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RENAISSANCE OF INDIAN MANUFACTURING SECTOR



A REPORT BY

NATIONAL INSTITUTE OF INDUSTRIAL ENGINEERING (NITIE)
MUMBAI - 400087 (INDIA)

WHERE ARE WE NOW

"For India to become a USD-5-trillion economy, our manufacturing sector has to sustainably grow in double digits." - NITI Aayog¹

India is the second-most populous country globally, with more than 1.35 billion residents reported in 2020. It is also the fastest-growing major economy in the last decade with an annual average gross domestic product (GDP) growth rate of 6-8% and contributed \$3.05 trillion to the world's total GDP in 2021². Although, the COVID-19 pandemic has significantly affected the economy and human lives that reduced the GDP up to -7.3 in 2020 and it is projected to be 9.5% and 8.5% in 2021 and 2022, respectively³. However, India's global GDP and international trade contributions are moderately low, contrary to its population and size. Further, the country lacks numerous societal, economic, and environmental issues compared to the developed world.

The manufacturing sector is one of the quintessential components to balance employment generation, economic growth, and environmental sustainability. Due to that, it is admitted as the backbone of the country's economy as it offers a significant contribution to GDP and job creation. Globalization further influences it by the driving forces of outsourcing and distributed manufacturing with technological advancements. However, the decreasing share in GDP and shrinking employment from the manufacturing sector has become concerning predicaments.

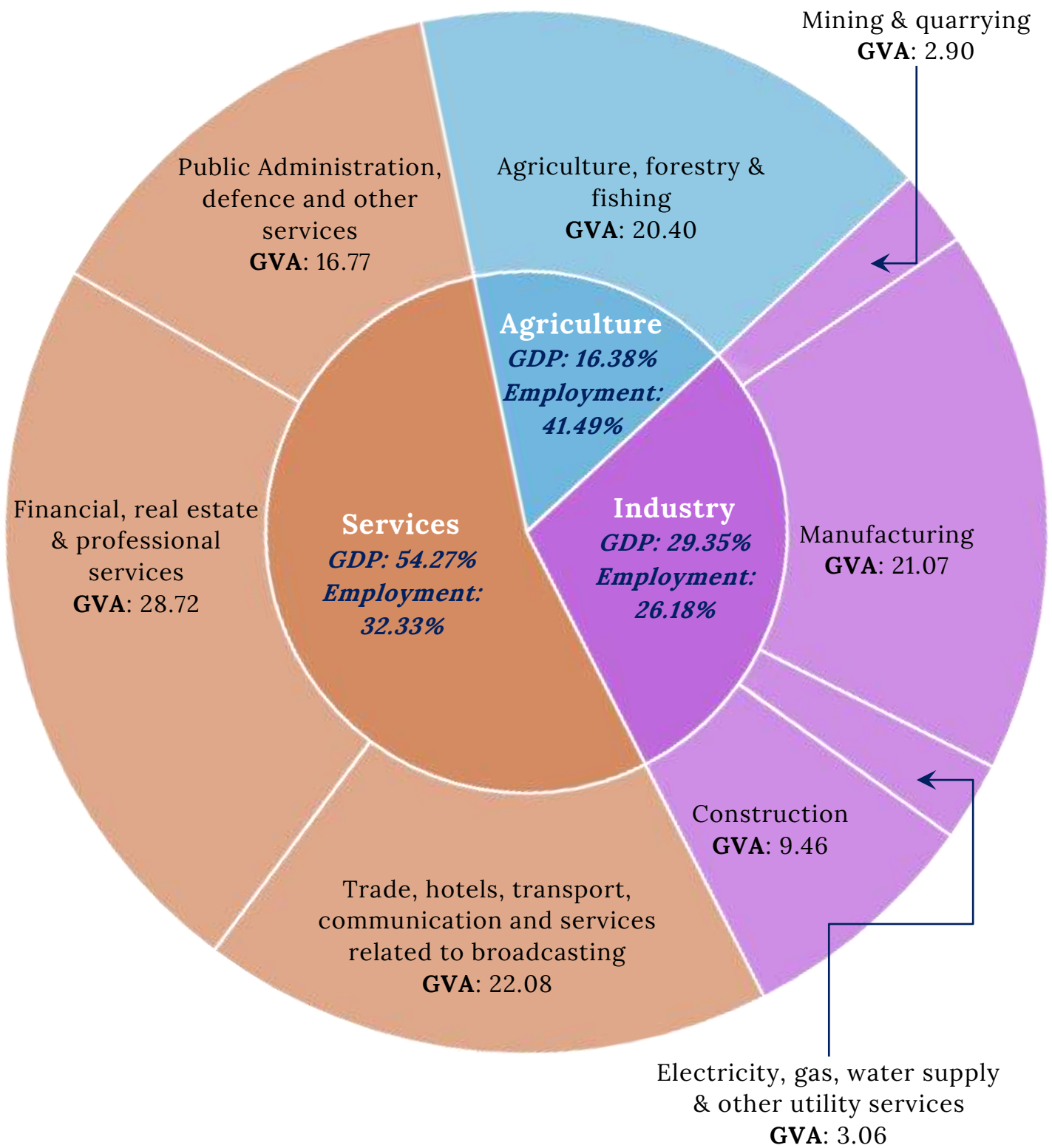
Micro, small, and medium enterprises (MSMEs) are the key players in the manufacturing domain because of their plentiful production output, export, and employment generation. However, in India, MSMEs are not well equipped with emerging technologies, and they do not follow up the quality and the environmental standards. However, in India, MSMEs are not well equipped with emerging technologies, and they do not follow up the quality and the environmental standards⁴.

¹NITI (2021). <https://www.niti.gov.in/battling-barrier-scale>

²IMF (April 2021). World Economic Outlook: Managing Divergent Recoveries. IMF, Washington, DC.

³IMF (July 2021). World Economic Outlook: Fault lines widen in the global recovery. IMF, Washington, DC.

⁴Singh et al. (2019). Framework and modelling of inclusive manufacturing system. International Journal of Computer Integrated Manufacturing, 32(2), 105-123.



GVA - Gross Value Addition
GDP - Gross Domestic Product

Source: <https://statisticstimes.com/economy/country/india-gdp-sectorwise.php>

Similarly, another concerning factor is environmental degradation, and in a 2018 report, India has been positioned at 168th rank out of 180 countries in the environmental performance index (EPI)⁵. Even Indian products fail to match the international requirement standards due to low-quality products produced from old technologies or Jugaad innovations in practices that lead to inferior quality products, import-export deficit, and encourage cheaper imports. Therefore, India was ranked in 68th place in 2019 on the global competitiveness index (GCI) out of 141 countries⁶. In a nutshell, India needs to introduce an emerging technology-equipped manufacturing system by envisioning the practical implications in the industrial sector that concur with several triple-bottom-line sustainability concerns. Moreover, India has an abundant opportunity because it is the only country from South Asia ranked in legacy countries with ranks 30 and 31 in production structure and driver of production, respectively, in a report released by the World Economic Forum on Industry 4.0 preparedness⁷. Therefore, we are confident that the evolution of systems would be a breakthrough for meeting the objective and vision of Make-in-India and the Indian Century - 21st Century⁸.

Rank	GCI ⁶	GMO ⁹	GMRI ¹⁰	Net Export ¹¹	GMCI ¹²	CIPI ¹³	GDP ¹⁴
1	Singapore – 84.8	China – 28.7%	China	China	China -100	Germany	US – 19.5
2	US – 83.7	US – 16.8%	India	Germany	US – 99.5	China	China – 12.2
3	Hong Kong – 83.1	Japan – 7.5%	US	Ireland	Germany – 93.9	South Korea	Japan – 4.8
4	Netherland – 82.4	Germany – 5.3%	Canada	Russia	Japan – 80.4	US	Germany – 3.7
5	Switzerland – 82.3	India – 3.1 %	Czech Republic	South Korea	South Korea – 76.7	Japan	UK – 2.7
India	68th – 61.4	5th	2nd	198th	11th – 67.2	42nd	6th – 2.6

GCI – Global Competitiveness Index (Score)
GMO – Global Manufacturing Output (Percentage)
GMRI – Global Manufacturing Risk Index (Rank)
GMCI – Global Manufacturing Competitiveness Index (Score)
CIPI – Competitive Industrial Performance index (Rank)
GDP – Gross Domestic Product Nominal (in Trillion USD)



⁵EPI (2018). Environmental performance index. Yale University and Columbia University: New Haven, CT, USA.
⁶WEF (2019). The Global Competitiveness Report 2019. World Economic Forum, Geneva, Switzerland.
⁷WEF (2018). Readiness for the Future of Production Report 2018. World Economic Forum, Geneva, Switzerland.
⁸NITI (2021). Annual Report 2020-2021. NITI Aayog, New Delhi, India.
⁹UNSD (2019). Global Manufacturing Output in 2019. United Nations Statistics Division, New York, USA.
¹⁰Cushman & Wakefield (2021) Global Manufacturing Risk Index 2021. Cushman & Wakefield, Chicago, USA.
¹¹CIA (2017). Countries by net exports. CIA World Factbook, Langlet, USA.
¹²Deloitte (2016). Global Manufacturing Competitiveness Index. Deloitte Touche Tohmatsu Limited, London, UK.
¹³UNIDO (2020). Competitive Industrial Performance Report. United Nations Industrial Development Organization, Vienna, Austria.
¹⁴World Bank (2020). GDP By countries. World Bank, Washington DC, USA.

SWOT Analysis

Strengths

- Cheap labor
- Potential market
- Financial support
- Growing economy
- Rising investments
- Boosting entrepreneurship
- Increasing per capita income
- Educated and young manpower
- Vast solar and renewable energy
- Governance stability (long terms)

Weaknesses

- Lack of R&D
- Low productivity
- Less digitalization
- Technology adoption
- Poor quality products
- Inefficient supply chain
- Inadequate infrastructure
- Unskilled and semiskilled labor
- Complicated norms and policies
- Scarcity of fuel and power sources

Opportunities

- Exports
- Employment
- Large market
- Self-reliant India
- Rapid Urbanization
- Unexplored Rural market
- Sustainable development
- Industry 4.0 technologies
- Expanding domestic demand
- Foreign Direct Investments (FDI)

Threats

- Local support
- Cyber security
- Cheaper import
- Dynamic market
- Juggad Technologies
- Global competitiveness
- Tax invasion/corruption
- Global market's rejection
- Environmental degradation
- Frequent technological changes

“We must develop a comprehensive and globally shared view of how technology is affecting our lives and reshaping our economic, social, cultural, and human environments. There has never been a time of greater promise, or greater peril.” -

Dr. Klaus Schwab, Founder and Executive Chairman, World Economic Forum

“In order to make India prosperous, all sections and regions of the society needed to be prosperous.” - **Shri Narendra Damodardas Modi**, Honorable Prime Minister of India

“सबका साथ - सबका विकास - सबका विश्वास - सबका प्रयास”



MANUFACTURING DEPENDENT SECTORS

ENERGY SOURCE & STORAGE

"Energy can neither be created nor destroyed - only converted from one form of energy to another" - **Law of Conservation of Energy**

Power is one of the critical requirements of the current time from the use in infrastructure development to economic growth and social welfare. The increasing demand for energy makes it a more essential sector because of the information world and sustainability concerns where in recent years, electric vehicles have become a part of society. Due to high demand, the Indian energy sector is the most diversified in the world using conventional sources (coal, natural gas, oil, hydro, and nuclear) to viable non-conventional (wind, solar, and bio-wastes).

In the list of 25 countries from the Asia-pacific region, India was ranked fourth overall, Similarly, India has been ranked fourth in wind power, fifth in each solar power and renewable power. India is the third-largest producer (383.37 GW capacity), and the second-largest consumer (1252.61 billion units)¹⁵. Even, a significant investment of \$90 billion has been made for the clean-energy. Further work under the scheme of "Power for All".

Government Initiatives



SAUBHAGYA- Pradhan Mantri Sahaj Bijli Har Ghar Yojana



Deendayal Upadhyaya Gram Jyoti Yojana (DDUGJY)



Unnat Jyoti by Affordable LEDs for All (UJALA) Distribution Scheme



Ujwal DISCOM Assurance Yojana



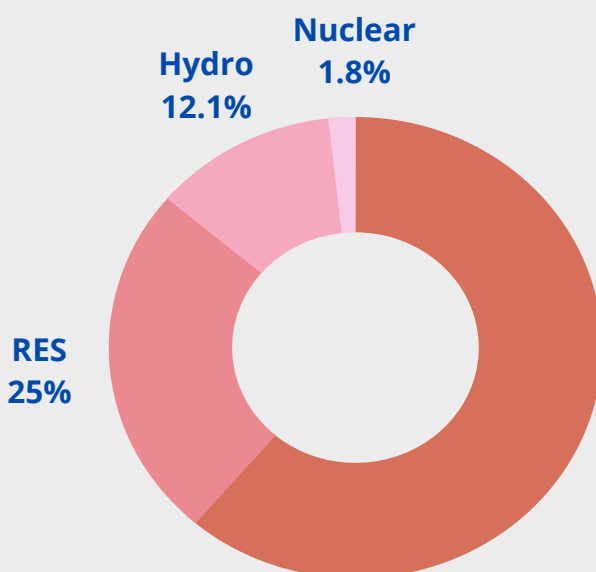
Ultra Mega Power Projects (UMPPs)



National Policy on Biofuels



Green Energy Corridor Project



Thermal
61.2%

¹⁵IBEF (July 2021). Indian Power Industry Report. Indian Brand Equity Foundation, New Delhi, India.

MAJOR CHALLENGES / RESEARCH ISSUES

Renewable energy



- India does not manufacture solar panels or related equipment as per the actual demand of the country. It enhances the dependency on other countries and imports.
- The quality of the Indian Solar Panels does not match the international standards.
- More suitable locations should be investigated to allocate the wind or solar projects because India has both the resources.
- Efficient supply chain and manufacturing process are the demand of the hour to achieve sustainability goals.

Policy and strategy



- Develop trade policy by analyzing requirements and concerns in this sector with respect to the country's economy, social issues, and environmental degradation.
- Privatization and liberalization improve the growth of this sector and impact the manufacturing of various items.
- Subsidies on renewable energy equipment to improve the business and demands of solar panels, electric vehicles, etc.
- Tradeoffs with high duties and tax on carbon-producing vehicles and its alternatives.
- Quick growth of this sector will help in self-reliant India.

Battery



- This is a core area to focus on developing efficient, lightweight, and cost-effective power storage devices.
- Analyze the applications of battery swapping and allocation of power stations as per the future demand in electric vehicles.
- Need significant research on sustainable materials (reusable, recyclable, remanufactured) for battery manufacturing to reduce the envisioned waste from this sector.
- Studies and investments are required in the battery supply chain to fulfill the upcoming demands.
- Improve the quality aspects such that India can export and contributes to the world's trade.

Alternate source



- Biomass, agricultural residue, and home waste can be considered as alternative sources for extracting energy.
- A very low contribution comes from nuclear power compared to thermal plants. So, much research is needed on these aspects to reduce the carbon emission and upcoming scarcity of fossil fuels.
- Manufacturing of highly precise and safe equipment for several applications including from windmill to biogas, biomass, and nuclear plants.

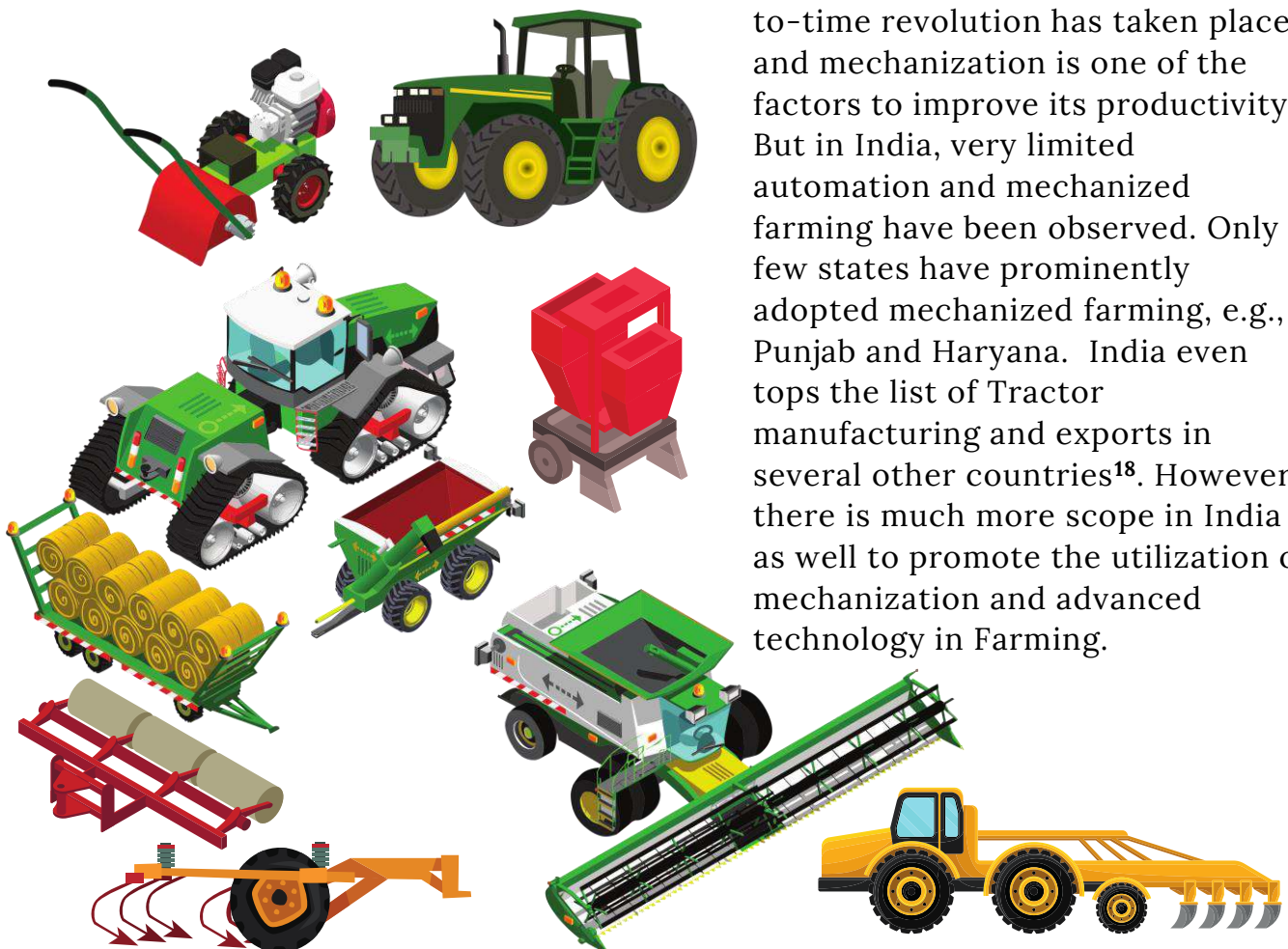
AGRICULTURE SECTOR

"If agriculture goes wrong, nothing else will have a chance to go right in the country." - M. S. Swaminathan, India's Green Revolution

India is an Agricultural country because it is the primary source of livelihood for more than 58% of the population and contributes around 18-19% of GDP¹⁶. India is ranked among the top 5 countries in the production of various crops and agricultural items, including bananas, sugarcane, wheat, rice, and many more. But still, it ranked at ninth position in exports and shares only 3.1% of agriculture produce¹⁷. Therefore, significant effort needs to be made in this regard to achieve the actual potential of this sector by exporting quality products either in the form of raw material or processed goods and items.



In the agriculture sector, a time-to-time revolution has taken place and mechanization is one of the factors to improve its productivity. But in India, very limited automation and mechanized farming have been observed. Only a few states have prominently adopted mechanized farming, e.g., Punjab and Haryana. India even tops the list of Tractor manufacturing and exports in several other countries¹⁸. However, there is much more scope in India as well to promote the utilization of mechanization and advanced technology in Farming.



¹⁶IBEF (July 2021). Indian Agriculture and Allied Industries Report. Indian Brand Equity Foundation, New Delhi, India.

¹⁷WTO (2020). World Trade Statistical Review 2020. World Trade Organization, Geneva, Switzerland.

¹⁸FICCI (2020). Farm Mechanisation: Ensuring a sustainable rise in farm productivity and income. PWC, New Delhi, India.

MAJOR CHALLENGES / RESEARCH ISSUES

In India, a huge opportunity is visualized in the food processing and farm machinery industries as per its actual potential and market size. There are numerous challenges that have been observed and accordingly research can be carried out in this domain:



Technology

- Implementation of emerging technologies like the Internet of Things (IoT), digitization, and automation should be realized in the farm tractors and related machinery for maximum efficiency and significant output.
- Analyze the impact of the use of technologies including Laser Land Leveler and advanced sensor-based irrigation systems on field yield.
- Utilization of Drone-based farming for surveillance and several tasks such as chemical spraying and fertilizer spreading for effective coverage of the field.
- Improve the supply chain from farm to table by utilizing newer technologies, proper packaging, and timely delivery.



Sustainability

- India faces a problem of environmental issues because of improper farming, for example, carbon emission, water pollution and soil degradation because of residue burning, excessive use of chemicals, and non-recycled cropping.
- Advanced machinery can be developed for crop residual collection and land plowing.
- Studies need to be carried out on efficient irrigation systems to minimize water consumption like drip and sprinkler irrigation.
- India wastes 40% of produced foods because of improper handling, and leading impacts can be investigated from a sustainability perspective and compare with the use of emerging technologies.



Trade and Marketing

- Indian tractors, harvesters, and farm machinery do not match the high standards of the western world, especially in European Countries and the USA. Even, it is difficult to compete with their large manufacturers. Thus, in this perspective, enough attention should be given by increasing the skilled workforce and adequate training.
- Unavailable machines and logistics facilities, most of the farmers have limited market access, and even they are bound by the act of selling the produce in fixed places. Thus, farmers should avail themselves of subsidies equipment and machines, and see the effects.
- The business strategy and market scenario have been captured by the e-Commerce and online marketing for all kinds of good producers, but still, farm produce and farming machines are mostly marketed by old traditions. Therefore, new policies should be studied.



Government Policies

- Government should provide subsidies in advanced technologies and machinery throughout the country for better farm yield. Presently, most of the benefits are taken by a few states, and others are unable to get the benefit.
- The land/plot size per farmer is continuously decreasing in the country and due to that they do not invest in the various machines, and it directly impacts the agriculture output. Therefore, the government should intervene in such a situation to maximum utilization of the farming land with mechanized facilities by either combining the farmlands or providing rental machinery to poor/small farmers.

CONSTRUCTION EQUIPMENT AND MATERIAL

The infrastructure industry is one of the key drivers not only for the Indian Economy but also globally. In a recent report, India is expected to be the third-largest construction market by 2022, just behind the United States and China¹⁹. In India, this sector contributes 7-9% of GDP worth around US\$ 200 billion and provides employment to more than 51 million. Infrastructure development is ubiquitous activity spreading in almost every other sector including the railway, airport, electricity generation, bridge and tunnel, national highway construction, seaports, housing development, and many more. Even, the Indian government plans to spend US\$ 1.4 trillion on Infrastructure during 2019-2023 under Bharatmal and Sagarmala projects²⁰.

Therefore, seeing the substantial ongoing development requires numerous advanced equipment and heavy machinery to carry out the work efficiently and quickly.

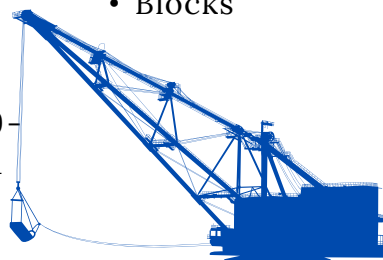
A few major construction materials are listed below that come as outputs from various other industries:

- Cement
- Steel
- Sand
- Concrete
- Aggregates
- Ready-mix concrete
- Binding wires
- Bricks
- Blocks



Excavator

heavy lifting, demolition, river dredging, tree cutting



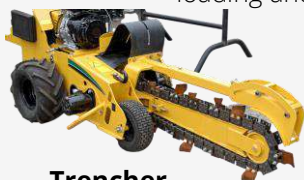
Dragline Excavator

port building, underwater excavations and silt removal



Backhoe

earth moving, small demolitions digging holes, landscaping, loading and unloading materials



Trencher



Bulldozer

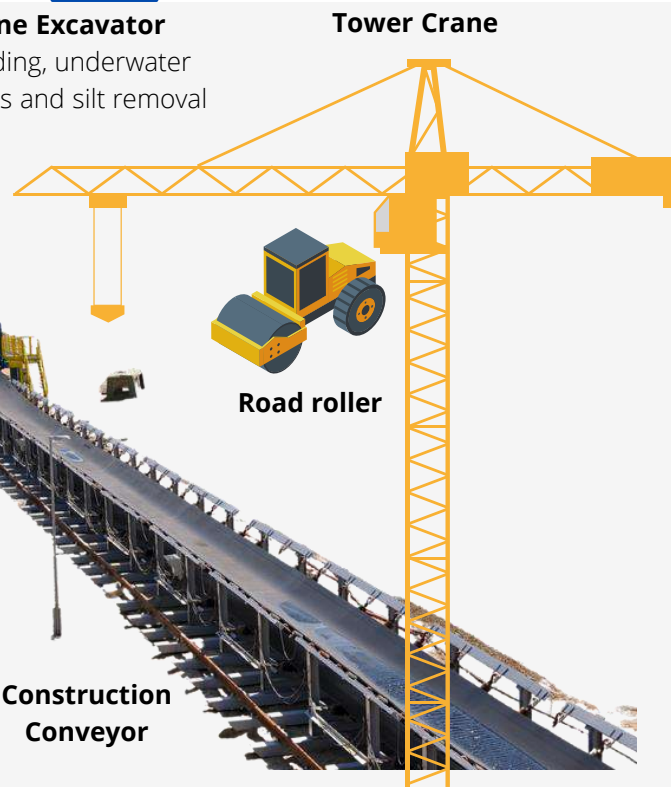
push or remove the soil, sand, and debris



Scraper



Dump trucker



Tower Crane

Road roller

Construction Conveyor

¹⁹Deloitte (2014). Infrastructure and Construction Sectors Building the Nation. Deloitte, New Delhi, India.

²⁰IBEF (2020). Indian Infrastructure Sector in India Industry Report. Indian Brand Equity Foundation, New Delhi, India.

TOP COMPANIES



CHALLENGES AND KEY ISSUES

- An influx in Material Costs
- Safety of the Employees
- Reduced Investment in the Real Estate Sector
- Environmental Preservation
- Provision of Electricity
- Effects of Natural Disasters
- Skilled Manpower
- Need for Multiple Clearances



RESEARCH PERSPECTIVE

To address the key challenges and issues in the construction industry and equipment manufacturing, there are several research objectives that need to be incorporated:

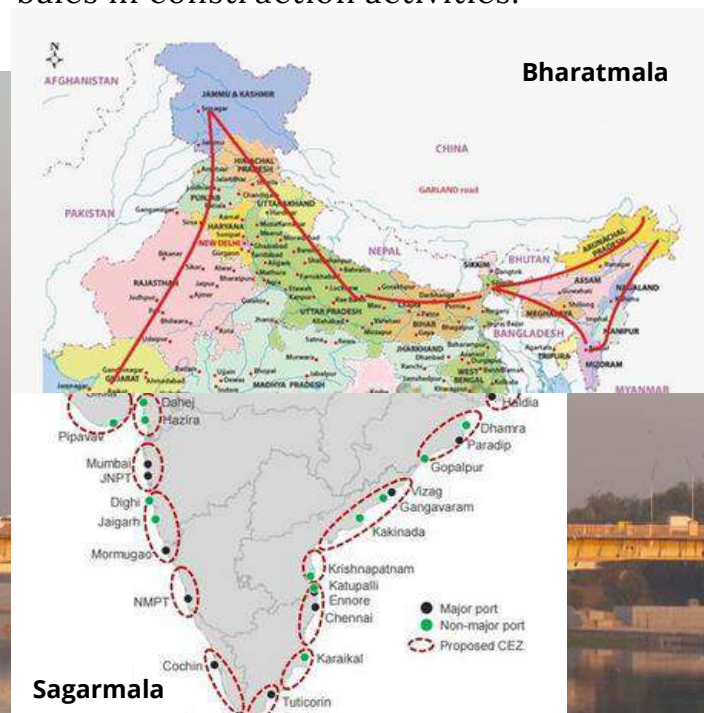
Virtual Design and Augmented Reality: In the era of emerging technologies, the construction sites should be well designed, and several tasks can be handled using augmented reality to improve labor and employee safety. Therefore, a significant requirement of carrying out the research on these aspects, and for that skilled force, needs to be evolved.

Advanced Methods and Materials: A huge scope has been envisioned for developing newer materials throughout the world. Therefore, India has a great opportunity to carry out research in this regard for better strength, longer life, and economic construction.

Environment and Waste Management: Over the last few decades, one of the prominent concerns has been witnessed by the research community and world-renowned organizations (e.g., WHO, United Nations, UNEP). To protect the environment, several innovative ideas have been introduced and implemented for example use of fly and bottom ashes in bricks and road construction, crushed glasses, tire shreds, and many more. Furthermore, utilization of green materials like Bamboo, cork, and straw bales in construction activities.

SCOPE OF IMPROVEMENTS

- Deploy Emerging Technologies
- Construction Planning Based on Data
- Adequate information sharing
- Implement and follow safety standards
- Adopt modular building systems
- Improve skills and provide proper training to employees and labor
- Use efficient and advanced machinery to achieve the goal
- Enhance job opportunities by engaging several stakeholders



STEEL AND METAL

“Making steel may be compared to making a chappati. To make a good chappati, even a golden pin will not work unless the dough is good” - J. R. D. Tata, TATA Group

India has a significant advantage in producing steel and other metals because of cheap labor and substantial raw materials from various mines. Therefore, India is ranked second-largest steel and coal producer and fourth in aluminum and iron ore. Furthermore, this sector extensively contributes to GDP and employment generation from the initial mining stage to semi-finished items for manufacturing the end products. The area near the mines and large material processing industries also gets developed with the direct and indirect influence of the market.



MAJOR CHALLENGES / RESEARCH ISSUES

India has a tremendous opportunity in this sector because of the growing market and developing society. But it faces various challenges from competitive countries with the cheapest imports, quality items, employment risk, and automation facilities.



Technology

- Indian steel plants need higher crude steel to produce saleable steel, which is 1.2 tons compared to 1.1 tons in other countries, Japan and South Korea²¹.
- Poor quality products are obtained because of old technologies and limited automation. Thus, a substantial investment is required to implement the emerging technologies practiced in the developed world.



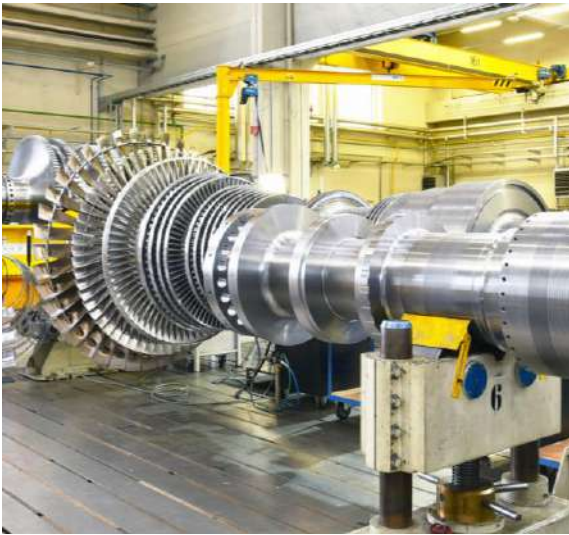
Sustainability

- Since the inception of the Industrial Revolution, India has been one of the primary sources of various metals and ore. Most of the materials have been exported in the raw form rather than the final product or own utilization. Thus, it seems a vital factor in fulfilling the domestic requirement in the future.
- Many mines and their improper handling have impacted the environment. Therefore, essential rules and regulations are needed with high standards to maintain sustainability.

²¹IBEF (2021). Indian Steel Industry Report. Indian Brand Equity Foundation, New Delhi, India.

ELECTRICAL EQUIPMENT & MACHINE TOOLS

"To make India the country of choice for the production of electrical equipment and reach an output of US\$ 100 billion by balancing exports and imports" - Department of Heavy Industry



India is the world's third-largest producer and third-largest consumer of electricity, and it requires a large number of heavy machinery including hydraulic, steam, gas, wind-powered turbines, turbo generators, steam generators, switch gears, and power grid equipment, transformers, rectifiers, and electric furnaces. This sector provides 5 million jobs and contributes by around 1.5% of GDP, but significant annual growth has been witnessed with 8-10%²². Still, the sector does not share as per its potential and only shares 1.0% of the global market export, i.e., USD 540 billion. Therefore, high demand for quality products with significant efficiency is required in this domain.

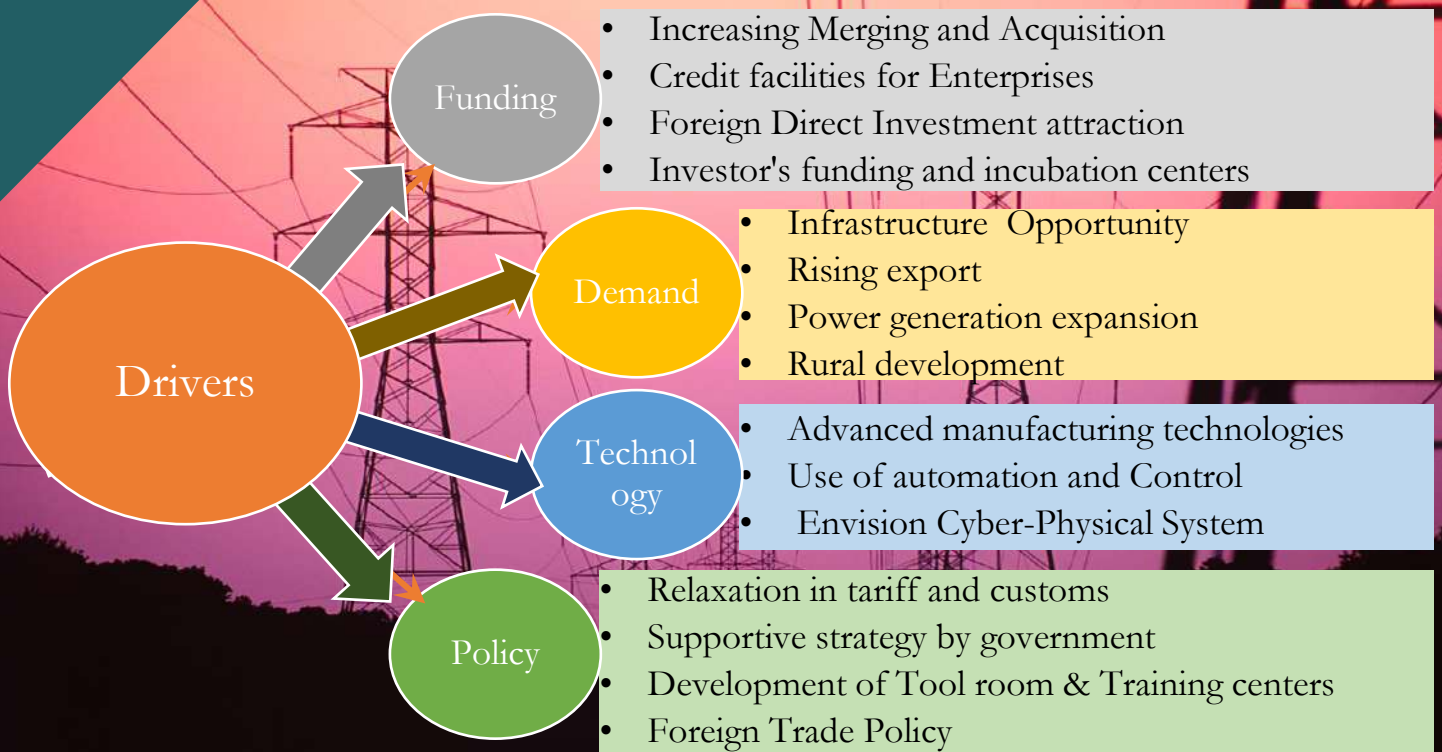
"India's machine tools industry is all set to become a key player in the global arena in the production of high-end precision tools" - Engineering Exports Promotion Council India

The machine tools industry plays an essential role in the Make in India and Skill India initiatives of the central government. Machine tools are the initial requirements of the companies for various applications including die molding, part manufacturing, aerospace, shipbuilding, electricals and electronics, healthcare, and consumer durables. One of the major users of Machine Tools in India is the automotive industry because of massive growth in the sector and dominance over other industries. The machine tools market is expected to reach \$2 billion by 2025 with approximately 13% of annual growth whereas the global market will be \$98.3 by 2027 with only 3.2% growth²³. A total of 1000 units are involved in Machine Tools production and 75% of them are ISO certified which helps in matching the global standard leads to export.



²²Make in India. <https://www.makeinindia.com/sector/electrical-machinery>

²³EEPC India. <https://www.eepcindia.org/>



MAJOR CHALLENGES / RESEARCH ISSUES

Government Regulations and Policies



- A growing list of environmental regulations hampers the growth of this industry because companies fear losing high investments. Therefore, before investing, research needs to be done on novel materials, fuel, and the circular economy of the products.
- Health and safety standards always bring new challenges for the machinery producers to re-invest in designing and manufacturing the equipment with new regulations. In such cases, companies should adopt virtual and augmented reality (AR/VR) to see workers' safety.

Rapid Advancements



- Large enterprises (LEs) and Micro, Small, Medium Enterprises (MSMEs) are reluctant to purchase high-valued equipment and machines with novel innovations. A collaborative system should be developed for resource sharing among enterprises to overcome this concern.
- It impacts the environment as well by increasing the waste material of existing technologies. Therefore, the concept of reuse and recycling needs to be adopted.

Skill Labor and Training



- The unavailability of skilled labor is also a major problem for the companies and accordingly, they avoid becoming owners of various costly machines and depend on outsourcing.
- Young graduates have less interest and are not willing to join manufacturing jobs.
- Adequate training programs can be initiated for large and trained workforce.

Sustainable Development



- Throughout the globe, thermal power plants are getting shut down, one of the major consumers of heavy and electric equipment. It impacts the heavy industry by disappearing an entire sector of power plants.
- Advanced technologies should be introduced and implemented in power plants that align with sustainability goals as well.

RAILWAYS

"The Indian Railways will become the growth engine of the nation's 'Vikas Yatra.'" –
Narendra Modi, Prime Minister, India

Indian Railways is among the world's largest networks with a route length network of 67956 km with more than 13000 passengers and 8500 freight trains to carry 23 million travelers and 3 million tones load daily from 7350 small and large stations²⁴. To sun such a vast network, the government spends a substantial amount from the central budget every year. On the other hand, Railway is the biggest employer and provides jobs to more than 1.25 million, and a large segment of them works in the manufacturing and maintenance division. Therefore, Indian Railways can be considered one of the manufacturing contributors in the economy in several aspects. Thus, massive attention is required to develop and implement newer technologies and innovations to gain its size's actual potential. It is estimated that Railway's infrastructure has needed more than \$715 billion in investments during 2018-2030 to reach the mark of speed and facilities, which has been achieved in the other corner of the world²⁵.

MAJOR CHALLENGES / RESEARCH ISSUES

Government Regulations and Policies



- A study needs to be carried out in the perspective of a tradeoff between government and private partners to maintain social responsibility and economic stability.
- Government should develop more trade policies to match the global standard and enhance exports from this sector.
- A speedy growth is required to achieve the target set by Indian Railways, and such a huge investment can not be taken from the central budget alone.



Technology



- The light and advanced materials should be developed to increase the life and efficiency of the railway network.
- Various data-based technologies are required to bring automation, optimized allocations of resources, timely operations, and smooth governing, such as Artificial Intelligence, Machine learning prediction, and many other IoT sensors.

Skill and Training



- Special innovation and training centers need to be opened such that young engineers and researchers can show interest in boosting these sectors with various entrepreneurship opportunities.
- A large segment of the budget should be allocated for Research & development at state and national level institutes and engineering colleges and special programs on railways to get a job quickly.

Sustainable Development

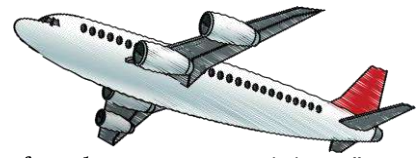


- Railways connect the entire country from north to south, east to west, rich to poor, with geographical and demographic diversity. Thus, several policies to align with sustainable goals are needed.
- Utilization of emerging energy sources, efficient production systems, and proper waste management by developing bioproducts will be another environmental benefit.

²⁴IBEF (2021). Railways. Indian Brand Equity Foundation, New Delhi.

²⁵NITI (2020). <https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1668249>

AVIATION SECTOR



"Ude Desh ka Aam Naagrik (UDAN) - An aviation country for the common citizen" -
Ministry of Civil Aviation, Govt. of India

The aviation sector has become an indispensable part of the global economy as it holds an important role in travel and transportation that contributes to the economic development of a nation. Airlines, customs, ground services, freight forwarders, brokers, domestic transportation, cargo terminals, distribution centers, and integrated international express services are all part of this sector.



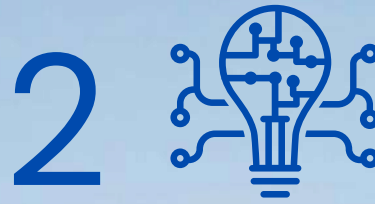
Source: IBEF (July 2021). Aviation. Indian Brand Equity Foundation, New Delhi, India.

MAJOR CHALLENGES / RESEARCH ISSUES



Sustainability

- One of the major concerns is the environmental impact of this sector.
- Maximum carbon emission per passenger or tons of load is generated by the airplane.
- Several improvements need to be made in this perspective by considering bio-fuel, technological innovations, plane design, engine efficiency, and maximum utilization of infrastructure and resources.
- Still, in India, significant modifications should be adopted for the best performance of this sector to enhance sustainable growth.



Advanced technologies

- Utilization of Additive Manufacturing in Aviation for just-in-time parts availability during failure.
- Develop augmented reality and virtual reality applications for safety standards, inspection, and maintenance.
- Advanced and lightweight materials to increase efficiency and strength for safety.
- Increase the sensor-based IoT applications for predicting failure and maintenance to reduce the breakdown time.



Digitization and Automation

- In the era of the Data world, substantial investment should be poured into the digitization of the entire system.
- Applications of Data Analytics for forecasting demand and customer requirements need to be realized, e.g., accidental analysis.
- Data should be adequately utilized to develop the operational strategy and route planning for increasing profitability and efficiency.
- Most of the activities need to be automated for Operational Safety and Accuracy.



Policies and Standards

- International standards are a requirement in the aviation sector for increasing the share in the global market.
- Financial support for foreign direct investment (FDI) should be provided to manufacturers and airline companies for the growth of the aviation sector.
- Micro, Small, and Medium-Sized Enterprises (MSMEs) should be aligned with this sector for their maximum benefits and widespread opportunity for the aviation industry.
- The trade-off model between privatization public and subsidy options can be analyzed as per the customer and social benefits.



SHIPBUILDING



India is the 16th largest maritime country in the world having a 7,517-kilometer coastline. According to the Ministry of Shipping, marine trade accounts for about 95 percent of India's volume and 70 percent of its value, with 12 major ports and 205 designated small and intermediate ports. Korea and Europe are currently focusing on complex ships (container ships and cruises), whereas emerging nations and China are dominating bulk vessels²⁶. The Indian Shipbuilding and Ship Repair business is made up of companies that design, construct, and repair navy ships, commercial ships, and offshore platforms for the shipping, naval defense, fishing, and oil and gas industries. In India, there are now 28 major shipyards (six under central government, two owned by state governments, and the remaining twenty in the private sector). India has a 6.3 percent global market share in the number of ships, but only a 0.5 percent contribution in terms of deadweight tonnage.

In India, the contribution from this industry is very low, and the government has set a target to achieve 0.2% of GDP by 2025, and also proposed the agenda for 2030 to develop more ports and waterways to boom this industry²⁷. As a result, engineering, fabrication, and machining offer the greatest potential for the Indian economy by 2025, with 2 million jobs and market share. To boost domestic shipbuilding, the Indian government has implemented a 10-year Shipbuilding Financial Assistance Policy. Increased investments, together with the 'Make in India' push, have the potential to boost the sector's contribution to GDP and trade volumes. The administration has also launched a number of large projects, including the Sagarmala project, port renovation, and the growth of inland waterways and coastal shipping.

²⁶Make in India: <https://www.makeinindia.com/sector/ports>

²⁷MPSW (2021). Maritime India Vision 2030. Ministry of Ports, Shipping, and Waterways, New Delhi, India.

MAJOR CHALLENGES / RESEARCH ISSUES

Shipbuilding is a slow-moving industry and faces a lot of challenges that must be addressed to improve the efficiency of the processes. India requires a thriving shipbuilding sector, since there is ample demand for this maritime asset, as more than 90% of Indian seaborne trade is carried out by foreign fleets owned by foreign businesses.



Tax Burden

- Materials sourced domestically for shipbuilding, capital items for shipbuilding, sale of ships, and replacement of yard infrastructure are subject to a 5% GST. IGST of 5% and customs charge of 2.5 percent on imported materials.
- Shipbreaking services are anticipated to be subject to 18 percent GST paid by the consumer, as well as corporate tax paid by shipbuilding enterprises.



Cost of Bank Guarantee

- Shipowners ask shipyards for bank guarantees such as performance guarantees for timely delivery of the vessel, refund guarantees for upfront payments, and post-construction guarantees for fault coverage.
- Financial institutions do not pay attention to the shipbuilding industry, and the government does not assist shipyards in giving these assurances.



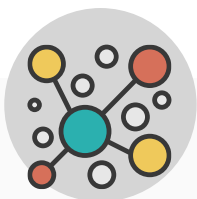
Rapid Infrastructure Modernization

- Finishing the projects early in the logistics chain is vital in order to fulfill future traffic estimates.
- India's transshipment freight is handled at South Asian hubs due to weak port facilities and productivity.



Technological Collaboration

- A consistent requirement to adopt emerging technologies and advancements in ship design, automation, and materials.
- Collaborate on environmentally beneficial technologies and solutions, such as LNG-powered vessels, to meet the goals of the International Maritime Organization.
- Manpower training and development programs to keep frontline workers up to date on world-class manufacturing techniques and processes.



Active development of maritime clusters

- Shipbuilding clusters and maritime parks stimulate innovation, create jobs, attract international investors, and generate new ideas.
- Development of numerous components of the maritime cluster, such as shipbuilding and ancillary services, boosting maritime tourism, maritime services, and marine products.
- Clusters also develop public-private partnerships and be a significant enabler in attracting new technologies, fostering strategic alliances, and increasing investment.
- Provide adequate training to the worker in this domain and develop the capacity.



Improve Global Competitiveness

- Maintaining competitiveness requires a focus on skill development and R&D.
- Ancillary industry support improves competitiveness.
- Critical Input Material Costs and Availability - Raw Materials, Manpower, and Technology
- To compete with international players in ship automation and technology, Indian players must put in a lot of effort. Indian shipyards are unable to construct huge and contemporary ships.

Defense Sector

“We must build up our national defense on such an unshakable foundation that never again in our history shall we lose our freedom” – **Netaji Subhas Chandra Bose, Indian National Army**

India is one of the top five largest military powers and has the third-highest active troops, tanks, and aircraft behind the USA and China. Furthermore, India spent a maximum portion of its annual budget on defense (\$66.95 billion) and stood third in military expenditure after USA and China²⁸. However, most of the budget is utilized in importing military equipment rather than domestic production. The government owns 80% of the Indian defense industry as 50 DRDO labs, four defense shipyards, 12 defense PSU, and 41 Ordinance factories; India only fulfills its 45-50% of defense products. India is the second-largest defense importer globally after Saudi Arabia and shares 9.2% of global arms imports. Very negligible defense exports were witnessed in 2018-19, approximately \$1.47 billion²⁹.

However, in recent years, the Government of India has taken several initiatives in this sector to save a considerable amount from importing the military equipment, for example, Indigenization, Make in India, FDI in defense, and banning more than 100 products from importing in the future³⁰. In addition, the world has seen significant improvements in defense technologies and developed various advanced weapons and vehicles to protect the country's border and military personnel. Robotics and drones have also gained popularity in this sector, and governments are spending a lot on achieving efficiency.



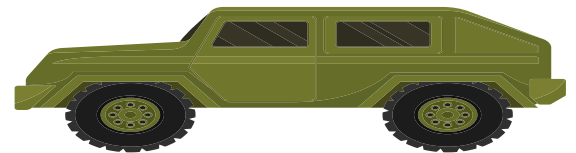
5.1 Million Military Personnel
Active – 1.44 Million
Reserve – 1.15 Million
Paramilitary – 2.52 Million



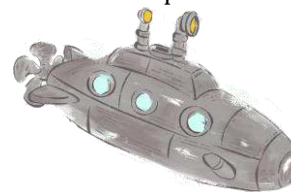
2119 Aircrafts
542 Fighters
775 Helicopters



4730 Tanks
10000 Armored vehicles
100 – Self-propelled artillery
4040 Towed Artillery
374 – Rocket launchers



1 – Aircraft carriers
17 – Submarines
139 – Ocean patrol vessels



²⁸SIPRI (2021). Trends in World Military Expenditure, 2020. Stockholm International Peace Research Institute, Stockholm, Sweden.

²⁹MOD (2019). Annual Report 2018-19. Ministry of Defence, Government of India, New Delhi, India.

³⁰IBEF (2021). Indian Defence Manufacturing Industry Report. India Brand Equity Foundation, New Delhi, India.



MAJOR CHALLENGES / RESEARCH ISSUES

Policy and Agreements



- Reduce the external dependencies of procuring defense products, and to do so, significant improvements are required in in-house production in this sector by inviting the FDI and private partners.
- From a large defense budget, some are spent on manufacturing; otherwise, maximum parts go to salary, pensions, and management. It should analyze and allocate a large portion of the budget to produce defense products and generate revenue.

Resources and Infrastructure



- India is a land of young engineers and professionals recognized worldwide and can be more interested in defense projects. Therefore, the government should ease policy and regulations for business development and startups.
- In 2021, a total of 63 million MSMEs work in India, so they should be allowed to participate in defense production by improving their skill and infrastructure.
- Indigenous innovations and ideas from remote areas should be welcomed and provide substantial infrastructure to bring reality from paper.

Technology

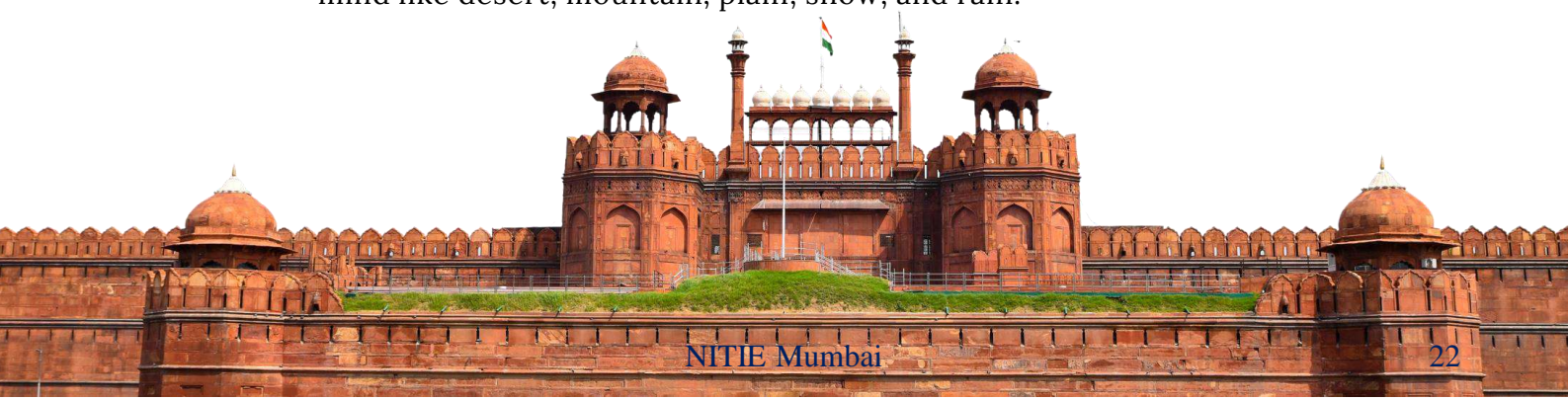


- India needs to invest in technology-based equipment for minimal life losses using IoT sensors, drones, and robots.
- Use of Artificial Intelligence, cybersecurity, and other digital technologies in defense systems will improve the strength.
- Development and adoption of advanced/innovative materials will improve the product life and utilization.
- The utilization of Additive Manufacturing and reverse engineering will reduce the spare parts and small components dependency of imports.
- Adopt global standards to match the international requirements for enhancing the defense export.

Supply and Operation



- To match the global expectations, a significant attention is required in improving the supply chain for timely delivery.
- The allocations of factories should be researched based on the availability of raw materials and other resources such that efficient supply and smooth operations can be performed.
- Develop hybrid vehicles and equipment by keeping the geographical diversity in mind like desert, mountain, plain, snow, and rain.

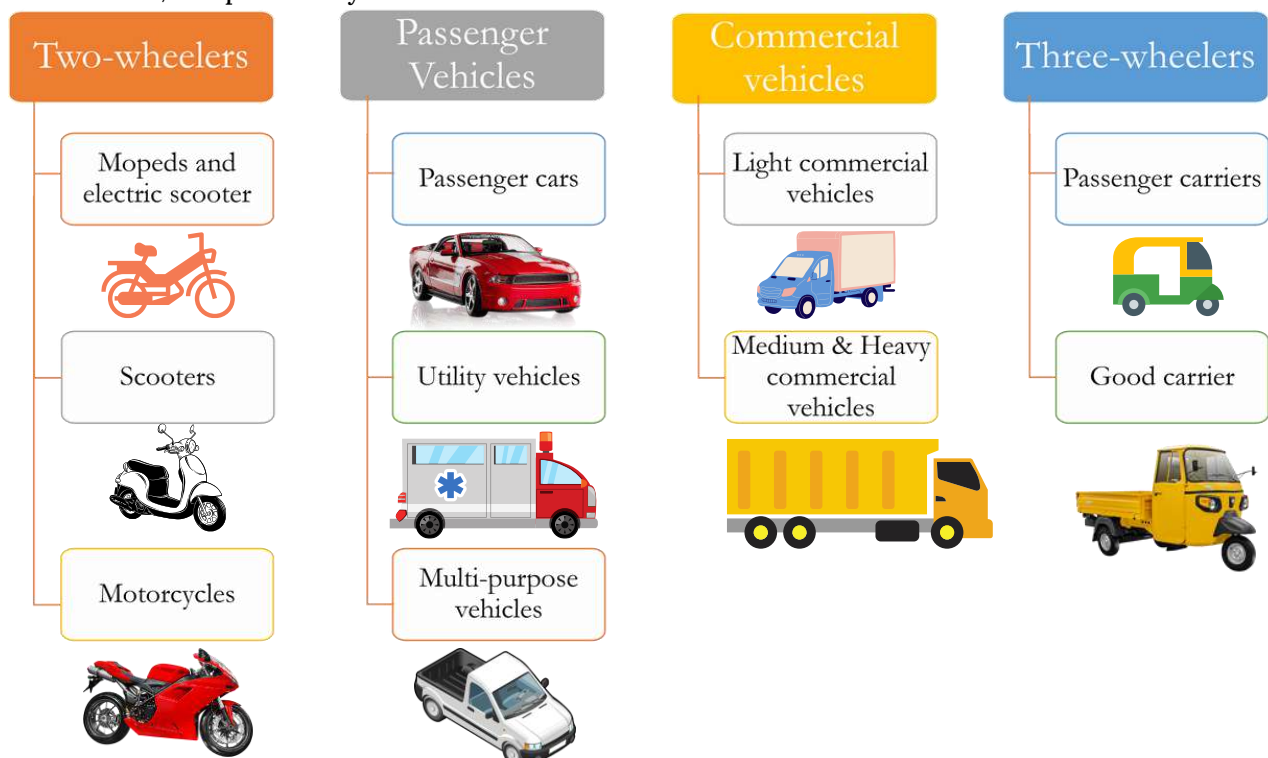


AUTOMOBILE AND AUTO COMPONENTS

"I have always been very confident and very upbeat about the future potential of India. I think it is a great country with great potential." – **Shri Ratan Naval Tata, Tata Group**

The automotive industry is a major contributor as well as a growth driver for the manufacturing sector and macroeconomics because of its significant share in GDP and employment generation. In India, 7.1% of National, 27% of Industrial, and 49% of Manufacturing GDP comes from automotive alone, and also contribute by providing more than 37 million direct and indirect jobs. The Indian Automobile Industry is the largest manufacturer of 2W and 3W, and 4th in cars manufacturing. But still, the export value does not compete with the global market and stood at \$23.6 billion only from more than \$800 billion of total exports worldwide. The annual production of vehicles is around 22 million, and it is dominated by 2W and passenger cars by 80.8% and 12.9%, respectively^{31,32}.

Out of these, 4.77 million are exported and mostly two-wheelers or passenger vehicles, and lacking in commercial vehicles, i.e, just 1.3%. Currently, the market focus is on Electrical Vehicles, but India is unable to compete with global players. Till now, in India, electric scooters are manufactured instead of cars, trucks, and other commercial vehicles because of several changes. The government's target is to become the third-largest automotive market (by volume) and a size of \$300 billion by 2026. The opportunity of \$206 bn in Electrical vehicles and total sales of 84.5 (all types) by 2030 has also been predicted. The auto-component industry has also grown substantially and contributed by 2.3% of GDP and 1.5 million jobs. The component market is expected to reach \$80 bn by 2026³³.



³¹Make in India: <https://www.makeinindia.com/sector/automobiles>

³²IBEF (July 2021). Indian Automobile Industry Report. Indian Brand Equity Foundation, New Delhi, India.

³³IBEF (July 2021). Indian Auto Components Industry Report. Indian Brand Equity Foundation, New Delhi, India.

POLICIES AND INITIATIVES

	Production Linked Incentives (PLI)
	National Automotive Testing and R&D Infrastructure Project (NATRIP)
	Faster Adoption and Manufacturing of Hybrid and Electric vehicle (FAME)
	Automotive Mission Plan 2016-26
	Foreign Direct Investment (FDI)
	Make in India
	National Automotive Test Tracks (NATRAX)

KEY PLAYERS



MAJOR CHALLENGES / RESEARCH ISSUES

Energy and Sustainability



- Presently, fossil fuels (diesel, gas, and petrol) are the main energy source, and India imports 82% of its oil and gas needs, creating a huge burden on the economy³⁴. Thus, there is a requirement of finding alternative solutions such as an electric vehicle (changed using solar power)
- With the increase in the number of vehicles and urbanization, carbon emission has significantly affected the environment. Further research is required to minimize pollution with alternative energy sources and upgrade the technology.
- Adopt recycling, reuse, remanufacturing concepts with reverse logistics to enhance the circular economy.

Technology



- Under the flagship of Industry 4.0, numerous advanced technologies have been introduced in the manufacturing sector, but India is still using the old technologies.
- Furthermore, frequent changes in various technology and software support also create problems for the manufacturers.
- Requirements like Vehicle technology upgrades (e.g., BS-VI) bring a huge burden to the manufacturers because it needs massive investments.
- Adoption of Electrical or Hybrid Vehicles has been rapidly growing worldwide, but Indian automakers are far behind the world leaders.

Skilled Worker and Training



- The unavailability of skilled workers and shortage of automobile experts is another big concern in this sector because of the priority difference between manufacturing and service jobs.
- More incentives and training should be offered to enhanced the experts and workforce.
- Adoption of automation and advanced technology are the core concept to fulfill labor shortage.

Government Policies

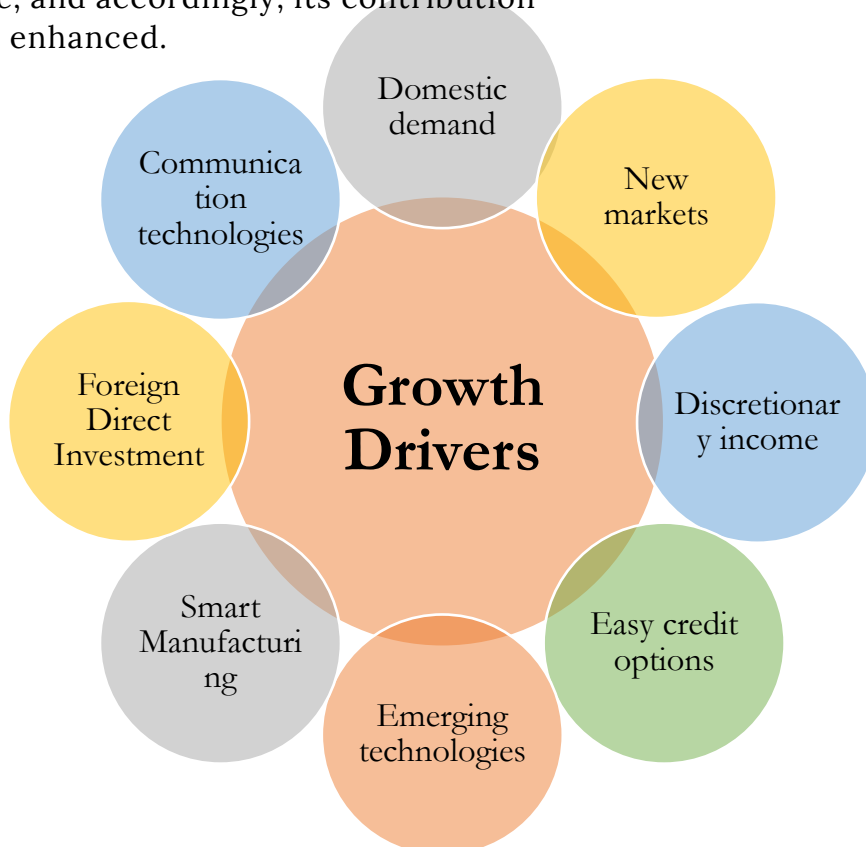


- Increase custom duty for empowering indigenous players such that it can compete with cheaper imports.
- Implementation of Information Systems in Supply Chain Management to ease the businesses and their tracking

³⁴Joon, Abhimanyu (September 2020). Can Oil Imports Make India Aatma Nirbhar? The Outlook Group, New Delhi, India.

ELECTRONICS INDUSTRY

The electronics industry is a key driver for the global economy, with continuous and exponential growth. The Indian economy is rife with the potential for being a global leader in this domain. The Indian semiconductor industry offers great opportunities for development as multiple industries that source semiconductors are witnessing high demand. These include multiple industries such as mobile devices, telecommunication equipment, Information Systems, Quality Assurance/Testing, Industrial Machinery, Automobile, IoT, and many more. The global electronic system design & manufacturing market size has been valued at over \$ 1 Trillion in 2020 with 8% annual growth, whereas India contributed only \$ 89.38 Billion, but it is expanded with the rate of 16.1% and is estimated to be reached at \$220 billion by 2025³⁵. The biggest concern is the huge imbalance of imports and exports at \$50 and US\$ 11.7 billion respectively. With the second-largest population, India is the biggest marketplace, and accordingly, its contribution needs to be enhanced.



³⁵IBEF (July 2021). Indian Electronics System Design & Manufacturing (ESDM) Industry Report. Indian Brand Equity Foundation, New Delhi, India.

India's key electronics manufacturing clusters



NCR (Noida, Greater Noida, Gurugram) ■

Chennai, Tamil Nadu ■

Chittoor, Andhra Pradesh ■

Pune, Maharashtra ■

Bengaluru & Mysuru, Karnataka ■

Hyderabad, Telangana ■

MAJOR CHALLENGES

- The unstable and uncertain supply chain for the required electronic components
- Sources of raw material and components exist in competing countries
- A dearth of emerging technology equipped-infrastructure and inefficient logistics systems enhances product cost and lead time
- Massive investment is required for infrastructure development
- Scarcity of skilled workforce
- A very thin profit margin at local value addition (5-15% only)
- Absence of Semiconductor Fabrication Plants (not a single)
- Cheaper imports of chips and national security concerns with cyber-security

RESEARCH PROBLEMS

- Develop a resilient and efficient supply chain of raw materials and finished goods to serve the market with full potential even during disruption
- Improve handling of electronic waste (e-waste) management to achieve the circular economy and sustainability goal
- Find potential areas to implement emerging technologies in Industry 4.0 where most of them are empowered by electronic infrastructure support
- Research on alternative development for replacing the current materials used in this industry, e.g., gallium nitride (GaN) and silicon carbide (SiC) for semiconductors.
- Innovate sustainable electronic products to enhance recycling, reuse, and remanufacturing.
- Utilization of automation for delivering quality products to compete with global players

Government Schemes



Production Linked Incentives (PLI)



Scheme for promotion of manufacturing of components and semiconductors (SPECS)



Electronic Manufacturing Clusters (EMC 2.0)

PACKAGING INDUSTRY

"Recycling, packaging, businesses are changing all of those things because that's what consumers want" - **Jerry Greenfield, Ben & Jerry's Homemade Holdings, Inc., USA**



With the e-commerce surge, the Indian packaging industry has seen burgeoning growth. Furthermore, due to the recent pandemic, many customers have shifted to online modes of food and beverage purchasing.



Market Size

- 200% in package consumption within the last decade
- Packaging in the e-commerce sector is valued at \$451 million in 2019 with a prediction to reach \$975 million by 2025.
- The annual growth rate of 13.8%



Growth Drivers

- Increasing demand for essential food items and shelf-stable foods
- healthcare and supplement products
- Booming e-Commerce and Online Marketing
- Efficient supply chain and logistics system



Packaging Material

- Mainly, two types, flexible (36%) and rigid packaging (64%).
- Further packaging material can be divided into plastic (55%), paper, cardboard, and glass
- Main items, food processing (45%), pharmaceuticals (25%), and personal care (10%).



Technology

- Information and Communication Technologies
- Tracking and tracing devices (RFID, IoT)
- Real-time visibility, e.g., Food Delivery apps
- Cloud-based computing and data storage
- Artificial Intelligence and Advanced Analytics

Source: Indian Brand Equity Foundation, <https://www.IndianBrandEquityFoundation.org/blogs/indian-packaging-industry-riding-on-the-e-commerce-wave>

MAJOR CHALLENGES / RESEARCH ISSUES

The increasing demand for packaging items over the last few decades has brought several issues for this industry. A few of them are discussed below:

1

Sustainability

- Plastic packaging has numerous deleterious effects on environmental externalities. 70% plastic packing is single-use.
- Production and incineration of plastic resulted in more than 850 million metric tons of greenhouse gasses
- Environmentally friendly packaging (reusable, recycled, advanced material) to realize a circular economy¹⁸

2

Big Data & Analytics

- Universal data access of the company, adequately managing the entire network of raw materials and items
- Advanced machine learning algorithms help in identifying market segments, demand prediction, and reducing inventory and wastage
- Optimize the cost, emission, and space utilization

3

Smart and Automation packaging

- Smart packaging involves the use of IoT such as QR codes, smart labels, RFID, and Near Field Communication (NFC) chips onto the packaging material.
- Improves security and real-time GPS tracking
- Processes in packaging material manufacturing can be automated using Intelligent IOT (IIOT) systems (depanning, filling, packing, storing, sealing, labeling, and palletizing the material)
- Further, IIOT systems can be used to determine defects and exclude them accordingly.
- Processes such as quality control, fault detection, and sorting can be streamlined using automation.

4

Design and space utilization

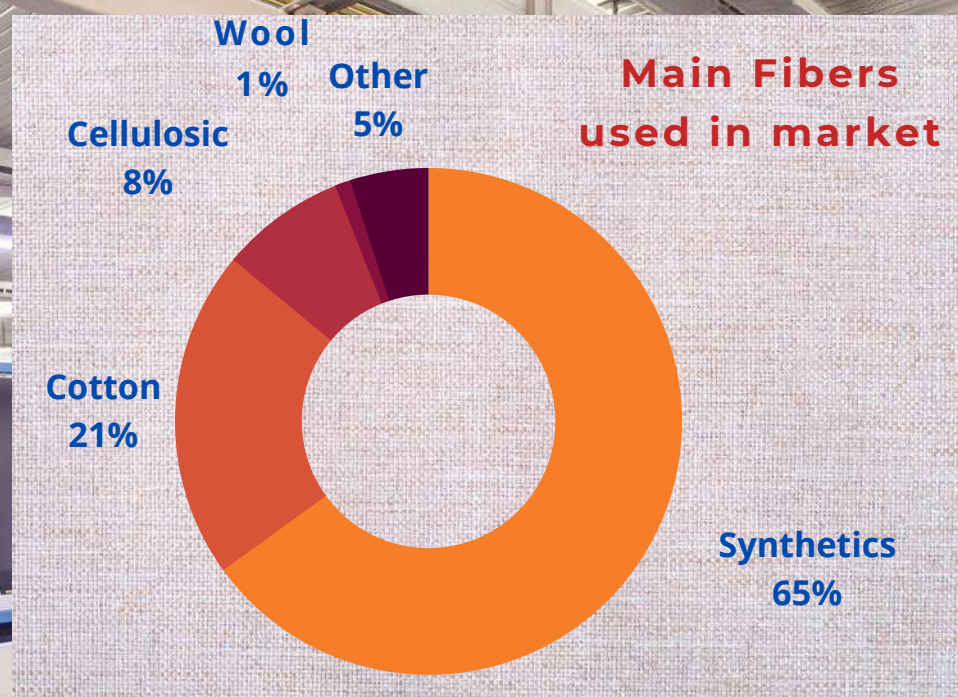
- Develop software to design efficient and economical packaging by properly utilizing the material as per product shape and size
- Analyze customer behavior on product packaging to increase customer attraction for high sales and avoid wastage.
- Durable and quality packaging guarantees the long life of the product, especially, food items and medicine
- Utilize foldable and flexible packaging boxes and pallets to increase availability in a warehouse
- Advanced machine to prepare packaging boxes in just-in-time as per product requirements

¹⁸FICCI (2020). Farm Mechanisation. PWC.

TEXTILE AND APPAREL INDUSTRY

India is among the world's largest Textile and Apparel producers. The Indian textiles industry has established a value chain from fiber, yarn, and fabric to final apparel and garments. This sector is hugely mixed with distinct segments from traditional handlooms, handicrafts, wool, and silk products to the organized textile industry because of diversified culture, geographical locations, and weather conditions. The organized textile industry is characterized by capital-intensive technology for mass production of textile products and includes spinning, weaving, processing, and apparel manufacturing³⁶.

The domestic textiles and apparel industry contributes 2% to India's GDP, 7% of industry output in value terms, and 12% of the country's export earnings³⁷. India is the 6th largest exporter of textiles and apparel in the world. The textiles and apparel industry in India is the 2nd largest employer in the country, providing direct employment to 45 million people and 100 million people in allied industries³⁸.



³⁶Tyagi, Astha (2021). [Textiles & Apparel](#)

³⁷IBEF (July 2021). Indian Textiles Industry Report. Indian Brand Equity Foundation, New Delhi, India.

³⁸Gupta, Devyani (May 2021). Textile & apparel: Weaving a new success story? Trade Promotion Council of India, New Delhi, India.

MAJOR CHALLENGES / RESEARCH ISSUES

Policy and Agreements



- Acceptance of the Indian textile and apparel is declining in developed countries because of Multi-fiber Arrangement quotas to save the jobs and businesses of their local farmers, suppliers, and workers.
- Improper follow-up of social, environmental, safety standards, and human rights are the barriers for Indian export in this sector. Thus, suitable training should be offered to workers.
- India lacks a Free-Trade Agreement with the world's major marketplaces, whereas other competitor countries enjoy duty-free access.
- Imbalance tax policy under GST between man-made fiber and fabric, and it affects their sustainability in the market.

Resources and Infrastructure



- India lags in manmade textiles in the apparel industry as demanded globally, and it is fulfilled by the competitor country.
- Inefficient operations and low productivity in the Indian apparel industry because of not adopting world-class machines and automation.
- Labor costs are higher in India than in several other top exporters because of the unavailability of skilled labor and training programs.
- The apparel industry has been hugely affected by both industrialization (economic activity beyond borders) and globalization (integration of supply chain activities).
- Urgent need for investments in infrastructure development and process standardization.

RESEARCH PERSPECTIVE

Technology



- The Indian apparel industry should use emerging technologies like Machine Learning and Artificial Intelligence to predict and analyze the market scenario, and accordingly set the export planning.
- One of the major reasons for product rejection in the international market is Quality, and significant improvement is required by strategically implementing the automation.
- Develop and innovate new and multipurpose fabrics as per the sustainability aspects like recycling, reusable, bio-degradable, and environment-friendly.

Supply and Operation



- The Indian market itself is one of the biggest business hubs, and therefore, an effort needs to be made to capture the maximum part by fulfilling the region-wise demands as per their requirements and standards.
- Efficient Supply Chain networks and Logistics systems are the need of the hour for the fastest and safest delivery from suppliers to manufacturers, and then finally to customers.
- Connects a maximum number of MSMEs and other stakeholders with the emerging market of e-Commerce to gain plentiful outcomes.



HANDICRAFT SECTOR

India is a country of rich culture, history, and traditions, and its handicrafts go back almost 5000 years now. The cultural heritage and centuries of evolutionary tradition are manifested by the wide variety of handicrafts made all over the country.

Handicrafts reflect the cultural connections of the ethnic people and transfer of the knowledge of artesian expertise from one generation to subsequent who make them. The craft of each state in India indicates the influence of different empires. India is one of the primary producers and suppliers of Handicrafts items in the world. Before the industrial revolution, the art and handicraft industry was a possible economic contributor.



Khadi (cloth that is woven from handspun yarn)



Zari (silver and gold threadwork and embroidery carpets)



Earthenware plating/ polishing/ engraving metals



silk handlooms (Saree)



miscellaneous products made of wood, bamboo, cane and grass



jewelry and related products

The Indian handicrafts industry is a highly labor-intensive, cottage based and decentralized Industry. Most of the manufacturing units are in villages and small towns, and there is tremendous market potential in big cities and abroad. The handicraft industry is a vital source of income for rural communities engaging over 6 million artisans, including women and people belonging to the weaker sections of society.

The handicraft sector is very imaginative and provides a large variety of crafts products. In India, the production of craft items is done on both small and large scales. People can start their businesses on a small scale because of low capital expenditure, and accordingly, demand and supply can be managed. Though the Indian Handicraft industry is considered a cottage industry, it has evolved as one of the most important revenue generators. There has been a steady growth of 15% over a few years, and the industry has emerged as one of the crucial contributors in export and cross-border business.

Handicraft items are not limited to India but also have a substantial influence in international markets. Therefore, a requirement to have more incredible technological support and innovative ideas with unique and quality items to match the demand and supply.

Source: <https://www.incredibleindia.org/content/incredibleindia/en/experiences/art-and-culture/handicrafts.html>

Handicrafts	Places	Handicrafts	Places
Wood	Jammu & Kashmir, Karnataka, Kerala, and Uttar Pradesh	Rock	Rajasthan, Madhya Pradesh, Jaipur, Nagpur, and Odisha
Weaving And Embroidery	Madhya Pradesh, Rajasthan, Gujarat, Bihar	Paper	Delhi, Rajgir, Patna, Gaya, Awadh, Ahmedabad, and Allahabad.
Shell	Gulf of Mannar, Goa, Odisha	Jute	West Bengal, Assam, and Bihar.
Brass	Rajasthan.	Dhokra	Madhya Pradesh, West Bengal, Bihar, and Odisha
Horn	Odisha, Karnataka, Kerala and Uttar Pradesh.	Bell Metal	Madhya Pradesh, Bihar, Assam, and Manipur
Cane	Vellore in Tamil Nadu	Bamboo	West Bengal, Assam, and Tripura.
Clay Or Pottery	West Bengal, Bikaner, Lucknow, Pune and Himachal Pradesh	Silver Filigree Or Meenakari Or Tarakashi	Cuttack in Odisha, Karimnagar in Telangana

Government Schemes

- Baba Saheb Hastshilp Vikas Yojana
- Design and Technology Up-gradation
- Marketing Support and Services
- Research and development
- Human and Resource Development
- Handicrafts Artisans Comprehensive Welfare Scheme
- Infrastructure and Technology Development Scheme

MAJOR CHALLENGES

Productivity

- Chaotic Production
- Educationally weak
- Old fashioned manufacturing system

Communication

- Poor information sharing only limited to local region
- Use of local language by artisans

Supply chain

- Poor market connectivity
- Control of mediator on maximum profit
- Insufficient collection centers and warehousing
- Poor co-ordination between Indian Manufacturer, exporter, and Governments

Inputs

- Poor quality materials
- No financial facility
- Lack of innovations in designs

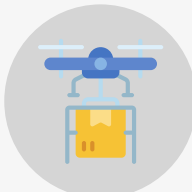
Advanced Technology

- Inadequate use of technology
- Outdated machines and equipment
- No use of design and simulation software

Environment Support

- The sector is not highlighted by the governments
- Less interest of next generation
- Improper implementation of the policies and standards

RESEARCH ISSUES



Using Emerging Technology

- Innovative and autonomous machines should be developed to improve the efficiency of the handicraft industry
- Provide access to cloud-based design software and ease of sharing
- Enhance the application of Additive Manufacturing
- Development of advanced and sustainable materials for this industry



Market Demand and Analysis

- Using data analytics approaches market demand and consumer opinion can be adequately predicted.
- Artificial Intelligence can help in analyzing the products' features, patterns, and uniqueness to satisfy the customer requirements.



Knowledge Capture and Training

- In the craft industry, knowledge sharing is limited to some communities that impact order fulfillment. So, using video and image recognition, artistic knowledge can be captured and shared.
- Courses should be launched to train people as per the market potential to capture diversity and artisans' base.

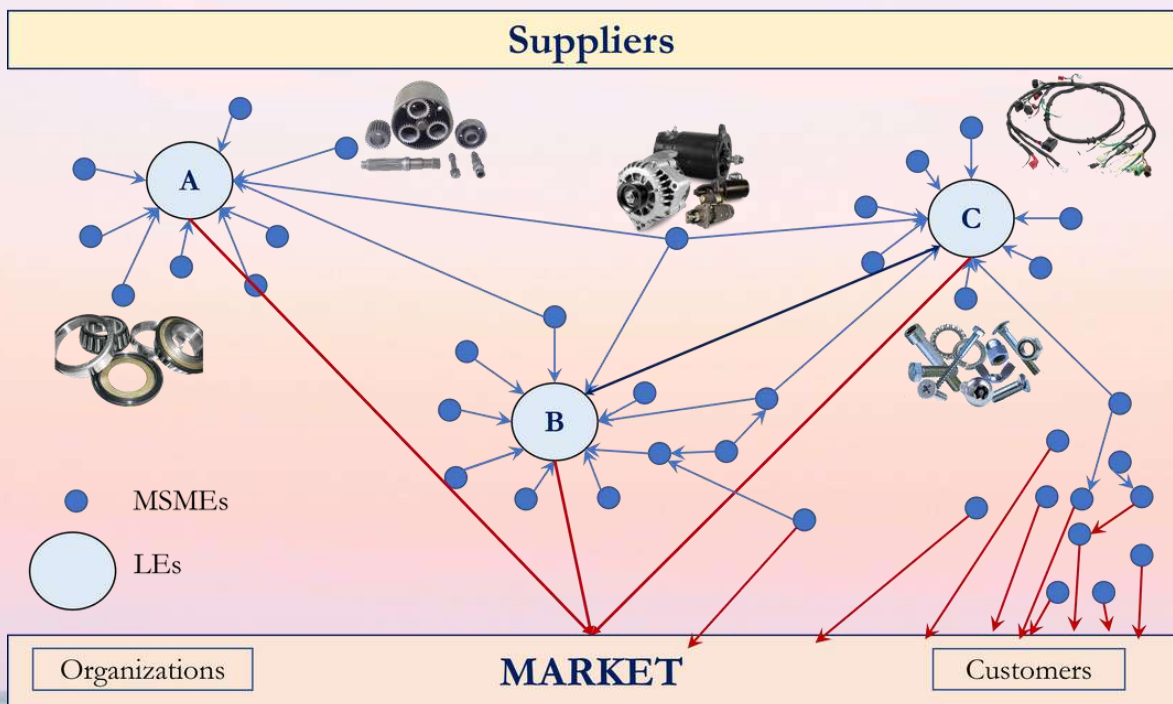


MICRO, SMALL, & MEDIUM-SIZED ENTERPRISES (MSMES)

"MSMEs are the backbone of the economy because of the significant contribution country's GDP and employment generation" - **Confederation of Indian Industry (CII)**

The MSMEs enact a crucial role in a country's manufacturing sector by serving the market and supporting the other large enterprises, as depicted in the following figure. The Confederation of Indian Industry (CII) reported that India's MSME sector contributes 6.11% and 24.63% of its GDP in the manufacturing and services sectors³⁹. Furthermore, the MSMEs employ 111.0 million people in 63.4 million units, the second-highest after the agriculture sector at a lower capital cost and investment than large enterprises⁴⁰. According to the India Brand Equity Foundation, the MSME sector gives 45% to total manufacturing output and 49.66% of total exports⁴¹. MSMEs are the backbone of hugely populated countries, like China and India, but most of these MSMEs are not well-equipped with emerging technologies.

MSMEs are also not fully aware of compliance, legalities, policies, and innovations. Indian MSMEs are widely scattered across the country and produce around 6000+ diverse range of products and services to meet local and global market requirements and blend into domestic and global value chains. The situation is quite different in the competing economies, especially in China, where the MSME sector grips on 90% of total market products and grants 80% of jobs in the national employment by contributing 60% of GDP⁴². The Indian manufacturing sector, particularly the MSME sector, lags in comparison with China, an almost equally populated country. The predominant cause for such a big gap is in not adopting technological changes and due to a lack of strategic clustering of the manufacturing enterprises.



³⁹CII (September 2019). Making Indian MSMEs Globally Competitive: Innovation. Confederation of Indian, New Delhi, India.

⁴⁰MSME (2021). Annual Report 2021. Ministry of Micro, Small, & Medium Enterprises. New Delhi, India.

⁴¹IBEF (November 2020). Manufacturing. Indian Brand Equity Foundation, New Delhi, India.

⁴²EUSME (July 2019). SMEs in China: Policy Environment Report. EU SME Centre. Beijing, China.

Definition of Micro, Small and Medium Enterprises (MSMEs) in India⁴³

Enterprise	Investment in a Plant and Machinery or Equipment (in INR)	Turnover (in INR)	Numbers (In lakhs)
Micro	< 1 crore	< 5 crores	630.5
Small	1-10 crores	6-50 crores	3.31
Medium	10-50 crores	50-250 crores	0.05

Major Challenges

-  Unable to use emerging technologies
-  Insufficient financial support
-  Inadequate infrastructural facilities
-  Expensive and complex IT systems
-  Incapable to design a complicated products
-  Limited capacity of resources
-  Improper follow-up of standards

A technological gap has been formed between micro, small and medium enterprises (MSMEs) and large enterprises (LEs), with continuous development in the manufacturing sector with the embracing of the ICT and several other promoting technologies. MSMEs are facing numerous challenges, such as not being able to utilize the core and emerging technologies (3D printing, robotics), not getting financial support (government or financier), inadequate infrastructural facilities (automation, storage capacity), incapability of designing complicated parts (design and simulation software, design experts), expensive and complicated IT system (high-performance computing, data management), limited capacity of the resources (fewer workers, insufficient



machines, raw material, and finished product storage), and improper follow-up of standards (Quality, environmental, security)⁴.

To overcome these challenges, MSMEs need to invest in high-quality equipment and machines for better productivity and acceptable quality of a product. But for MSMEs, it is difficult to afford the additional cost of new technology because of their limited turnover, considerations of perceived benefits and expected returns, limited skills, and high risks⁴⁴. Such difficulties arise as most MSMEs are unregistered, have unskilled or semiskilled labor, have limited internet facilities and digitization, and lack abundant market access.

⁴Singh et al. (2019).

⁴³MSME (2021). Annual Report 2020-2021. Ministry of Micro, Small and Medium Enterprises, New Delhi, India.

⁴⁴Kurnia et al. (2015). E-commerce technology adoption: A Malaysian grocery SME retail sector study. Journal of business research 68 (9): 1906-1918.

MSMEs rely on resource collaboration to grow their business and ensure order achievement. In developing the collaboration among the distributed units located scattered at various places, several issues arise related to information sharing, data access, trust, and many more as discussed below:

COLLABORATION CHALLENGES

Issue of accessing the Enterprises Knowledge (*security, trust*)

Unstructured format of the Data (*pricing, time, efficiency, availability, etc.*)

Insufficient Information Sharing (*internet connectivity, data storage capacity, computing*)

Absence of Real time Data Monitoring (*manufacturing sensors, RFID for traceability*)

Unavailability of Cloud Service (*design and simulation software, HPC, etc.*)

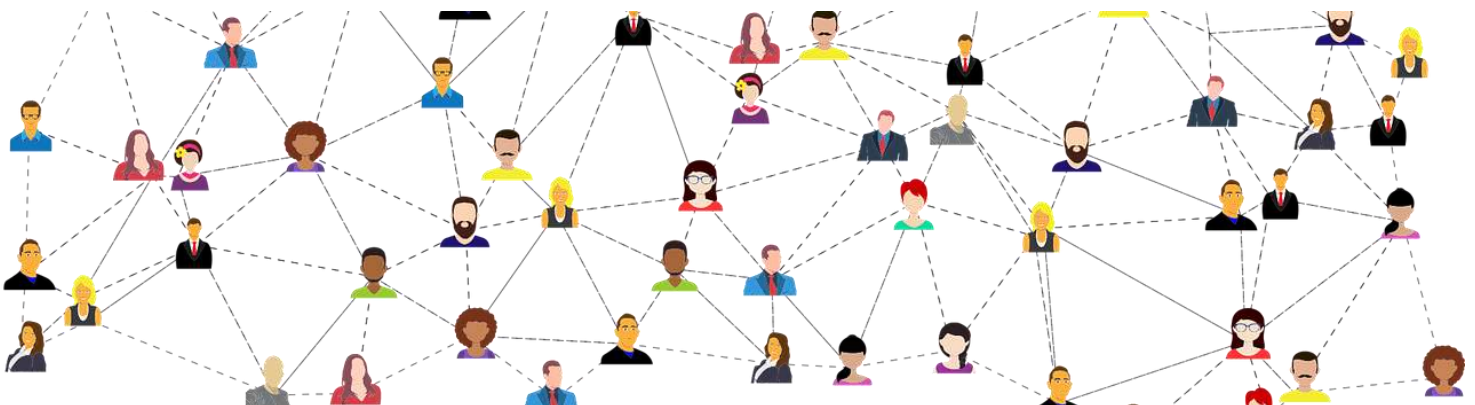
Insignificant collaboration of MSMEs (*only very few MSMEs collaborate*)

Expensive emerging technologies (*Robotics, 3D printing*)

Improper follow up of Standards and Policies (*Quality, labor laws, and environmental policies*)

With the changing scenario, customer expectations and technological advancements have brought such a shift in paradigm, and it needs to be seen in the manufacturing sector. In achieving the goal of Industry 4.0, India is facing numerous challenges, for example, suitable labor and their skills, innovative design, emerging technologies, reducing energy and raw material cost, and sustainability and circular economy by using industrial waste.

Currently, only two companies from India are listed in the Industry 4.0 lighthouse that measures the adoption of innovation on the World Economic Forum (WEF) learning networks released in 2021⁴⁵. The advancements in manufacturing technologies are so rapid that MSMEs are either incapable or late in adopting technological changes. Large Enterprises (LEs) may be competent in adopting mushrooming technologies, but most MSMEs are petrified because of high investment and complexity with insecure profit. Due to such barriers faced by MSMEs, the LEs and conglomerates mainly capture the market⁴⁶.



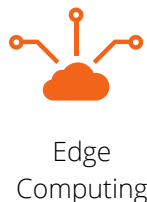
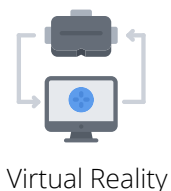
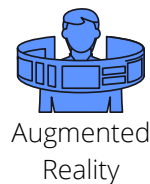
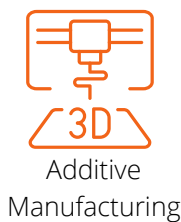
⁴⁵WEF (September 2021). Global Lighthouse Network: Unlocking Sustainability through Fourth Industrial Revolution Technologies. World Economic Forum, Geneva, Switzerland.

⁴⁶WEF (January 2020). Accelerating the Impact of Industrial IoT in Small and Medium-Sized Enterprises: A Protocol for Action. World Economic Forum, Geneva, Switzerland.

EMERGING TECHNOLOGIES

Since 2011, the world has entered a new era, widely known as Industry 4.0 or Fourth Industrial Revolutions because numerous emerging technologies were introduced, and their applications are visualized in the manufacturing domain.

The essential technologies are Internet of Things (IoT), Blockchain, Collaborative Robotics (Cobots), High-Performance Computing (HPC), Artificial Intelligence, Additive Manufacturing, Drone system, and Cyber-Physical System that plays a crucial role in envisioning digital and smart manufacturing systems⁴⁷. It is estimated that by 2030 IoT annual revenue will be increased to \$1058 Billion⁴⁸, Artificial Intelligence is growing to \$300 Billion by 2025⁴⁹, Blockchain market increasing to 39.7 Billion by 2025⁵⁰, HPC to 49.4 Billion in 2025⁵¹, Additive Manufacturing to 37.2 Billion by 2026⁵², Drone market touches the 501.4 billion⁵³, and similarly, CPS will reach to 12.7 Billion by 2026⁵⁴.



All over the globe, a tremendous effort has been made to adopt these technologies and digitization on an early basis, and accordingly, the World Economic Forum released an Industry 4.0 preparedness report by ranking the countries based on the current structure of production and driver of production. Entire ratings were also sorted by leading, legacy, high-potential, and nascent countries. Abundant opportunities for India are seen because it is the only country from South Asia ranked in legacy countries with ranks of 30 and 31 in the structure and driver of production respectively.

⁴⁷Deloitte (2015). Advanced Technologies Initiative Manufacturing & Innovation. Deloitte Touche Tohmatsu Limited, London, UK.

⁴⁸Statista (2021): <https://www.statista.com/statistics/1194709/iot-revenue-worldwide/>

⁴⁹McKinsey (2017). [Artificial Intelligence the next digital frontier?](#) McKinsey Global Institute.

⁵⁰MarketsAndMarkets (2019): [click here](#)

⁵¹MarketsAndMarkets (2019): [click here](#)

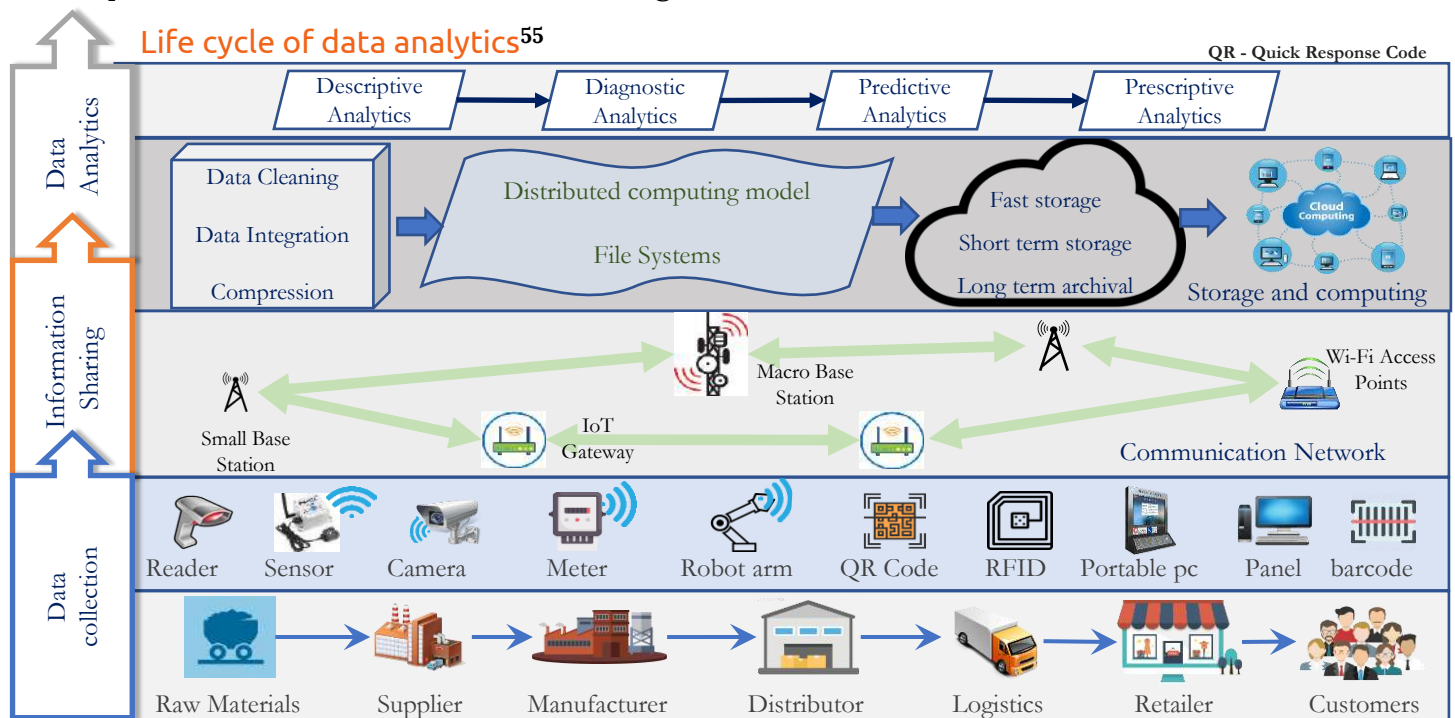
⁵²Statista (October 2021). 3D printing industry - worldwide market size 2020-2026. Statista Research Department

⁵³MarketsAndMarkets (September 2021). Drone Services Market Size and Scope.

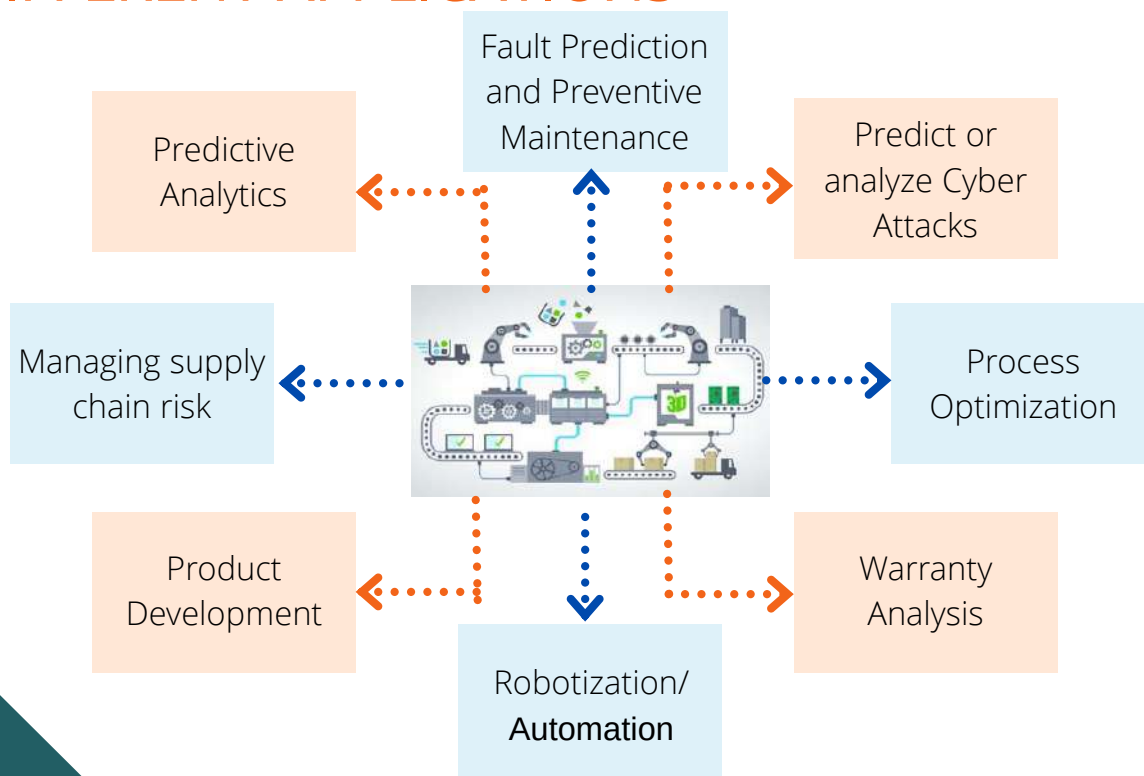
⁵⁴360Research Reports (2020): [Click here](#)

1. DATA ANALYTICS

Realizing an integrated and complex manufacturing system accessing data from enterprises and stakeholders who are involved in the entire supply chain is one of the prominent tasks using various sensors. The obtained data is shared with the main database using cloud services. Then as per the requirements of the system, different kinds of analytics need to be performed for efficient functioning.



DIFFERENT APPLICATIONS



⁵⁵Dai et al. (2020). Big data analytics for manufacturing internet of things: opportunities, challenges and enabling technologies. Enterprise Information Systems, 14(9-10), 1279-1303.

WHAT DOES ANALYTICS DO FOR MANUFACTURING?



Maximum Utilization & Decreasing downtime

- By predicting Machine breaks and failures
- Maximize the operating time of critical assets
- improvements in operational efficiency
- improve the uptime of an individual asset



Optimizing network complexity

- Optimize the interaction machines and processes
- Encompasses every step from purchasing to production to sales
- Help manufacturers in **what to buy**, **what to make**, and **how they should make** it to yield the most profit
- Creates strong data base for Customer relationship management by (CRM) by detailed customer profiling.



Data-driven manufacturer

- Optimize the productivity of individual assets
- Maximize their productivity and profitability
- Dynamically optimize their tactical planning and
- Make better strategic decisions in the long term



Manage Warehouse and Inventory Better

- Establishing efficient arrangements of various sections and structures
- Most effective replenishment procedures
- Inventory management with different servicing policies, like, first come first serve (FCFS), and First Come Last Out (FCLO).

ANALYTICS APPROACHES

Statistical modeling schemes

- Descriptive statistics
- Inferential statistics
- Stochastic modeling methods

Data mining schemes

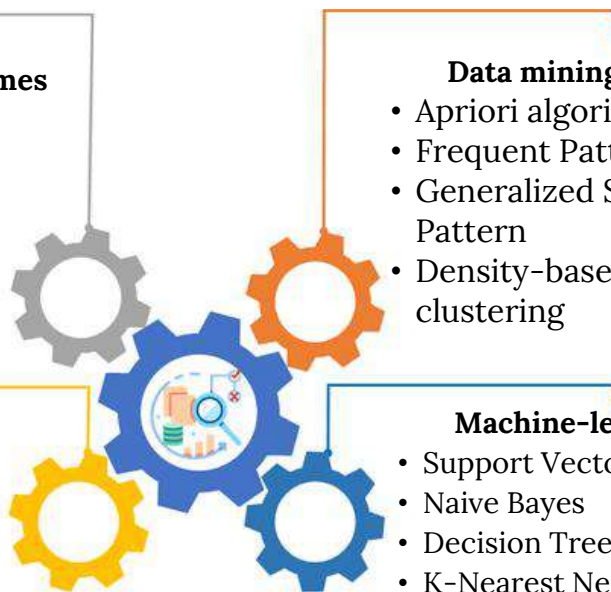
- Apriori algorithm
- Frequent Pattern Growth
- Generalized Sequential Pattern
- Density-based spatial clustering

Data visualization

- MATLAB plot
- Gnuplot
- Python's Seaborn
- Pandas plot
- Matplotlib

Machine-learning schemes

- Support Vector Machines (SVM)
- Naive Bayes
- Decision Tree Learning
- K-Nearest Neighbors
- Singular Value Decomposition (SVD)
- Reinforcement Learning Algorithms

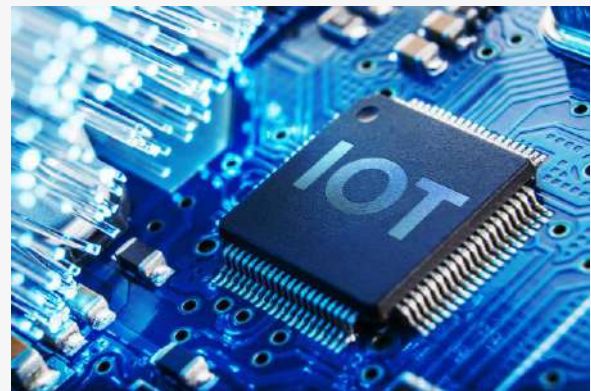


Source: McKinsey (August 2017). [Manufacturing: Analytics unleashes productivity and profitability.](#)

2. INTERNET OF THINGS (IOT)

The Internet of Things (IoT) is defined as the internet in devices employing wired and wireless sensor networks (WSN), embedded systems, Radio Frequency Identification (RFID), and Near Field Communication (NFC). The scenario of the manufacturing sector has been transformed with the application of IoT gadgets that assist in promoting Machine to Machine (M2M) communication, constant communication between elements, data generation on the cloud, collaborative robots (Cobots), and object tracking while manufacturing, warehousing, and transportation.

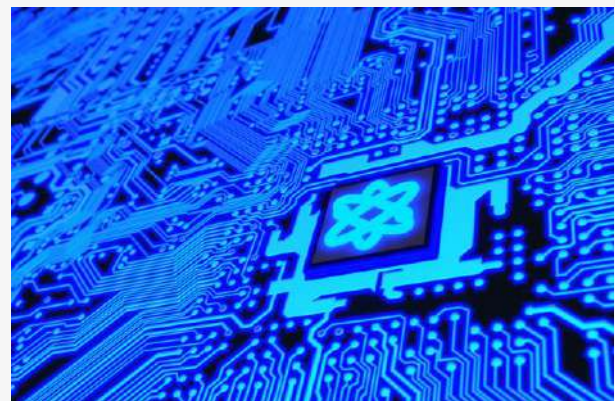
Furthermore, in recent years, blockchain technology has gained researchers' attention, especially with IoT devices for real-time monitoring of finance, logistics, cybersecurity, and various others.



3. QUANTUM COMPUTING

High-Performance Computing and Quantum Computing have been considered as one of the essential technologies for realizing advanced manufacturing systems because of the growing complexity and size of datasets generated from users, machines, enterprises, and manufacturing operations. Various multinational tech companies have invested hugely to expand cloud applications, for example, IBM, Amazon, Rackspace, and Microsoft. Additionally, the idea of parallel processing has been introduced for advanced and complicated applications to get quick and efficient quick results.

Using advanced systems, the problem can be solved and obtain the optimized value, and it also assists in linking the design and simulation software in real-time with the cloud server.



4. SEMANTIC TECHNOLOGY

The semantic web is also known as the 'Web of Linked Data' by World Wide Web Consortium (W3C). The Resource Description Framework (RDF) format has been recommended as one of the W3C standards for linking data. Furthermore, RDF schema (RDFS) finds out the connections between resources by applying semantic analysis techniques. The semantics can be seen as a necessary technology in manufacturing systems, like IMS to structure the massive information and knowledge management. Standard semantic vocabulary is required to integrate diversified information to define various manufacturing equipment and operations, e.g., MTConnect.

Therefore, the idea of a semantic web can be utilized in the manufacturing sector for enhancing automation and machine-to-machine communication by structuring the information in a machine-readable format that improves the precision of understanding of uncertain data.



5. ADDITIVE MANUFACTURING

3D printing or additive manufacturing is the process of making three-dimensional solid objects from a digital file. The creation of a 3D printed object is achieved using additive processes. Additive Manufacturing and smart materials have obtained significant consideration from industries and academicians because of their applications in the defense, space, and toy sectors. The utility of advanced materials, innovative surfaces, open-source design, intelligent factories, electronics devices, and additive manufacturing has been designated as part of manufacturing innovations.

Benefits	
	High Speed (from design to realize)
	Single step manufacture
	Cost (drastically reduces the labor cost)
	Risk mitigation (during disruption)
	Complexity and design freedom
	Customization
	Ease of access
	sustainability

6. INFORMATION TECHNOLOGY & TELECOM INFRASTRUCTURE

"We are all now connected by the Internet, like neurons in a giant brain." -
Stephen Hawking



India's information and communication technology (ICT) business has been among the world's fastest expansions during the last decade. IT services, Business Process Management (BPM), software products, engineering services, and hardware are the four key segments of the Indian IT and ITeS industry. Telecommunications, coupled with information technology, provide around 8% of India's GDP and have substantially expedited the expansion of the economic and social sectors, and will continue to do so in the future. According to the National Association of Software and Service Companies (NASSCOM), the Indian IT industry's revenue is estimated to reach US\$ 194 billion in FY21, an increase of 2.3% YoY. The sector is the largest employer within the private sector.

The Push towards Cloud Services has Boosted Hyper-scale Data Center Investments, with Global Investments Estimated to Exceed ~USD 200 Billion annually by 2025⁵⁶.

India is the world's second-largest telecommunications market with a subscriber base of 1.16 billion and 785 million internet subscribers and has registered strong growth in the last decade⁵⁷.

⁵⁶IBEF (July 2021). Indian IT & BPM Industry Report. Indian Brand Equity Foundation, New Delhi, India

⁵⁷IBEF (July 2021). Indian Telecommunications Industry Report. Indian Brand Equity Foundation, New Delhi, India

ICT ROLE IN MANUFACTURING



In the era of Industry 4.0 and the information world, the importance of Information and Telecommunications technologies has significantly increased. Therefore, numerous research objectives are observed to envision the future of manufacturing systems, and a few of them are highlighted below:

- Enhance inter-organizational connectivity by providing high-quality internet facility, i.e., 5G technology
- Identify the key region on a priority basis for infrastructure development to serve various manufacturing clusters in the country such that the actual potential of the manufacturing sector can be utilized.
- Analyze the environmental and social impact of the ICT infrastructure.
- Design an innovative framework to see the role of ICTs in socio-economic growth
- Develop an efficient and resilient supply chain of the essential items required in the adoption of information and communication technologies.
- Implement novel materials of high strength and harmlessness feature in creating the ICT infrastructure.

5G



7. ARTIFICIAL INTELLIGENCE (AI)

The AI technique has played a notable role in achieving the intelligence-based advanced manufacturing system with the decision support system. In artificial intelligence, machine learning, and deep learning are viewed as the two leading contributors with the support of numerous algorithms and techniques, for example, versions of Neural Networks (NN) and evolutionary algorithms. Artificial intelligence helps IMS by providing quick and efficient results in getting the decision proactively while progressing various manufacturing and logistics activities.

Analytics Types⁵⁸

Descriptive

- What has happened?

Diagnostic

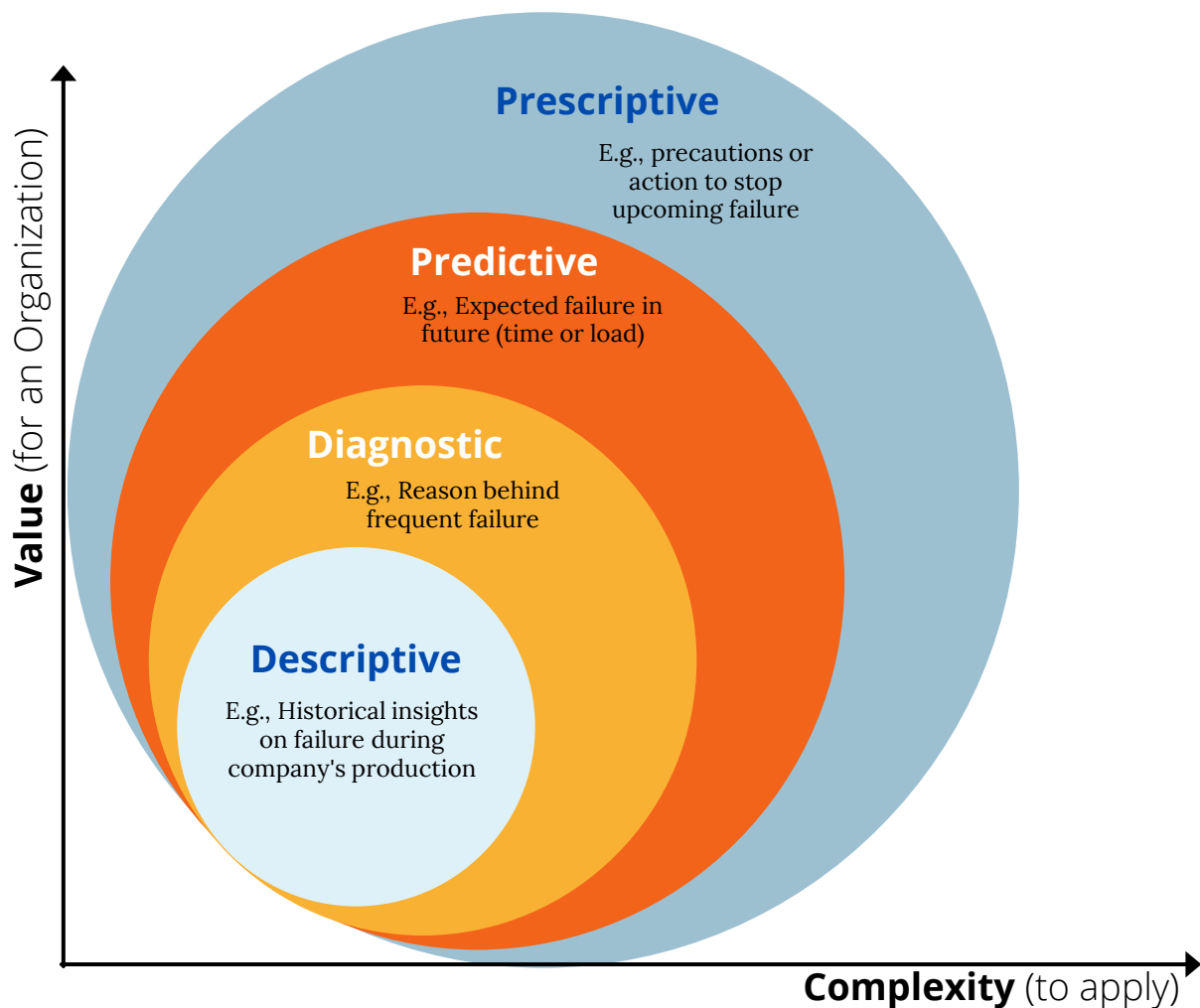
- Why did it happen?

Predictive

- What will happen next?

Prescriptive

- What should be done?



⁵⁸Shi-Nash and Hardoon (2017). Data analytics and predictive analytics in the era of big data. Internet of things and data analytics handbook, 329-345.

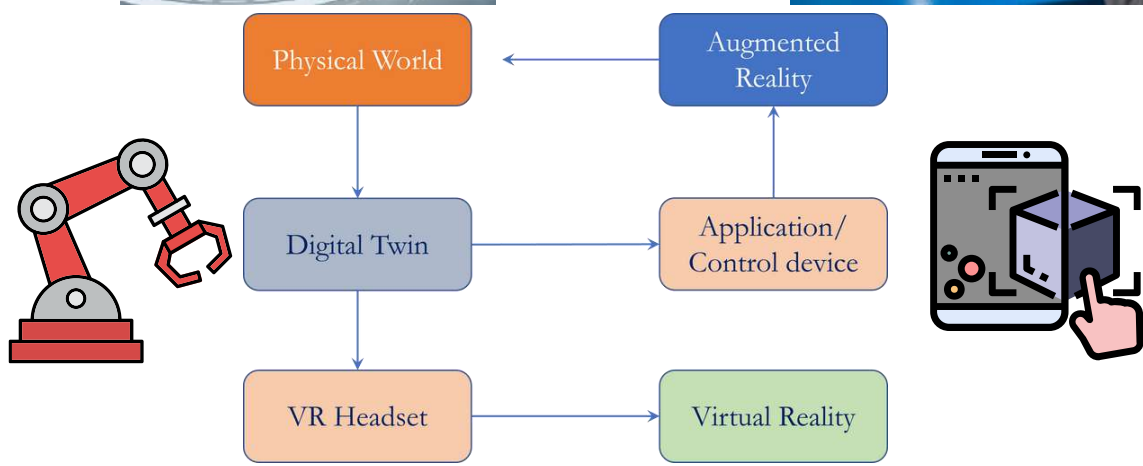
8. CYBER-PHYSICAL SYSTEM

Cyber is linked to computation, communication, and control. The integration of traditional manufacturing systems with the internet and cloud computing has been proposed as a cyber-physical production system (CPPS). The adoption of advanced technologies like IoT devices, sensors, big data, blockchain, and cloud services have the potential to boom CPS-based manufacturing. Furthermore, the digital twin (DT) has been identified as a vital technology in achieving the cyber-physical system. Digital Twin reveals a replica of the physical system, whereas CPS is the use of a computer with any physical system. It has been considered a connecting technology between the virtual and

physical world in the manufacturing system. To support the CPS, virtual reality and augmented reality also play a crucial role where Virtual Reality provides the opportunity to visualize the data and Augmented reality gives an interactive experience with the real world by controlling the system.

Benefits of Augmented Reality

- Production
- Faster and smarter
- Expert support
- In training
- Product assembly
- Machine maintenance
- Quality assurance

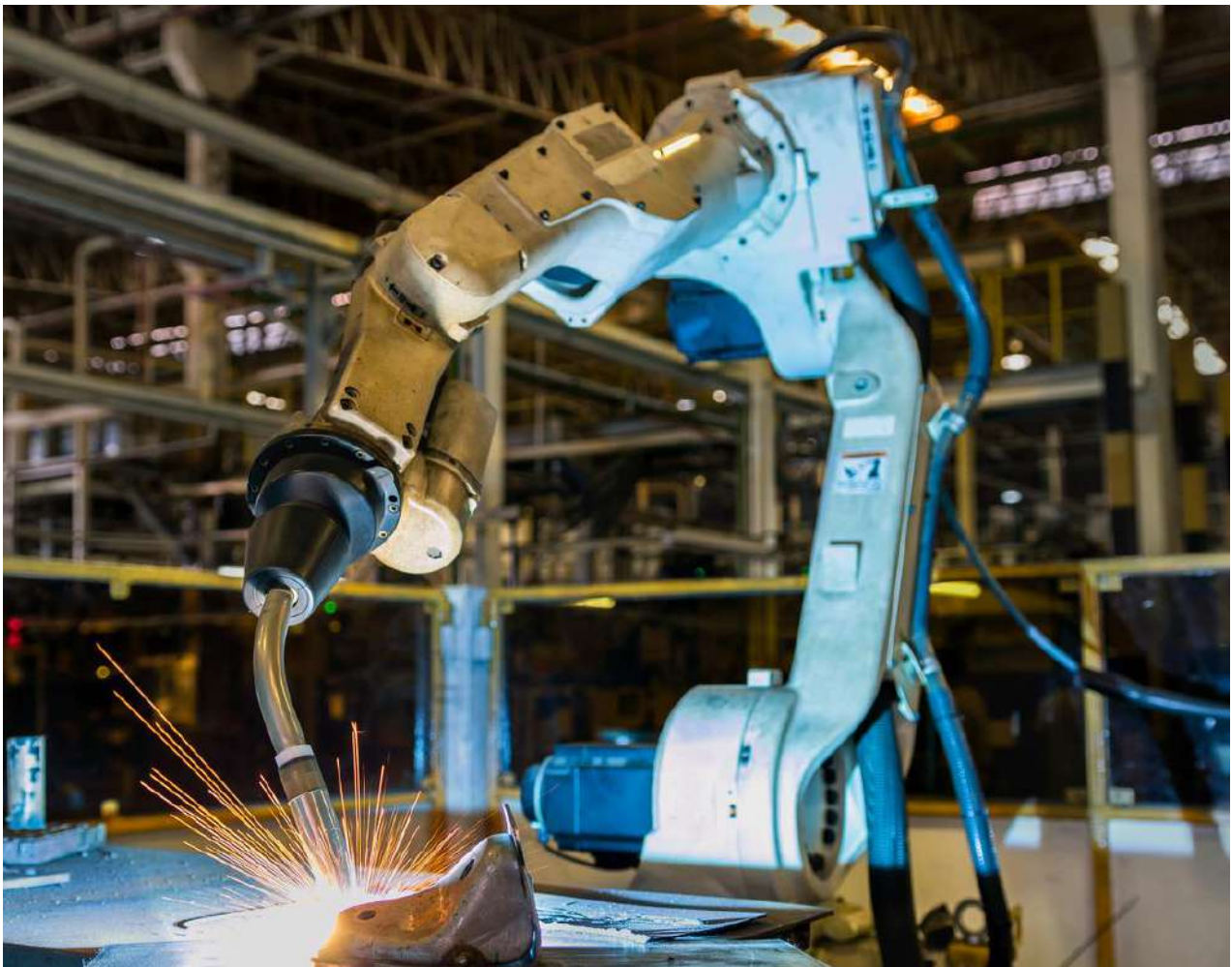


9. ADVANCED ROBOTICS & COBOTS

Advanced robotics has been involved in high-level automation with minimal human interventions supported by AI techniques, especially data analytics and machine learning, to achieve workplace navigation and exercise complex activities. Robots optimize the manufacturing performance related to cost, quality, accuracy, productivity, and reliability. In recent developments, the application of drones has been recognized as one of the disruptive technologies for the upcoming future of the delivery system. For full automation, the manufacturing systems are being shifted to the usage of collaborative robots (Cobots)

Applications

- Accepts high-level mission-oriented commands, for example, navigating to a workplace, and performing complex tasks in a semi-structured environment with minimal human intervention.
- Role in arc welding, spot welding, and fully automatic robotic welding systems.
- Perform moving, storing, and retrieving products.
- Help in material handling, painting, automobile bodies, and assembly line work.
- Mechanizing the production line to improve efficiency
- Human-machine interaction is the next big trend in robotics as Cobots.



10. CYBER-SECURITY

With the growing digitalization across the globe, cyber security has become the core services market for incident response and security testing services. Cyber attacks target any of the components in the entire information network, like computers, smartphones, USBs, and power sources, if significant investments are not made in security. The security implementation services market in India is estimated to increase from USD 221 million in 2019 to USD 320 million by 2022, at a CAGR of 13.2%, given that drawing up effective cyber security strategies depends on successful security implementation⁵⁹. Security consulting services, which include planning of cyber security strategies, policy development, and building security architecture.

Control and mitigation

People-centric solutions

- Security awareness
- Education and training
- Usability of security technology

Process-centric solution

- Least privileged policy
- Least route principle
- Separation of duties
- Well-formed transaction policies

Technology-centric solution

- Network architectures
- Intrusion/anomaly detection
- Network segregation
- Access Controls
- Data diodes and unidirectional gateways
- Firewalls
- Intrusion Detection Systems (IDSs)
- Cryptography



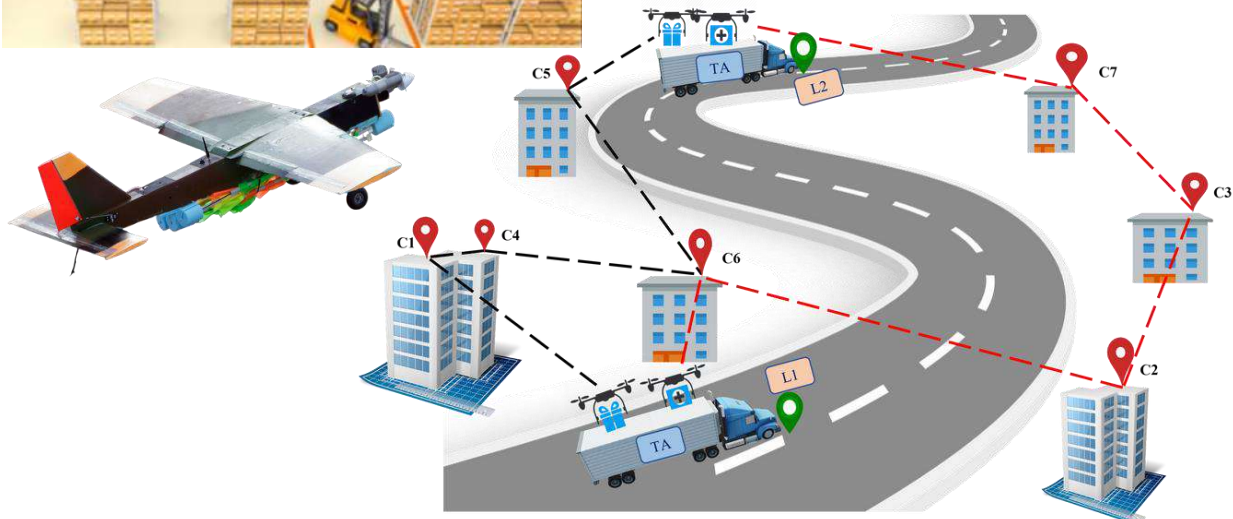
⁵⁹DSCI (December 2019). [Cyber Security India Market - What lies beneath](#). Data Security Council of India (DSCI) and PWC India, Noida, India.

11. DRONES

In recent years, drone technology has gained attention from researchers, academia, and industry that is also known as Unmanned Aerial Vehicles (UAV). It also noted that the drone industry is one of the fastest-growing because of its wide range of applications, from the factory floor to warehouse management, online delivery, and defense services including navigation devices and weapons. In India, the use of drones is increasing, and accordingly, the Government of India released Drones Rule 2021 for various activities related to it like Preliminary, Classification, Certification, Registration, Operations, Remote Pilot Licenses, and Training, Drone services are estimated to be worth \$127 billion globally, \$13 billion of which is based on drone-powered transportation⁶⁰.

Benefits

- Faster than delivering with traditional vehicles
- Road infrastructure cannot limit its application
- Faces less complex obstacle avoidance scenarios.
- Significantly reducing the cost and time during last-mile deliveries and responding quickly to emergencies.
- Least expensive to maintain than traditional delivery vehicles and can lower labor costs by performing tasks autonomously.
- Maintain shop floor management and operation flow
- Efficiently operationalized automated warehouse system



⁶⁰PWC (July 2017). [Welcome to the era of drone-powered solutions.](#)

12. BLOCKCHAIN

Blockchain is a peer-to-peer distributed ledger that is secure and used to record transactions across many computers. It was introduced in the 1990s but has recently become more popular because of envisioned applications in various activities including supply chain monitoring, additive manufacturing, quality and loyalty awards, transfer of property, digital IDs, and many more related to traceability. In a recent report, it is estimated that blockchain value being more than \$10 billion by 2022, and further expand the business to \$176 billion by 2025 and \$3.1 trillion by 2030⁶¹. In a recent report, NITI Aayog has mentioned the implementation possibilities of blockchain uses in supply chain, financial reconciliation, document verification, and land transfer⁸. Similarly, in upcoming future more applications will be realized in manufacturing domain.



Capturing data

- Data required to facilitate traceability and visibility
- Globally unique and persistent identification of all products and locations
- Leverage a common, standardized data model for physical supply chain events
- Capture information in a business application



Sharing data

- Share the data required to facilitate traceability and visibility
- Use standardized data formats
- Leverage a common data model between parties (system interfaces and protocols)
- Standardized communication protocol



Ensuring governance

- Establish governance and agreement principles
- Develop rules to minimize data sharing and communication between parties and members of a network.



Identifying partners

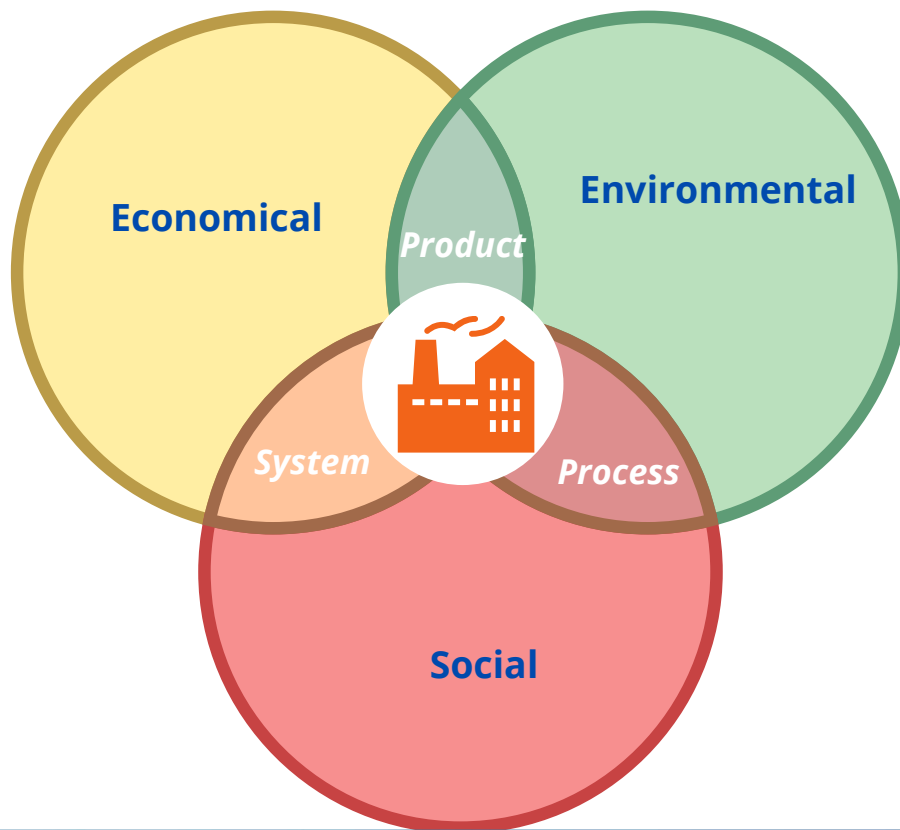
- Discover parties (known and unknown) to communicate and share data
- Make data exchange relatively easy
- Develop a discovery mechanism (such as a routing or registry service)

⁶¹Gartner (June 2019). [Gartner Predicts 90% of Current Enterprise Blockchain Platform Implementations Will Require Replacement by 2021.](#)

⁸NITI (2021).

SUSTAINABILITY CONCERNS IN MANUFACTURING

"Climate change is destroying our path to sustainability. Ours is a world of looming challenges and increasingly limited resources. Sustainable development offers the best chance to adjust our course." - **Ban Ki-moon, Secretary-General of the United Nations**



- Sustainability adoption in manufacturing, minimize waste, maximize resource utilization, reduce environmental impact, conserve and be safe for societies.
- The main goal is to choose appropriate methods that influence the product design, process design, service design, and production design.
- 1.5°C Supply Chain leaders has taken the initiative to reduce the greenhouse gas emission across value chain, halve by 2030 and net zero emissions before 2050.
- To achieve sustainability, integration of the three critical elements are required, i.e., Products, Processes, and Systems, in three dimensions of Environmental, Economic, and Social.
- Sustainability has become more significant for manufacturing because customers, governments, and investors demand more sustainable products in the coming future.
- It may take time to incorporate and see the impact on the organization and society, but the timeline has already begun.

ENVIRONMENTAL POLICIES AND STANDARDS

- Environmental degradation has been identified as a vital concern by world-level organizations like the United Nations, International Finance Corporation, and several countries' governments.
- Various environmental policies have been described to defeat air pollution, water pollution, waste management, soil contamination, and climate shifts that also need to be considered by the manufacturing enterprises.
- In support of these policies, a few international standards have also been established by the International Organization for Standardization (ISO) regarding manufacturing, for example, ISO 14000 series.
- In India, the Environmental Protection Act, 1986, Water (Prevention & Control of Pollution Act, 1974), Air (Prevention & Control of Pollution Act, 1981), and Environmental Impact Assessment Notification 2006 have been introduced by governing authorities to preserve the environment.



ECONOMIC POLICIES



- The manufacturing sector is the backbone of any economy because of its contribution to GDP and employment generation.
- The Indian government has started numerous ambitions under the plan of Make in India, for example, Foreign Direct Investment (FDI), Goods and Services Tax (GST 2017), and Foreign Trade Policies (2016-2020) to match the level of a developed economy.
- MSMEs will add substantially from a fully developed advanced manufacturing system by managing taxation and transactions efficiently and systematically.

Source: ⁴Singh et al. (2019).

SOCIETAL LAWS AND POLICIES

- Societal problems have been observed since the first industrial revolution, such as overtime, inappropriate work distribution, salary gap, protection claim, healthcare, and essential facilities.
- The Government of India has described several acts and laws to protect labor rights that improve living standards, for example, the trade union act and industrial employment act.
- Labor laws and policies should be the compulsory guidelines for MSMEs for registration.



QUALITY STANDARDS

- The quality of a product performs a vital role in winning the attention of the customer.
- Due to inferior quality and non-standardization, several Indian products get rejected several times in the international market, thus incurring vast expenses called the Cost of Quality.
- The reason behind such inadequate quality is an inappropriate follow-up of the quality standards by the manufacturer.
- For quality control, the International Organization for Standards (ISO 9000 series), American Society for Quality (ASQ), and Bureau of Indian Standards (BIS) have been considered as the premier institutions in the world, the USA, and in India respectively that must be followed by Indian manufacturers to expand the cross-border trade.
- Even low quality also invites cheaper imports from competing countries.

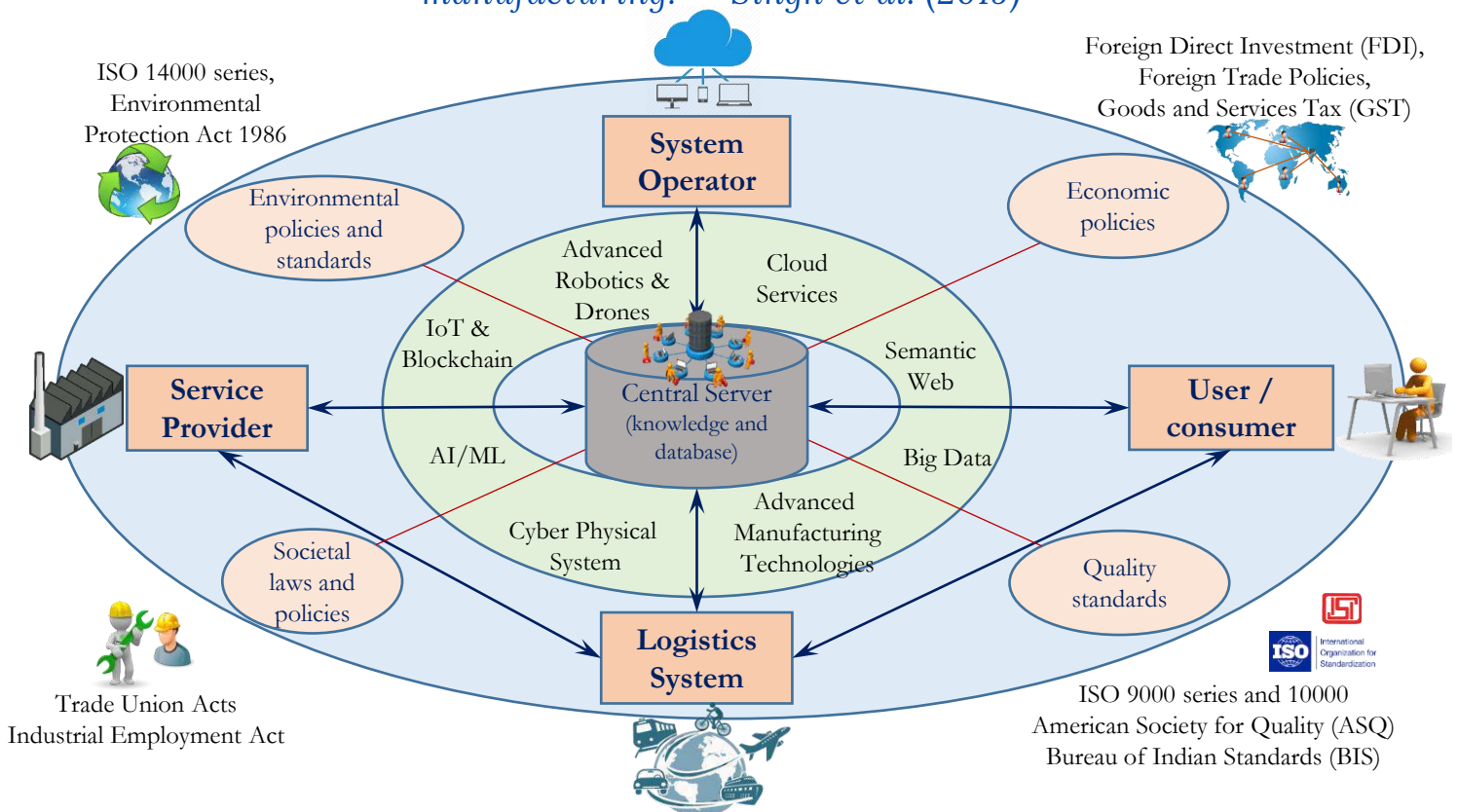
Source: *Singh et al. (2019).

INCLUSIVE MANUFACTURING SYSTEM

The MSMEs are the backbone of hugely populated countries, like China and India, but most of these MSMEs are not well equipped with emerging technologies. Also, they are not fully aware of compliances, legalities, policies, and innovations. As per the current situation of highly populated and developing countries, especially India, a new manufacturing paradigm, inclusive manufacturing system (IMS) has been introduced, as depicted in the Figure.

Inclusive Manufacturing can be defined as:

“inclusion of the innovations and advancements in manufacturing domain for finding out the solutions of societal (employment, education, healthcare, and labor), economical (cross-border business, trade policies, cost of products and services, and manufacturing contribution in GDP), and environmental (natural resources, energy, air quality, clean water availability, recyclable and sustainable products) issues by composing the resources in a geographically distributed environment with the support of advanced manufacturing technologies (IT systems, Artificial Intelligence, High-Performance computation, and CPSs) through integrating semantic web and internet of things to achieve the objective of minimum market time, better quality, low cost, faster services, and environment-friendly manufacturing.” - Singh et al. (2019)⁴



Source: ⁴Singh et al. (2019).



System Operator

- One of the foremost IMS members operates and manages the entire system with support from platform providers.
- Essential help to service providers and customers is provided by facilitating the newest technologies.
- System operators and platform providers work as brokers because these assist as a third party by connecting consumers and service providers.



Logistics System

- The logistics system is the fourth partner in the proposed inclusive manufacturing system.
- It serves to provide transportation and physical goods movement from one location to another, storage, and warehouse activities implementing technologies for real-time data monitoring and tracking.



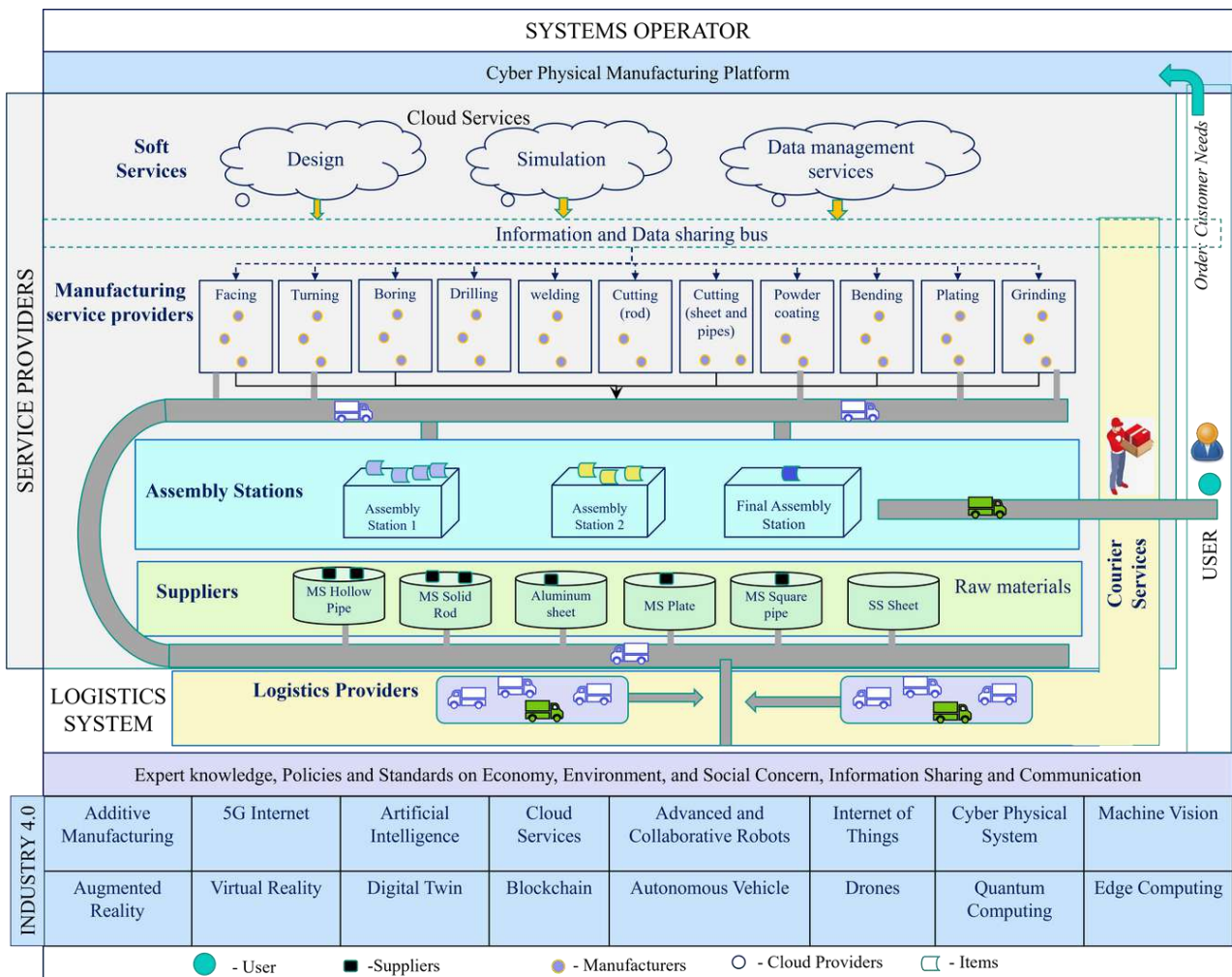
Service Provider

- Manufacturing resources and capabilities are offered by this participant in the form of service.
- Service providers fulfill the engineering demands of a physical item or design activity requested by customers.



User or Organization

- Consumers are crucial players in a business that purchases and consumes manufactured goods and related services.



Source: *Singh et al. (2019).

The figure depicts the framework of IMS by considering four participants performing various activities from order initialization to final delivery that includes user or customer (end-user and organization), system operator, service providers (software services, suppliers, manufacturing services, and assembly stations), and logistics system (transportation and courier services). Suppliers provide raw material and semi-finished entities (e.g., in this study, only raw material). The logistics providers assist in connecting the suppliers to manufacturers, manufacturers to other manufacturing units and assembly stations, and assembly stations to customers through courier services. Different manufacturers perform numerous operations (e.g., facing, drilling, boring) to modify the initial raw material to a final item by following the production steps (e.g., operations). Multiple manufacturing operations can be performed at an enterprise based on available resources, i.e., machines. The assembly stations bring the product's final shape by gathering the parts and assemblies from the manufacturers. Ultimately, courier service providers manage product delivery to customers by utilizing logistics providers.

PROSPECTS AND SCOPE OF IMS

To achieve the sustainable goals of UNDP, the target of 'Make in India', and Inclusive growth of the economy, emerging trends of the current marketing strategy, and changing customer behaviors and requirements, tremendous opportunities are envisioned for the Inclusive Manufacturing System. A few of the reasons are mentioned herewith:

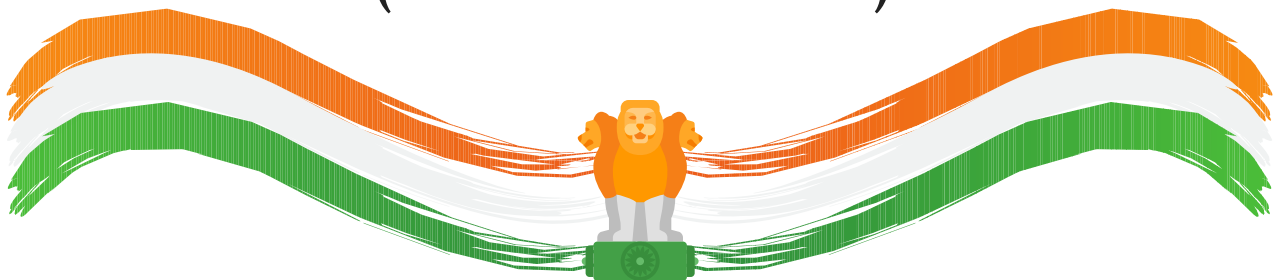
- IMS implementation provides a centralized platform to Micro, Small, and Medium Enterprises (MSMEs) for their collaboration with resource composition.
- Based on historical data and customer demand, personalized and customized orders can be fulfilled.
- Various environmental, economic, and societal issues can be resolved with the implementation of associated policies and standards, and it helps in maintaining the sustainability aspects.
- Continued monitoring and selection of the best players from the market through the system, improving product quality and efficient services that lead to significant growth in cross-border business and contribution of the manufacturing sector.
- Novel innovations, potential opportunities, job creation, improving lifestyle, and inclusive growth can be witnessed with the expansion of the manufacturing sector.
- Finally, such concepts can play a big role and become the backbone of Atmanirbhar Bharat (Self-reliant India), giving the ideas of 'vocal for local', 'local for global', 'make for world' and 'brain drain to brain gain'.

Disclaimer:

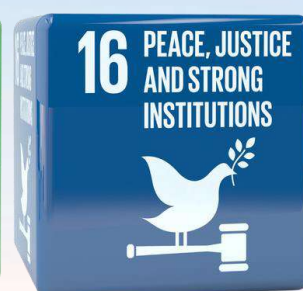
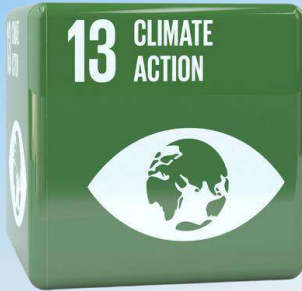
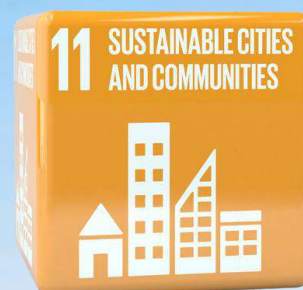
This report is prepared for contributing to a project on emerging technologies and advancements in manufacturing systems at the National Institute of Industrial Engineering (NITIE) Mumbai. Various reports (by international organizations, government offices, and consulting firms), research articles, and news and magazine stories have been reviewed to develop this document. This report tries to bring a structured document with several insights, interpretations, and information from various sources with suitable citations. Any typos or data mismatches can be incorporated during future updates, but it does not express our intentional misinterpretation. Nevertheless, this report may help researchers and practitioners enrich their understanding of the manufacturing sector's issues and challenges and its widespread influence on associated industries.



आत्मनिर्भर भारत -Atmanirbhar Bharat (Self-reliant India)

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SUSTAINABLE DEVELOPMENT GOALS

