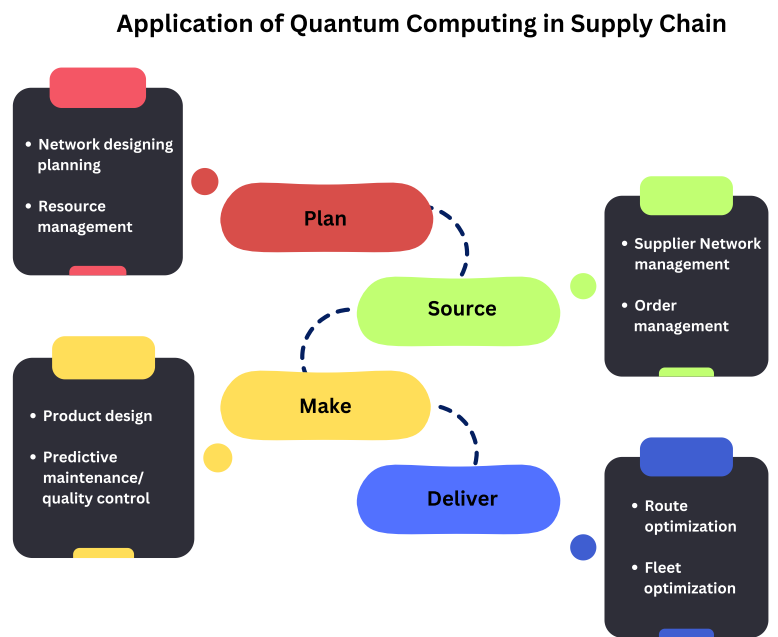


Figure 3.13: Process Flow for application of Quantum Computing in Supply Chain

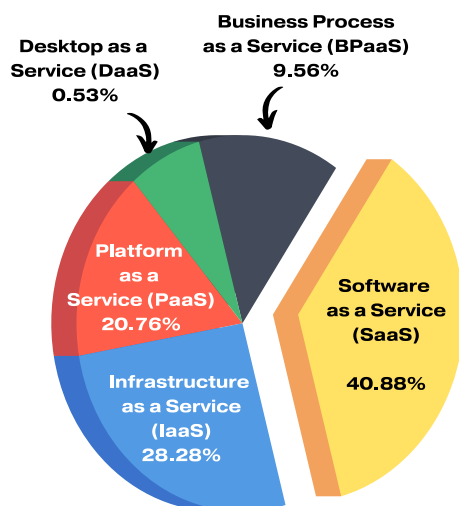


Figure 3.14: Cloud Computing Market Share by Various Cloud-based Services

3.4.2. Software-as-a-Service (SaaS)

SaaS has emerged as a game-changer in logistics supply chain management, offering scalable, cost-effective software solutions accessed via the internet. Its importance lies in streamlining operations, enhancing visibility, and improving collaboration across the supply chain ecosystem. With SaaS, logistics companies can efficiently manage orders, inventory, transportation, and warehousing while adapting to evolving market demands and customer expectations.

The global market for SaaS in logistics supply chain management is projected to grow steadily and is projected to reach USD 24.19 billion by 2028, growing at a CAGR of 4.52% whereas, India's SaaS products in LSCM is forecasted to reach INR 3384.05 crores (USD 405.40 million) by 2028 at a CAGR of 10.01% (see Figure 3.15).

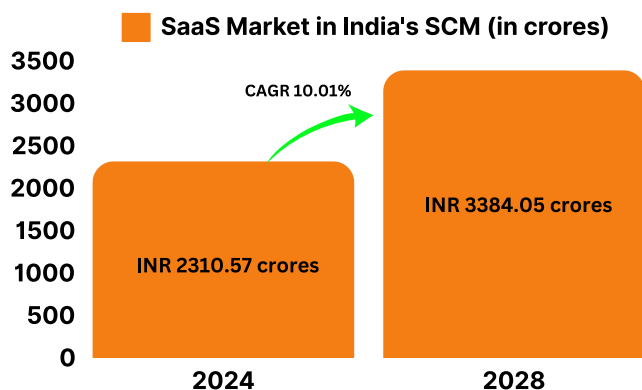


Figure 3.15: Growth in SaaS market in India's Supply Chain

3.5. Blockchain Technology

Blockchain Technology is crucial in securing the logistics supply chain, ensuring integrity, transparency, and security of data and transactions. As supply chains become more digitized and globalized, robust cybersecurity measures are essential.

Blockchain's decentralized ledger secures transactions with cryptographic hashes, ensuring transparency and tamper resistance. According to a report by Deloitte, approximately 74% of the companies interviewed from the logistics sector have implemented or plan to implement blockchain technology to enhance supply chain visibility and traceability.

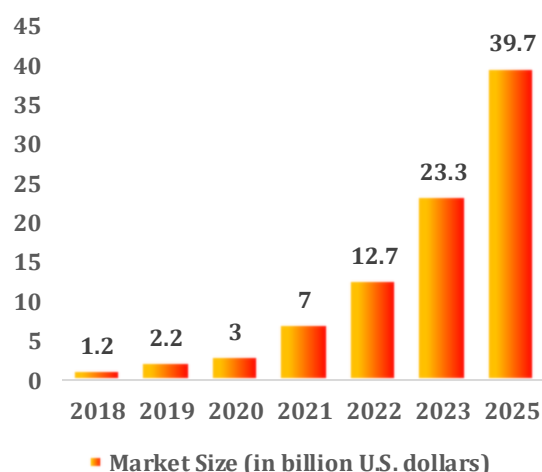


Figure 3.16: Global Blockchain Market Size

Blockchain solutions provide a secure framework for tracking products from manufacturer to end-user, ensuring authenticity, and compliance with regulatory requirements. The global blockchain technology market is forecasted to surpass INR 325.5K crores (USD 39 billion) by 2025 (see Figure 3.16). In India, blockchain technology is set to revolutionize the logistics industry. Projections indicate a compound annual growth rate (CAGR) of 45% from 2020 to 2025, with the market expected to reach INR 37.57K crores (USD 4.5 billion). This transformation promises benefits such as improved traceability, decreased fraud, and significant cost savings.

In a 2021 survey, 45% of respondents stated that their organizations were prioritizing secure information sharing as a primary blockchain use case, making it the most common application for this technology (see Figure 3.17). Additionally, digital currencies like Bitcoin and Ethereum, as well as asset tracking and management, were identified as other popular blockchain applications. This trend underscores the increasing importance of secure information transmission for businesses and acknowledges the significant roles of digital currency and asset tracking in promoting blockchain adoption.

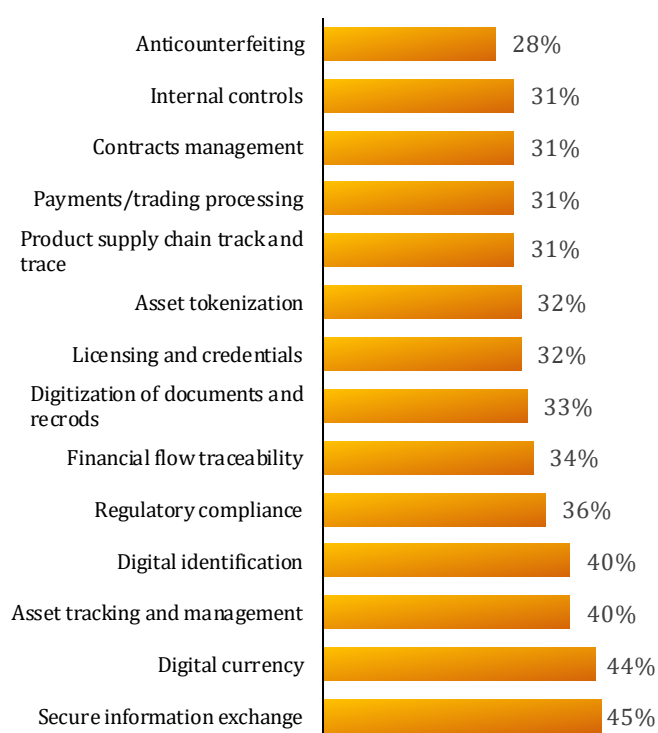


Figure 3.17: Blockchain Use Cases in Organizations Worldwide in 2021

Despite the potential of Blockchain and cryptocurrencies, Indian organizations face adoption obstacles such as regulatory uncertainty, high installation costs, and compatibility concerns amongst blockchain platforms. Overcoming these challenges requires legal certainty, investments in infrastructure and personnel, and an emphasis on interoperability. The future workforce must receive proper education and expertise in Blockchain technologies to facilitate seamless integration with logistics.

The Centre of Excellence in Blockchain Technology (CoE-BCT) aims to establish an interoperable blockchain ecosystem in India, fostering stakeholder. It will drive innovation, test blockchain solutions for government initiatives, and promote transparency in government services to enhance service delivery and increase confidence in government procedures.

3.6. Internet of Things (IoT)

The Internet of Things (IoT) refers to a network of physical devices, vehicles, home appliances, and other items embedded with sensors, software, and connectivity capabilities that enable them to collect and exchange data over the internet. IoT combines the power of analytics, cloud computing, mobile computing & internet networks to change how companies manage their supply chain and logistics. IoT devices include sensors, trackers & more to connect computer systems through Wi-Fi networks, GPS, and other technologies to track products & deliveries. They collect real-time data, which is then stored, processed & analyzed in the cloud. In the logistics sector, IoT device applications encompass a broad spectrum, including shipment tracking, risk mitigation, inventory and storage management, ETA prediction, and post-delivery process management (see Figure 3.18)



Figure 3.18: IoT Applications in Supply Chain

For instance, IoT devices such as GPS trackers, RFID tags, and sensors are being utilized extensively to monitor the movement of goods, track inventory in real-time, and streamline various processes in Medical Supply Chain (see Figure 3.19). Additionally, IoT devices are facilitated by seamless integration of AI algorithms and cloud computing, further enhancing visibility and predictive analytics capabilities in the supply chain.

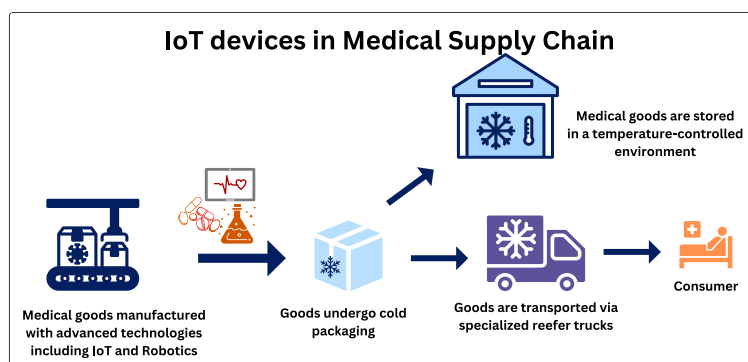


Figure 3.19: Process Flow of application of IoT devices in the Medical Supply Chain

3.6.1. Sensors, Radio Frequency Identification (RFID), Quick Response (QR) Code

IoT devices such as Sensors and Radio Frequency Identification (RFID) technology serve critical roles in optimizing operations and ensuring the integrity of goods. Various sensors are deployed to monitor environmental parameters like temperature, humidity, and vibration levels, ensuring that perishable items stay within specified conditions during transit. This real-time monitoring helps prevent spoilage or damage to sensitive goods, such as food products or pharmaceuticals, thereby maintaining quality and compliance with regulatory standards. Additionally, RFID technology facilitates automatic identification and tracking of goods throughout the supply chain by affixing RFID tags to products, containers, or pallets.

These tags facilitate seamless data capture and offer accurate insights into inventory levels, asset locations, and shipment statuses, thereby streamlining processes such as inventory management and shipment tracking.

Quick Response (QR) Codes streamline logistics supply chains by providing instant access to detailed product information, facilitating efficient inventory management and traceability throughout the distribution process.

3.6.2. 6G Technology

The revolutionary 6G technology is expected to provide data speeds up to 100 times faster than the canonical 5G, along with ultra-low latency, thus enabling real-time data exchange and analysis, crucial for various industries. The integration of supercharged connectivity of 6G technology with IoT in logistics supply chains brings forth several transformative applications. Continuous and instant communication between stakeholders, real-time tracking capabilities are significantly enhanced, allowing for instantaneous monitoring of shipments and assets, thereby improving overall efficiency and visibility throughout the supply chain network.

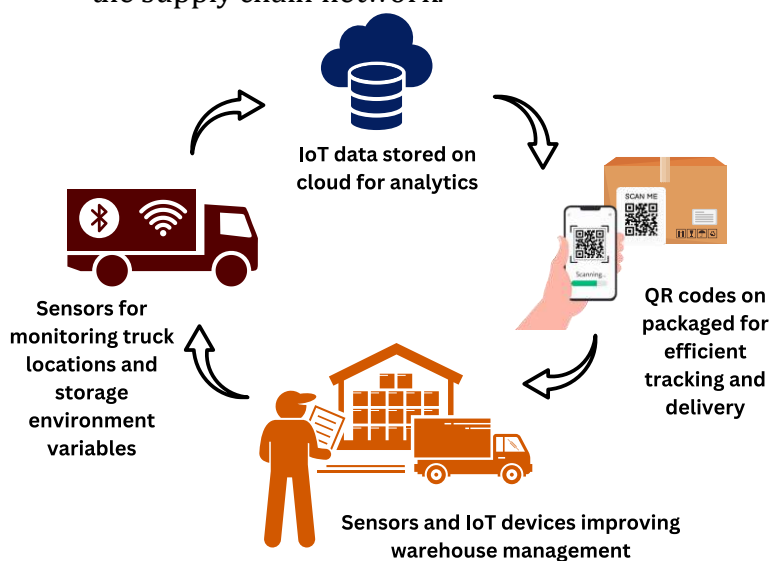


Figure 3.20: Application of Sensors and 6G-powered IoT devices in Supply Chain

Additionally, 6G-powered IoT devices enable remote monitoring of inventory conditions, ensuring quality control and minimizing losses. Smart devices and sensors can communicate seamlessly, optimizing inventory management, reducing wastage, and improving overall efficiency. Furthermore, the fast data transmission capabilities of 6G facilitate the implementation of predictive analytics, enabling logistics companies to optimize routes, reduce congestion, and enhance delivery accuracy based on real-time insights. The introduction of autonomous vehicles and drones, enabled by 6G connectivity, optimizes warehouse operations and final-mile delivery, leading to quicker and more economical logistics solutions. However, the widespread adoption of 6G in supply chains encounters obstacles such as infrastructure investment, data privacy and security concerns, integration complexities, and workforce readiness. To achieve successful integration, strategic planning, infrastructure investments, and collaborative efforts among stakeholders are essential.

3.6.3. Geo-Spatial Technologies: Geographic Information System (GIS), Remote Sensing (RS), Global Positioning System (GPS)

Geo-spatial technologies encompass a suite of powerful tools with a potential to revolutionize how modern businesses plan, execute, and optimize their logistics operations. At the forefront are Geographic Information Systems (GIS), which provide a robust framework for capturing, storing, analyzing, and visualizing spatial data. GIS enables logistics professionals to make informed decisions by overlaying various datasets, such as transportation networks, population density, and land use, to identify optimal routes, distribution centers, and market areas, thus facilitating data-driven decisions and operational efficiency.

Remote Sensing (RS) complements GIS by leveraging satellite imagery, aerial photography, and other remote sensing techniques to monitor environmental conditions, detect changes in terrain, and assess natural hazards along supply chain routes. Global Positioning System (GPS) enables precise location tracking and navigation capabilities, which are essential for fleet management, asset monitoring, and last-mile delivery optimization. GPS receivers installed on vehicles or carried by personnel continuously receive satellite signals to pinpoint their precise locations, enabling real-time monitoring of shipments, streamlined route planning, and precise arrival time predictions.

In transportation, GIS and GPS enable route optimization, traffic management, and vehicle tracking. Warehousing operations benefit from RS and GIS by optimizing storage layouts, inventory placement, and facility design. Moreover, RS aids in monitoring inventory levels, detecting theft or spoilage, and assessing infrastructure conditions in remote or hazardous environments. Inventory management is streamlined through the use of GPS-enabled tracking systems, ensuring accurate stock replenishment, minimizing stockouts, and improving overall supply chain resilience.

3.7. Digital Twin

Digital twins, virtual replicas of physical objects or systems, have revolutionized various industries with their applications in predictive maintenance, product design, and operational optimization. Digital twin creation begins with comprehensive data capture of the physical asset's parameters and performance metrics, seamlessly feeding into modeling systems to generate an accurate virtual representation. In the realm of logistics and supply chain management, digital twins offer unprecedented insights and capabilities. By mirroring real-world logistics processes in a digital environment, companies can simulate, analyze, and optimize their supply chain operations with greater precision and efficiency.

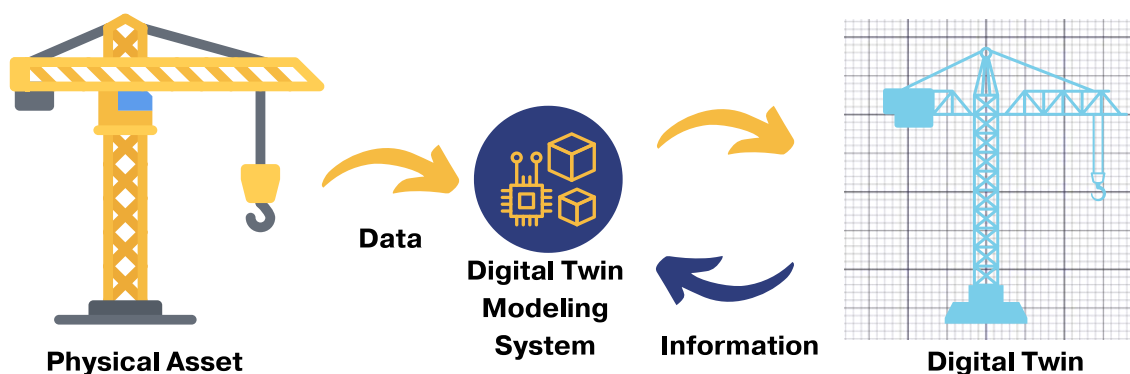


Figure 3.21: Process Flow for Creation of a Digital Twin

This digital twin subsequently provides the necessary information for optimized decision-making within the logistics supply chain (see Figure 3.21).

The Digital Twin market in India is poised for significant expansion, projected to reach INR 67.29K crores (\$8.06 billion) in 2030 with an impressive CAGR of 45.8% from 2024 to 2030 (see Figure 3.22).

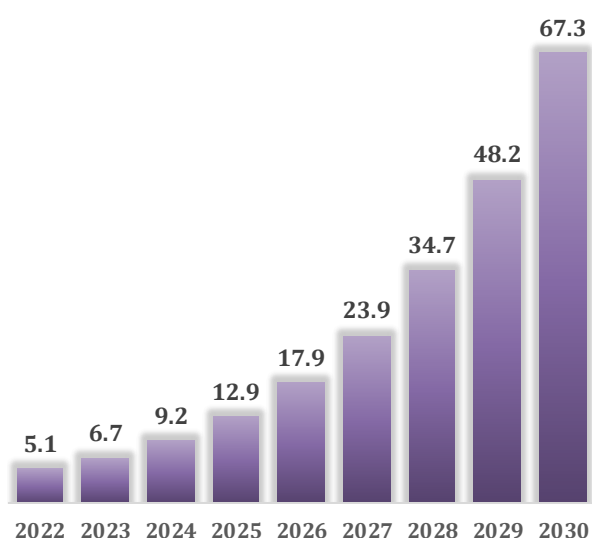


Figure 3.22: Projected Market Growth of Digital Twins in India (in thousand crores INR)

Digital twins offer a transformative solution by enabling companies to develop and assess innovative materials for packaging, such as compostable plastics and recycled content materials, through simulations of their performance under various transit conditions. Advanced technologies such as 3D photographic scanning play a pivotal role in boosting efficiency by enabling automated detection of container issues. This facilitates timely interventions and informed decision-making regarding asset usage and maintenance.

Warehouses, distribution centers, and cross-dock facilities can leverage digital twins for efficient functioning. A digital twin could combine a 3D model of the facility itself with IoT data collected in connected warehouse platforms as well as inventory and operational data including the size, quantity, location, and demand characteristics of every item. Warehouse digital twins can support the design and layout of new facilities, allowing companies to optimize space utilization and simulate the movement of products, personnel, and material handling equipment.

The application of digital twins holds immense prominence, particularly in addressing challenges related to packaging and container management. Given the industry's heavy reliance on single-use packaging and fleets of reusable containers, optimizing these assets is crucial for both sustainability and improved operational efficiency.

3.8. Augmented Reality(AR) and Virtual Reality(VR)

Augmented Reality (AR) and Virtual Reality (VR) technologies have emerged as game-changers in the logistics supply chain, revolutionizing traditional practices by enhancing efficiency, reducing errors, and optimizing operations. With the ability to overlay digital information onto the physical world or immerse users in simulated environments, AR and VR offer unparalleled opportunities for innovation in logistics management.

Augmented Reality



Instruction manuals for workers for step-wise implementation of a task

Virtual Reality



Equipment design and analysis in virtual reality



AR-supported remote assistance for support and guidance



VR-based training for workers

Figure 3.23: Exploring Industry Applications of Augmented Reality (AR) and Virtual Reality (VR)

AR-VR technology improves warehouse management by overlaying real-time data for inventory tracking and optimizing order fulfillment. It also offers immersive training simulations for staff. Additionally, it assists in transportation planning by visualizing routes and obstacles and provides remote assistance for troubleshooting and maintenance tasks. Furthermore, AR-VR enhances customer experiences with immersive product visualizations and enhances supply chain transparency through real-time tracking and analytics. It also aids delivery drivers in navigating urban environments and verifying packages, thereby enhancing last-mile delivery efficiency.

These cutting-edge technologies are actively leveraged for VR-based workforce training, creating guiding tutorials for task implementation, AR-supported remote assistance during transportation, equipment design and failure analysis.

The AR & VR market in India is anticipated to surge, reaching a projected revenue of INR 6.59K crores (\$789.0 million) in 2024, with an estimated CAGR (2024-2028) of 10.47%, poised to elevate the market volume to INR 9.77K crores (\$1.17 billion) by 2028. Surveys indicate that more than 70% of logistics companies are either actively exploring or implementing AR and VR solutions within their supply chain processes (see Figure 3.23).

Warehousing and Distribution stands out as a key sector in the logistics industry that gains advantages from AR and VR technologies. These tools empower workers to observe inventory in real-time, refine picking and packing procedures, and improve navigation within expansive warehouse spaces. AR-enabled smart glasses or headsets offer hands-free access to vital information, like item locations and order details, resulting in quicker and more precise fulfillment operations.

AR-VR Indian Market Size (in crores INR)

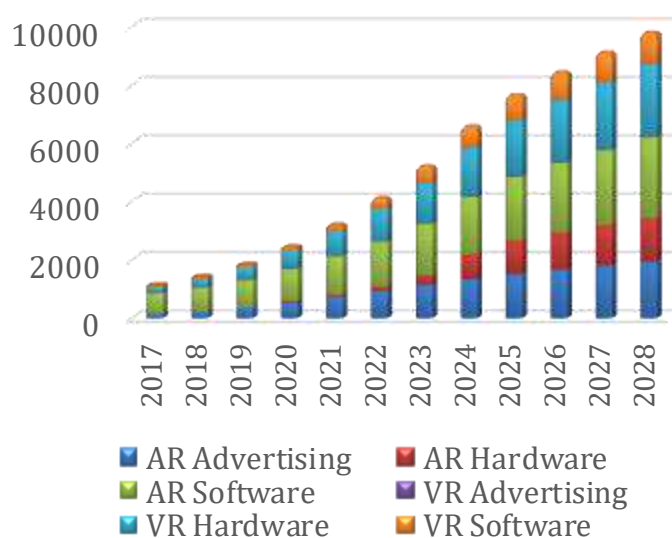


Figure 3.24: Projected Growth of Indian AR-VR Market by Sub-sections

Moreover, VR simulations are increasingly used for employee training, allowing staff to familiarize themselves with warehouse layouts and equipment operation in a safe and controlled virtual environment.

3.9. Control Tower

Control towers serve as crucial nerve centers in modern logistics operations, providing organizations with real-time visibility and actionable insights across their supply networks.

These control towers are personalized dashboards that provide a holistic perspective on crucial business metrics and events. They utilize cloud computing to gather data from transportation systems, warehouse operations, and external factors such as weather conditions and market trends. This integration empowers control towers to proactively identify potential disruptions, optimize resource allocation, and make real-time data-driven decisions.

In the logistics sector, control towers play a pivotal role in optimizing the movement of goods from suppliers to customers. They offer end-to-end visibility into transportation and fulfillment processes, allowing logistics managers to track shipments, monitor delivery performance, and manage exceptions effectively.

By providing advance shipping notifications, track-and-trace capabilities, and inventory insights, logistics control towers help streamline operations, reduce costs, and improve customer satisfaction.

Moreover, they facilitate collaborative information sharing among stakeholders, enabling swift decision-making and response to unplanned events.

In 2022, the global market for control towers boasted a valuation of INR 40.8K crores (USD 4.89 billion). Projections indicate a robust growth trajectory, with anticipated market expansion to INR 97.5K crores (USD 11.68 billion) by 2028, with a CAGR of 15.59%. Indian government initiatives such as PM GatiShakti, National Logistics Policy 2022 are some key enablers for advancement of Control Tower solutions in Indian logistic sector.

The Unified Logistics Interface Platform (ULIP), launched under India's National Logistics Policy, provides a dedicated portal for simplified, transparent data requests, fostering collaboration and innovation within the logistics sector.

ULIP facilitates real-time data-driven solutions through seamless API integrations, enabling tasks like compliance verification and risk management thereby enhancing efficiency and driving down operational costs throughout the supply chain, akin to a control tower solution.

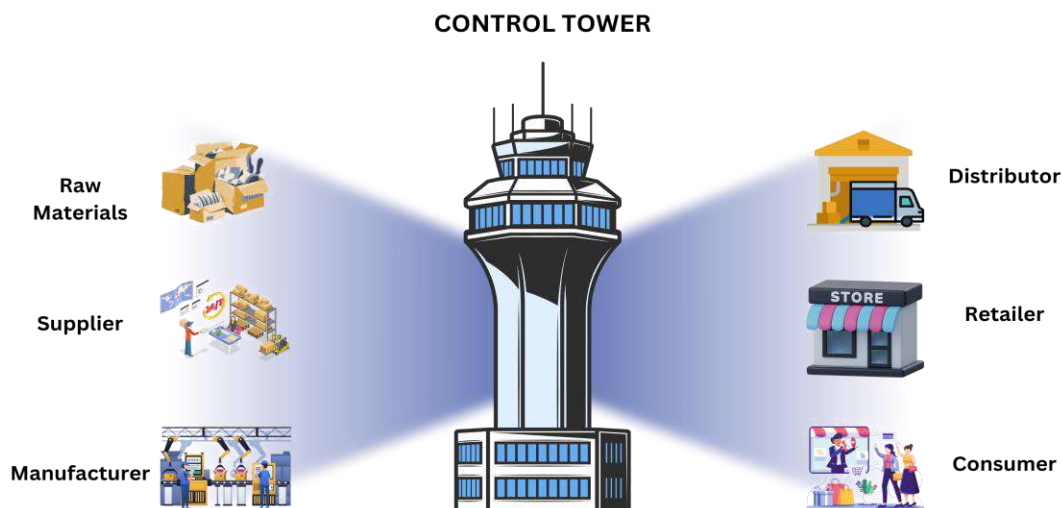


Figure 3.25: Control Tower Diagram Providing End-to-end Visibility Across the Supply Chain

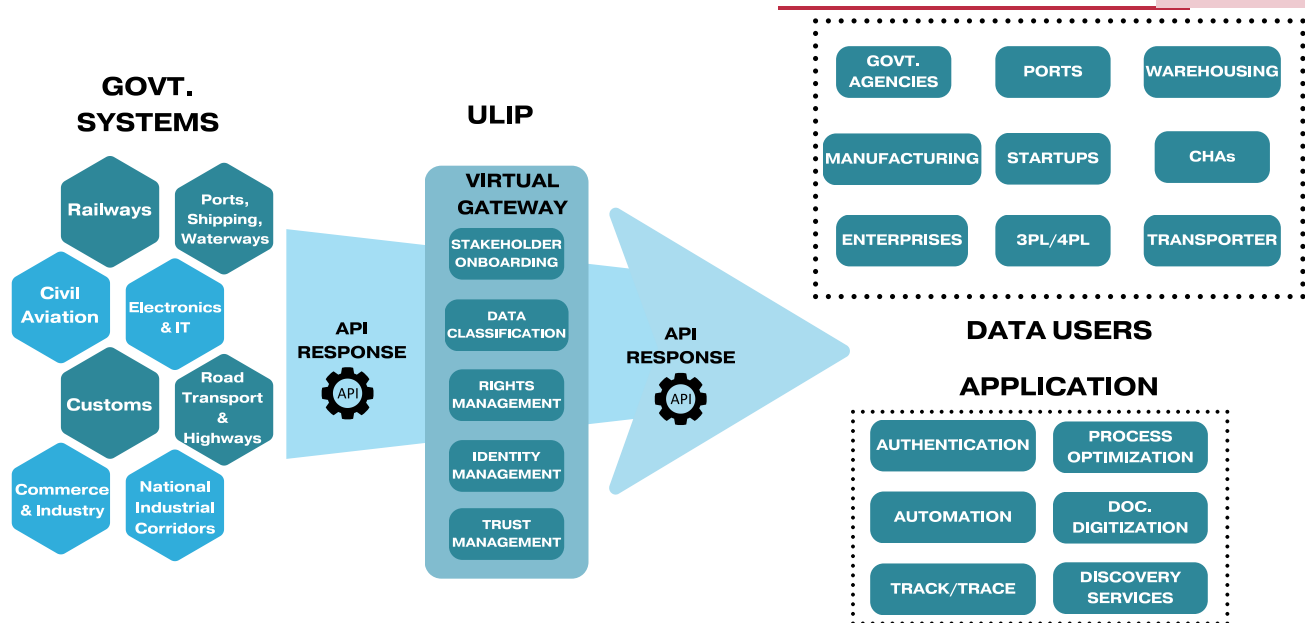


Figure 3.26: Process Flow of Unified Logistics Interface Platform (ULIP)

By leveraging the capabilities of control towers, organizations can achieve greater visibility, efficiency, and resilience in their logistics operations.

3.10. Robotics and Automation

Supply chains are becoming more reliant on automation and robotics to meet the demands of faster and more efficient logistics. These transformative technologies not only streamline operations but also significantly reduce long-haul expenses, enhance workforce productivity and minimize errors. In the logistics sector, robotics and automation are used in automated warehousing for picking and packing, employing autonomous mobile robots (AMRs) and optimizing material flow with material handling systems. Autonomous industrial robots, such as collaborative robots (Cobots) and robotic process automation (RPA), are increasingly deployed to manage routine and repetitive tasks, requiring intricate programming for their setup and execution. The growth potential of the robotics industry in supply chain management is significant.

According to Allied Market Research, the global market for robotics in the logistics sector is projected to reach INR 983.9K crores (USD 117.89 billion) by 2027, with a CAGR of 23.6%.

Various industries, including retail, e-commerce, manufacturing, and logistics, are increasingly demanding automation to meet the challenges of the evolving market. In e-commerce logistics, robotics and automation are extensively adopted across various stages, including order processing, shipment scheduling, inventory management, and customer support. These technologies streamline operations, improve efficiency, and enhance the overall customer experience by automating tasks such as onboarding partners, invoicing, procurement, and supply and demand planning.

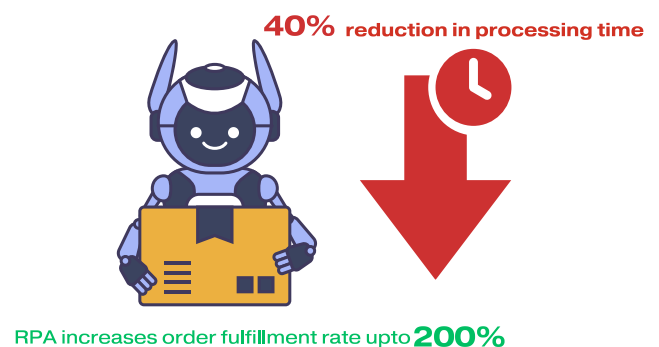


Figure 3.27: RPA enables a Remarkable Improvement in Processing Time and Order Fulfilment Rate

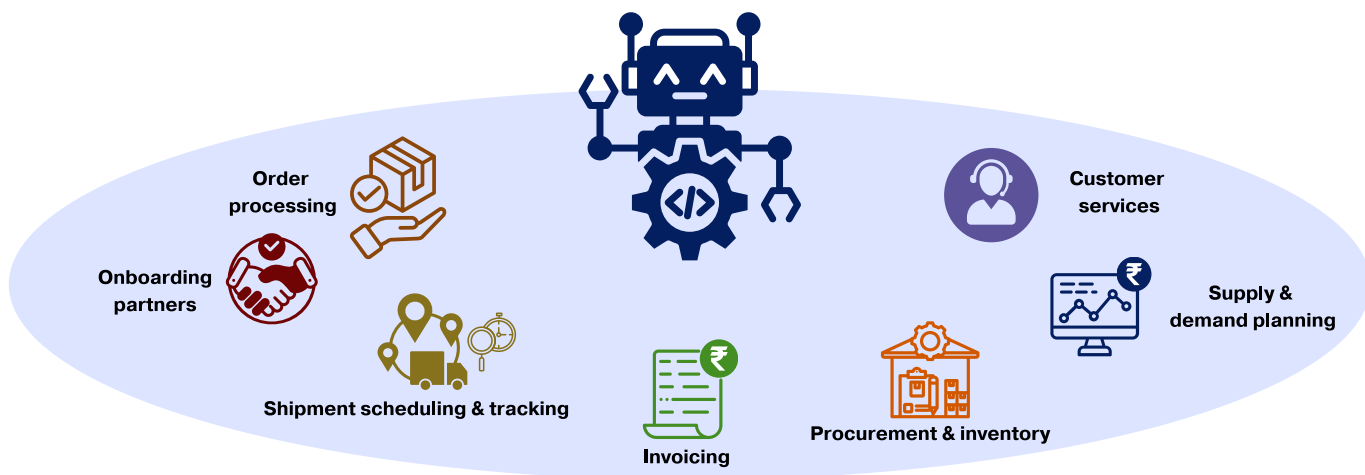


Figure 3.28: Benefits of Robotics Automation in e-commerce Supply Chain

In warehouses, light-weight cobots can increase order fulfillment rates by up to 200%, while logistics costs can be reduced by 30%-40%, leading to substantial savings and improved profitability. According to a report by McKinsey, implementing RPA in the return order process can lead to a 30%-50% reduction in processing time, and a 25%-50% reduction in operational costs.

As robotic automation continues to advance and become more sophisticated, the benefits for the supply chain of the future are expanding. With decreasing setup times, reduced need for supervision, and seamless collaboration alongside human counterparts, these advancements promise a future of unprecedented efficiency and productivity in logistics.

3.11. Autonomous Vehicles and Drones

3.11.1. Autonomous Vehicles

Autonomous Vehicles (AVs) are revolutionizing transportation and logistics by enhancing efficiency, reducing costs, and improving safety. These vehicles operate without human intervention, leveraging advanced technologies like AI, sensors, and GPS. These vehicles enhance supply chain efficiency by facilitating seamless integration between different stages of the process, improving inventory tracking, and ensuring timely and accurate deliveries.

Recent statistics indicate a significant uptick, with the global autonomous vehicle market projected to reach INR 4646K crores (USD 556.67 billion) by 2026, growing at a CAGR of 39.47% from 2021 to 2026. A study by McKinsey predicts that autonomous vehicles could account for up to 15% of global vehicle sales by 2030.

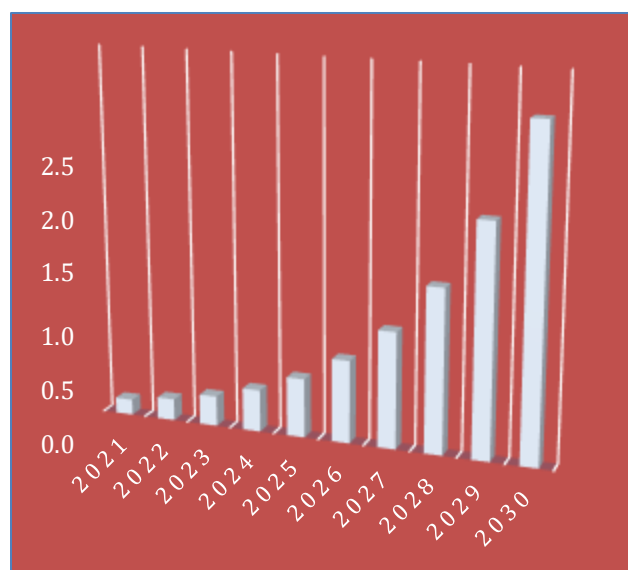


Figure 3.29: Projected Autonomous Vehicles Market Size in India from 2021-2030

Moreover, AVs bring substantial cost savings to the transportation and logistics industry. By eliminating the need for human drivers, companies can reduce labor costs significantly, while fuel optimization and efficient route planning further contribute to cost reduction.

Additionally, AVs operate around the clock, maximizing vehicle utilization and enhancing overall efficiency. A key use case of AVs is in Last-Mile Delivery (LMD) solutions, especially in urban areas. AVs effortlessly navigate congested city streets, optimizing delivery routes and ensuring timely delivery of goods to customers' doorsteps. This not only improves customer satisfaction but also reduces operational costs associated with traditional delivery methods.

Furthermore, AVs contribute to sustainability efforts by reducing emissions and congestion, particularly with the integration of electric variants. By adopting AVs, companies can minimize their carbon footprint and contribute to a cleaner, more sustainable environment. However, safety rules and regulations play a crucial role in the deployment of AVs, and ensuring adherence to standards is a key challenge in passenger and road safety.

AVs represent a paradigm shift in transportation, offering safer, more efficient, and sustainable mobility solutions. Despite challenges, including safety concerns and regulatory hurdles, the future for AVs looks promising. Collaboration among stakeholders is crucial for realizing the full potential of AVs and reshaping transportation for a safer, smarter, and more connected future.

3.11.2. Drones

Drone technology has emerged as a transformative force in the logistics supply chain, offering innovative solutions to traditional challenges. Initially utilized primarily for surveillance and military purposes, drones have evolved to become versatile tools in various industries, including logistics. With different types of drones catering to specific functions, such as multirotor drones for maneuverability and fixed-wing drones for extended flights, the range of applications has expanded.

In the logistics sector, drones offer unparalleled benefits in efficiency, speed, and accessibility. From the last-mile delivery in urban areas to reaching remote and rural locations, drones offer unique advantages in navigating challenging terrains and congested city landscapes. Companies like Dunzo and Marut Drones in India have already demonstrated the feasibility and effectiveness of drone deliveries in such scenarios. Additionally, drones facilitate inventory management in warehouses, disaster response, and humanitarian aid, showcasing their versatility across different facets of the logistics industry.

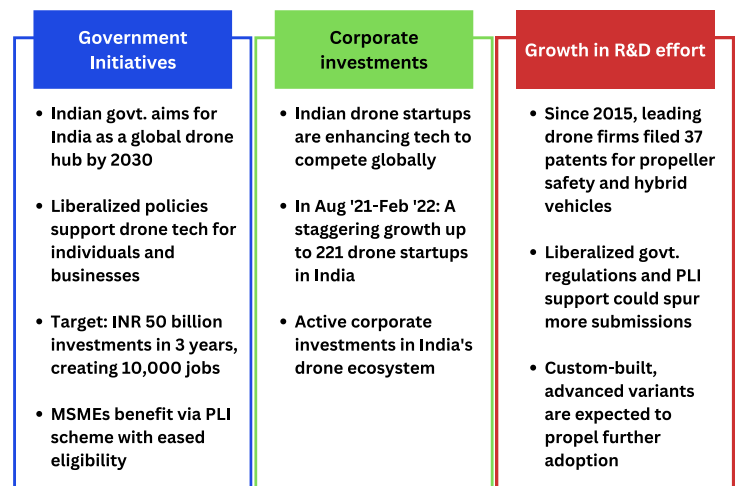


Figure 3.30: Key Initiatives by the Indian government to Promote Drone Technology

Key Initiatives such as Drone Rules 2021 to establish a regulatory framework, Production-Linked Incentive (PLI) scheme to incentivize drone manufacturing and UAS Traffic Management (UTM) Policy Framework have been instrumental in promoting the industry (See Figure 3.30). The government's vision to establish India as a global drone hub by 2030 is further supported by initiatives like the Drone Shakti program, which fosters drone adoption across various sectors. These efforts, coupled with enhanced government engagement, are propelling India's drone industry towards its projected INR 408.01K crores (USD 4.9 billion) market potential by 2030.

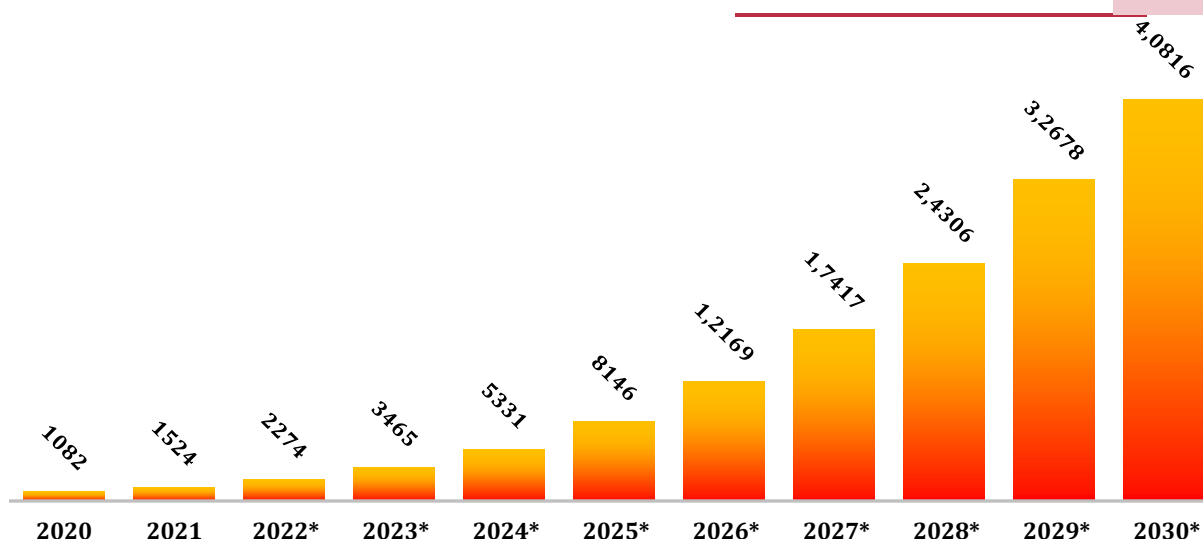


Figure 3.31: Projected Drone Market Size in India from 2022-2030 (in INR crores)

Integrating drone technology into the logistics supply chain involves careful planning and consideration of various factors. Stringent regulations, concerns about privacy and security, technical limitations, and high acquisition costs are some of the obstacles that need to be addressed.

However, with the Indian government's initiatives to promote the drone industry, including regulatory frameworks and incentives for manufacturing, the sector is poised for significant growth. With the right enablers, drones have the potential to reshape the future of logistics supply chains in India and beyond.



Figure 3.32: 3D Printing Powering Rapid Prototyping in Automobile Industries

The automotive industry has seen a rise in integration of Advanced Manufacturing technologies (see Figure 3.32). The automotive supply chain is highly complex, involving numerous components and parts sourced from various suppliers globally. Advanced manufacturing technologies enable automotive manufacturers to streamline production, improve quality control, and respond quickly to changes in demand. For instance, implementing robotics and automation in assembly lines can increase production speed and accuracy while reducing labour costs. Additionally, 3D printing technology allows for on-demand spare parts manufacturing, reducing inventory levels and minimizing downtime for maintenance and repair. This integration of advanced manufacturing technologies enhances operational efficiency and enables greater innovation and sustainability in the industry.

3. 12. Advanced Manufacturing

Advanced manufacturing technology is a multifaceted realm that spans a spectrum of cutting-edge processes, tools, and systems meticulously crafted to elevate manufacturing operations. This technology revolutionizes the logistics supply chain by enhancing efficiency, reducing costs, and improving flexibility. The core of Advanced Manufacturing revolves around innovative technologies encompassing Additive Manufacturing (such as 3D printing), Advanced Materials and Nanofabrication Technology. These technological innovations refine workflows, shorten lead times, personalize products, and adapt to market shifts, fuelling operational efficiency and fostering competitiveness in manufacturing.

3.12.1. Additive Manufacturing

Additive manufacturing revolutionizes traditional manufacturing processes by building objects layer by layer instead of subtracting material from a solid block. This method utilizes 3D designs transformed into machine language for additive machines to understand and execute. It encompasses various technologies, with 3D printing being a prominent example. Unlike subtractive manufacturing, Additive Manufacturing requires minimal manual labor and tooling, leading to cost savings and increased flexibility in production.



Figure 3.33: Key Benefits of Additive Manufacturing in Logistics Supply Chain

Additive Manufacturing enables companies to streamline their supply chains by reducing the need for extensive inventories and long-distance transportation of goods. By decentralizing production and shifting towards on-demand manufacturing, companies can respond more swiftly to changing market demands and minimize the risk of overstocking or stockouts. Additionally, it allows for the creation of spare parts on-site, eliminating the need for extensive warehousing of replacement components.



Figure 3.34: On-site Spare Parts Design using 3D Printers

3.12.2. Advanced Materials

Advanced materials are crafted with intentionally engineered properties to outperform conventional counterparts and offer enhanced durability, lightweight properties, and improved efficiency. Examples include carbon fiber composites, advanced polymers, and nanomaterials, which boast the potential to substantially diminish the weight of packaging and transportation vehicles. The durability of advanced materials ensures the protection of goods during transit, minimizing losses due to damage or spoilage. Moreover, the weight reduction translates to lower fuel consumption and emissions, thereby aligning with sustainability objectives. Integrating advanced materials in logistics and supply chain management (LSCM) enhances operational efficiency and contributes to sustainability goals by reducing environmental impact.

INDIA'S ADVANCED MATERIALS MARKET

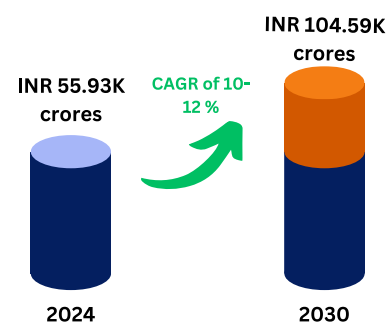


Figure 3.35: Projected Growth in India's Advanced Materials Market

3.12.3. Nanotechnology and Nanofabrication

Nanotechnology and nanofabrication offer transformative potential for integration within the logistics supply chain. At its core lies the ability to miniaturize and enhance the efficiency of components crucial to logistics operations. Nanomaterials enable the development of ultra-lightweight yet robust packaging solutions, reducing shipping costs and environmental impact. Nanosensors enhance real-time monitoring of goods, enabling precise tracking of inventory and environmental conditions during transit.

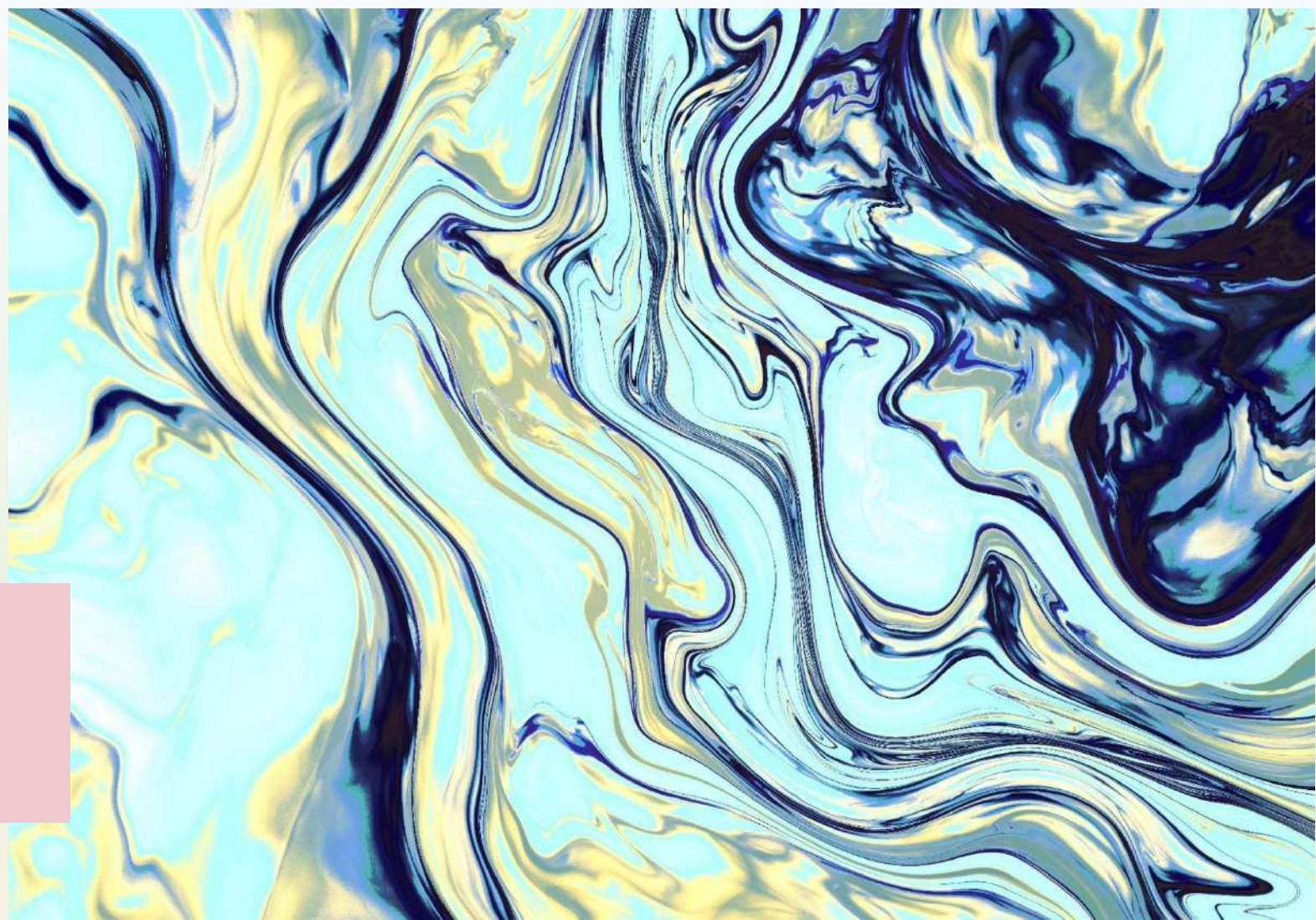
Furthermore, nanofabrication techniques facilitate the production of micro-scale devices, optimizing warehouse space utilization and enabling the creation of smart logistics systems (see Figure 3.35). Integrating nanotechnology and nanofabrication into logistics also unlocks unparalleled data-driven decision-making and automation opportunities. Nanoscale devices embedded within products and packaging can autonomously communicate vital information throughout the supply chain. This connectivity enables predictive maintenance, ensuring the integrity of goods and reducing downtime.



Figure 3.36: A Close-up View of a Nanotechnology Machine, Showcasing its Intricate Design and Precise Functionality at the Nanoscale

Moreover, nanotechnology facilitates the development of energy-efficient transport systems and renewable energy sources, addressing sustainability concerns within logistics operations.

The seamless integration of these technologies across several supply chain sectors marks a fundamental transition in India's logistics environment, fostering a more flexible, cost-effective, and dependable future for product transportation, distribution, storage, and delivery.



4

Sustainable Logistics: Advancing through SDG Integration and Technological Innovation

4. Sustainable Logistics: Advancing through SDG Integration and Technological Innovation

In India, the logistics sector is pivotal to the nation's economic growth, influencing trade efficiency and overall competitiveness on the global stage. Successfully incorporating the SDGs within this sector is not merely beneficial but essential for sustainable development and enhancing India's standing in the global market.

4.1. Sustainable Development Goals (SDGs)

The United Nations Sustainable Development Goals (SDGs) offer a critical framework for addressing major global challenges including poverty, inequality, climate change, environmental degradation, peace, and justice.

Supply Chain Management (SCM) is vital in this context as it directly impacts production and distribution networks worldwide. By integrating SDGs into SCM practices, businesses can address economic, social, and environmental sustainability effectively.

4.1.1. Exploring SDGs in Supply Chain Management

This study explores how integrating SDGs into SCM enhances operational efficiency and sustainability within the logistics sector.

SDG 8 promotes sustained economic growth and decent work, focusing on improving labor conditions and ensuring fair wages throughout the supply chain.

SDG 9 improves infrastructure and fosters innovation, streamlining supply chains to reduce costs.

SDG 11 focuses on sustainable cities and communities, ensuring that urban logistics systems contribute to safer, more sustainable urban environments.

SDG 12 targets sustainable consumption and production, advocates for optimized packaging, and facilitates effective recycling through reverse logistics.

SDG 13 addresses the environmental impacts of SCM, promotes the adoption of renewable energy, and advocates for cleaner transportation methods to reduce carbon footprints.

Lastly, **SDG 17** emphasizes the importance of partnerships in SCM, encourages collaboration among stakeholders to enhance transparency and sustainability.

These goals collectively highlight the integration of economic, environmental, and social sustainability within SCM, which is essential for advancing global and local community welfare (see figure 4.1).



Figure 4.1: Key Sustainable Development Goals (SDGs) Relevant to the Logistics Sector

4.1.2. Technology Usage in Supply Chains for SDGs

Technological advancements play a crucial role in aligning SCM with SDGs:

Blockchain: Enhances transparency and traceability, crucial for ethical sourcing and consumer trust.

Internet of Things (IoT): Allows real-time monitoring of goods and conditions, improving logistics and reducing waste.

Artificial Intelligence (AI) and Machine Learning (ML): Supports better demand forecasting and efficient route optimization, minimizing overproduction and transit distances.

4.1.3. Current SCM faces several challenges

Climate Change: Affects agricultural outputs and disrupts supply networks. Global

Inequality: Influences labor markets and economic stability across global supply chains

Degradation of Natural Resources:

Threatens the sustainability of supply operations.

4.1.4. Strategy for Improvement

For India to close the gap and enhance its logistics sector to meet SDG targets effectively, it needs to:

- Invest in technology upgrades and training programs.
- Improve infrastructure through increased investment and better planning.
- Enhance regulatory frameworks to reduce bureaucracy and promote ease of doing business.
- Increase focus on sustainability.
- Foster innovation through better industry-academia collaboration.

4.1.5. Future Improvements by 2047 in India

By 2047, it is imperative for SCM in India to embrace robust sustainability practices:

Adoption of Green Technologies: Utilize renewable energy sources extensively to minimize carbon emissions.

Enhanced Recycling and Waste Management: Develop efficient systems for recycling and waste management to reduce environmental impacts. Building Resilient Infrastructure: Upgrade infrastructure to cope with environmental changes and crises.

Inclusive Economic Growth: Promote equitable supply chain benefits distribution to enhance social sustainability.

Policy and Governance: Enforce strict environmental and social governance regulations across all supply chain levels.

4.2. Carbon footprint

The logistics sector is a major contributor to carbon emissions, primarily due to its reliance on less energy-efficient road transport. Road transport, which predominates in the logistics sector, significantly contributes to national greenhouse gas emissions. Annually, the sector handles approximately 4.6 billion tonnes of freight, resulting in about 2.3 gigatonnes of CO₂ emissions, making it the third-largest emitter globally

4.2.1. Future Projections

If current practices continue, emissions from this sector are projected to increase sharply. Estimates indicate that road freight could rise to 9.6 trillion tonne-km by 2047, potentially increasing freight emissions by more than 50%.

4.2.2. Decarbonization Strategies

Several strategies have been identified to reduce the carbon footprint of the logistics sector:

Enhanced Road Transport Efficiency: Improvements in load efficiency and the reduction of empty runs can significantly decrease emissions.

Modal Shift to Rail: Rail transport emits less CO₂ than road transport and can significantly reduce overall emissions.

Cleaner Fuel Adoption: Transitioning to alternative fuels such as LNG or electric vehicles can reduce emissions and fuel costs.

Energy-Efficient

Incorporating solar panels and LED lighting can reduce energy consumption.

Warehousing:

Advanced Logistics Technologies: Using AI for route optimization and fleet management can effectively reduce mileage and emissions.

4.2.3. Policy and Industry Actions

Robust policy support is crucial to promote sustainable practices within the logistics sector. This includes incentives for adopting green technologies, stringent emission standards, and regulatory support for sustainable technologies.

Table 4.1: Bridging Gaps: Benchmarking India's Logistics Sector Against Developed Nations in SDG Achievement

SDG / Country	India	Germany	Singapore	Japan	USA
SDG 8	Emerging job market; requires more skilled workforce development	High-quality logistics jobs supported by strong vocational training	Strategic focus on job creation and skills enhancement in logistics	Comprehensive employment opportunities with advanced skills training	Significant employment generation with high standards for skills development
SDG 9	Infrastructure development ongoing; challenges with modernization and efficiency	Advanced logistics infrastructure with a focus on innovation and efficiency	Highly efficient and technologically advanced transport systems	Strong infrastructure investment; leading in technological integration	Extensive infrastructure with ongoing modernization efforts
SDG 11	Needs better integration of logistics in urban planning to reduce congestion	Advanced urban logistics systems reducing environmental impact	Efficient urban logistics practices integrated within smart city developments	Urban logistics solutions focused on sustainability and efficiency	Progressive urban planning incorporating sustainable logistics solutions
SDG 12	Slow in adopting sustainable logistics practices; potential for improvement	Leader in sustainable logistics practices; focus on resource efficiency	High standards for sustainability in logistics operations	Strong commitment to sustainable and efficient logistics systems	Emphasis on sustainability and reducing environmental footprint in logistics
SDG 13	Initiatives for reducing emissions in logistics; needs faster implementation	Aggressive climate policies in logistics; widespread use of renewable energy	Leadership in implementing low-emission logistics systems	Commitment to reducing logistics emissions through innovative solutions	Strong policies and initiatives to reduce logistics emissions
SDG 17	Growing collaborations but needs stronger global partnerships	Robust international collaborations enhancing logistics technologies and practices	Strategic alliances with global logistics leaders for operational excellence	Active international cooperation in logistics technology and innovation	Extensive global partnerships driving advancements in logistics technologies

4.3. Water Footprint

In India, the logistics sector's water footprint is significant, largely due to extensive vehicle maintenance and large-scale warehousing operations which require substantial water use for cleaning and cooling.

4.3.1. Challenges

High Consumption: Many logistics operations are located in regions facing water scarcity, exacerbating local water stress.

Pollution: Water pollution from the runoff of chemicals and fuels used in vehicle maintenance is a persistent issue.

4.3.2. Mitigation Strategies

Water Recycling Systems: Implementing systems to recycle water can mitigate the impact, especially in vehicle washing and facility operations.

Efficient Water Management: Introducing technologies such as IoT sensors to monitor and control water usage helps minimize waste.

Rainwater Harvesting: Encouraging the installation of rainwater harvesting systems in logistics parks to supplement water needs.

4.4. Smart and Sustainable Contract

In India, smart contracts could significantly enhance efficiency by automating the enforcement of contract terms using blockchain technology, ensuring compliance with sustainability standards.

4.4.1. Applications

Transparency in Transactions: Ensures all parties adhere to contractual obligations without delay or falsification.

Enforcement of Sustainability Standards: Integrates environmental standards directly into contract terms, automatically enforcing compliance.

4.4.2. Challenges

Adoption Barriers: Integrating blockchain technology within the traditional setups of Indian logistics.

Regulatory Recognition: Establishing legal frameworks that recognize and enforce smart contracts.

4.4.3. Future Prospects

Adopting smart contracts in logistics can streamline operations, reduce disputes, and ensure sustainability is maintained across the supply chain.

4.5. Clean Technology

The push for clean technologies in India's logistics sector aims to reduce environmental impacts by adopting energy-efficient practices and reducing emissions.

4.5.1. Key Technologies

Electric Vehicles (EVs): Promoting the use of EVs in delivery fleets to decrease reliance on diesel and petrol.

Solar Energy: Implementing solar panels across logistics infrastructures, such as in warehouses, to reduce electricity consumption from non-renewable sources.

Software Solutions: Utilizing advanced routing software to optimize delivery routes, thereby reducing fuel consumption and emissions.

4.5.2. Challenges

Initial Investment Costs: High costs associated with transitioning to clean technologies can be a significant barrier.

Infrastructure Needs: Development of necessary infrastructure, such as EV charging stations, is still in nascent stages.

4.5.3. Policy and Industry Actions

Government incentives and subsidies are crucial to accelerate the adoption of clean technologies. Policies that support investment in sustainable infrastructure can facilitate this transition.



5

Shaping the Future

Logistics Workforce

5. Shaping the Future Logistics Workforce

India's logistics sector stands at a crucial juncture, driven by the convergence of technological innovations, regulatory government reforms and the increasing demand for skilled workforce. In the dynamic landscape of technology, it is imperative for India's future logistics workforce to harness and leverage technological advancements for their professional growth and the advancement of the sector.

With a burgeoning population within the working age bracket, India emerges as a promising contender poised to lead the global logistics and supply chain sector. In India, the working-age population, defined as individuals between 15 to 60 years old, constitutes a significant portion of the total populace. As of 2021, this demographic represented over 64% of the country's population, numbering approximately 92.16 crore individuals. Projections suggested a further increase in this figure, expected to reach 65% by 2031, encompassing around 93.6 crore people.

India's logistics sector is set to expand, with projections indicating the addition of 10 million jobs by 2027, driven by a growth rate of 12%. Despite this growth, this sector is facing a multitude of pressing issues which demand urgent attention. Foremost among them is the persistent talent gap, which threatens to impede the sector's growth trajectory. With only marginally over 51% of the Indian workforce being deemed employable in 2024, less than half of the workforce in India possesses the necessary skills for employment. Many logistics companies struggle to find skilled professionals to meet the demands of an ever-evolving industry.

Lack of awareness about the diverse career opportunities within the logistics field is deterring the potential entrants and exacerbating the talent shortage. Furthermore, the sector's branding and visibility efforts are often overshadowed, hindering India's ability to position itself as an attractive destination for logistics professionals seeking career advancement. Without effective branding and visibility strategies, the industry risks being overlooked by both job seekers and investors, stalling its progress on the global stage.

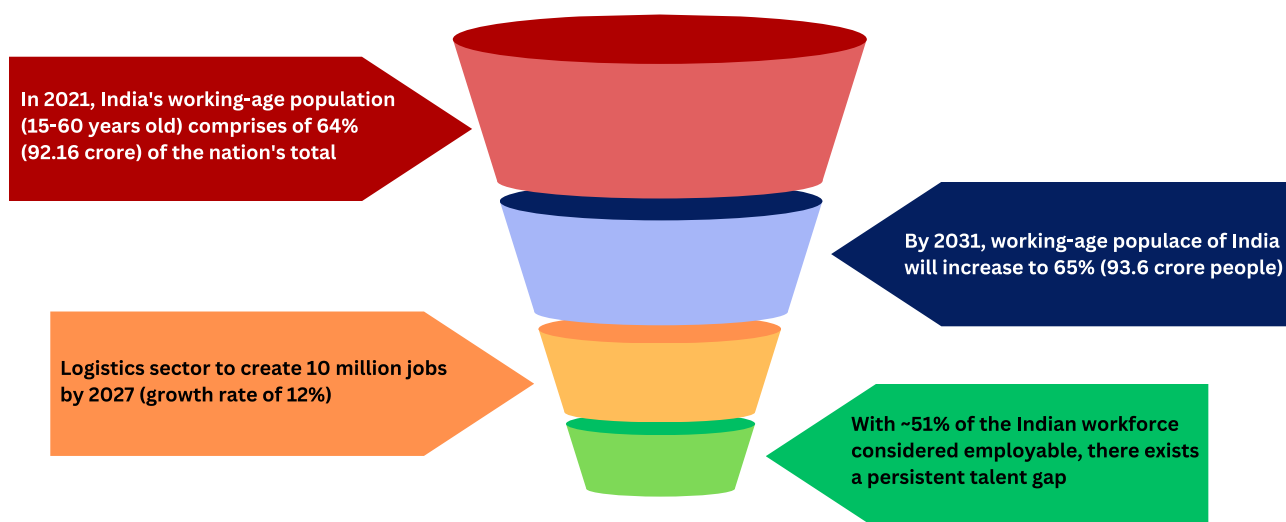


Figure 5.1: Current Scenario of India's Working Population

However, amidst these challenges lie opportunities for transformation and progress. By implementing targeted training initiatives, educational programs, and outreach activities, India can bridge the talent gap and demystify the logistics sector for aspiring professionals. Strategic investments in competitive compensation packages, professional development avenues, and partnerships with educational institutions can enhance the industry's appeal and foster a pipeline of skilled talent. Moreover, recognizing the critical role of human resources (HR) departments is paramount. By adopting holistic HR strategies that prioritize talent acquisition, development, and retention, organizations can cultivate a skilled and sustainable workforce, driving India's logistics revolution forward.



Figure 5.2: Key Attributes for Shaping the Future of Indian Logistics Workforce

In essence, by addressing these pressing issues head-on and implementing strategic solutions, India can solidify its position as a global logistics powerhouse, poised for sustained growth and success. This chapter outlines the essential transformation needed in the logistics workforce model, sheds light on the overlooked potential within the logistics sector's human resources and explores the emerging job prospects and skill demands amidst the evolving logistics landscape.

5.1. Evolution in Logistics Workforce Model

Historically, logistics firms have long abided by hierarchical organizational frameworks, marked by compartmentalized roles and centralized decision-making processes. In these traditional hierarchical organizational frameworks, decision-making processes are centralized, with a transparent chain of command dictating communication and control. While this structure offers perceived efficiency and power, it often leads to rigidity and slow adaptation to market changes. Compartmentalized roles result in impeded communication, hindering collaboration and innovation. Employees at lower levels may feel disengaged due to limited autonomy and opportunities for input, leading to lower morale and productivity. Moreover, the hierarchical model tends to prioritize organizational goals over customer needs, potentially compromising service quality and responsiveness. The imperatives of today's dynamic marketplace compel a transformative shift towards an agile, decentralized, and synergistic workforce model. According to a study by PwC, **78%** of logistics CEOs acknowledge the need to redesign their organizational structures to enhance agility and responsiveness.

Modern organizational frameworks are shaped around the technological advancements in the logistics industry and thus address these flaws by embracing decentralized authority and networked collaboration. With technology facilitating real-time communication and data-driven decision-making, organizations can empower employees at all levels to make informed decisions autonomously. Cross-functional teams bring together diverse expertise to tackle complex challenges and drive innovation.

Agile work practices enable quick responses to changing market dynamics, while an emphasis on customer-centricity ensures that services and processes are tailored to meet customer needs effectively. Investment in digital infrastructure further enables seamless integration and connectivity across the supply chain, fostering a culture of innovation and continuous improvement. The modern framework prioritizes flexibility, collaboration, and customer-centricity, ensuring logistics firms adapt and thrive in today's dynamic business environment.

Table 5.1: A Brief Comparison of Traditional Hierarchical Framework and Modern Frameworks

Feature	Traditional Hierarchical Frameworks	Modern Frameworks with Technology Advancements
Communication Structure	Hierarchical lines of communication with limited cross-departmental interaction	Networked collaboration, facilitating real-time communication and information sharing
Decision Making	Centralized decision-making processes with limited autonomy at lower levels	Decentralized authority, empowering employees to make informed decisions autonomously
Specialization	Compartmentalized roles to maximize efficiency within departments	Cross-functional teams bringing together diverse skill sets and expertise
Efficiency	Perceived efficiency due to clear chain of command	Agile work practices allowing for quick responses to changing market dynamics
Control	Centralized decision-making for greater control over operations	Data-driven decision-making leveraging advanced analytics and AI
Rigidity	Structures may be rigid and slow to adapt to changes in the market	Emphasis on customer-centricity, tailoring services and processes to meet customer needs
Communication Barriers	Siloed communication, hindering collaboration and innovation	Investment in digital infrastructure enabling seamless integration and connectivity
Employee Engagement	Limited autonomy and opportunities for input from lower-level employees	Foster a culture of innovation and continuous improvement

Embracing cross-functional teams, flatter hierarchies, and distributed decision-making frameworks enables companies to swiftly adapt to dynamic market conditions and capitalize on emerging opportunities.



68.9%

India would have the highest share of working age population by 2030

Figure 5.3: Forecast of India's Share of Working Age Population

5.2. Human Resource: India's Aging Workforce

India's human resources landscape is undergoing a significant transformation, as evidenced by a plethora of statistical insights and projections. With a projected working-age population surpassing 1.04 billion by 2030, India solidifies its position as a hub of human capital. Alongside this demographic strength, a forecasted historic low dependency ratio of 31.2% in 2030 embarks on India's pivotal role in shaping the global workforce. India would be retaining its status as the world's primary source of human resources and is set to contribute to 24.3% of the incremental global workforce in the next decade.

However, amidst the promising demographic projections lie emerging challenges, particularly concerning the aging of the workforce. The data paints a nuanced picture of this phenomenon, revealing a notable decline in the number of young workers entering the labor force. For instance, in 2016-17, there were 10.34 crore people under the age of 30 years in the workforce, but by 2022-23, this number had fallen by over 3 crore to just 7.1 crore. This decline in the share of young workers, coupled with a concurrent increase in the proportion of older individuals aged 45 and above, signifies the onset of an aging workforce paradigm. Approximately 40% of India's logistics workforce comprises individuals aged 45 and above. This highlights the significant presence of older workers within the logistics sector, indicating a notable aging trend in the workforce.

Moreover, there has been a notable 31% decline in youth employment over the past seven years. The dwindling employment rate among 15 to 30-year-olds, now at 19 out of 100, demands the urgent need for youth empowerment. The implications of these demographic shifts are profound, necessitating a strategic response from policymakers, industry leaders, and educational institutions. At the forefront of this response is the imperative to integrate technology into workforce development strategies. Statistics reveal a rapid rise in technology adoption across various sectors, with significant implications for skill requirements and job roles. For instance, the employment rate among the age group of 25 to 29 years displays an upward trend over the last seven years, attributed in part to technological advancements driving demand for digital skills.

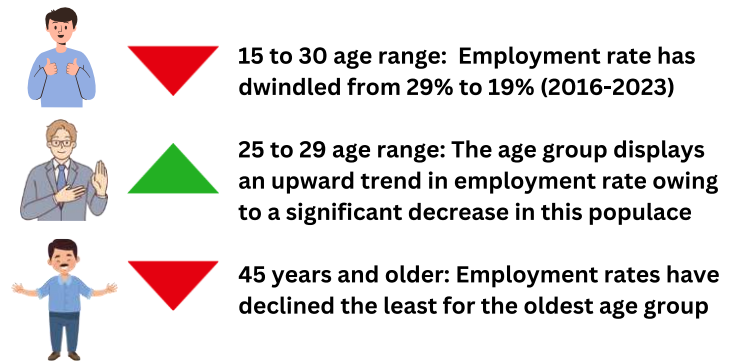


Figure 5.5: India's employment rate from (2016-2023)

Thus, the logistics sector needs to catch up, with a notable shortage of talent proficient in sustainable logistics operations and carbon footprint reduction strategies. This shortage impedes the industry's growth and undermines progress towards achieving global sustainability objectives.

Moreover, it intensifies competition among companies for the limited pool of qualified candidates, potentially inflating recruitment costs and diminishing organizational productivity and efficiency. Resolving this skill gap necessitates collaborative efforts between industry stakeholders, educational institutions, and policymakers to realign curricula with industry demands, promote internships, and foster lifelong learning initiatives tailored to evolving skill requirements in sustainable logistics operations.

As we delve deeper into workforce development strategies for the logistics sector, we need to prioritize technology-enabled learning and upskilling initiatives to ensure the workforce remains competitive and adaptable in the face of evolving job market dynamics.

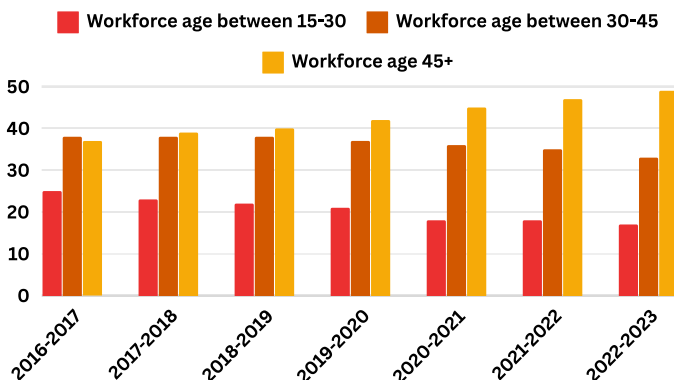


Figure 5.4: India's Working Age Distribution from 2016-2023

Sustainability in logistics operations faces a formidable challenge with broad implications within the logistics sector. Globally, the figures indicate that only 1 in 8 employees possess the requisite green skills for roles in sustainable industries. This stark reality stresses a critical issue: As companies increasingly prioritize environmentally sustainable practices and green initiatives, they need help sourcing qualified individuals with the necessary expertise.

5.3. Emerging Skills and Job Opportunities for Logistics Professionals

The evolving dynamics of the logistics landscape necessitate a commensurate evolution in the skill sets demanded of industry professionals. In addition to mastering conventional skills like inventory management and supply chain optimization, proficiency in emerging technologies is indispensable for ensuring future success. A comprehensive study conducted by Deloitte reveals the growing demand for data analytics expertise within the logistics domain, with over 70% of logistics companies citing analytics as a critical skill for enhancing operational efficiency and decision-making. Furthermore, soft skills such as adaptability, resilience, and effective communication are increasingly valued in an environment characterized by volatility and uncertainty.

As logistics and supply chain management undergoes technological transformation, professionals must acquire required skills and proficiency in emerging technologies such as Internet of Things (IoT), Generative AI, Machine Learning and Big Data analytics, Robotics and Blockchain.

These technologies are revolutionizing traditional logistics operations by enabling real-time tracking and scheduling, predictive maintenance, warehouse and inventory automation and optimization, and secure transaction processing. As technology advances and swiftly integrates into the logistics sector, it is imperative for the current workforce to evolve and acquire technical skills, reducing reliance on external sources for managing such technology.

Beyond technical skills, logistics professionals must also cultivate soft skills such as adaptability, critical thinking, and collaboration.



Figure 5.6: Emerging and Redundant Jobs in Logistics Sector

In a fast-paced and unpredictable environment, the ability to adapt to change and think creatively is essential for overcoming challenges and seizing opportunities. Moreover, effective communication and collaboration are vital for fostering strong relationships with clients, suppliers, and internal stakeholders. As logistics operations become increasingly interconnected and globalized, professionals must demonstrate cultural sensitivity, empathy, and negotiation skills to navigate diverse environments and build successful partnerships. By fostering a culture of continuous learning and development, logistics companies can empower their workforce to thrive in an ever-evolving industry landscape.

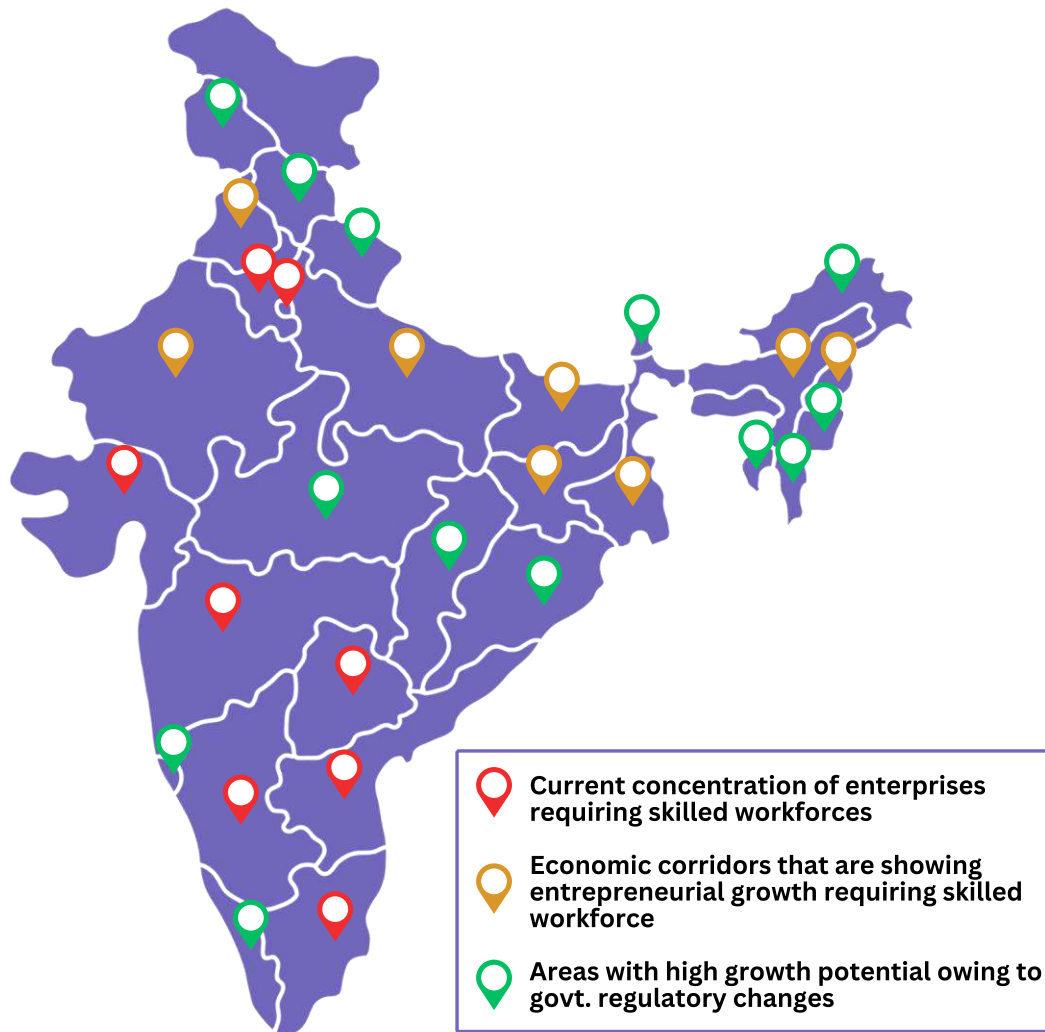


Figure 5.7: Concentration of Current Workforce, Economic Corridors and Potential Areas of Growth in India

The burgeoning growth of India's logistics sector heralds a plethora of job opportunities across diverse functional domains. A seminal report by the Indian Brand Equity Foundation (IBEF) forecasts that the logistics industry is poised to generate over 10 million new jobs by 2025. This surge in employment is underpinned by the exponential expansion of e-commerce, warehousing, transportation, and supply chain management segments. Furthermore, the rise of emerging technologies augurs the creation of novel job roles requiring specialized skill sets. Thus, to meet the evolving demands of the logistics industry, educational institutions and training providers must redesign their programs to incorporate emerging technologies and industry best practices.

Hands-on experience with state-of-the-art tools and technologies, such as simulation software and virtual reality training modules, can enhance practical skills and prepare professionals for real-world scenarios.

Industry-academic collaborations and experiential learning opportunities, such as internships and apprenticeships can bridge the gap between classroom theory and industry practice. By investing in the professional development of its workforce, India can cultivate a talent pool of skilled logistics professionals capable of driving innovation, efficiency, and sustainability in the logistics sector.

5.4. Strategies for Addressing Talent Shortages

A comprehensive analysis conducted by Ernst & Young reveals that while seasoned professionals bring invaluable industry experience, the influx of younger talent, particularly from STEM (Science, Technology, Engineering, and Mathematics) disciplines, injects fresh perspectives and technological acumen into the workforce. Approximately 40% of the logistics workforce in India, highlighting the imperative for organizations to adopt inclusive talent management practices that cater to the distinct needs and aspirations of different age demographics.

Initiatives aimed at fostering diversity and inclusivity, coupled with targeted efforts to address the specific needs of older workers, are essential for maximizing the potential of India's human resources. By harnessing the power of technology to enhance workforce knowledge and skills, India can navigate demographic shifts, drive innovation, and ensure sustainable economic growth in the logistics sector and beyond.

5.4.1. Educational Institutes, Training Methodologies for Skill Development

Addressing the pervasive skills gap necessitates a concerted emphasis on education and training initiatives tailored to the evolving needs of the logistics sector. Collaborative partnerships between industry stakeholders, educational institutions, and government bodies are instrumental in fostering a conducive ecosystem for skill development. A study by KPMG highlights the efficacy of vocational training programs in augmenting employability, with over 80% of graduates from certified vocational courses securing gainful employment in the logistics sector within six months of completion.

Leveraging digital platforms and immersive learning technologies further enhances accessibility and scalability of training initiatives, empowering aspiring professionals to acquire industry-relevant competencies irrespective of geographical constraints. In the endeavor to cultivate India's prospective workforce in the logistics domain, several esteemed institutions hold significant importance.

These institutes include Indian Institute of Technology (IIT) (Department of Industrial and Management Engineering), Indian Institute of Management (IIM), National Institute of Technology Tiruchirappalli (NIT Trichy) (Department of Management Studies), Indian Institute of Logistics (IIL), Indian Maritime University (IMU), Indian Institute of Foreign Trade (IIFT), Indian Institute of Materials Management (IIMM), Indian Institute of Packaging (IIP), Indian Institute of Export Management (IIEEM), Central Institute of Fisheries Education (CIFE) (Department of Fisheries Business Management) and many more.

These institutions prioritize the development of curricula and the implementation of training methodologies that constantly evolve to reflect the latest industry advancements. They offer a wide range of courses encompassing pertinent topics such as optimizing supply chains, formulating logistics strategies, managing transportation logistics, as well as incorporating cutting-edge disciplines like artificial intelligence, cybersecurity, big-data, robotics and automation, etc. into logistics and supply chain management practices. These programs stand out for their adept utilization of cutting-edge technology, elevating the learning experience.

Employing virtual simulations and interactive tools, they provide students with immersive opportunities to grapple with real-world challenges encountered in the logistics sector. Furthermore, practical exposure holds a paramount position within these educational endeavors. Through engagement in authentic projects and industry internships, students acquire hands-on skills that are highly valued by potential employers. Moreover, these institutes foster strategic collaborations with leading logistics firms to ensure the continual relevance of their offerings.

By orchestrating guest lectures and workshops, they facilitate student exposure to contemporary industry practices and emerging trends. Such knowledge centers present a compelling proposition for aspiring young professionals seeking to establish a career in the logistics sector. Through their industry-aligned courses and experiential learning opportunities, they effectively equip the youth with the requisite skills and knowledge to thrive in the dynamic landscape of the logistics sector.

5.4.2. Government Initiatives and Policies

Governmental interventions play a pivotal role in shaping the contours of the logistics workforce ecosystem. The enactment of progressive policies and regulatory frameworks is instrumental in incentivizing skill development initiatives and fostering public-private partnerships.

A case in point is the Pradhan Mantri Kaushal Vikas Yojana (PMKVY), a flagship scheme launched by the Government of India to impart skill training to over 10 million youth across diverse industry sectors, including logistics and transportation. Furthermore, regulatory reforms such as the implementation of the GST regime have streamlined logistics operations, catalyzing operational efficiencies and cost optimization across the supply chain spectrum.

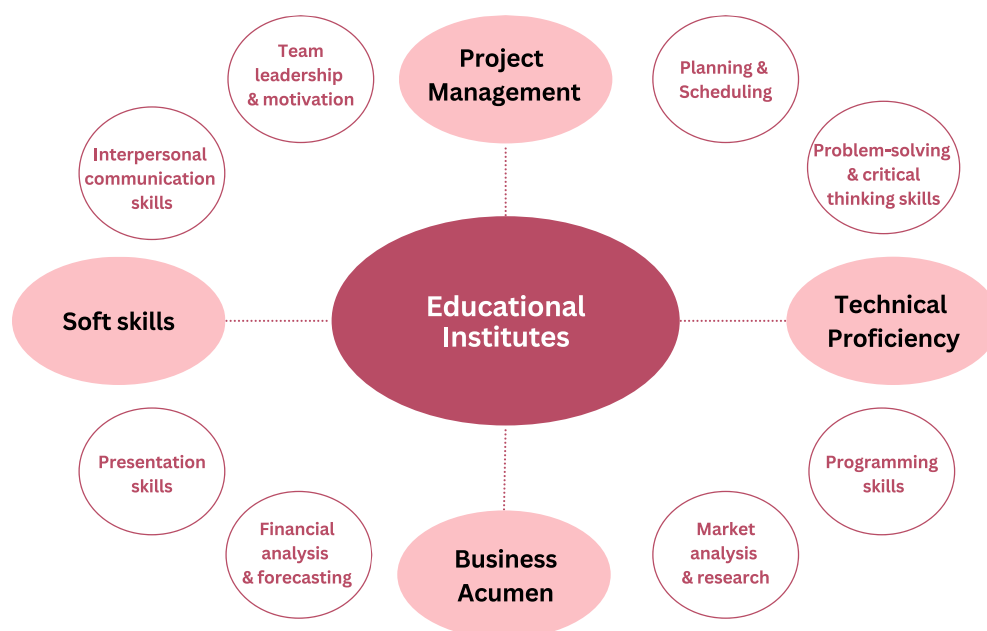


Figure 5.8: Key Skills Enhanced by Educational Institutes

The Aatmanirbhar Bharat package announced to mitigate the adverse impact of the Covid-19 pandemic, encompasses various long-term schemes, programs, and policies aimed at fostering self-reliance and creating employment opportunities. This comprehensive package provided a fiscal stimulus exceeding INR 27 lakh crore. Investments in infrastructure and productive capacity are acknowledged as catalysts for growth and employment. The budget allocation for capital investment has seen a significant increase, reaching INR 10 lakh crores in the fiscal year 2023-24. This surge in investment, amounting to 3.3% of GDP, reflects the government's strategic focus on enhancing growth potential and job creation. The Aatmanirbhar Bharat Rojgar Yojana (ABRY), launched as part of the Aatmanirbhar Bharat package 3.0, incentivizes employers to create new employment opportunities while providing social security benefits. Implemented through the Employees' Provident Fund Organization (EPFO), this scheme aims to alleviate the financial burden on employers and stimulate job creation.

Additionally, initiatives like the Pradhan Mantri Mudra Yojana (PMMY) facilitate self-employment by extending collateral-free loans up to INR 10 lakh to micro and small business enterprises. The Production Linked Incentive Schemes hold the potential to create 60 lakh new jobs, further contributing to employment generation across various sectors.

The Garib Kalyan Rojgar Abhiyaan (GKRA) served as a lifeline for returnee migrant workers and affected individuals in rural areas, providing employment opportunities through targeted interventions in select districts. PM GatiShakti initiative is a transformative approach for economic growth and sustainable development, focusing on enhancing infrastructure across seven key sectors, including logistics.

By leveraging clean energy and fostering inclusive participation, this initiative creates significant job and entrepreneurial opportunities, driving India's economic progress. The government's emphasis on railways, roads, urban transport, power, telecom, textiles, and affordable housing, alongside initiatives like the National Infrastructure Pipeline and Production Linked Incentive schemes, embarks its commitment to generating employment and boosting output in the medium to long term. Furthermore, initiatives such as the Prime Minister's Employment Generation Programme (PMEGP), Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS), and various skill development programs demonstrate the government's multi-pronged approach towards employment generation and skill enhancement.

In synergy with flagship programs like Make in India, Start-up India, Digital India, and Smart City Mission, these initiatives are instrumental in creating a conducive environment for employment generation, paving the way for a robust and resilient workforce poised to shape India's future economy.



Figure 5.9: Government Initiatives Empowering India's Logistic Workforce

5.5. Women in Logistics Sector

The logistics and supply chain management industry, traditionally viewed as male-dominated, is experiencing a notable shift with increasing representation of women professionals. Statistics indicate that women continue to be an untapped resource in the talent pool of this industry. Fostering an inclusive work culture has become imperative for nurturing new and innovative ideas crucial for the sector's growth. Recent industry trends show a shift towards skill-based recruitment approaches, indicating a departure from traditional gender biases. According to a report by Gartner, women constituted around 41% of the supply chain workforce in 2021, with approximately 15% holding top echelon positions. Factors such as the pandemic-induced labor shortage have contributed to the rise of women professionals in the industry, prompting logistics companies to increase hiring rates. Women have played pivotal roles during the pandemic, driving sustainability efforts, advocating for employee rights, and embracing new technologies, inspiring young women to join the sector.

To accommodate female professionals, logistics companies are reevaluating traditional roles and embracing digitization. Many women in the industry currently hold 9 to 5 office jobs, but there is recognition of the need for diverse skills such as conflict management, decision-making, and goal attainment, which women often excel in. Moreover, advancements in digitization have made physical strength less of a prerequisite, opening doors for increased inclusivity in roles traditionally perceived as physically demanding.

Diversity, equity, and inclusion (DEI) have emerged as key priorities for the transportation and logistics industry, with approximately 74% of companies making DEI a priority in their hiring processes. To attract more women to the workforce, companies are setting clear gender equality targets, adopting new technologies, and fostering a culture of growth. By embracing gender diversity and inclusion, logistics companies can leverage a broader range of perspectives and expertise, ultimately enhancing their bottom-line performance.

Shaping India's logistic workforce necessitates a multifaceted approach predicated on collaboration, innovation, and foresight. By embracing technological advancements into logistics operations and skill development, India can forge a future-ready logistics workforce ecosystem capable of driving sustainable growth, fostering socio-economic development, and enhancing global competitiveness in the dynamic landscape of global trade and commerce.

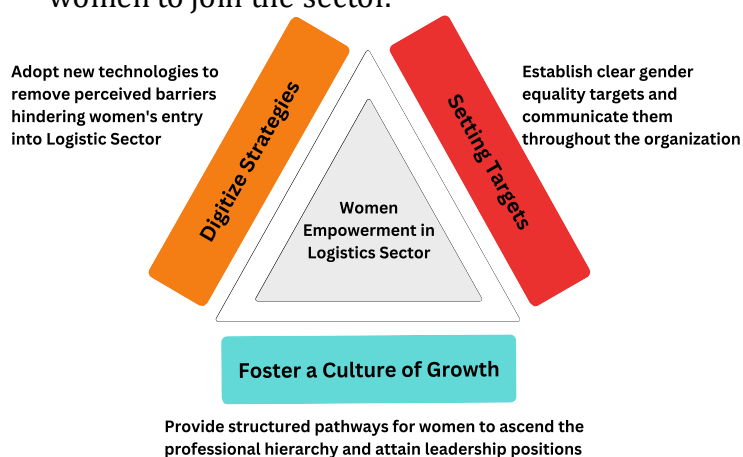


Figure 5.10: Key Aspects to Implement for Empowering Women Workforce in Logistics Sector



6

Recommendations

6. Recommendations

The recommendations have been designed to improve the curriculum, training program, certification program, research environment, the culture of innovation and entrepreneurship, considering technological advancement, current and future industry requirements, and national education policy related to manufacturing, logistics and supply chain management. Above all, there is a need to grow a dynamic ecosystem of practical learning, problem solving skills, research, and innovation in manufacturing and logistics to serve as a solid base for India's excellence and leadership.

6.1. Recommendations on Curriculum

Considering the significant workforce demands in the logistics sector, alongside technological advancements and future industry needs, our objective is to develop a highly employable knowledge base by revising the curriculum integrating hands-on learning with real-world case studies. We recommend institutions offer "Introduction of Logistics and Supply Chain" to all 1st year engineering students to develop an understanding of the essential components of logistics and transportation.

Educational institutions can prepare curricula for the evolving needs of the manufacturing, logistics, and supply chain management industries for different levels, such as:

Foundational Courses

- Supply Chain Management Fundamentals
- Logistics Management

Advanced Courses

- Programming With AI for Problem Solving
- Design Thinking With AI
- Operation Research
- Supply Chain Analytics
- Global Procurement & Supply Management
- Supply Chain Finance

Experiential Learning

- Applied Projects
- Simulation and Modeling

Soft Skills Development

- Communication and Collaboration
- Problem-Solving and Strategic Thinking

Emerging Topics

- Reverse Logistics
- Service Supply Chains

To equip students for the evolving demands and digital advancement, institutions can develop 15 hours or 30 hours of certification courses, global online courses through SWAYAM and NPTEL platforms and video lectures on Multimodal Logistics, Road Transport, Rail Freight Transport, Maritime Transport, Air Cargo Shipment, E-Commerce and Q-commerce, Omnichannel Commerce, Reverse Logistics, Return Management, Healthcare Logistics, Agri-Food Supply Chain, Cold Supply Chain, Emergency Supply Chain Management, Metal and Mineral Supply Chain, Oil and Gas Supply Chain, Semiconductor Supply Chain, Warehouse Automation, Automotive Industry and Household Sectors, Supply Chain for the Energy Sector, Space Industry Supply Chain, Nuclear Power Plant Supply Chain, Military Logistics, Spare Parts Supply Chain, Generative AI, Big Data Analytics, Cloud Computing, Quantum Computing, Internet of Things, 6G Technology, Geo-Spatial Technologies, Digital Twin, Augmented Reality (AR) and Virtual Reality (VR), Control Tower, Robotics, Autonomous Vehicles, Drones, SDG in Supply Chain Management, Clean Technology, Carbon Footprint, Water Footprint, 3D Printing.

Several institutions have been motivated by different initiatives of the Ministry of Education and started offering several courses in logistics, but not in a coordinated manner.

Several institutions have been motivated by different initiatives of the Ministry of Education and started offering several courses in logistics for undergraduate (UG) and postgraduate (PG) students, but not in a coordinated manner. The civil engineering department of IITs, NITs and Central Universities offers courses like traffic management, Urban Transportation Systems Planning, Traffic Flow Modeling And Simulation, Transportation Economics, Airport Systems Planning And Design, Cyber Security Threats in Supply Chain, Hazards Identification and Risk Analysis in Industries, Geospatial technology and its applications etc. They even run subjects like transportation engineering and planning.

It is observed that several B-schools have also launched subjects related to logistics and supply chain management for their PG, diploma and MBA students.

Indian Institutes of Management (IIM) Mumbai accepted the request from AICTE, conducted several meetings with experts from industry and academia, and prepared a detailed syllabus for the bachelor and master programs (details are given in annexure). These courses have been designed to meet the need of industry to meet the requirements of logistics and its coherence and compatibility with technological advancements.

Part of NEP implementation IIM Mumbai (earlier NITIE) was declared as the nodal hub by the Ministry of Education and designed several subjects (details are given in annexure) related to logistics and supply chain management.

In order to stay competitive and remain relevant in the global arena, it is crucial to adapt and enhance plans in line with the constantly evolving dynamics of the industry, advancements in technology, and the expectations of stakeholders.

Even keeping pace with emerging technologies and talent requirements in logistics sectors, IIMs launched several courses like Supply Chain Digitization and Management, Business and Operations Analytics, End-to-End Supply Chain Transformation through Digitization, Supply Chain & Demand Analytics, Data-Driven Supply Chain Transformation, Competing in Business through AI-powered supply Chains, Reinventing Business Operations with Data Analytics, Generative AI in Supply Chain Management, Supply Chain Operations and Disruptions Management, Modelling and Building Digital Supply Chain Twins using anyLogistix and trained more than 20k individuals including students and industry professionals. Now, it is time to offer similar courses in other institutions for diploma, graduate and vocational education to meet the futuristic skilled workforce requirements.

To support the Logistics Human Resource Development and Capacity Building under the PM Gati Shakti National Master Plan, IIM Mumbai established the Centre of Excellence in Logistics and Supply Chain Management and the Center for Innovation Incubation & Entrepreneurship, IIT Madras set up the National Technology Centre for Ports, Waterways & Coasts and the Centre for Railway Research, IIM Bangalore established TCI-IIMB Supply Chain Sustainability (TCI-IIMB SCSL) Lab and the Supply Chain Management Centre, NIT Calicut launched Centre of Excellence in Logistics and Supply Chain Management (CoELSCM), and Doon University proposed to establish a Centre of Excellence in Logistics and Supply Chain Management.

It is interesting to note that the Tata Institute of Social Sciences (TISS) and the Logistics Sector Skill Council (LSC) offered Post Graduate Diploma in Supply Chain and Logistics Management, Post Graduate Diploma in Data Science for Logistics, and Post Graduate Diploma in Drone Management to meet the future logistics challenges.

To enhance the educational offerings in logistics, it is essential to map the existing courses, identify gaps in their content and delivery, and provide suggestions to bridge these gaps. This approach ensures that the courses remain relevant, comprehensive, and aligned with the evolving needs of the logistics industry.

Existing Courses:

Fundamentals of Supply Chain Management, Supply Chain Strategy and Design, Inventory Management and Optimization, Supply Chain Analytics

Gaps:

- Limited focus on the integration of emerging technologies (e.g., AI, IoT, blockchain)
- Insufficient real-world case studies and simulations
- Lack of emphasis on sustainability and green logistics

Suggestions to Bridge Gaps:

- Introduce modules on AI, IoT, geospatial technologies and blockchain applications in supply chain management.
- Incorporate interactive simulations and case studies based on current industry challenges.
- Add courses or modules focused on sustainable practices and green logistics.

Existing Courses:

Transportation Systems and Planning, Logistics Operations and Management, Freight Transport and Distribution

Gaps:

- Insufficient coverage of multimodal transport solutions
- Limited practical training on logistics software and tools
- Lack of focus on regulatory and compliance issues in global logistics

Suggestions to Bridge Gaps:

- Expand content to include multimodal transport and intermodal logistics strategies.

- Provide hands-on training with industry-standard logistics software (AnyLogic, anyLogistix, Power BI, XLMiner, TMS, WMS, Tableau).
- Include comprehensive modules on international logistics regulations and compliance.

Existing Courses:

Warehouse Design and Layout, Inventory Control Techniques, Warehouse Operations Management

Gaps:

- Minimal exposure to advanced warehousing technologies (e.g., automated storage and retrieval systems, robotics)
- Limited training on warehouse safety and risk management
- Lack of focus on lean warehousing practices

Suggestions to Bridge Gaps:

- Introduce advanced warehousing technology modules and virtual tours of automated warehouses.
- Add dedicated sessions on warehouse safety standards and risk mitigation strategies.
- Incorporate lean warehousing principles and practices into the curriculum.

Existing Courses:

Data Analytics for Logistics, Predictive Analytics in Supply Chain, Logistics Performance Measurement

Gaps:

- Insufficient practical exercises and real-time data analysis
- Limited coverage of big data applications in logistics
- Lack of training on data visualization tools and techniques

Suggestions to Bridge Gaps:

- Integrate more hands-on projects and real-time data analysis exercises.
- Expand content to include big data and its applications in logistics.
- Provide training on advanced data visualization tools (e.g., Tableau, Power BI).

Existing Courses:

Global Logistics and International Trade, International Logistics and Supply Chain Management, Global Trade Compliance and Documentation, Cross-Border Transportation

Gaps:

- Limited focus on the impact of geopolitical factors on global logistics
- Insufficient practical training on customs procedures and international shipping
- Lack of emphasis on cross-cultural communication and negotiation skills

Suggestions to Bridge Gaps:

- Include modules on geopolitical risk management in logistics.
- Provide practical training sessions on customs procedures and documentation.
- Incorporate training on cross-cultural communication and negotiation strategies.

Existing Courses:

Strategic Procurement, Procurement and Supplier Management, Supplier Relationship Management, Contract Negotiation and Management

Gaps:

- Limited focus on digital procurement technologies (e-procurement, blockchain)
- Insufficient case studies on successful supplier relationship management
- Lack of emphasis on ethical sourcing and sustainability in procurement

Suggestions to Bridge Gaps:

- Introduce modules on digital procurement technologies and their applications.
- Incorporate detailed case studies and best practices in supplier management.
- Add content on ethical sourcing practices and sustainability in procurement.

In the coming days, it is necessary to develop sector-specific courses to create a knowledge base and meet the demand for futuristic logistics workforce by integrating domain knowledge, advanced technologies, and real-world use cases. Some sample courses are:

- GIS Application in Shipping and Port Management
- Application of IoT in Food Supply Chain
- Application of Geospatial Technology in Humanitarian Logistics
- Smart Contracts for Global Supply Chain
- Sustainable Packaging for E-Commerce
- Robotic Material Handling for Chemical Industry
- Retail Logistics Network Simulation
- Digital Twin for Port Operations
- Warehouse Digital Twin
- Smart Contracts for Construction Supply Chain
- IoT Enabled Cold Supply Chain
- Control Tower for Integrated Logistics
- Risk Assessment in Purchase Order Financing
- Supply Chain Finance Analytics
- AI-driven Resilient Supply Chain
- Blockchain integrated Multimodal Logistics
- Data-driven Forecasting for CPG Industry
- RUL Prediction using Machine Learning for Pharma Industry
- VR for Driver Training
- GEN-AI for CPG Supply Chain
- Energy Efficient Cold Supply Chain
- Smart Packaging & Carton Set Optimization
- Knowledge Graph Driven Retail Supply Chain



6.2. Recommendations for Faculty Training

The need for faculty members with expertise in logistics (advanced equipment) and emerging technologies (tools, algorithms, automation) is a pressing issue that requires immediate attention.

It is crucial that faculty remain aware of emerging developments that can impact real-world operations, and accordingly they must modify teaching materials, teaching patterns and research objectives.

The following recommendations have been made to overcome the identified challenges and capitalize on the contextual reality while drawing upon the global framework and incorporating the spirit of NEP-2020.

Provide Training on Digital Supply Chain Technologies

- Offer workshops and seminars on the latest digital technologies impacting supply chains, such as AI, machine learning, IoT, and blockchain.
- Encourage faculty to earn certifications in specialized areas like supply chain analytics and digital transformation.

Utilize Experiential Learning Tools

- Incorporate simulation software and analytical tools into the curriculum to provide hands-on experience in supply chain decision-making.
- Collaborate with industry partners to develop case studies and projects that expose faculty to real-world supply chain challenges.

Compulsory Induction Program and Continuous Refresher Courses for Newly Joined Faculty Members

Implement compulsory induction programs for new faculty members, complemented by regular refresher courses. These initiatives should align with the integration of Indian Knowledge Systems (IKS) as outlined in the NEP-2020.

Enhanced Peer Review of Teaching:

- Foster a culture of reflective practice by encouraging faculty members to exchange feedback on teaching, scholarship, and presentations.
- Collaborative approach promotes self-evaluation and continuous improvement of faculty performance.

In-Service Professional Training and Development

- To improve faculty skills and knowledge to fulfill the educational profession's changing needs, on-the-job training is essential. It covers a range of elements essential to efficient instruction and learning. One component is setting up courses for professional development that address the fundamentals of effective teaching and classroom dynamics. These courses offer resources, including learning objectives, syllabi, daily lesson plans, and efficient teaching strategies designed to support higher-order thinking.
- Including components of cultural communication in responsive teaching strategies is another crucial feature. Faculty members will then have the tools and information needed to create welcoming, stimulating learning environments that meet the requirements of a wide range of students and improve academic achievement.

Foster Online Collaboration and Knowledge Sharing

- Create online communities and discussion forums for faculty to share best practices, resources, and insights.
- Encourage faculty to participate in webinars, virtual conferences, and online courses to stay updated on industry trends

Clearly Stated Goals and Excellence Acknowledgment

- Define precise, quantifiable performance criteria for the teaching profession and put in place systems to encourage faculty members to reach and beyond these goals in order to establish excellence in teaching.
- Establish a mentorship program in which faculty members choose their own mentors according to their own requirements and preferences. This gives mentees the freedom to select mentors who may offer them individualized advice and assistance in line with their aspirations for professional growth.

Development of a Mentorship Program

- Mentorship Program would be a self-selection effort that enables faculty members to personally choose their mentors. This method leads to a more nuanced and tailored guidance process.
- The program promotes personalized support by enabling individuals to select mentors who are aligned with their specific needs and ambitions. This customized approach not only improves professional growth but also fosters a stronger sense of ownership and dedication among participants.

Provide Technical Support and Resources

- Ensure faculty access to reliable IT infrastructure and technical support for online teaching and collaboration.
- Curate a repository of digital resources, such as online tutorials, videos, and articles, to support faculty in integrating technology into their teaching.

Structured Faculty Development Initiatives

- Provide extensive professional development courses that encompass teaching methodology, networking strategies, mentorship possibilities, educational administration, course design, research methodologies, and avenues to career advancement.
- Some examples of professional development opportunities include pedagogy workshops, technology integration seminars, mentoring sessions, curriculum creation workshops, diversity training, and participation in the Malaviya Mission Teacher Training Programme (MMTTP).

Conformity with the objectives of the institution:

- Ensuring that the faculty growth programs are closely linked to the institutions long-term goals is important.

6.3. Recommendations on Industry Involvement

It is now very important to include strategies for industry involvement in the education process in order to find the next generation of professionals who can really meet the needs of the logistics industry. The following are strategy suggestions that have been made for educational institutions:

- Make strategic partnerships and work with major shipping, handling, logistics, and supply chain companies. Because these kinds of partners help spread some of the most useful information about new trends, problems at work, and wins, they make sure that the information taught in schools is always up to date.
- Add more cases and projects and focus on getting people from areas related to the industry to help. These projects give students the chance to put their theoretical knowledge into practice and learn everything there is to know about the subject. For example, they can come up with plans to solve problems within an organization or find sources that give them in-depth analyses of current market trends.
- Create advisory boards with people from the sector to provide guidance on curriculum creation, program improvements, and new trends in the business. By utilizing these specialists' experience, educational programs may stay current, relevant, and adaptable to the market's changing needs.
- Students can obtain certificates recognized by the industry, such as those granted by prestigious associations like the Council of Supply Chain Management Professionals (CSCMP) or the Association for Supply Chain Management (APICS). The skills and expertise of students in vital areas of supply chain management and logistics are validated by these credentials.

- Plan field trips to places like warehouses, depots, stocks, and other places where transportation ends. These active learning journeys help the students better understand how the business and everything that goes with it works in real life.
- Promote lifetime learning to students by actively engaging them in industry conferences, webinars, workshops, and professional development programs. To successfully navigate the ever-changing logistics market, one must stay up to date on industry innovations and best practices.
- Students should be able to be paired up with experienced adults who can help them. The employer above gave the students the right skills and tools and helped them find their way through the complicated logistics job path by giving them timely and personalized counseling and coaching.
- Creating strong internship programs can help students learn by letting them see how things really work. Not only do these learning experiences help you develop these important skills in the real world, but many of them also give you the chance to meet people who work in different fields, which can help you get hired in today's competitive job market.
- Improve education by holding great lecture series and workshops with guest speakers and experienced professionals as the main focus. These meetings, which cover topics like supply chain, inventory, and logistics, give students a chance to work in real business settings, which helps them think more critically and solve problems better.
- Incorporate case studies and simulations based on actual logistics situations into the curriculum. With the help of these interactive tasks, students may apply theoretical ideas to real-world situations, which helps them build strong problem-solving abilities.

6.4. Creation of a World Class Research and innovation Ecosystem in Logistics

Develop valuable collaboration and partnership opportunities by connecting with a wide range of esteemed research universities, institutions, and companies worldwide. To fully leverage global opportunities in logistics study, engaging in collaborative research, maintaining co-authorship on articles, and organizing joint exchange programs are essential strategies. It is important to allocate resources to establish state-of-the-art research centres, laboratories, and technological platforms dedicated to logistics research. These investments include state-of-the-art data analytics tools, simulation software, and experimental logistics facilities, all aimed at fostering advanced research and innovation.

Conduct awareness-raising activities and promote knowledge to showcase research findings, best practices, and innovations in the field of logistics. Coordinate a variety of events, including conferences, symposiums, seminars, and other gatherings, to facilitate the exchange of knowledge among researchers, practitioners, policymakers, and other interested parties.

It is crucial to develop systems that facilitate the transfer of technology and the commercialization of research findings. To effectively translate research findings into practical applications and commercial products that can benefit the logistics industry, offering assistance for patenting, licensing, and spin-off endeavors is crucial.

It is important to regularly assess and enhance the research and innovation ecosystem through feedback mechanisms, performance measurements, and benchmarking against global norms.

In order to stay competitive and remain relevant in the global arena, it is crucial to adapt and enhance plans in line with the constantly evolving dynamics of the industry, advancements in technology, and the expectations of stakeholders.

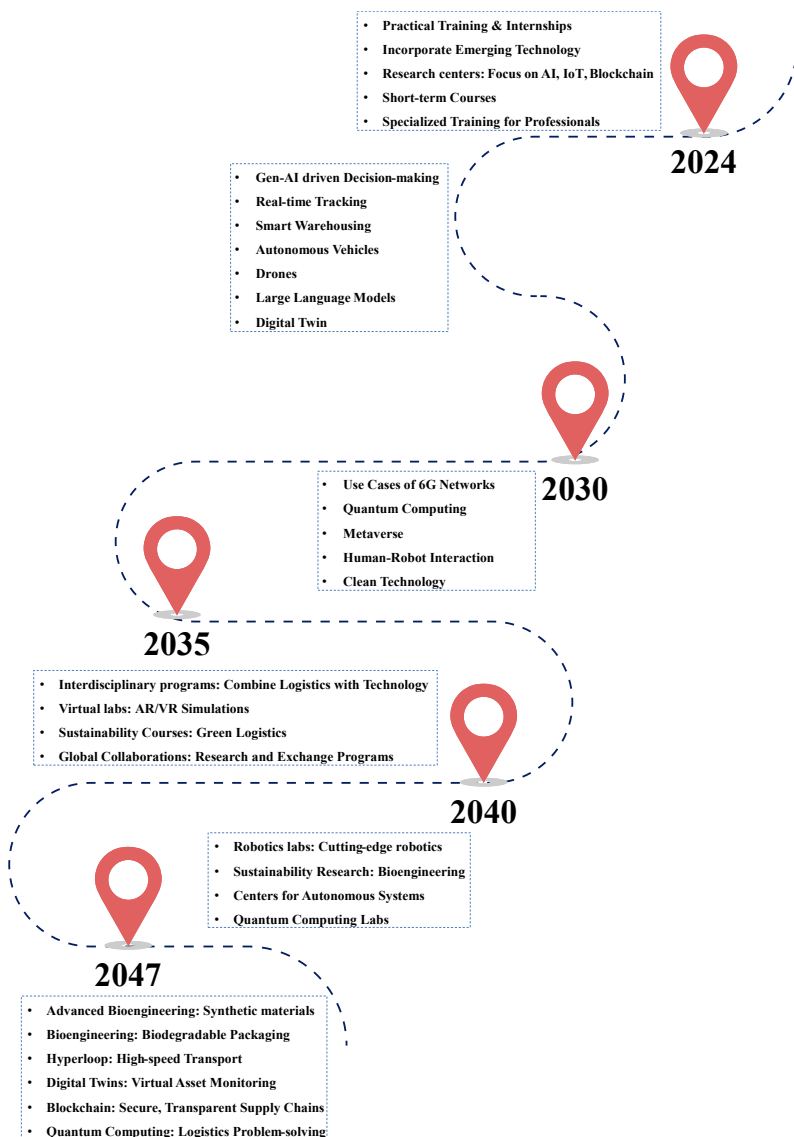
Create more research centers or institutes that are interconnected and dedicated to advancing knowledge in the field of logistics. Furthermore, these centers can become a central point for interdisciplinary collaboration and scholarly dialogue while prioritizing sustainability in their research activities and projects. In addition, collaborating with industry can help support the development of research agendas that are ambitious and innovative.

The Centre of Excellence in Blockchain Technology (CoE-BCT) aims to establish an interoperable blockchain ecosystem in India, fostering stakeholder. It will drive innovation, test blockchain solutions for government initiatives, and promote transparency in government services to enhance service delivery and increase confidence in government procedures.

Cultivate strong partnerships with influential industry stakeholders to collaboratively fund research initiatives, share data, and work together on innovative solutions. Establish industry advisory committees to provide guidance on research priorities and ensure alignment with industry needs and emerging trends.

Providing funding opportunities and competitive research grants to support innovative logistics research initiatives is important. Encourage faculty members and research teams to seek external funding from philanthropic organizations, government agencies, and industry consortia to expand the reach and impact of their projects.

Programs catering to the needs of students and researchers in the field of logistics should be developed with a strong emphasis on innovation and entrepreneurship. Offering support to startups and entrepreneurial ventures in the logistics industry, providing access to capital and assistance with incubation, mentoring, and other resources.



Implementation Mechanism

As discussed in different sections and sector-wise details, academic institutions should offer courses tailored to various skill levels based on candidate requirements to fulfil talent requirements in logistics sectors. Professional bodies such as the Logistics Sector Skill Council (LSC), the National Skill Development Corporation (NSDC), the Company of Master Mariners of India (CMMI), the Ministry of Ports, Shipping and Waterways, the Ministry of Skill Development and Entrepreneurship (MSDE), and Freight Forwarders can be roped by the individual institutions to support the skill development programs.

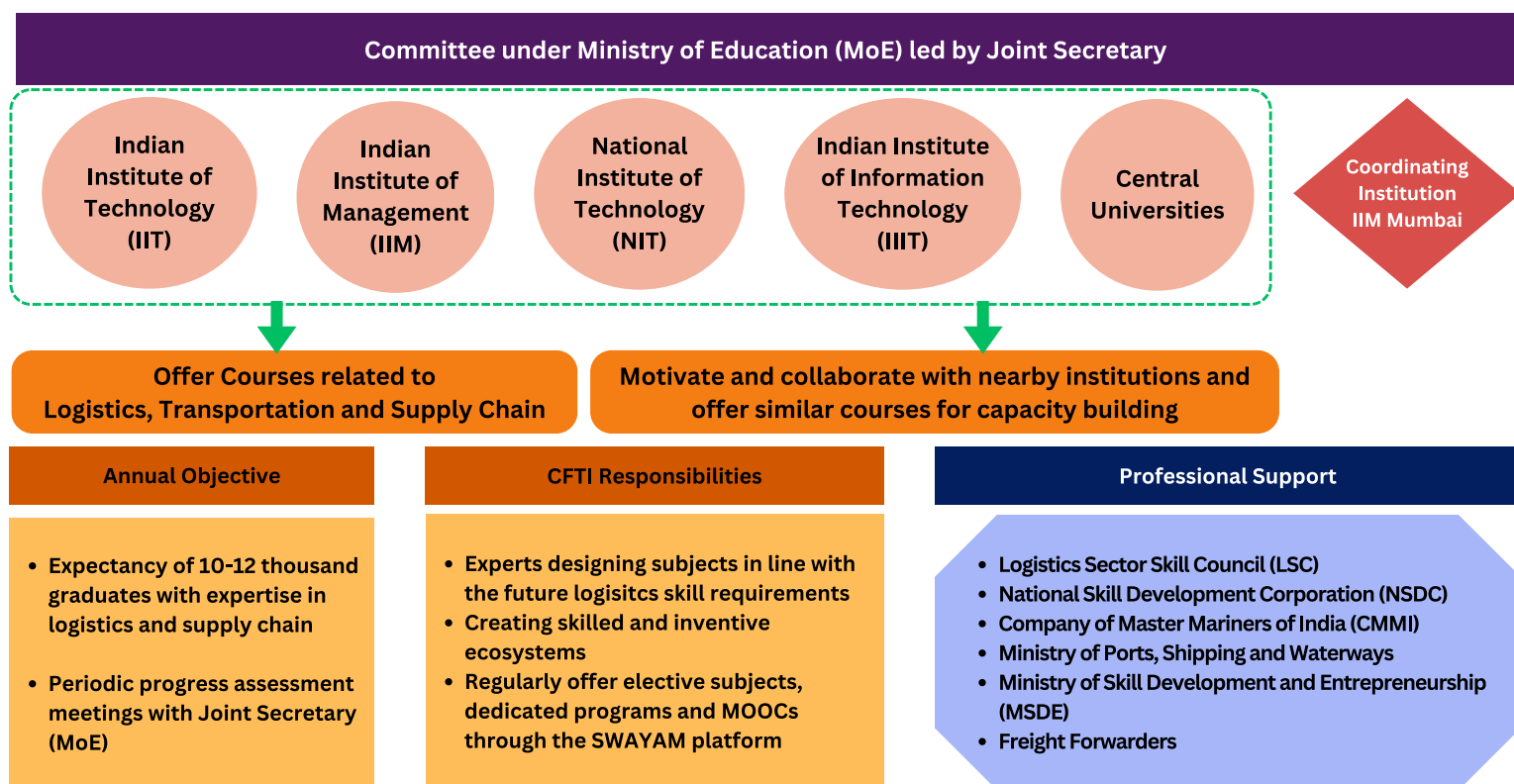
In order to implement the entire plan under the Ministry of Education (MoE), a committee of ten members should be formed, including three representatives from IITs, three from IIMs, two from NITs, and two from IIITs. This committee will oversee the immediate launch of these courses at various centrally funded institutions in India.

IIM Mumbai could serve as the coordinating institute to assist the Joint Secretary of the MoE in launching and monitoring these programs across different institutions.

To reach a large number of students and industry participants, premier institutions with expertise in the relevant domains of logistics should launch courses listed in the Annexure through the SWAYAM and SWAYAM+ platforms.

According to the plan, elective courses related to supply chain, logistics, and transportation can be offered to bachelor's and master's students, such as

- Civil Engineering department can offer Transportation Logistics, Urban Transportation System Planning using Geospatial Technology, Traffic Flow Modeling And Simulation.
- Supply chain optimization and digitization can easily be offered by Mechanical, Industrial, and Mathematics department.



Implementation Mechanism

- Institutions that are offering MBA programs can launch courses like Supply Chain Analytics, Manufacturing Operations Management, Logistics & Supply Chain Management.

Premier institutions like IITs, IIMs, NITs, IIITs, and central universities have to take responsibility for creating skilled and inventive ecosystems. The committee will request every IIT, IIM, NIT, and IIIT to offer at least three programs listed in this report and one course through the MOOC or SWAYAM platform within the next 100 days. Also, institutions can design or modify the subjects based on their expertise in line with the future skill set requirements in the logistics sector. Also, premier institutions will be requested to motivate and collaborate with nearby colleges and offer similar courses for capacity building.

The committee will request the All India Council for Technical Education (AICTE) to identify ten institutions and encourage them to offer executive programs such as Supply Chain Digitization and End-to-End Transformation, Supply Chain Operations and Disruptions Management, Data Science for Logistics, Air Cargo Logistics Management, Warehouse Automation, and Digital Innovations & Technology in Supply Chain Management.

Several stand-alone institutions and universities should be engaged to offer skill-based programs for vocational, diploma and postgraduate students in the various domains outlined in this report.

Additionally, the University Grants Commission (UGC) will be requested to nominate a nodal officer to focus on initiating and launching these courses in some universities.

By the end of the upcoming semester or module, at least five thousand students should Undergo one or two of the courses listed in the Annexure.

The goal is for at least 10 to 12 thousand students should learn at least two courses in the emerging area of logistics and supply Chain.

Institutions can offer additional courses based on demand and requirements in the fields of transportation, logistics and supply chain. Progress assessment meetings led by the Joint Secretary should be held every two months to review the overall scope and development of the program.

Annexure

B.Tech. in Logistics and Supply Chain Management

First Semester

Mathematics-I, Physics, Introduction to Biological Systems, Indian Knowledge System, Engineering Graphics, Computer Programming: C and Python, English for Communication Skills, Extra-curriculum (Yoga, Cultural, and Sports)

Second Semester

Mathematics -II, Introduction to Management Science, Environmental Studies, Basic Economics, Engineering Mechanics, Electrical Engineering Fundamentals, Workshop Practice

Third Semester

Introduction to Probability and Statistics, Operations Research-I, Managerial Accounting, Data Analytics for managerial decisions, Introduction to logistics and supply chain management, Naya Bharat and Logistics

Fourth Semester

Operations Research-II, Introduction to Multi-Modal Logistics, Material Handling and Packaging, Financial management for supply chain leaders, Global Logistics and Supply Chain Management, Introduction to AI & Machine Learning

Fifth Semester

Supply Chain Risk Modeling, Logistics Network Design and Optimization, Port terminal management, Air Cargo Management, Innovation and Entrepreneurship, Simulation and digital twin lab

Sixth Semester

Maritime logistics, Blockchains and smart contracts for Digital Supply Chains, Procurement and Supplier Relationship Management, Warehouse and Distribution Management, Enterprise Lab, Elective

Seventh Semester

Internship, Digital Innovation and Technology in Supply Chain Management, Intermodal transportation and containerization, Global trade management SDGs and Logistics, Elective

Final Semester

Industrial Training/Internship, Project Work

List of Elective Courses

Supply Chain Analytics, Reverse Logistics, Lean Six Sigma in Logistics and Supply Chain, Retail Supply Chain Management, Humanitarian Logistics, Emerging Technologies in SCM, Agile project management, Competitive strategy for the supply chain, Green Transportation economics, Green supply chain management, Business law and ethics, Storage systems and equipment for warehouse 4.0, Industry 5.0, Robotics Process Automation Stochastic operation research, Consumer choice models, Dynamic pricing and revenue management

M.Tech. in Logistics and Supply Chain Management

First Semester

Logistics & Supply chain management, Business Analytics, Digital Innovation and Technology in SCM, Finance and Accounting, Operations Management, Operations Research

Second Semester

Global Supply chain and Logistics, AI & ML Techniques for Supply chain and Logistics, Procurement and Materials Management, Multimodal Transportation System, Supply Chain Finance, Leadership and Entrepreneurship, Enterprise Lab

Third Semester

Global Trade Management, Risk, Disruption and Resilient Supply Chain, Indian Knowledge System, Warehouse Automation and Management, Simulation Modelling and Supply Chain Digital Twin, Electives

Annexure

Fourth Semester

M.Tech Dissertation, Blockchain and Smart Contracts, Advanced Supply Chain Analytics, Electives

List of Elective Courses

Advanced AI for Supply chain and Logistics, Advanced Operations Research, Retail and e-commerce Supply Chain Management, Modern-day SCM for E-commerce in India, Green Logistics, Business Law and Contract Management, Lean Six Sigma in Logistics and Supply Chain, Managing people and organizations, Logistics for Naya Bharat, Applied GIS & Spatial Data Analytics, Behavioural SCM, AR/VR in Logistics Innovations in Waste Management, Management of Intellectual Property Rights (IPR) for Logistics, Materials Handling Systems, Supply Chain Network Design, Supply Chain Contracts, Robotic Process Automation, Negotiations & Stakeholder Management, Case studies of successful startups/Unicorns in Logistics, Case studies related to PM Gati Shakti NMP

Post Graduate Diploma in Supply Chain and Logistics Management

First Semester

Introduction to Logistics & Supply Chain, Applied GIS and Spatial Data Analytics, Logistics Documentation-International Trade Procedures, Data Analytics, Strategic Management, Optimization Technique-Distribution Management for Global Supply Chain, Skill Training on Transportation Management Systems (TMS)

Second Semester

Containerization & Multimodal Transport, Inventory Control-Procurement, Storage & Warehouse Management, Project Management-Plant Location & Layout, Port and Airport Management for Logistics, Operation and Green Supply Chain Risk Modelling & Management, Skill Training on Warehouse Management System (WMS)

Third and Fourth Semester

Industrial Training/Internship, Capstone Project

Post Graduate Diploma in Data Science for Logistics

First Semester

Supply Chain Management, Data Analytics and Statistics, Fundamentals of Logistics, Optimization Technique, Data Structure and Algorithms, Plant Location & Layout, Skill Training on Transportation Management Systems (TMS)

Second Semester

Application of Blockchain in Supply Chain, Concept & Application of Internet of Things (IoT), Logistics Documentation, Advanced Logistics, Machine Learning and its Applications, Revenue and Distribution Management, Skill Training on Warehouse Management System (WMS)

Third and Fourth Semester

Industrial Training/Internship, Capstone Project

Sample Courses for Capacity Building

Generative AI in Supply Chain Management

Introduction of Generative AI and its Models, ChatGPT and Generative AI, Demand Forecasting & Inventory Management, Procurement Optimization

Business Operations with Data Analytics

Introduction to Business Analytics, Prescriptive, Predictive and Integrated Analytics, Neural Network, Digital Transformation, Pricing and Online and Offline Retailer

Annexure

Modelling and Building Digital Supply Chain Twins

Supply Chain Optimization and Simulation, Digital Supply Chain Twins, Supply chain network design, Supply chain simulation, Supply chain resilience

Supply Chain Digitization and End-to-End Transformation

Supply Chain Integration, Push-Pull and Complexity Reduction, Supply Chain Segmentation to Improve Operations, Supply Chain Resiliency & Flexibility, Inventory Management and Risk Pooling Strategies

Supply Chain Operations and Disruptions Management

Supply Chain Operations Management, Supply Chain Disruptions Management, Robust and resilient Supply Portfolio, Primary and Recovery Supply and Demand Portfolio, Selection of Resilient Multi-Tier Supply Portfolio

Air Cargo Logistics Management

Understanding the basics of air cargo operations, Operation of Key Players in air cargo service, Coordination and Contract in air cargo supply chain, Complexity in air cargo operations, Demand analytics, Capacity planning, Revenue Management, Terminal Operations & Cargo Handling, Fleet routing and flight scheduling, Decision making under risk and uncertainty, Applications of various AI/ML and optimization models in air cargo operations, Information technology and GIS for managing air cargo operations, Heavy-lift air transportation, Humanitarian operations using Air Transport, Information technology and GIS for managing air cargo operations, Applications of Geospatial Technologies in Air Cargo Handling and Management, Sustainable Intermodal Freight Transportation, Optimizing Periodic Maintenance Operations

Digital Innovations & Technology in Supply Chain Management

VUCA (Volatility, Uncertainty, Complexity, and Ambiguity) Environment & Business Needs, Understanding IT challenges and integrated business processes in supply chain and logistics, Opportunity Identification for Digital Transformation, Business models and Innovation frameworks for supply chain, Enterprise Systems for Supply Chain, Data Lake and Data Integration, Emerging Technologies for Digital Transformation of Supply Chain, Application of AI, ML, IoT, Blockchain, Robotics & Automation, Platform Economy and Eco-Systems, Product life cycle management for supply chain, Technology life cycle for supply chain management, Understanding Risk & Cyber-attacks in Supply Chain; Security Controls and Information Security Posture, Analyzing and assessing the Risks, Strategies for successful implementation and use-cases, Applications of Geo-Informatics and Geospatial Technologies for Supply Chain Management, Application of Geospatial technology and GIS for cybersecurity supply chain.

Warehouse Automation

Role of a Warehouse and a Warehouse Manager, Major warehouse processes and End-to-End Warehouse Operations, Automation in warehouses, Order picking methods, Warehouse Layout, Material Handling Systems in a Warehouse and Other resources, People management in Warehouse, Health and Safety issues in a Warehouse, Inventory Accounting and Cost analysis, Key Performance Indicators, Warehouse Automation Analysis, Optimizing Order Picking, Data Analytics in different functions – Inventory, Order Fulfilment, Procurement and Storage, Use of Geospatial Technology in Warehousing – like Global positioning systems (GPS), Remote sensing (RS).

Annexure

Agri-Food Supply Chain Management

Concept of agricultural food supply chain, Operations Management in agri-food supply chain, Cold Logistics – Food, Flower & Medicines, Resource Utilization, Human resource management in agri-food supply chain management, Logistics and Transportation, Network Design, Digital supply chain management in the era of circular and sustainable economy, Use of Geospatial technologies in enabling end-to-end agri-based supply chain.

Port Management

Introduction to Port Management, Managing Port Operations through data-driven models, Sustainability, Safety & ESG in Port Management, Collapsible Container, Less than Container Load Handling, Advanced Materials Handling, Case Studies/Real-life applications, Applications of Geo-informatics and Geospatial technology for efficient planning, port handling, coordination, Real-time tracking of vessels, responsive routing and scheduling.

Transportation Systems & Network Design

Introduction to Transportation Systems & Network Design, Intelligent Data-Driven Transportation System and Effective Network Design, Sustainable and Safe Transportation, Case Studies/Real-life applications, Finding potential locations for various infrastructures. Real-time tracking of vehicles on Roads, Railways, and Waterways, Mitigating transportation risk by rerouting optimally using real-time geospatial information.

Shipping Logistics Management

Introduction and Role of Maritime Logistics in International Trade, Coordination in Maritime Logistics, Types of shipping loads, Port Logistics, People, safety, and environmental aspects in Shipping Logistics, Economics of Shipping Logistics.

E-commerce Supply Chain

E-commerce business models and supply chain design, B2C vs B2B e-commerce supply chain, Cross-border e-commerce, Quick commerce inventory management, Fulfilment centre operations, Fulfilment centre automation, Robotic material handling, Returns management and reverse logistics, Visibility and Traceability in e-commerce supply chain, Information security risks and cyber attacks, Supply and Demand Disruptions in e-commerce supply chain, e-commerce distribution network design, Last mile e-commerce delivery, 3PL and 4PL in e-commerce, Drone delivery model, Predictive shipping, Last mile e-commerce delivery and route planning using GPS, GIS for facility location of e-commerce facilities.

Healthcare Supply Chain

Overview of Indian Healthcare Supply Chain, e-business models in health care supply chain, Telemedicine and Omnichannel health care delivery, Medical equipment procurement, Cold chain for drug transportation, Advanced technologies in healthcare supply chain, Cold chain visibility using GPS, GIS and blood supply chain.

Multimodal Transportation Systems

Introduction to Multimodal Transport, Parking and cargo Management, Financial and costing in multimodal transportation system, Logistics & Sustainable Supply Chain Management, Data-driven transportation system.

Supply Chain Finance

Introduction to Supply Chain Finance (SCF), Purchase Order Financing, Financing Operations and Inventory, Trade Cycle Analysis, Understand the Forex Risk, Legal aspects of SCF contracts, Future of Supply Chain Finance in the Digital era, FinTech Products and Evaluation – Case analysis

Notes on Contributors

Shri. Ashish Chauhan, CEO&MD NSE

Mr. Ashish Chauhan, the CEO of the National Stock Exchange (NSE) and Chancellor of the University of Allahabad, has had an illustrious career in finance and technology. Previously, he served as CEO of the Bombay Stock Exchange (BSE) for 10 years and was a key figure in the establishment of the National Stock Exchange, earning him the title 'Father of Derivatives' in India. He has held significant roles at Reliance Group and served on numerous boards, including CDSL and IIM Raipur. Ashish holds a B.Tech from IIT Bombay and an MBA from IIM Calcutta.

Prof. S G Deshmukh, IIT Delhi

Prof. Deshmukh completed his B.Tech in Mechanical Engineering from IIT Bombay in 1982. Subsequently he completed his M.Tech and PHD in Industrial Engineering and Operations Research from IIT Bombay in 1984 and 1990 respectively. He is a very renowned Professor with a robust background in higher education, specializing in Mathematical Modeling, Operations Management, Analytical Skills, Technology Management, and Statistical Modeling. Recognized for excellence in research, awarded the Emerald Literati Network Awards for best papers in 2010 and 2012. Notable works include advancements in repair inventory models and environmentally responsive supply chains.

Prof. Gitakrishnan Ramadurai, IIT Madras

Prof. Gitakrishnan is a Professor in the Transportation Engineering Division at IIT Madras and a core faculty member at the Robert Bosch Center for Data Science and AI. He holds a Ph.D. in Transportation Engineering from Rensselaer Polytechnic Institute, an M.S. in Civil Engineering from the University of Texas at Austin, and a B.Tech. with honors from IIT Roorkee. His research

focuses on developing safe and sustainable transportation systems, with interests in network modeling, dynamic traffic simulation, ITS, vehicular emissions, urban freight, public transit systems, and road safety. He has authored over 65 papers and advised numerous government projects on transportation planning and ITS technology implementation.

Shri. Peeyush Gupta, Vice President – TQM, Group Strategic Procurement & Supply Chain

Mr. Peeyush Gupta serves as the Vice President of TQM, Group Strategic Procurement & Supply Chain at Tata Steel Group, overseeing critical operations in sourcing, logistics, and integrated planning across India, the Netherlands, and the UK. With over 30 years of experience, he has previously led Tata Steel's Indian operations as Vice President of Marketing & Sales. A Mechanical Engineer, he is an MBA from McGill University, Montreal, Canada. He is a Chevening Scholar from Leeds University, UK and has completed senior management development programmes at CEDEP and INSEAD, France.

Shri. Ketan Kulkarni Chief Growth Officer, Allcargo Logistics Ltd.

Mr. Ketan leads high-impact initiatives from the office of the Executive Chairman at Allcargo Group, focusing on stakeholder value creation, investor relations, and customer relationships. With over 30 years of experience in supply chain, logistics, and FMCG, he previously served as Chief Commercial Officer at Blue Dart Express (DHL Group) for over 17 years. He holds an MBA in Marketing from the University of Mumbai and has completed the Asia Pacific Business Leadership Program at UNSW.

Notes on Contributors

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Mr. Neelesh leads Asia Manufacturing & Supply Chain and India Travel, Logistics, and Infrastructure practices at McKinsey, where he has served for 16 years. With expertise in supply-chain transformations across various industries, he has helped optimize supply chains for leading automotive, cement, and chemical companies in India. He has also advised multinational and e-commerce logistics companies on enhancing operational efficiencies and has published reports on supply chain and logistics. He holds an MBA from IIM Mumbai and a BE in Electronics from the University of Mumbai, and previously worked with P&G in its supply-chain division.

Prof. Manoj Kumar Tiwari, Director IIM Mumbai

Prof. Tiwari is the Founding Director of IIM Mumbai and serving as the Vice-Chancellor of TISS as an additional charge. He is a Professor on lien with a Higher Academic Grade in the Department of Industrial and Systems Engineering at the IIT Kharagpur. He is actively involved in research relevant to the application of optimization, modelling, decision support systems, and data mining in logistics, supply chain management, and manufacturing research domains. is an author of more than 370 articles in leading international journals with an H index of 86 and citations more than 30k. He is recognized with the David F. Baker Distinguished Research Award (IISE, USA) 2023. He is the Chairman of the West Zone Committee for ViksitBharat@2047 vision. He is a fellow of the National Academy of Sciences India (NASI), the Indian National Academy of Engineering (INAE), the West Bengal Academy of Science and Technology (WAST), the Indian Academy of Sciences (IASc), the Institute of Industrial and Systems Engineers (IISE), USA.

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