ICRA ANALYTICS LTD

Assessment of Infrastructure Industry in India

LCC Projects Limited

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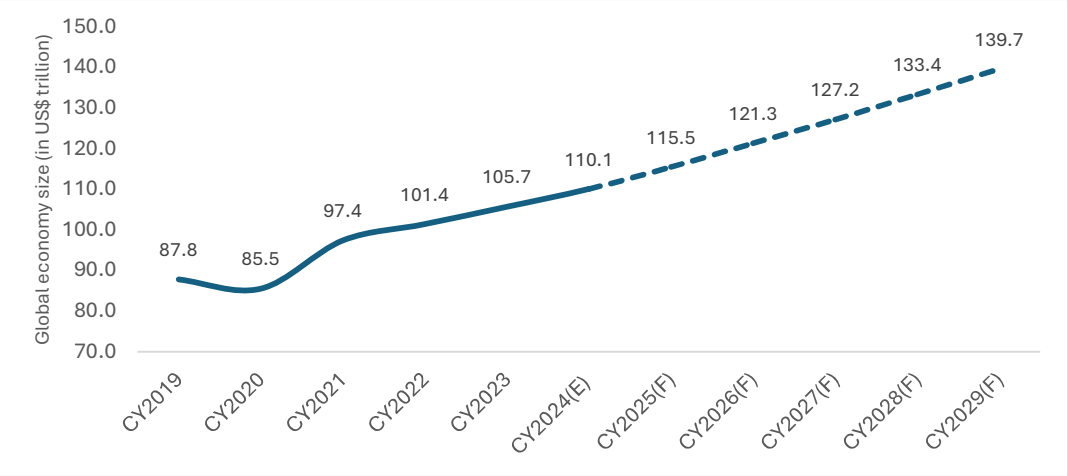
Contents

1. Global Macroeconomic Overview and Future Outlook

As per IMF's World Economic Outlook published in October 2024, the size of the global economy increased from US$ 87.8 trillion (in nominal terms) in CY2019 to US$ 105.7 trillion (in nominal terms) in CY2023 at a CAGR of ~4.8%. The global economy is expected to reach US$ 110.1 trillion (in nominal terms) in CY 2024 and continue to expand to US$ 139.7 trillion (in nominal terms) in CY 2029, at a CAGR of 4.9%.

Chart 1: Global GDP historical review (CY2019-CY2023) and outlook (CY2024-CY2029) (in US$ trillion-nominal terms)

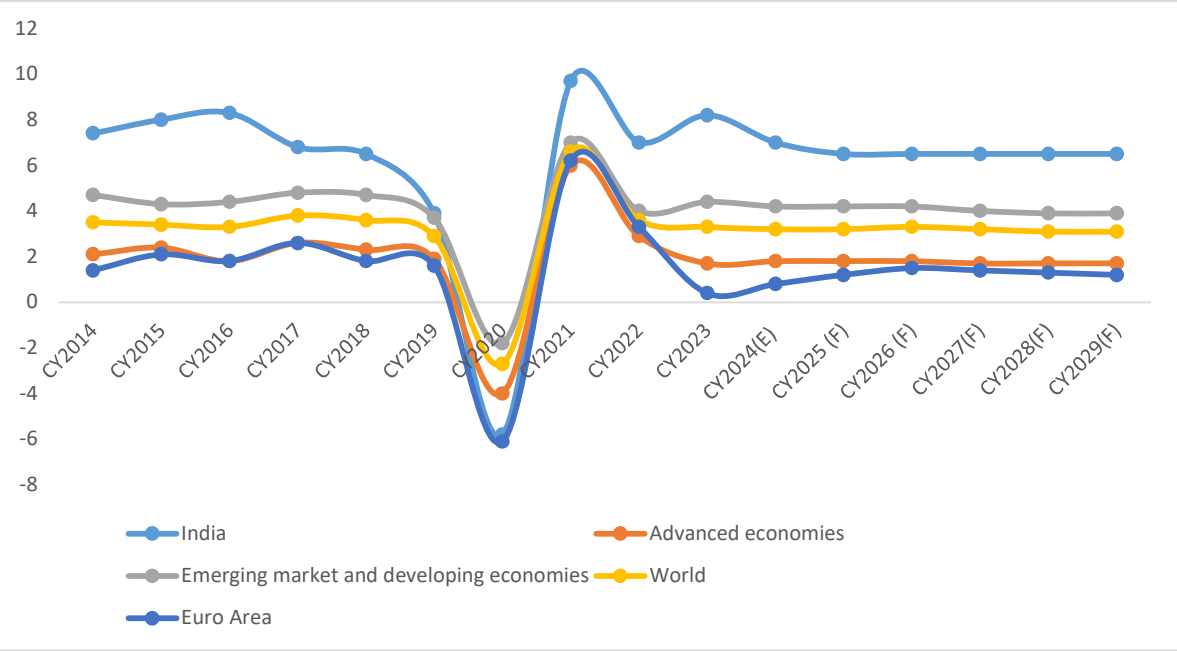


Source: International Monetary Fund (IMF), October 2024 release, ICRA Analytics,
Note: F-Forecasted; data from CY2024-2029 are forecasted

The global growth rate declined from ~6.6% in CY2021 to ~3.6% in CY2022 and is projected to stabilize at ~3.2% for CY2024-2027, dropping slightly to ~3.1% by CY2029 (IMF). Despite high interest rates, geopolitical tensions, and inflation, the global economy remains resilient. Inflation is expected to decline from 6.7% in CY2023 to 4.3% in CY2025, driven by tighter monetary policies and easing price shocks.

1.1 Global Economies and Growth Trend

Chart 2: Real GDP growth rate (annual % change) of different economies, including India



Source: International Monetary Fund (IMF), ICRA Analytics, October 2024 release
Note: F-Forecasted; data from CY2024-2029 are forecasted
Note: For India, data and forecasts are presented on a fiscal year basis, and GDP from 2011 onward is based on GDP at market prices with fiscal year 2011/12 as a base year.

Table 1: India v/s Other Economies (Real GDP, Y-o-Y % change)

Real GDP growth (Annual % change)	CY 2018	CY 2019	CY 2020	CY 2021	CY 2022	CY 2023	CY 2024(F)	CY 2025(F)	CY 2026(F)	CY 2027(F)	CY 2028(F)	CY 2029(F)
India	6.5	3.9	-5.8	9.7	7	8.2	7.0	6.5	6.5	6.5	6.5	6.5
Advanced economies	2.3	1.9	-4.0	6	2.9	1.7	1.8	1.8	1.8	1.7	1.7	1.7
Emerging market and developing economies	4.7	3.7	-1.8	7	4.0	4.4	4.2	4.2	4.2	4	3.9	3.9
World	3.6	2.9	-2.7	6.6	3.6	3.3	3.2	3.2	3.3	3.2	3.1	3.1

Source: International Monetary Fund (IMF), ICRA Analytics, October 2024 release
Note: F- Forecasted; data from CY2024-2029 are forecasted

- The global economy is estimated to expand at ~3.2% during CY2024 and is expected to remain steady at ~3.1% till CY2029.

 Advanced **economies**: Real GDP growth is expected to rise from ~1.7% in CY2023 to ~1.8% in CY2024 and remain stable at ~1.7% until CY2029.
 Key economies:

- **USA**: Growth to slow from ~2.9% in CY2023 to ~2.8% in CY2024 and ~2.2% in CY2025.
- **Canada**: Expected to rise from ~1.2% in CY2023 to ~1.3% in CY2024 and ~2.4% in CY2025.
- **Japan**: Declining from ~1.7% in CY2023 to ~0.3% in CY2024, rebounding to ~1.1% in CY2025.
- **UK**: Growth to improve from ~0.3% in CY2023 to ~1.1% in CY2024 and ~1.5% in CY2025.
- **Euro area**: Recovery from ~0.4% in CY2023 to ~0.8% in CY2024 and ~1.2% in CY2025 due to easing inflationary pressures.

 Emerging & developing economies: Growth to remain stable at ~4.2% in CY2024-2025, down from ~4.4% in CY2023.

- **Asia**: Declining from ~5.7% in CY2023 to ~5.3% in CY2024 and ~5.0% in CY2025, mainly due to China's slowdown.
- **Europe**: Falling from ~3.3% in CY2023 to ~3.2% in CY2024 and ~2.2% in CY2025.
- **Latin America & Caribbean**: Slight dip from ~2.2% in CY2023 to ~2.1% in CY2024, rising to ~2.5% in CY2025.

1.2 Major infrastructure initiatives by various economies worldwide

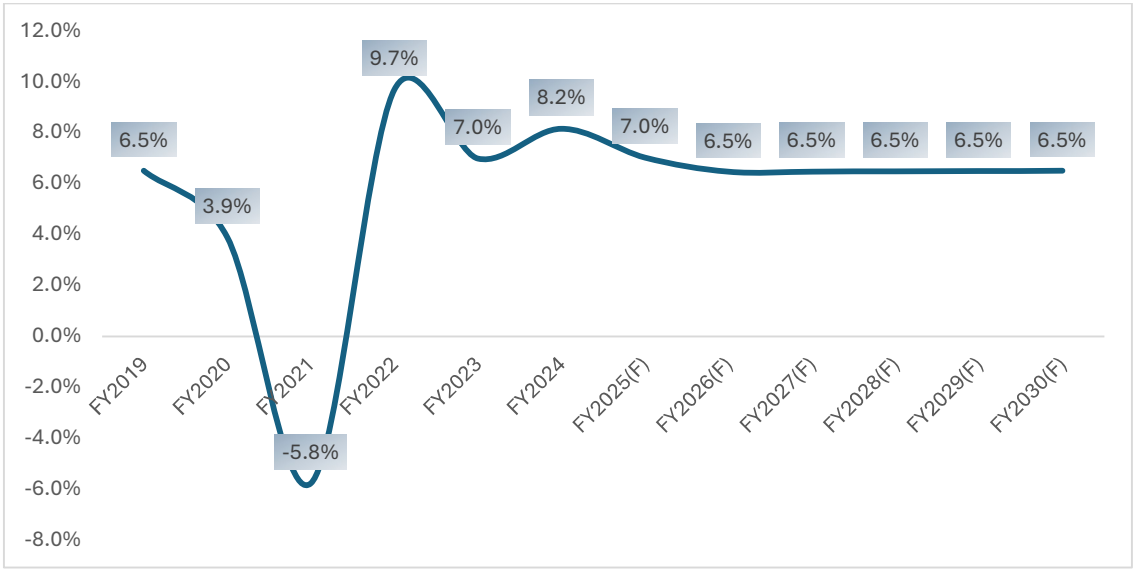
China: China is struggling to meet key infrastructure targets from its 2021-2025 five-year plan, with delays in high-speed rail and nuclear power. To reach 50,000 km of rail by 2025, it must add 3,800 km, far exceeding the 1,210 km built in early 2024. Similarly, nuclear capacity stands at 58.08 GW, well below the 70 GW target. The government may accelerate infrastructure investments in 2025 to bridge these gaps.

European Union: The EU's Green Deal drives sustainable infrastructure trends, emphasizing green financing, climate-resilient projects, and sustainable transport. The Global Gateway Initiative aims to invest EUR 300 billion in infrastructure, focusing on green transitions and digitization.

2. Indian Macroeconomic Outlook

2.1 GDP trend and outlook

Chart 3: GDP growth trend in India (in real terms)



Source: RBI, IMF October 2024 release (ICRA Analytics)
Notes: F-Forecasted

India remains the fastest-growing major economy, with real GDP estimated at ₹173.8 lakh crore in FY2024, reflecting ~8.2% growth despite global challenges. Growth surpassed 8% in the first three quarters before moderating to ~7.8% in Q4. In Q1 FY2025, GDP growth reached ~6.7%, driven by strong private consumption and investment. RBI revised its FY2025 growth estimate from 7.2% to 6.6%, citing balanced risks. Key drivers include rising investment, rural demand, industrial performance, and government infrastructure spending. However, global uncertainties, geopolitical tensions, and trade imbalances pose challenges. RBI projects GDP growth at ~6.8% in Q3 FY2025, ~7.2% in Q4, ~6.9% in Q1 FY2026, and ~7.3% in Q2, indicating a softening momentum.

Table 2: RBI estimates of GDP growth

Real GDP Growth (at constant 2011-12 prices)	FY2024				FY2024	FY2025				FY2025
% change	**Q1**	**Q2**	**Q3**	**Q4**		**Q1**	**Q2**	**Q3(F)***	**Q4(F)***	**(F)***
GDP at market prices	8.2	8.1	8.6	7.8	8.2	6.7	5.4	6.8	7.2	6.6

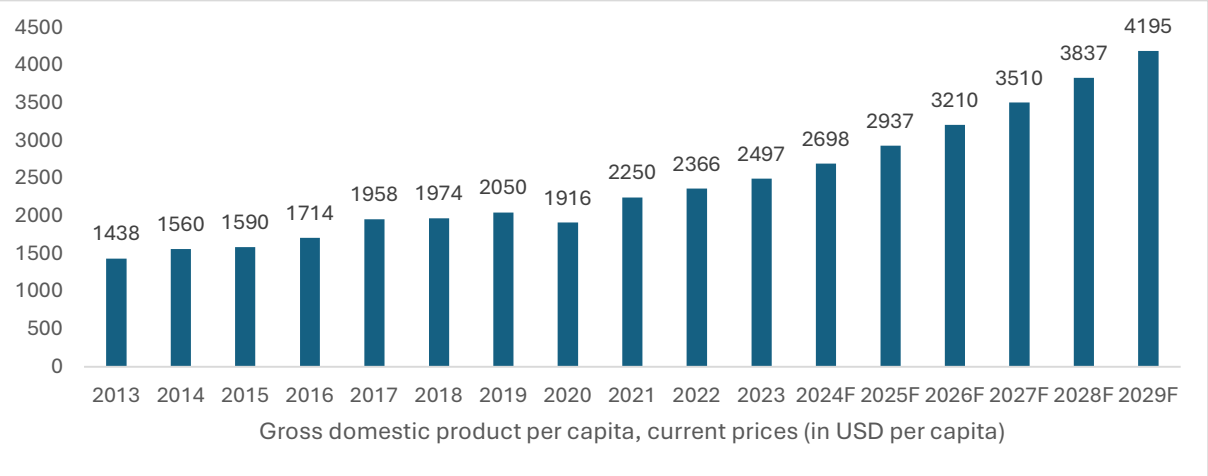
F- Forecasted
Source: RBI, ICRA Analytics

On the other hand, International Monetary Fund (IMF) has forecasted India's real GDP growth at 7.0% in FY2025, and 6.5% from FY2026 to FY2030. The growth rate is mainly projected due to the continuous growth in consumption, investment activity, some improvement in export figures and rise in manufacturing sector as the companies shift towards emerging economies.

2.2 Per capita GDP

India's GDP per capita in 2023, (at current US$), was US$ 2,497, reflecting an increase from US$ 2,366 in 2022. The IMF predicts that India's GDP per capita will grow at a CAGR of ~9.0% through 2029 from 2023, reaching approximately US$ 4,195.

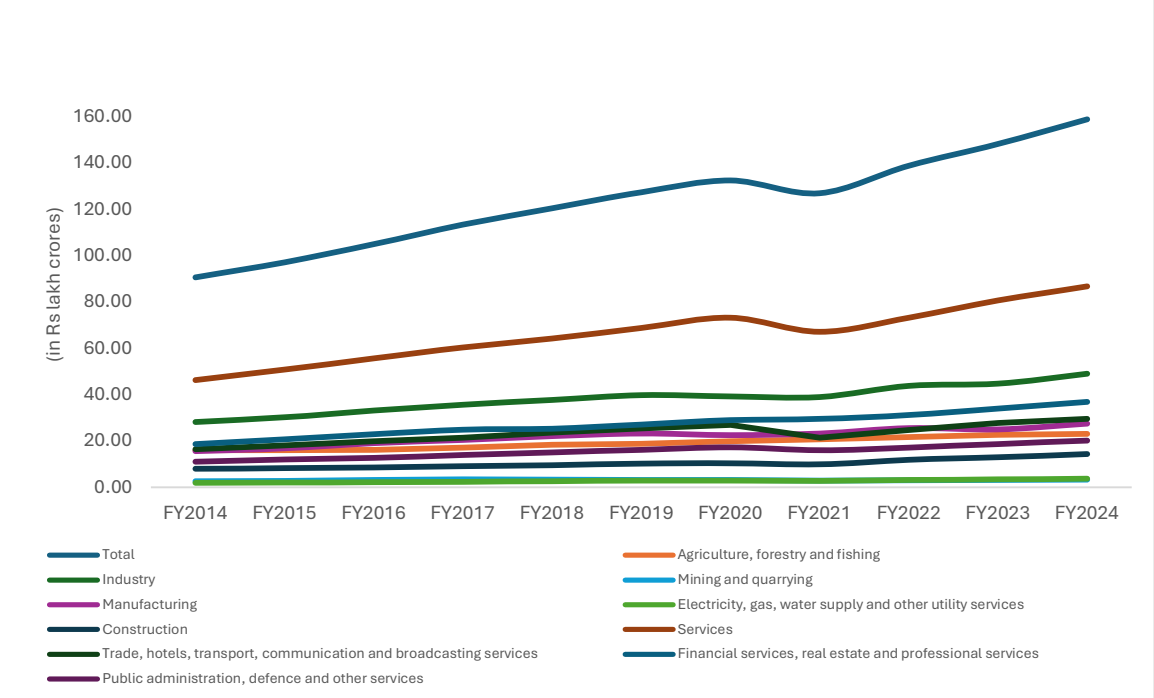
Chart 4: Per Capita GDP trend of India (at current US$)



Source: IMF, World Bank, ICRA Analytics
Note: F- Forecasted
Note: For India, data and forecasts are presented on a fiscal year basis, and GDP from 2011 onward is based on GDP at market prices with fiscal year 2011/12 as a base year.

2.3 Sectoral growth trend

Chart 5: Gross Value Added (GVA) at Constant Basic Prices: By Economic Activity: Base Year 2011-12



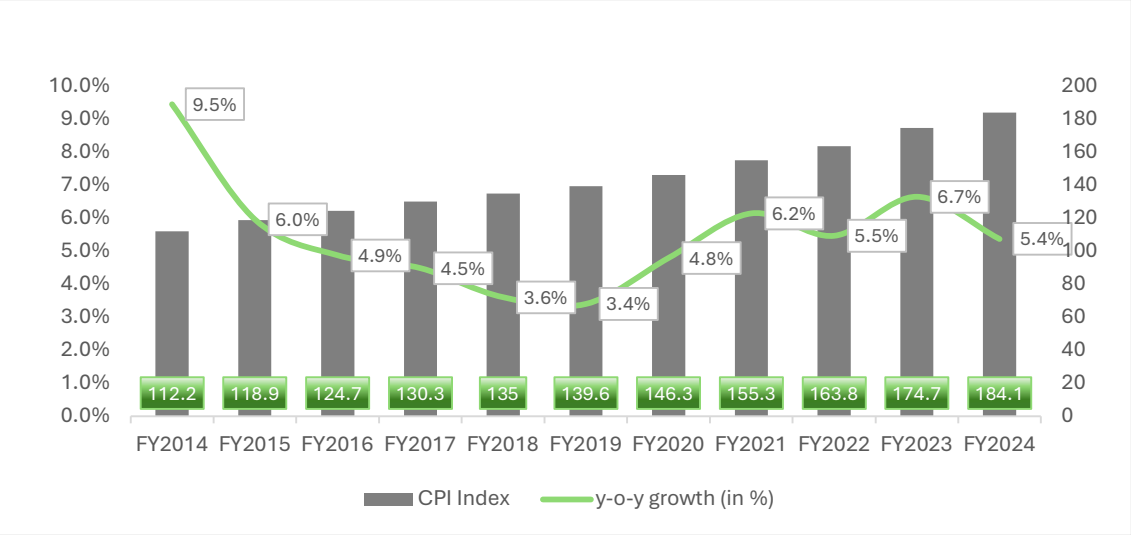
Source: RBI, ICRA Analytics

The services sector's GVA, or gross value added, at constant prices, stood at Rs. 87 lakh crore in FY2024. It contributes 55% to India's total GVA of Rs. 159 lakh crore. The industry sector, with a GVA of Rs. 49 lakh crore in FY2024 comprised 31% of the total GVA while the agriculture, forestry, and fishing sector, with a GVA of Rs. 23 lakh crore contributed about 14 % to the total.

In FY2024, the agriculture sector's share has increased by 1.4%. On the other hand, between FY2023 and FY2024, the industry sector's and the services sector's respective shares have increased by 9.5% and 7.6%, respectively. The service sector and the industry sector have both expanded over the past ten years by 73% and 87%, respectively.

2.4 CPI general and Inflation trends

Chart 6: Inflation and CPI y-o-y growth trend



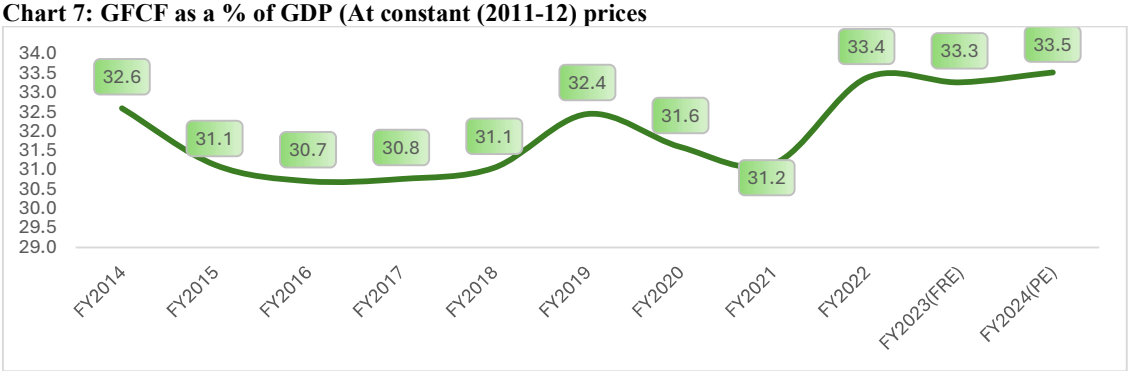
Source: MOSPI, ICRA Ltd, ICRA Analytics

In FY2023, consumer price inflation averaged 6.7%, staying above the RBI's tolerance level. CPI declined in early FY2024, reaching 4.3% in May 2023, but rose to 7.4% in June due to food price hikes. Prices of cereals, pulses, spices, milk, and vegetables contributed to this surge, the highest since April 2022 (7.8%). Government intervention helped lower food inflation in August, with CPI moderating to 5% in September due to a drop in vegetable and LPG prices. Retail inflation fell to 4.9% in October due to fuel and light category deflation but rebounded to 5.6% in November and 5.7% in December. Inflation eased to 4.9% in Q4 FY2024, marking a 10-month low.

CPI remained within RBI's 2-6% tolerance range in early FY2025, declining from 4.8% in April 2024 to 4.8% in May, before rising to 5.1% in June due to food price hikes. The vegetable sub-group saw a sharp rise (29.3%) due to extreme weather conditions, and July predictions indicate a further increase due to supply disruptions. Since July 2023, inflation has trended downward, reflecting the slowest price rise in a year. Key factors influencing inflation include global crises, geopolitical tensions, supply chain disruptions, and commodity price volatility. RBI retained its FY2025 inflation projection at 4.5%, with quarterly estimates at 4.9% (Q1), 3.8% (Q2), 4.6% (Q3), and 4.5% (Q4). ICRA projects a slightly higher 4.6% CPI inflation for FY2025.

2.5 Gross fixed capital formation (GFCF)

Chart 7: GFCF as a % of GDP (At constant (2011-12) prices



Source: MOSPI, ICRA Analytics
Note: FRE- First Revised Estimates; PE-Provisional Estimates

India's Gross Fixed Capital Formation (GFCF) has increased from Rs. 32.78 lakh crore in FY2015 to Rs. 58.26 lakh crore in FY2024 at a CAGR of ~ 6.6%. The ratio of GFCF to GDP inched up to 33.5% in FY2024 from 33.3% in FY2023. The GFCF accelerated by ~9% in FY2024 from ~6.6% in FY2023. This indicates an uptick in investment, led by government spending on infrastructure coupled with growth in domestic demand. Among the

components of GFCF, the construction sector showed a robust growth marked by the growth in its proximate coincident indicators - steel consumption and cement production.
In Q1 FY2025, YoY growth in GFCF accelerated to 7.5% from 6.5% in Q4 FY2024 in contrast with the trends seen in the high frequency data (such as sales of passenger vehicles, hotel occupancy, and the Government and private capex) which depict a slowdown in investment activity between these quarters because of the Parliamentary Elections.

2.6 Concluding remarks

The global economy remains resilient but is moderating, with inflation retreating, though services price inflation persists. Easing food, energy, and metal prices support stability. In India, above-normal monsoon and strong kharif sowing will boost rural demand, while steady manufacturing and services sustain urban growth. Investment indicators like steel consumption, capacity utilization, and infrastructure spending reflect a healthy outlook. However, geopolitical tensions, commodity price volatility, and geo economic fragmentation pose risks.

3. Infrastructure Industry in India

3.1 Overview of National Infrastructure pipeline

Infrastructure is an enabler for growth in India. It is estimated that India would require to spend more than $4.5 trillion on infrastructure to achieve the goal of becoming $7 trillion economy by CY2030. During FY2008-17, India pumped in about $1.1 trillion on infrastructure. Keeping this in view, the National Infrastructure Pipeline (NIP) was launched with projected investments of around Rs. 111 lakh crore ($1.5 trillion) during for FY2020-25 to build world- class infrastructure in the country. A taskforce to draw up the NIP was constituted under the chairmanship of the Secretary, Department of Economic Affairs (DEA), Ministry of Finance. It aims at identifying technically feasible and financially or economically viable infrastructure projects that would improve the quality of life for the citizens.

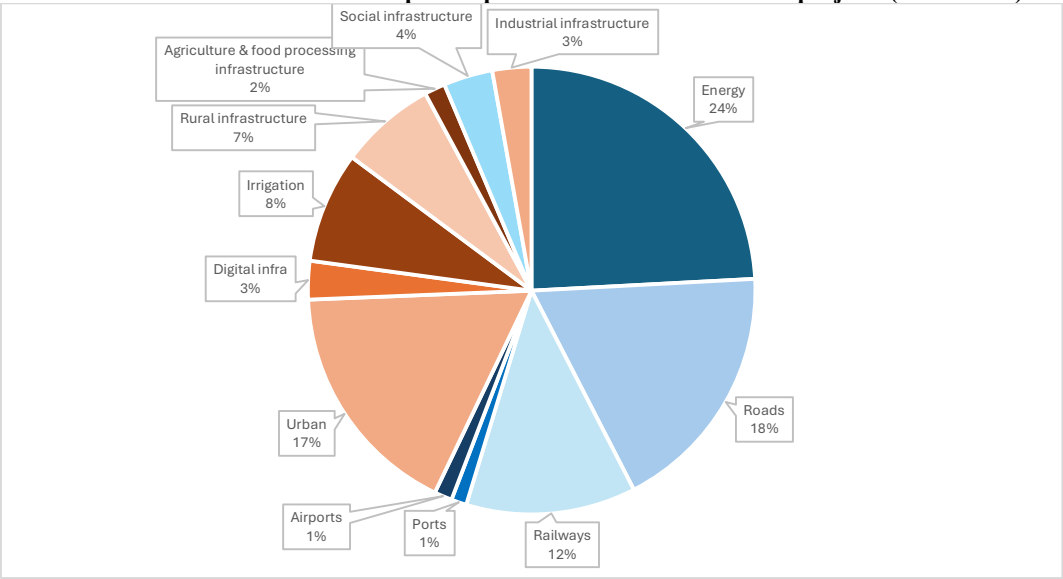
Within NIP, major investments have been earmarked for the irrigation sector. Given that India has water resource scarcity, investments are required in efficient water management technologies such as micro irrigation. Priority is also given to interlinking of rivers to increase the overall area under irrigation, domestic, industrial water supply and hydropower generation. National Water Development Agency (NWDA) identified 30 inter-basin transfer of water that are under various stages of preparation. As per the vision of NIP, total irrigated land target is ~85 million Ha comprising ~61% of the total by FY2025. This would ensure reduced dependency on monsoons and contribute to increasing farmers' overall income.

The investment in infrastructure aims to achieve the following by CY2025, ultimately contributing to Sustainable Development Goals (SDG) of 2030:

- Affordable & clean energy
- Convenient & efficient transportation and logistics
- Housing and water supply for all
- Digital services access for all
- Quality education
- Doubling farmers' income
- Good health & well-being
- Sustainable and smart cities
- Climate action
- Infrastructure innovation

3.2 Sectoral breakdown

Chart 8: Sector breakdown of total capital expenditure for infrastructural projects (FY2020-25)

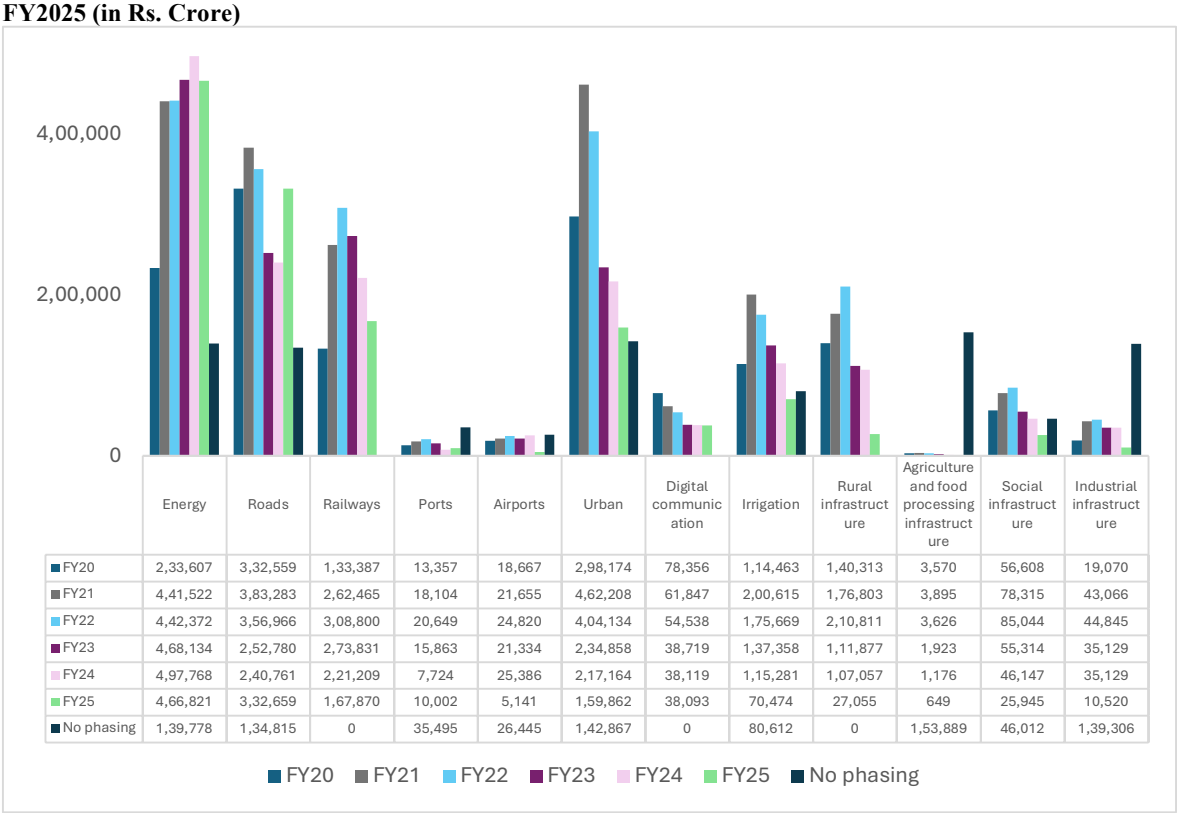


Source: NIP, DEA, ICRA Analytics

During FY2020 to FY2025, the projected infrastructure investment in India was divided among different sectors with the energy sector dominating with a share of 24%, closely followed by the transport sector- Roads, Urban and Railways with shares of 18%, 17% and 12% respectively. These sectors together comprise ~71% of the total projected infrastructure investments.

3.3 Expenditure outlay

Chart 9: Sectoral breakdown of projected annual capital expenditure in infrastructure during FY2020-FY2025 (in Rs. Crore)



	Energy	Roads	Railways	Ports	Airports	Urban	Digital communication	Irrigation	Rural infrastructure	Agriculture and food processing infrastructure	Social infrastructure	Industrial infrastructure
FY20	2,33,607	3,32,559	1,33,387	13,357	18,667	2,98,174	78,356	1,14,463	1,40,313	3,570	56,608	19,070
FY21	4,41,522	3,83,283	2,62,465	18,104	21,655	4,62,208	61,847	2,00,615	1,76,803	3,895	78,315	43,066
FY22	4,42,372	3,56,966	3,08,800	20,649	24,820	4,04,134	54,538	1,75,669	2,10,811	3,626	85,044	44,845
FY23	4,68,134	2,52,780	2,73,831	15,863	21,334	2,34,858	38,719	1,37,358	1,11,877	1,923	55,314	35,129
FY24	4,97,768	2,40,761	2,21,209	7,724	25,386	2,17,164	38,119	1,15,281	1,07,057	1,176	46,147	35,129
FY25	4,66,821	3,32,659	1,67,870	10,002	5,141	1,59,862	38,093	70,474	27,055	649	25,945	10,520
No phasing	1,39,778	1,34,815	0	35,495	26,445	1,42,867	0	80,612	0	1,53,889	46,012	1,39,306

Source: NIP, DEA, ICRA Analytics

The FY2025 budget prioritizes infrastructure spending in energy, roads, railways, and urban development, including Smart Cities, MRTS, and Jal Jeevan Mission.
Private sector investment will be encouraged through viability gap funding and supportive policies.
NIP's investment target has increased from ₹111 trillion to ₹160 trillion, with a significant rise in project count.
Around 2,600 projects worth ₹49 trillion are in the conceptualization stage.
Energy receives the highest share of investments at 24%, reflecting its critical role.
Roads and urban infrastructure follow with 19% and 16%, respectively, emphasizing connectivity and urban growth.
Railways account for 13%, highlighting the focus on transportation enhancement.
Irrigation and rural infrastructure each receive 8%, supporting agriculture and rural development.
Industrial, social, and digital infrastructure receive 3% each, showing moderate investment.
Ports, airports, and agriculture receive 1% each, indicating a lower priority in overall spending.

3.4 Key infrastructural projects undertaken by Indian government

NIP includes infrastructure projects of more than Rs.100 crore each covering greenfield and brownfield investments. NIP currently has a total of 9814 projects and schemes covering 59 sub-sectors, of which 2005 projects are under development as of July 2024.

Road sector:

An overall capital expenditure outlay of Rs. 2,033,823 crore is estimated to be incurred during FY2020-FY2025. Some of the key projects identified are:

- Delhi-Mumbai Expressway
- Ganga Expressway
- Chennai-Bengaluru Expressway
- Mumbai-Nagpur Super Expressway
- Some other projects such as Pandoh bypass to Takoli of NH-21 (Rs 2,587 crore); Nidagatta-Mysore link road (Rs 2,760 crore); Teliamura-Amarpur-Sabroom road link in Tripura (Rs 2,667 crore); Kim-Achad road link in Gujarat (Rs 11,850 crore) Tambaram-Chengalpattu-Tindivanam (Chengalpetu-Tindivanam) road (Rs 3,394 crore); Bangalore Ring Road Project Phase-1 and 2 (Rs 8,600 crore) are under development.
- Development of Rural Roads - Pradhan Mantri Gram Sadak Yojana (PMGSY) focuses on providing connectivity through an all-weather road with necessary culverts and cross-drainage structures to eligible unconnected habitations in rural areas.

Railway sector:

An overall capital expenditure outlay of Rs. 1,367,563 crore is estimated to be incurred during FY2020-FY2025. Some of the key projects identified are:

- Amrit Bharat Station Scheme- focused on developing the railway stations on a continuous basis. For upgradation, around 1,324 stations have been identified.
- Mumbai-Ahmedabad High Speed Rail (MAHSR) project - It has achieved 41.7% completion till March 2024 with Rs 59,291 crore capital expenditure incurred.
- Dedicated freight corridors (DFCs)- two DFCs are under implementation. Eastern DFC with route length of 1,337 kilometre and Western DFC with route length of 1,506 kilometre. It achieved 96.1% completion till March 2024.
- Some of the major projects under implementation include 100% electrification of railway tracks (Rs 29,450 crore); production of electric locomotive (Rs 81,375 crore); manufacture of passenger coaches by production units of Indian Railways from FY2020 to FY2024 (Rs 102,500 crore).

Water Transport sector:

An overall capital expenditure outlay of Rs. 121,194 crore is estimated to be incurred during FY2020-FY2025. Some of the key projects identified are:

- Major Port Authorities Act, 2021 focused on decentralised decision-making and PPP models in order to enhance efficiency and improved governance of major ports.
- 'Harit Sagar'- initiative by four major ports to generate renewable energy, launched in May 2023.
- 'Sagar Aankalan', a national benchmarking of Indian ports performance applicable to all Indian seaports was released in February 2024.

- Under Sagarmala national programme, total of 839 projects worth Rs.5.8 lakh crore were undertaken across different key areas such as port modernisation and fresh development, connectivity enhancement, port-led industrialisation, coastal community development and coastal shipping and inland water transport.
- An all-weather greenfield deep draft major port development at Vadhavan, Maharashtra is under construction as approved by the Cabinet. Its estimated cost is around Rs. 76,220 Crore. The project will create a cumulative capacity of 298 million metric tonnes per annum and it will include core infrastructure, terminals and other commercial infrastructure in PPP mode.
- Pradhan Mantri Krishi Sinchayee Yojana is a scheme undertaken by the government to ensure water conservation and better management of water. Drip and Sprinkler Irrigation system ensures water use efficiency at the farm level.
- Namami Gange Programme was launched in June 2014, has been extended to FY2026, which focuses on restoring River Ganga and its tributaries. The government has disbursed funds and taken up various measures such as wastewater treatment, solid waste management, river front management, e-flow, afforestation, biodiversity conservation and Public Participation and so on, to ensure cleaner Ganges.
- National Mission for Sustainable Agriculture (NMSA), a part of the National Action Plan on Climate Change (NAPCC), focuses on developing and implementing strategies to make Indian agriculture more resilient to the climate change. Rainfed Area Development (RAD), implemented under the NMSA aims at minimising risks associated with climate change and enhance productivity. Under this program, expenditure of Rs. 1,740 crore has been made & an area of 7.33 lakh Ha has been covered.

Civil aviation sector:

Globally, India is amongst the fastest-growing aviation markets. An overall capital expenditure outlay of Rs. 143,448 crore is estimated to be incurred during FY2020-FY2025. Some of the key projects identified are:

- New terminal buildings at 21 airports were made operational during FY2024. It led to the overall increase in passenger handling capacity by approximately 62 million passengers per annum.
- Under the Regional Connectivity Scheme (RCS), Ude Desh ka Aam Nagrik (UDAN)- 1390 valid awarded routes were assigned to various airlines.

Power and renewable sector:

An overall capital expenditure outlay of Rs. 2,690,003 crore is estimated to be incurred during FY2020-FY2025. Some of the key projects identified are:

- NPHC undertaking the 2,880 MW Dibang Hydel Power Project (Rs 15,150 crore) to be built over the Brahmaputra River in Arunachal Pradesh.
- Other hydro projects include- Subansari hydro power project (Rs 8,770 crore), Teesta-VI hydro power project (Rs 4,975 crore), Tawang II hydro power project (Rs 3,200 crore).
- Unnat Jyoti by Affordable LEDs for All (UJALA), where LED bulbs replaced the conventional lighting. As per Ministry of Power, this has resulted in an estimated energy savings of 48.42 billion kWh per year with avoided peak demand of 9,789 MW and GHG emission reduction of 39.30 million tonne CO2 per year, and annual monetary savings of Rs.19,335 crore in consumer electricity bills.
- Street Lighting National Programme replaced conventional streetlights with smart and energy-efficient LED streetlights. Over 1.31 crore LED streetlights have been installed so far.

Telecommunication sector:

An overall capital expenditure outlay of Rs. 309,672 crore is estimated to be incurred during FY2020-FY2025. Some of the key projects identified are:

- The BharatNet project implemented in a phased approach which aims at providing broadband connectivity to all (2,50,000) the Gram Panchayats (GPs) in the country.
- 6,85,501 km of optical fibre cable has been laid, 2,11,021 GPs have been connected by Optical Fiber Cable (OFC) and a total 2,12,229 GPs are service-ready (OFC+ Satellite), as of 30th April 2024.

3.5 Major infrastructure developmental plans in the economy – (FY2024 & FY2025)

Road sector development plans:

India is transforming its road infrastructure through strategic planning and substantial investments.

Bharatmala Pariyojana is focused on expanding the national highway (NH) network, increasing the length of high-speed corridors by 12 times and 4-lane roads by 2.6 times between CY2014 and CY2024. Further, due to the systematic push through the corridor-based National Highway development approach, the efficiency of highway construction has improved. The progress has been significant, with about 60% growth achieved in NH networks over the past 10 years. 34,800 km of National Highway length was planned for development under Phase-I of Bharatmala Pariyojana. As of December 2023, road projects of 26,418 km (i.e., 76% of 34,800 km) have been granted for construction with completion of about 15,549 km. To further enhance logistic efficiency, Ministry of Road Transport & Highways (MoRT&H) has dedicated Multi-Modal Logistics Parks (MMLP). A total of six multimodal logistics parks (MMLPs) have been awarded until FY2024, and Rs. 2,505 crore have been awarded for dedicated multimodal logistics parks (MMLPs) in FY2024. Further, seven MMLPs are planned to be awarded in FY2025.

Under Pradhan Mantri Gram Sadak Yojna (PMGSY), a total of 8,29,409 km of road length has been sanctioned out of which, 7,63,308 km of road length has been completed as on 18th June 2024 under various interventions/verticals of PMGSY at an expenditure of Rs. 3.23 lakh crore (including state share).

As a part of national industrial corridor programme, Indian government is developing 11 industrial corridors in a phased manner. These include industrial corridors connecting Delhi-Mumbai, Chennai-Bengaluru, Amritsar Kolkata, East Coast and Vizag Chennai Corridor, Bengaluru-Mumbai, extension of CBIC to Kochi via Coimbatore, Hyderabad-Nagpur, Hyderabad-Warangal, Hyderabad-Bengaluru, Delhi-Nagpur and Odisha Economic Corridor. A total of 308 Plots (1,789 acres) have been allotted until March 2024 in four cities. At present, about 2,104 acres of developed industrial land and 2,250 acres of commercial/ residential/ other land use are readily available for allotment.

Rail sector development plans:

Capital expenditure on Railways has increased by 77 per cent over the past 5 years (Rs. 2.62 lakh crore in FY2024) with significant investments in the construction of new lines, gauge conversion, and doubling. As of January 2024, more than 100 Vande Bharat train services are operational across the Indian Railways. In February 2024, additional 10 Vande Bharat trains have been flagged by the government.

Under Amrit Bharat Station Scheme, 1,324 stations have been identified for upgradation so far. For the Mumbai-Ahmedabad High Speed Rail (MAHSR) project, land acquisition and civil conduct award have been completed. Overall physical progress of 41.7 per cent has been achieved and financial expenditure of ₹59,291 crore was incurred until 31st March 2024.

Two Dedicated freight corridors (DFCs) are under implementation, namely the eastern DFC with route length of 1,337 kilometre and the western DFC with route length of 1,506 kilometre. By the end of FY2024, 96.1 per cent of the total DFC route length has been completed.

Rail Sagar (port connectivity) corridors- plans to reduce logistics cost and carbon footprint. This reduction is aimed to be achieved largely by sourcing of its energy requirements through renewable energy sources.

Indian railway is moving towards 100% electrification of Broad-Gauge tracks. Total Broad Gauge (BG) network of 61,508 Route Kms have been electrified up to December 2023 which is 93.83 % of the total Broad-Gauge route (65,556 RKMs) of Indian Railways.

Renewable energy sector development plans:

The Ministry of New and Renewable Energy is working towards achieving 500 Giga Watt (GW) of installed electricity capacity from non-fossil sources by 2030.

PM - Surya Ghar: Muft Bijli Yojana- Aimed to install rooftop solar plants in 1 crore households with a total financial outlay of Rs.75,021 crore and to be implemented until FY2027. This is expected to enable an installation of around 30 GW of residential rooftop solar capacity and 40-45 GW of overall rooftop solar capacity addition by FY2027.

Green Energy Corridor (GEC) projects- Initiated to facilitate renewable power evacuation and reshaping of the grid for future requirements. GEC-I is under implementation in eight states with cumulative achievement of 9,111 circuit kilometres (ckm) transmission lines and 21,303 MVA substations. GEC-II is under implementation in seven states.

National Green Hydrogen Mission- Approved in January 2023 with outlay of Rs.19,744 crore. The mission targets to achieve about 5 million metric tonne (MMT) of annual Green Hydrogen production capacity, associated

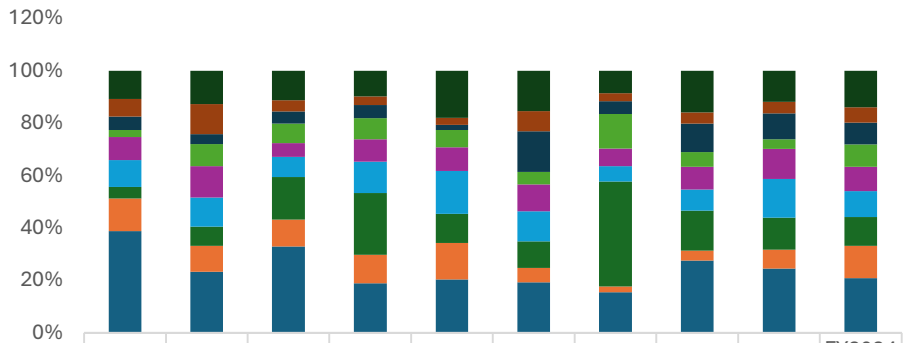
renewable energy capacity of about 125 GW, Rs. 8 lakh crores in total investments, and 50 MMT CO_2 annual emission expected to be averted by year 2030.

Production Linked Incentive Scheme for National Programme on High Efficiency Solar Photovoltaic (PV) Modules- focused to achieve manufacturing capacity of GW scale in High Efficiency Solar PV modules with capital outlay of Rs.24,000 crore. As of 31 March 2024, four manufacturers have started manufacturing of solar PV modules.

Solar Parks Scheme- to provide solar power developers with a plug and play model, by facilitating necessary infrastructure along with all statutory clearances. Scheme has a sanctioned capacity of 39.7 GW for the development of 56 Solar Parks in 13 States. Solar projects of capacity 11.59 GW have been commissioned in these parks and the remaining capacity is at various stages of implementation.

3.6 FDI inflows in Indian infrastructure industry

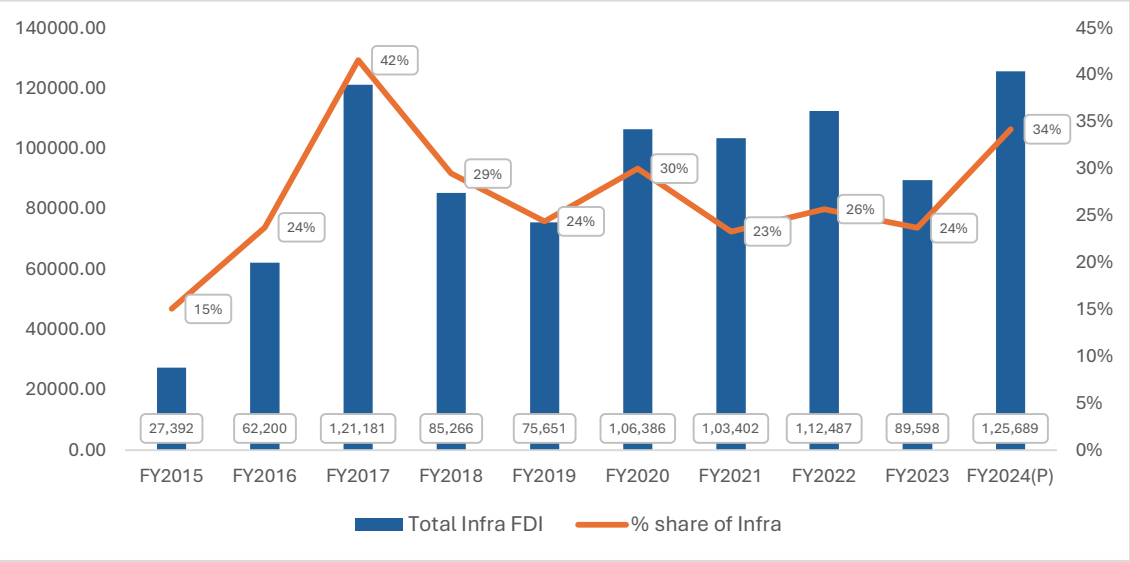
Chart 10: FDI in various infrastructure sectors in India from FY2015 to FY2024 (% share)



	FY2015	FY2016	FY2017	FY2018	FY2019	FY2020	FY2021	FY2022	FY2023	FY2024 F
Others	11%	13%	11%	10%	18%	15%	9%	16%	12%	14%
Construction	7%	11%	4%	3%	3%	8%	3%	4%	4%	6%
Electricity and other energy Generation, Distribution & Transmission	5%	4%	5%	5%	2%	16%	5%	11%	10%	8%
Business services	3%	8%	7%	8%	7%	5%	13%	6%	4%	9%
Computer Services	9%	12%	5%	8%	9%	10%	7%	9%	12%	9%
Retail & Wholesale Trade	10%	11%	8%	12%	16%	11%	6%	8%	15%	10%
Communication Services	4%	7%	16%	24%	11%	10%	40%	15%	12%	11%
Financial Services	12%	10%	10%	11%	14%	6%	2%	4%	7%	12%
Manufacturing	39%	23%	33%	19%	20%	19%	16%	28%	25%	21%

Source: RBI, ICRA Analytics
Note: Others include Miscellaneous Services, Transport, Restaurants and Hotels, Education, Research & Development, Mining, Real Estate Activities, Trading etc.

Chart 11: FDI inflows in infrastructure sectors in India between FY2015 to FY2024 (Rs. crore)



Source: RBI, ICRA Analytics

India has achieved a remarkable milestone in its economic journey, with gross foreign direct investment (FDI) inflows reaching an impressive US$1 trillion since April 2000. This landmark achievement was bolstered by a nearly 26% rise in FDI to US$42.1 billion during the first half of the current fiscal year. Such growth reflects India's growing appeal as a global investment destination, driven by a proactive policy framework, a dynamic business environment, and increasing international competitiveness. FDI has played a transformative role in India's development by providing substantial non-debt financial resources, fostering technology transfers, and creating employment opportunities. Initiatives like "Make in India," liberalised sectoral policies, and the Goods and Services Tax (GST) have enhanced investor confidence, while competitive labour costs and strategic incentives continue to attract multinational corporations.

As per the projected FDI inflow data published by RBI, significant increase in manufacturing, financial services, communication and retail & wholesale and construction.

3.7 Investment trend in infrastructure in India

Budgetary outlay towards infrastructure and government infra projects

The revised budget of FY2025 focused on a continued infrastructure push via maintaining the gross capex target, enhancing job creation and skills to sustain growth over the medium term. In pursuit of 'Viksit Bharat', infrastructure has been one of the key priorities. The significant highlights announced in Union Budget FY2024-25 for the different sectors are as follows:

Infrastructure:

- The capital outlay for FY2025 Budget Estimate (BE) is at Rs. 11.11 trillion, in line with the Interim Budget, which is 16.9% higher than FY2024 Revised Estimates (RE). This continues to bode well with infrastructure and construction sector.
- The special assistance as long-term interest-free loan from Central government to state governments has been increased to Rs. 1.50 trillion from Rs. 1.06 trillion in FY2024 RE. This increase in capital expenditure will support infrastructure development.
- The Government plans to promote water supply and sewerage treatment projects for 100 large cities in partnership with state governments and multilateral development banks.
- A capital outlay of Rs. 625.93 billion is proposed for 'New Schemes' under the Department of Economic Affairs. It accounts for 6% of the overall Rs. 11.11 trillion of capex, which was a new inclusion in the Union Budget.
- The higher outlay towards Railways (+5.0% over FY2024 RE) and road sectors (+2.9% over FY2024 RE) remains optimistic.

Port, Shipping and Shipbuilding:

- **Sagarmala Project**: ₹7.0 billion (BE FY25) vs. ₹5.3 billion (RE FY24), maintaining last year's levels.

 Shipbuilding & R&D: ₹1.0 billion (BE FY25) vs. ₹1.1 billion (RE FY24).
 Inland Waterways: ₹1.0 billion capital grant for IWAI, aiding infrastructure and port connectivity to reduce logistics costs.
 Shipping Reforms: Ownership, leasing, and flagging reforms to strengthen the industry.
 Customs Duty: Reduced to nil on vessel components, boosting shipbuilding profitability and India's global market share.
 MRO Sector: Export period for repaired goods extended to 1 year; re-import under warranty extended to 5 years, reducing reliance on overseas MRO facilities.

Power and Renewables:

- **Green Energy Focus**: The Budget reinforces energy transition goals, emphasizing renewables to cut carbon emissions and promote sustainability.
- **PM Surya Ghar Yojana**: ₹164 billion allocated (FY25 BE), a 171% rise from FY24 RE, targeting rooftop solar for 1 crore households, benefiting solar module manufacturers and EPC players.
- **Solar Manufacturing**: Customs duty exemption on capital goods for solar cell and panel production to boost domestic capacities.
- **Pumped Storage & Critical Minerals**: Policy for pumped storage projects to integrate renewables; Critical Mineral Mission launched for production, recycling, and overseas acquisition, with customs duty exemptions.
- **Power Sector**: ₹162 billion allocated for RDSS and power system strengthening, supporting electricity demand growth (6.0-6.5% in FY25).

Roads and Highways:

- The Government has increased the capital allocation for the Ministry of Road Transport & Highways (MoRTH) by 3% to Rs. 2.72 trillion in FY2025 BE from Rs. 2.65 trillion in FY2024 RE. The Government has maintained healthy allocation levels for the road sector to meet the completion targets for the Bharatmala Pariyojana and the National Infrastructure Pipeline (NIP).
- The allocation to the National Highways Authority of India (NHAI) has remained flat at Rs. 1.68 trillion in FY2025 BE compared to FY2024 RE. Further, the Government has continued with the nil borrowing programme for the NHAI. The Government had set Rs. 350 billion asset monetisation targets in FY2024. The NHAI has realised Rs. 317 billion through monetisation (excluding project-based finance) and achieved 90% of the target. It received Rs. 160 billion through 4 TOT bundles and Rs. 157 billion from the third round of asset sale to NHAI InvIT. The monetisation target for FY2025 has marginally reduced to Rs. 300 billion.
- The Government plans to launch Phase IV of Pradhan Mantri Gram Sadak Yojana (PMGSY) to provide all-weather connectivity to 25,000 rural habitations. The allocation towards PMGSY increased to Rs. 190 billion in FY2025 BE from Rs. 170 billion in FY2024 RE and is expected to support the order book of small construction contractors.

3.8 Growth drivers and risk factors

3.8.1 Drivers of Growth in infrastructure investment

The infrastructure expansion in India, witnessed a huge growth in the last five years due to the various projects undertaken by government. Strategic planning and step up in public investments resulted in significant increase in physical and digital connectivity and social infrastructure including sanitation and water supply helping to improve quality of life of the people. This sector therefore has been crucial for overall economic growth.

The different projects undertaken by the government acts as a driver for infrastructural investment growth. Some of the key initiatives are:

1. Development of Greenfield industry projects based on the principles of ESG in order to include optimal resource utilization and management, adopting state-of-the-art technologies with inclusive smart growth and innovation. India's National Industrial Corridor Development Programme is one of the most ambitious infrastructure projects which focuses on developing futuristic industrial cities in India that can compete with the world's top manufacturing hubs. As part of this program, 11 Industrial Corridors are being developed in 4 phases.
2. PM Gati Shakti National Master Plan (NMP)- It is a transformative approach that facilitates National Master Plan for multimodal connectivity, including implementation, monitoring, and support mechanisms.

3. National Logistics Policy- It aims at providing a comprehensive initiative to reduce the logistics costs by addressing the inefficiencies, improve the effectiveness of India's logistics ecosystem.
4. Investment opportunities have been created under National Infrastructure Pipeline (NIP) and National Monetisation Pipeline (NMP), India Industrial Land Bank (IILB), Industrial Park Rating System (IPRS).
5. Bharatmala Pariyojana, 34,800 km of National Highway length planned for development under Phase-I. It is an umbrella program for the highways sector that focuses on optimizing efficiency of freight and passenger movement across the country by bridging critical infrastructure gaps through effective interventions.
6. Pradhan Mantri Awas Yojana (PMAY), launched in June 2015, is a major flagship programme of the government. It focuses on providing housing in all the urban areas and is implemented by Ministry of Housing and Urban Affairs (MoHUA). Under this scheme, more than 1.18 crore homes have been sanctioned, of which about 1.14 crore have been grounded for construction and more than 84 lakhs have been completed. The government has more than doubled the fund allocation to Rs. 10 lakh crores under PMAY Urban 2.0, to provide benefits over the next five years. This would ultimately boost the affordable housing segment, providing secure and reasonable accommodation to the ones migrating to the cities.
7. Jal Jeevan Mission (JJM) – Har Ghar Jal focuses on making provision of tap water supply to the rural households. It was launched in August 2019 by the central government in partnership with the state governments. Under this scheme, 9.42 Crore rural households have been provided individual household tap connections, ensuring safe and adequate drinking water.
8. Various Metro rail projects are being operated, constructed or proposed across the country. The expansion of Metro rail aims to improve urban mobility, reduce traffic congestion and enhance the quality of life for all citizens. At present, total operation length is 945 km, while projects covering 939 km are under construction across 27 cities. Some of the proposed metro projects are: Jammu Metro- 43.5 km, Bangalore Metrolite- 60 km, Chennai Metrolite – 15.50 km.

3.8.2 Challenges or risk factors in infrastructure investment

There are few challenges faced by infrastructure sector that could contribute as risk factors.

1. Infrastructure and energy related assets have a large build-up of connectivity but there are delays in land acquisition and land related clearances. In the case of airport development, greenfield airport projects are time-intensive due to the need for appropriate site selection, land acquisition and necessary approvals. In physical infrastructure, challenges arise relating to land acquisition and necessary approvals that need to be coordinated with different tiers of the Government for smooth implementation. In case of road construction, delays in rehabilitation and utility shifting, contractual issues relating to performance of contractors, litigation can be some of the reasons for slow progress.
2. In case of aviation sector, limited number of original equipment manufacturers have the technical knowledge for the development of segments such as maintenance, repair and overhaul (MRO) operations and manufacturing. Airline industry is also highly exposed to external shocks such as oil prices, exchange rates, epidemics, wars, and equipment issues. These shocks can affect the overall operations of an airline including its viability. Specialised technical skills are required for various aspects related to project development, feasibility assessment, financial return analysis and different stages of project management that need to be nurtured based on systematic need assessment. Hence, lack of skill could affect the smooth implementation of the projects.
3. Public sector financing predominantly contributed to the addition to the stock of infrastructure in the last five years. Participation from the private sector is not approaching the desired extent. Lumpy capital investment and long payback period, contractual issues and prolonged litigation cases, lack of independent regulator for infrastructural sectors are some of the reasons for obstructing private participation in infrastructure building.
4. There is an absence of aggregation of financial flows in infrastructure. Different kinds of instruments for resource mobilisation are used, such as credit, bonds, equities, hybrid instruments like mutual funds, foreign capital inflows and so on. Also, multiple stakeholders are involved in Infrastructure financing structures, including all the tiers of the government, public sector enterprises, commercial banks and non-banking financial companies, special purpose vehicles, capital market players, development financial institutions and foreign investors.
5. Tracking physical progress of infrastructure projects is a challenge as there is alack of sources that gives an inventory of infrastructure projects in the country, undertaken at different levels so as to evaluate progress for each sector and sub-sector in regard to corresponding targets.
6. Infrastructure construction activities face several environmental risks such as pollution of air, water, land degradation, habitat destruction, inadequate disposal of hazardous water materials. Carbon emission from

equipment, vehicles and industrial processes contribute to poor air quality. Construction activities also contribute to high levels of noise pollution, disrupt the natural water flows and drainage patterns.

7. Infrastructure Industry faces various political risks such as policy or regulatory changes affecting the project viability, land acquisition challenges due to social or political opposition, corruption and bribery affecting the project timelines and costs, election related delays in implementation, slow decision making and inefficiencies in government bureaucracy and lack of coordination between the government agencies and departments involved.
8. Infrastructure projects are vulnerable to extreme climate related disasters such as floods, draughts, heat waves or storms that can cause immense damage and degradation. Decreased water availability can also affect the construction and operations of infrastructures. Overconsumption of these natural resources (water, energy) can lead to resource depletion and thereby affect the industry.

To overcome these challenges, the central government along with the state governments, third tiers of government working with project authorities, including public sector enterprises and private partners, need to collaborate and work closely towards building world-class infrastructures in India.

3.9 SWOT Analysis of Infrastructure Industry in India

Strengths:

- Stable business environment and governmental support. It attracts foreign investors across the various sectors.
- Diversified infrastructure including a network of roads, railway, shipping and airways. It provides opportunities for further investment and development.
- Large scale developmental projects undertaken by the government with the ability to expand further and produce inclusive growth.

Weakness:

- Inadequate investment and funding, leading to delay in the project implementation.
- Land acquisition challenges, due to disputes and resistance from local communities.
- Lack of skilled workforce, engineers and professionals to manage the projects.
- Environmental impact due to the large-scale construction, leading to delays and opposition.
- Lack of private sector involvement due to their hesitancy in participation.
- Lack of transparency and progress tracking of the projects across various sectors.

Opportunities:

- Government initiatives, investment and policy support such as Public Private Partnerships (PPP), Greenfield and Brownfield projects, direct FDIs, joint venture collaboration and so on. This is to ensure overall infrastructural development and economic growth.
- Technological innovation and advancements assist in efficient and effective infrastructural growth.
- Rapid Urbanisation is leading to growing demand for better infrastructure services.

Threats:

- Economic slowdown or regulatory changes could reduce the government's expenditure and decrease the private investment and FDIs, thereby delaying various infrastructural projects.
- Growing environmental concerns could act as an opposition to construction projects. Climate change and natural disasters could also impact infrastructure resilience.
- Inflation or interest rate fluctuations could reduce the demand for various projects and affect the project viability.
- Geopolitical tensions, global conflicts, trade wars or diplomatic tensions could impact the investment and collaborations with foreign nations.

4. Irrigation Industry in India

4.1 Overview:

Agriculture and allied activities form an integral part of the Indian economy and currently, ~18% of India's GVA is contributed by this sector. India, possessing ~4% of the world's water resources supports a population of 1.4 billion. Limited water resources for agricultural activities, coupled with erratic monsoons and change in weather patterns, intensifies the need for efficient irrigation practices so as to ensure reduction of water stress in the country. Furthermore, this has resulted in irrigation systems becoming critical in maximizing agricultural output

and ensuring food security for the nation. The disparity between availability of water and the actual demand for it necessitates innovation and sustainable management practices in the agricultural sector.

4.2 Agriculture and Irrigation in India:

As per PLFS (Periodic Labour Force Survey), the agricultural sector of India employs an estimated ~45% of India's workforce and comprises an estimated ~15% of India's GVA, making itself pivotal to the economy. However, traditional farming methods often yield less efficiency and productivity. This led the Government of India (GoI) to bring about the fourth agricultural revolution known as Agriculture 4.0. This initiative aims to improve yield quality and precision, while minimizing environmental damage, leading to more efficient and sustainable farming methods. Despite recent global headwinds, the sector has shown resilience and has even been a driving force to boost the economy forward.

Table 3: Agricultural Land by use in India

Classification	FY2007	FY2008	FY2009	FY2010	FY2011	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017	FY2018	FY2019	FY2020
			(P)	(P)	(P)	(P)	(P)	(P)	(P)	(P)	(P)	(P)	(P)	(P)
I. Geographical Area	328.7	328.7	328.7	328.7	328.7	328.7	328.7	328.7	328.7	328.7	328.7	328.7	328.7	328.8
II. Reporting Area for Land Utilisation	307.1	307.2	307.4	307.4	307.2	307.1	307.2	307.5	307.5	307.5	308.1	307.5	307.5	306.5
1. Forest	71.5	71.5	71.5	71.6	71.6	71.6	71.6	71.9	72.1	72.1	72.3	72.3	72.3	71.8
2. Not Available for Cultivation	42.7	42.9	43.1	43.3	43.4	43.3	43.4	43.7	44.0	43.8	44.6	44.1	44.3	44.3
3. Other Uncultivated land excluding Fallow Land	27.0	26.8	26.4	26.5	26.2	26.1	26.0	25.8	25.9	25.6	25.6	25.7	25.6	25.6
4. Fallow Lands	26.0	25.0	24.5	26.9	24.7	25.3	26.5	25.0	26.2	27.0	26.6	26.6	26.9	25.0
5. Net Area Sown	139.8	141.0	141.9	139.2	141.4	140.8	139.8	141.2	139.5	139.0	139.0	138.8	138.4	139.9
6. Total Cropped Area (Gross Cropped Area)	192.4	195.2	195.3	189.2	198.1	195.6	194.5	201.3	198.3	198.1	201.2	200.9	201.2	211.4
7. Area Sown more than once	52.6	54.2	53.4	50.0	56.8	54.8	54.7	60.1	58.8	59.2	62.2	62.1	62.7	71.5
8. Cropping Intensity*	137.6	138.4	137.7	135.9	140.2	138.9	139.2	142.5	142.2	142.6	144.7	144.8	145.3	151.1
III. Net Irrigated Area	62.7	63.2	63.6	61.9	63.9	66.0	66.6	68.4	68.6	67.8	69.2	70.1	72.2	75.5
IV. Gross Irrigated Area	86.8	88.1	88.9	85.1	89.3	91.9	92.8	96.3	97.9	97.8	99.4	101.3	104.5	112.2

Source: Agricultural Statistics at a Glance 2022, Ministry of Agriculture & Farmers Welfare, Ministry of Water Resources, River Development and Ganga Rejuvenation, ICRA Analytics; *Note: Data available till FY2020

Irrigation schemes in India can be classified based on either cultivable command area (CCA) or by way of water application schemes used.

1. **Based on Cultivable Command Area (CCA):**
   - **Minor Irrigation schemes:** Projects having Cultivable Command Area (CCA) of less than 2,000 hectares (ha).
   - **Medium Irrigation schemes:** Projects having Cultivable Command Area (CCA) of more than 2,000 but less than 10,000 ha.
   - **Major Irrigation schemes:** Projects having Cultivable Command Area (CCA) of more than 10,000 ha.
2. **Based on the Way of Water Application:**
   - **Gravity/Flow Irrigation Scheme:** In this type, water is usually stored at a higher elevation, enabling supply by way of gravity. It can be further classified into perennial and non-perennial irrigation schemes based on supply of water during crop period.
   - **Lift Irrigation Scheme:** In this type of systems, water is required to be pumped from lower elevation to the field or canal network.

In India both traditional and modern irrigation techniques are used in tandem. Traditional methods include moats, chain pump, dhelki, Rahat which are primarily dependent on surface and well waters. These are simpler and less costly, but lack precision, as compared to modern methods. Sprinkler system, drip irrigation system are modern irrigation methods, which provides extreme precision and reduces wastage of water, but can often be costlier to install and maintain.

4.3 Major Irrigation projects in India:

During the First Five Year Plan, India had 74 major and 143 medium irrigation projects. This number increased significantly with the government taking up 406 major, 1135 medium and 259 ERM schemes during FY1951 to FY2012 (end of XI Plan). 231 major, 880 medium and 122 ERM projects have been recorded as completed by end of XI Plan.

In FY2023, the government has invested in various irrigation projects (both major and medium), which are at various stages of construction. Many projects are also approved by the Advisory Committee of DoWR, RD&GR in the year. A detailed list of these projects has been mentioned below:

Table 4: Status of Irrigation Projects under Appraisal in D&R Wing of CWC

Sl. No	State	Name of the Project	Status
1	Arunachal Pradesh	Flood Protection and River Front Development work on Yomgo River at Aalo Township under West Siang District.	Comments Issued
2	Arunachal Pradesh	Flood Management Work at Sub-Basin Kley River at Ziro Lower Subansiri District.	Comments Issued
3	Arunachal Pradesh	Anti Erosion Work Over Senki River at Chandranagar, Itanagar.	Comments Issued
4	Arunachal Pradesh	Anti Erosion Work Over Pachin River from DPS Bridge Point, Rechi to Tagatara under Itanagar.	Comments Issued
5	Arunachal Pradesh	Anti Erosion Work & River Front Development on Kameng River in East Kameng District.	Under Examination
6	Himachal Pradesh	Phina Singh Medium Irrigation Project	Cleared
7	Karnataka	Bhandura Nala Diversion Scheme.	Cleared
8	Karnataka	Kalasa Nala Diversion Scheme.	Cleared
9	Madhya Pradesh	Parbati-Kuno-Sindh Link(ERCP-PKC)	Under Examination
10	Madhya Pradesh	ERM of Sanjay Sarovar Project	Under Examination
11	Odisha	Upper Udanti Irrigation	Under Examination
12	Rajasthan	Eastern Rajasthan Canal Project	Comments Issued

13	Rajasthan	Revised DPR of Transfer of Rajasthan Share of Yamuna Water at Tajewala Head Works to Churu and Jhunjhunu Districts of Rajasthan by underground conveyance system and its utilization.	Comments Issued
14	Rajasthan	Gang Canal Automation	Cleared/ Under Examination
15	Telangana	Palamuru Rangareddy Lift Irrigation Scheme	Under Examination
Projects in Foreign Countries: 01 No.			
1	Nepal	Detailed feasibility study or Nepal Gandak Irrigation System Extension Project, Nawalparasi	Comments Issued

Source: Central Water Commission (CWC); ICRA Analytics Ltd.

Table 5: List of the Irrigation / Multipurpose Projects Accepted by the Advisory Committee of DoWR, RD&GR during FY2023

Sl. No	Name of the Project	State	Type of the project	Estimated Cost (in Crore)	Intended Benefits
1	North Koel Reservoir Project (8th RCE)	Jharkhand & Bihar	Major Irrigation	3199.9	125500 Ha
2	Improvement to Swarnamukhi Anicut under Andhra Pradesh Irrigation & Livelihood Improvement Project, Phase –II (APILIP-II)	Andhra Pradesh	Medium Irrigation	53.6	4128 Ha
3	Rukni Irrigation Project	Assam	Major Irrigation	764.1	17566 Ha
4	Sonai Irrigation Project	Assam	Major Irrigation	740.9	10850 Ha
5	Phina Singh Multipurpose Project	Himachal Pradesh	Multipurpose	643.7	4025 Ha Power1.88 MW
6	Mukteshwar (Chinna Kaleshwaram) lift irrigation scheme, Major, Telangana	Telangana	Major Irrigation	545.2	18211 Ha.
7	Rudha (Channaka - Korata) Barrage (Medium) - Inter State Project of Telengana & Maharashtra	Telangana & Maharashtra	Medium Irrigation	452.5	6680 Ha.
8	Choutpally Hanmanth Reddy Lift Irrigation Scheme (Medium), Nizamabad, Telangana	Telangana	Medium Irrigation	48.2	3359 Ha.

Source: Central Water Commission (CWC); ICRA Analytics Ltd.

4.4 Government initiatives:

GoI has several welfare schemes to improve and develop the plight of farmers and the agricultural and allied sectors. Some major welfare schemes are Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), Pradhan Mantri Kisan Samman Nidhi (PM-KISAN), Pradhan Mantri Kisan MaanDhan Yojana (PM-KMY), Pradhan Mantri Fasal Bima Yojana (PMFBY), Modified Interest Subvention Scheme (MISS), Agriculture Infrastructure Fund (AIF), National Beekeeping and Honey Mission (NBHM), Rastriya Krishi Vikas Yojana, Soil Health Card (SHC) to name a few. These are put in place to support and develop the farming sector of India. The PMKSY scheme along with its potential and impact is further discussed below.

Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)

GoI in recent times have highly prioritized water conservation and its management. The Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) initiative was launched in FY2016 to improve physical access of water on farm, expand cultivable area under assured irrigation, boost on-farm water use efficiency and provide sustainable water conservation practices. It is an umbrella scheme that comprises of two components: Accelerated Irrigation Benefit Programme (AIBP), and Har Khet Ko Pani (HKKP). The implementation of the scheme for the period FY2022 to FY2026 has been approved by the government with an outlay of Rs. 93,068.6 crore which includes assistance from central government, NABARD combined with state governments. As of March 2024, 1044 projects were completed, while 1685 projects with project cost Rs.32, 780 crore and subsidy of Rs. 9,300 crore have been approved.

Accelerated Irrigation Benefit Programme (AIBP): The AIBP scheme was launched by the GoI in FY1997. It was introduced to provide assistance to medium and major irrigation projects which were beyond the state's resource capability and at an advanced stage of completion. Projects in drought prone areas or ones which benefitted tribal communities were prioritized. In FY2016, after the launch of PMKSY, the AIBP scheme was

merged into the PMKSY as one of its components. Approximately 297 irrigation projects have been included in the AIBP for funding since its inception, out of which 143 projects have already been completed and 5 have been foreclosed. An Irrigation potential of 25.5 Lakh ha. has been created against a targeted potential of 34.6 Lakh Ha. during FY2017 to FY2023.

Table 6: Potential created under AIBP

Sl.No.	Name of State	Potential Created under AIBP during						
		FY2016	FY2017	FY2018	FY2019	FY2020	FY2021	FY2022*
1	Andhra Pradesh	29.1	11.9	10.4	2.0	0.0	0.0	0.0
2	Assam	0.0	28.3	0.0	1.2	0.0	0.0	7.1
3	Bihar	0.0	10.3	0.4	0.2	1.9	0.2	6.6
4	Chhattisgarh	1.1	6.7	9.9	0.0	0.0	0.1	0.0
5	Goa	0.0	0.1	0.0	0.2	0.0	0.0	0.1
6	Gujarat	185.9	116.5	312.2	98.6	28.7	14.0	12.3
7	Haryana	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	Himachal Pradesh	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	Jammu & Kashmir	1.0	0.0	0.0	0.0	5.3	0.9	0.4
10	Jharkhand	0.0	79.2	0.0	0.0	0.0	0.6	0.0
11	Karnataka	88.4	24.6	81.0	6.9	1.9	1.3	0.0
12	Kerala	0.5	0.1	0.2	0.8	1.0	0.0	0.0
13	Madhya Pradesh	52.0	73.7	72.3	16.2	11.2	1.7	2.6
14	Maharashtra	24.3	66.5	31.5	74.1	66.2	33.2	51.0
15	Manipur	2.0	4.0	3.2	2.4	0.0	3.8	0.9
16	Meghalaya	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	Odisha	7.3	5.4	17.6	13.1	15.2	3.8	4.4
18	Punjab	2.9	0.0	11.6	0.0	0.0	1.4	21.9
19	Rajasthan	6.3	0.0	7.1	0.1	0.1	0.0	0.0
20	Tamil Nadu	0.0	0.0	0.0	0.0	0.0	0.0	4.1
21	Telangana	69.2	20.1	84.1	9.7	3.7	20.4	40.9
22	Tripura	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	Uttar Pradesh	63.8	67.4	61.1	384.9	182.0	48.5	20.1
24	Uttarakhand	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	West Bengal	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total		**533.7**	**514.7**	**702.7**	**610.4**	**317.2**	**129.9**	**172.4**

Source: Agricultural Statistics at a Glance 2022, Ministry of Agriculture & Farmers Welfare, Ministry of Water Resources, River Development and Ganga Rejuvenation, ICRA Analytics; *Note: Data captured till FY2022

Har Khet Ko Pani (HKKP):

Under the surface minor irrigation sub-component, out of 4305 schemes, 2497 were completed, creating irrigation potential of 266.49 thousand ha during FY2017 to FY2024. Similarly, under Repair, Renovation and Restoration of Water Bodies subcomponent, out of the 3450 schemes, 1489 have been completed, restoring irrigation potential of 109.14 thousand ha during FY2017 to FY2024.

- **Watershed Development component** (WDC): This CSS was initially started as 'Integrated Watershed Management Programme' (IWMP) in FY2010, which was later integrated into the PMKSY in FY2016 as the Watershed Development Component. The main purpose of the scheme is to improve productive potential of rainfed / degraded land by way of integrated watershed management and improve watershed sustainability.

- **Per Drop More Crop** (PDMC): Under the PMKSY, the Per Drop More Crop (PDMC) scheme was introduced in FY2016, with an aim to enhance water use efficiency by introduction of micro irrigation, namely drip and sprinkler irrigation systems at farm level. The Centrally Sponsored Scheme (CSS) provides financial assistance of ~55% to small and medium farmers and ~45% to other farmers for installation of micro irrigation systems. The scheme is currently implemented under the Rashtriya Krishi Vikas Yojana (RKVY) from FY2023.

Table 7: State-wise area covered under Micro Irrigation through PDMC from 2015-16 to 2023-24 (till date) and percentage

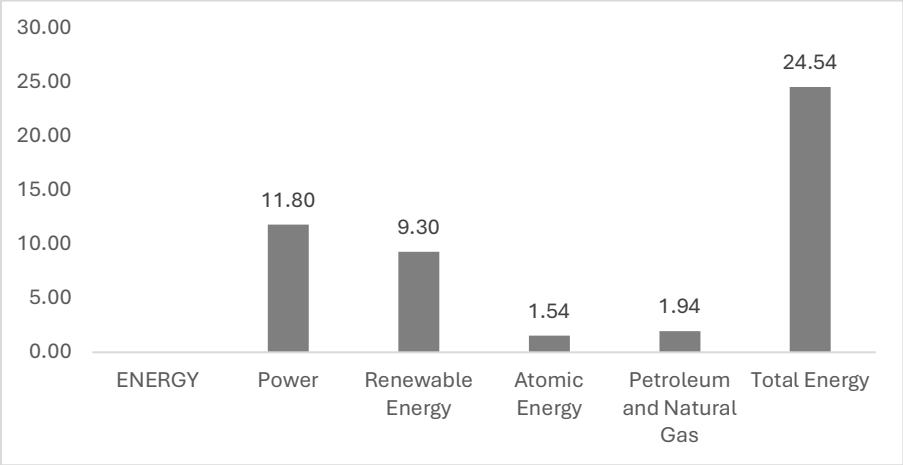
S. No.	State/UT	Area covered under Micro Irrigation in hectare [2015-16 to 2023-24 (till date)]	% to total coverage in the Country [2015-16 to 2023-24 (till date)]
1	Andhra Pradesh	919780	11.0
2	Bihar	28258	0.3
3	Chhattisgarh	148146	1.8
4	Goa	875	0.01
5	Gujarat	1087039	13.0
6	Haryana	168336	2.0
7	Himachal Pradesh	12235	0.2
8	Jharkhand	34675	0.4
9	Jammu & Kashmir	1104	0.01
10	Karnataka	1801629	21.6
11	Kerala	5608	0.07
12	Madhya Pradesh	356091	4.3
13	Maharashtra	938089	11.2
14	Odisha	95475	1.1
15	Punjab	15173	0.2
16	Rajasthan	708193	8.5
17	Tamil Nadu	1097910	13.2
18	Telangana	326338	3.9
19	Uttarakhand	32257	0.4
20	Uttar Pradesh	355116	4.3
21	West Bengal	95964	1.2
22	Arunachal Pradesh	12442	0.2
23	Assam	44356	0.5
24	Manipur	15894	0.2
25	Mizoram	8559	0.1
26	Nagaland	19180	0.2
27	Sikkim	12971	0.2
28	Tripura	4145	0.05
29	Ladakh	3	0.0
	Total	**8345840**	

Source: Ministry of Agriculture & Farmers Welfare, ICRA Analytics

4.5 Rise in Irrigation Investments in India (FY2019-FY2028):

The irrigation sector of India is projected to achieve healthy growth with a forecasted CAGR of 10.9% expected during FY2023-28. India has one of the largest irrigated crop areas globally, covering 8.3 million hectares, while boasting the second-largest arable land area, encompassing 159.7 million hectares. This offers potential for development and investment in the nation's irrigation sub-sector. The Pradhan Mantri Krishi Sinchai Yojana (PMKSY) scheme launched by the GoI, with overall outlay of Rs. 93,069 crore (Central assistance: Rs. 37,454 crore, debt servicing to NABARD: Rs. 20,435 crore, State Governments: Rs. 35,180 crore), is dedicated to developing irrigation sources, provide lasting solutions to drought and ensuring prosperity of the agricultural landscape. Furthermore, NABARD has also created a Micro Irrigation Fund (MIF) of an initial corpus Rs. 5,000 crore, to help the states mobilise their resources to expand coverage of micro irrigation.

Chart 12: Top performing states of India in Irrigation sector (no. of projects)



Source: indiainvestmentgrid.gov.in, ICRA Analytics

4.6 Overview of Key Technological Trends in the Irrigation Sector:

In India, some key technological trends in the irrigation sector include

- **Crop & Soil Sensors:** Real time data on soil moisture levels, water requirements for crops, and other environmental conditions are provided by crop and soil sensors to avoid over or under-irrigation, unnecessary wastage of resources and crop stress.
- **Micro-Irrigation:** This type of sprinklers directly provide water to the root zone of the plants in a manner that is controlled and precise, reducing water wastage. Drip irrigation and micro-sprinklers are important examples which distribute water slowly and evenly.
- **Renewables-based Irrigation:** New developments are being made in the irrigation technologies which use renewable power sources like solar, wind or hydropower. These effectively reduce pollution and result in sustainable farming practices.
- **Advanced Water Pumps:** Novel water pumps incorporate processes like variable speed drives, pressure sensors, and automatic control systems that optimizes water usage by way of adjusting pump speed and pressure as per the irrigation requirements.
- **Smart Irrigation Controllers:** Smart controllers use sensors, sophisticated algorithms, soil moisture level data, evapotranspiration rates and weather data to formulate precise irrigation schedules and adjust watering based on real-time requirements.
- **Remote Monitoring:** This method combines Internet of Things (IoT) and data analytics, providing real time monitoring of soil moisture, irrigation system performance and weather conditions. This enables farmers to remotely control, time and adjust irrigation infrastructures as per requirements.
- **Leak Detection Systems:** New age leak detection systems use modern technology like pressure sensors, flow meters, and acoustic devices to quickly locate leaks in the pipelines. This also enables early discovery and prompt repairs, thereby preventing water loss.
- **Weather Modeling:** Many start-ups are developing weather models to help farmers utilize accurate and localized weather information, thus enabling them to effectively plan irrigation schedules, water requirements and timing. The models use meteorological data, satellite observations, and computer simulations to provide localized weather forecasts which are then used by the farmers.
- **Soil Modification:** Techniques for modifying the soil, such as the incorporation of organic matter and soil conditioning agents, improve the structure, capacity for water retention, and availability of nutrients in the soil. This establishes an ideal climate for plant roots. By upgrading soil quality through designated alterations, water system proficiency is improved as water is better consumed and held in the root zone.
- **Water Enrichment:** Startups are developing irrigation water solutions that include fertilizers, soil amendments, or micronutrients. Plants get the nutrients they need to grow and develop optimally when water enrichment processes improve the water's nutrient content and quality, thereby also addressing the challenge of nutrient deficiencies in crops.
- **Water Recycling and Reuse systems:** These systems have become an important growth driver in the Indian irrigation industry. Growing population, industrialization and urbanization has led to increased water demand, stressing the existing water resources of the country. Thus, efficient water management has become exceedingly important for the agricultural sector, which is the largest freshwater consumer

in the nation. Water recycling and reuse systems offer an innovative alternative which can reduce the existing water scarcity while enhancing irrigation efficiency and lead to sustainable agricultural practices.

- **Vertical Farming and Hydroponics:** Vertical farming and hydroponics offer a unique solution to the various challenges which riddle the agricultural sector like limited arable land, water scarcity, and unpredictable agricultural yields. These new techniques make efficient use of limited resources while providing higher yields in return, thus helping India reach sustainable agricultural practices.

4.7 Key growth drivers for the irrigation sector:

Advancements in farming techniques and tools: Advent of modern farming techniques like vertical farming, hydroponics, drip and sprinkler irrigation method, precision farming etc. has helped achieve more agricultural yield and efficiency, while reducing wastage. India is gradually integrating these improved agricultural tools and techniques to meet its growing agricultural demands.

Growing awareness and education: Government initiatives to increase knowledge and awareness among the farmers about modern methods of irrigation and agriculture has led to improvement in the agricultural sector. Some notable GoI schemes to raise awareness regarding modern technologies and techniques are Skill Training (7 days) of Rural Youth (STRY), Krishi Vigyan Kendras, Digital Agriculture- India Digital Ecosystem of Agriculture (IDEA), Sub Mission on Agricultural Mechanization (SMAM), Integrated Scheme for Agricultural Marketing schemes (AGMARKNET) to name a few.

Rise of Micro irrigation: The centrally sponsored scheme (CSS) of Per Drop More Crop (PDMC) was introduced in FY2016 under PMKSY. It aims to enhance water use efficiency through micro irrigation (mainly drip irrigation and sprinkler irrigation systems). This initiative has helped in adoption of micro irrigation practices by farmers more easily.

Sustainable farming practices: The GoI is boosting more sustainable farming practices. The Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM) aims to provide energy and water security and reduce dependency on diesel in the sector. Solar pumps are seen as a greener alternative to this. Another initiative of utilizing treated wastewater and irrigation through underground pipelines implemented in some states have shown a significant decrease in carbon emission generation.

Robust demand: Both domestic and international demand of agricultural products have grown over the years and have boosted the economy positively.

Competitive advantage: India possesses climatic and geographic advantage when it comes to agricultural production. Wide variety of crops farmed, robust demand and employment scope has helped the sector thrive in India. This also acts as a competitive advantage over other economies.

Farmer cooperatives and local bodies: Farmer and agricultural cooperatives are people centered enterprises, which uses pooled funds from the members to realize their common economic, social, and cultural goals and aspirations. India boasts one of the largest cooperative networks which are spread across various agro-economic sectors like agriculture, credit, dairy, housing, fisheries etc. GoI announced the “Sahkar se Samriddhi” scheme (Prosperity through Cooperation) to help strengthen cooperative movement in the country, thereby deepening its reach to the grassroots and enhancing performance, productivity and profitability of cooperative societies. The Ministry of Cooperation has taken various measures to reach this vision:

- Making Primary Cooperatives Transparent and Economically Vibrant
- Strengthening the Urban and Rural Cooperative Banks
- Relief to Cooperative Societies in Income Tax Act
- Revival of Cooperative Sugar Mills
- Three new Multi-State Societies at the National Level
- Capacity Building in Cooperatives
- Use of Information Technology for 'Ease of Doing Business'
- Other Initiatives such as formulation of New National Cooperative Policy, new National Cooperative Database for authentic and updated data repository etc.

Research and Development (R&D): R&D in the agricultural sector of India is helping achieve more efficient and sustainable irrigation practices, while aiming to optimize water usage, reduce wastage, and improve crop yields. Various modern techniques like drip and sprinkler irrigation systems, soil moisture sensors, and smart irrigation technologies, which are slowly becoming more accessible and affordable for farmers. The R&D is also focused on tailoring solutions for the diverse climatic and soil conditions of India. Research institutes and

universities are developing irrigation methods as per requirements of different agricultural zones and regions. Indian research institutions are also collaborating with international organizations and experts, thereby helping in seamless knowledge transfer and bringing in latest irrigation and agricultural advancements in India.

Financial Incentives and Subsidies: Various subsidies and incentives are provided by the GoI to encourage the usage and adoption of modern irrigation technologies. Programs like PMKSY offer financial support to farmers, which reduces initial investment costs for them, making it easier to adopt modern techniques and technologies like drip and sprinkler irrigation systems. Furthermore, financial institutions which are oftentimes supported by government backing offer low interest loans and credit facilities to farmers for purchasing irrigation equipment. In addition to this, GoI and state agencies offer incentives for adopting water-efficient irrigation practices, like reduced electricity tariffs, rewards for using collective irrigation projects etc.

4.8 Challenges faced by the irrigation sector:

Despite many major improvements in the agricultural and allied sectors in recent years, uncertainty arising from heavy dependence on the monsoons remains a concern. The agricultural sector remains primarily dependent on seasonal rainfall and inconsistent sources of water, thereby affecting crop production and yields. Another major constraint is the high cost of installation and maintenance of modern irrigation and agricultural methods, which is often beyond the capabilities of small and marginal farmers. Substandard or counterfeit agricultural technologies and tools in the market might also raise questions on the quality and hamper crop yields. Some key challenges are mentioned below:

Ground water depletion: Groundwater is a key source of irrigation in India, and over reliance on it has resulted in significant depletion. The groundwater levels are dropping at a rapid rate due to absence of stringent regulations, unregulated use by farmers without long-term consideration and over-extraction due to lack of awareness.

Policy and Regulatory Changes: Frequent changes in government policies and incentives can lead to uncertainty among farmers. This inconsistency can result in reduced investment in long-term irrigation infrastructure and technologies. Furthermore, even if policies are well formulated and consistent, if the same is not implemented properly at local levels, it might not yield the desired results. Corruption, lack of awareness, and inadequate enforcement mechanisms are causes contributing to this challenge.

Environmental pollution: Agricultural run-offs without proper treatment can result in ground water and surface water contamination, posing a threat to both aquatic ecosystems and human health. Over irrigation can also lead to soil degradation. Issues like salinization and waterlogging can reduce soil fertility and result in lower yields.

Climate Change: Climate change has a significant impact on India's agriculture sector. Changes in weather patterns, severe weather events and erratic monsoons can lead to lower yields and crop failure, making irrigation and farming difficult. The overall rising temperature has also increased the need for water in farming practices. This too acts as a major challenge faced by the farmers in India.

Infrastructure and financial challenges: India's irrigation infrastructure like dams and canals are aging and is in need of modernizing, which is a complex and costly affair. Leakages and inefficient use of water can negatively impact the farming process. Additionally, modern methods of irrigation like drip and sprinkler systems require heavy investment which might act as a barrier to small and marginal farmers. In regions where crop prices are volatile, the return on investment for the farmers might be low or negative due to hight costs and low returns. This too acts as a barrier for modernization of the farming sector.

Water Distribution Inefficiencies: The distribution of irrigation water is inequitable in India, with farmers of certain regions receiving more water than others. This may result in conflicts and exacerbate water scarcity in underserved areas. The irrigation water is also prone to loss, leakage, evaporation and theft during conveyance, leading to reduction in overall efficiency of irrigation.

Social and Institutional challenges: Small and marginal scale farmers, especially from remote regions are often unaware of modern tools and techniques used in irrigation and farming. Their lack of awareness along with financial and social constraints deprive them from the benefits of modern agriculture methods. Their land holdings too are often fragmented in nature. This also acts as a barrier to adoption of advanced technologies.

Energy consumption: Irrigation process consumes high amount energy, which can be a burden to the farmers, particularly in regions with unreliable or expensive electricity supply. Furthermore, the agriculture sector is still largely dependent on fossil fuels and contribute largely to carbon emissions.

5. Construction of Dams

5.1 Overview

Dams are large structures which are built across rivers or streams to control the flow of water. These are substantial social investments serving one or more of four primary purposes:

- Providing water supply to domestic and industrial sectors
- Production of energy
- Irrigation
- Controlling flood

In India, dams play a meaningful role in the agricultural sector, providing water for irrigation while protecting downstream areas from damages caused by flooding. Major dams also double as hydropower projects, helping in meeting energy needs. India has around 6138 operational dams (as of 2023) and 143 more are under construction. Out of these operational dams, 3789 dams are more than 25 years old. The central government has implemented several initiatives to improve the safety conditions of the dams across India. The Dam Safety Act was enacted in December 2021 providing a comprehensive framework for proper operations, inspection, surveillance and maintenance of the large (specified) dams thereby helping in safe operations and avoiding dam failure related disasters.

Analysis of climate change on water resources and dam safety measures

Climate change is a major threat for water resources and dam safety. One of the major risks of climate change is changing weather patterns and increased frequency of severe weather events. Erratic rainfalls, risk of increased natural disasters like severe floods (including more frequent flash floods), landslides etc. have the potential to damage dam safety and infrastructure, leading to dam failure related tragedies. Aging dams are especially more prone to such risks.

- **Hydropower as climate mitigation:**
    - India remains on course with regards to its climate strategies and emission reduction targets. This has brought to forefront the need for greater renewable energy mix in the overall power consumption of the nation, hydropower being a key segment. To combat carbon emissions and support journey towards renewable energy, the government is making significant investments and taking major initiatives to improve and develop hydropower infrastructure.
    - Keeping both dam safety and renewable energy demand into consideration, hydropower infrastructure development remains a top priority for the government. The impact of climate change and water stress has propelled the government to enact schemes boosting hydropower investment and advancement.
- **Integrated water management:**
    - "One Water" approach is a holistic approach. According to it, all water (drinking water, wastewater, storm water or grey water) holds value and needs to be managed efficiently to achieve long term resilience and reliability thereby meeting the requirements of the community and ecosystem.
    - India's climate is impacted by erratic monsoon regime where flood and droughts are a common phenomenon. Southern and western states are water deficient while the basins in the east collect surplus water. Water resource management plays an important role in altering and diverting the flow for meeting the socio-economic needs. Dams also acts as structural interventions, mitigating the risks of drought and floods.
    - India still needs a dynamic and flexible dam management plan which not only integrates climate change considerations in dam designs but also includes monitoring on real time basis, sustainable technologies, vigilance on disasters with adaptive measures, restoration of ecosystems, ensuring overall environmental and social sustainability.
- **Environmental flow regulation:**
    - Regular management of water releases is needed to ensure healthy river ecosystem downstream. It includes protection of natural river habitats, ensure sufficient water levels and quality for wetlands, fisheries and other aquatic systems.
    - Environmental flow assessment is an important technique that balances the water requirements between human consumption, irrigation and industrial uses. It plays an important role in protecting and improving the structure and function of the downstream ecosystems.

- Integrated environmental flow management helps in minimizing the negative impact of the dams thereby sustaining the freshwater and estuarine ecosystem and promoting sustainable development.

Constructed and under construction dams in India

As per National Register of Large (Specified) Dams (NRLD) report in September 2023, there are a total of 6281 dams in India, out of which 6138 are operational and 143 are under construction. The gross storage capacity stands at 343.6 billion cubic meters (BCM) while the live storage capacity is around 258.5 BCM.

Table 8: State-wise List of Large Dams as per NRLD-2023

Sl. No.	States/UT	Operational dams	Under Construction dams	Total number of dams
1	Andhra Pradesh	140	24	164
2	Arunachal Pradesh	1	3	4
3	Assam	3	2	5
4	Bihar	27	1	28
5	Chhattisgarh	339	7	346
6	Goa	5	0	5
7	Gujarat	487	4	491
8	Haryana	1	0	1
9	Himachal Pradesh	23	6	29
10	Jharkhand	55	24	79
11	Karnataka	231	0	231
12	Kerala	61	0	61
13	Madhya Pradesh	1354	0	1354
14	Maharashtra	2333	41	2374
15	Manipur	3	1	4
16	Meghalaya	8	1	9
17	Mizoram	1	0	1
18	Nagaland	1	0	1
19	Odisha	210	0	210
20	Punjab	18	1	19
21	Rajasthan	310	4	314
22	Sikkim	2	0	2
23	Tamil Nadu	127	0	127
24	Telangana	161	13	174
25	Tripura	1	0	1
26	Uttar Pradesh	151	4	155
27	Uttarakhand	32	5	37
28	West Bengal	36	0	36
29	Andaman and Nicobar Island (UT)	2	0	2
30	Jammu and Kashmir (UT)	13	2	15
31	Ladakh (UT)	2	0	2
	Total	**6138**	**143**	**6281**

Source: National Register of Large (Specified) Dams (NRLD) 2023, PIB, ICRA Analytics

Table 9: State-wise Storage of Large Dams as per NRLD-2023

		Gross Storage (BCM)			Live Storage (BCM)		
Sl. No.	**States/UT**	**Operational dams**	**Under Construction dams**	**Total**	**Completed dams**	**Under Construction dams**	**Total**
1	Andhra Pradesh	16.0	5.5	21.5	8.4	4.2	12.7
2	Arunachal Pradesh	0.0	0.0	0.1	0.0	0.0	0.0
3	Assam	0.4	1.5	1.9	0.2	0.5	0.7
4	Bihar	0.7	0.0	0.8	0.9	0.0	0.9
5	Chhattisgarh	7.8	0.0	7.8	6.9	0.0	7.0
6	Goa	0.3	0.0	0.3	0.3	0.0	0.3
7	Gujarat	23.8	0.1	23.9	18.9	0.0	18.9
8	Haryana	0.0	0.0	0.0	0.0	0.0	0.0
9	Himachal Pradesh	19.5	0.0	19.5	15.0	0.0	15.0
10	Jharkhand	5.9	7.2	13.0	7.2	0.0	7.2
11	Karnataka	35.3	0.0	35.3	30.8	0.0	30.8
12	Kerala	16.5	0.0	16.5	12.7	0.0	12.7
13	Madhya Pradesh	52.8	0.0	52.8	33.8	0.0	33.8
14	Maharashtra	35.8	1.9	37.8	28.3	1.7	30.0
15	Manipur	0.1	0.2	0.3	0.1	0.1	0.2
16	Meghalaya	0.4	0.0	0.4	0.3	0.0	0.3
17	Mizoram	1.4	0.0	1.4	0.7	0.0	0.7
18	Nagaland	0.6	0.0	0.6	0.4	0.0	0.4
19	Odisha	32.5	0.0	32.5	23.4	0.0	23.4
20	Punjab	3.5	0.1	3.6	2.4	0.0	2.4
21	Rajasthan	11.1	0.3	11.4	10.5	0.1	10.6
22	Sikkim	0.0	0.0	0.0	0.0	0.0	0.0
23	Tamil Nadu	7.9	0.0	7.9	7.3	0.0	7.3
24	Telangana	22.0	0.6	22.6	16.1	0.5	16.6
25	Tripura	0.0	0.0	0.0	0.0	0.0	0.0
26	Uttar Pradesh	20.4	0.3	20.8	18.1	0.2	18.4
27	Uttarakhand	7.5	0.9	8.4	6.1	0.3	6.4
28	West Bengal	1.9	0.0	1.9	1.6	0.0	1.6
29	Andaman and Nicobar Island (UT)	0.0	0.0	0.0	0.0	0.0	0.0
30	Jammu and Kashmir (UT)	0.8	0.0	0.8	0.2	0.0	0.2
31	Ladakh (UT)	0.1	0.0	0.1	0.0	0.0	0.0
	Total	**324.8**	**18.8**	**343.6**	**250.6**	**7.9**	**258.5**

Source: NRLD 2023, ICRA Analytics

5.2 Government initiatives for safety and improvement in dam construction

To holistically develop the dams and combat the various dam safety issues, the GoI enacted the Dam Safety Act in December 2021.

- **Dam Rehabilitation and Improvement Project (DRIP):** The GoI also implemented the Dam Rehabilitation and Improvement Project (DRIP) in 2012 to rehabilitate and upgrade over 200 selected dams across the country.
    - The DRIP Phase-I was funded by the World Bank and was implemented from April 2012 till March 2021. It focused on 223 existing dams across 7 states, incurring a cost of ~Rs. 2567crore.
    - After the completion of Phase-I, the GoI has undertaken DRIP Phase-II and III encompassing 736 dams across 19 states, comprising a budget outlay of Rs. 10,211crore (Phase II: Rs 5,107 crore; Phase III: Rs 5,104 crore). DRIP Phase-II became operational from October 2021and is co-financed by two multi-lateral funding Agencies- the World Bank and the Asian Infrastructure and Investment Bank (AIIB), with funding of US$ 250 million each.
- **Dam Safety Act, 2021:** Under the Dam Safety Act 2021, a four-tier institutional mechanism was implemented, where National Committee on Dam Safety (NCDS) and National Dam Safety Authority (NDSA) were established at Centre level and State Committee on Dam Safety and the State Dam Safety Organization were established at the state level.
    - **Central Level:**
        - National Committee on Dam Safety (NCDS)
        - National Dam Safety Authority (NDSA)
    - **State Level:**
        - State Committee on Dam Safety
        - State Dam Safety Organization

  The NCDS is tasked with coming up with necessary dam safety policies and recommend regulations for proper inspection, surveillance and maintenance of specified dams. NDSA acts as the regulatory authority overseeing the implementation of the stipulated policies and regulations. At the state and union territory level, the State/UT Dam Safety Committees & Organisations are also similarly established. Currently all large dams of India fall under the ambit of the Dam Safety Act, 2021.

  India's aging dam infrastructure coupled with challenges faced due to climate change can lead to dam failure related disasters. The implementation of the Dam Safety Act helps minimize this risk through regular maintenance, surveillance and upgradation of infrastructure to modern standards. It also helps in maintaining downstream ecosystems and employs sustainable procedures for reduced environmental impacts.
- **Central Water Commission (CWC):** The DRIP Phase-II and III are supervised and implemented by the Department of Water Resources, River Development and Ganga Rejuvenation through Central Water Commission (CWC). The main objective is to promote the safety of selected dams (in the participating States) and strengthen dam safety management in the country through institutional strengthening.

Quest for renewable sources

- As per the Economic Survey 2023-24, India's annual per capita carbon emission is approximately one third of the global average, despite being one of the fastest growing economies.
- India achieved its Nationally Determined Contributions (NDC) targets well before its 2030 targets while also being the only G20 country to stay in line with the 2°C climate scenario. Subsequently, the Indian NDCs were upgraded in the Glasgow COP26 and the same was communicated to UNFCCC.
- India's energy needs are estimated to increase 2 to 2.5 times by FY2047 to keep up with economy's developmental aspirations and initiatives. The need for more energy, along with India's sustainable commitment paves the way for its renewable journey and an opportunity to successfully disengage its growth from carbon emissions.
- India's renewable energy capacity has seen significant growth in the past few years. The installed Renewable Energy (RE) capacity stood at 197.2 GW (as in July 2024):
    - Solar- 87.2 GW
    - Large Hydro- 46.9 GW
    - Small hydro- 5.0 GW
    - Wind- 47.1 GW
    - Bio-power- 10.4 GW
    - Waste to Energy- 0.6 GW
- Nuclear energy based installed capacity amounted to 6.8 GW

- Furthermore, as in May 2024, the share of non-fossil sources in the installed electricity generation capacity reached 45% from 32% in April 2014.

Hydropower acts as a major source of renewable power generation and plays a significant role in the energy mix of the country.

5.3 Potential for hydropower in India

India is currently experiencing an energy transition, opting for more renewable alternatives to the traditional fossil-fuel based energy sources. Solar, wind and hydropower take the lion's share, amounting to more than 90% of the renewable energy mix as in July 2024. Hydroelectric power especially has played a key role by providing essential peaking support to the electricity grids, thereby providing stable power. The potential to develop this renewable source is quite high since out of the total assessed hydro power potential of 133.4 GW (projects of over 25MW capacity), only 42.1 GW (32%) is developed. This is due to infrastructural challenges faced like remote location, unpredictable terrain, natural disasters, environmental and ecological issues, Rehabilitation and Resettlement (R&R) issues, legal problems, cross-border conflicts etc. To help mitigate these problems, the GoI has enacted various initiatives some of which are mentioned below:

- Large Hydro Power projects (> 25 MW projects) are declared as Renewable Energy source.
- Within Renewable Purchase Obligation (RPO), provision has been created for Hydro Purchase Obligation (HPO) as a separate entity.
- Bringing down hydropower tariff through tariff rationalization measures.
- Budgetary support provided for enabling infrastructure.
- New mechanisms introduced to effectively address contractual disputes.
- Waiving off Inter State Transmission System (ISTS) charges from new hydroelectric projects and Pumped Storage projects (PSPs).
- Reduction of timeline by Central Electricity Authority (CEA) for concurrence of Detailed Project Report (DPR)

All these initiatives are aimed at boosting the efficiency of hydropower generation and developing the country's hydro power potential further.

Table 10: State/UT-wise details of Hydro Potential including Pumped Storage Potential (as on 30.06.2024)

	CONVENTIONAL	PUMPED STORAGE
Region/ State/ UT	**Exploitable Potential (GW)**	**Exploitable Potential*(GW)**
NORTHERN		
Jammu & Kashmir	12.3	
Ladakh	0.7	
Himachal Pradesh	18.3	7.3
Punjab	1.3	
Haryana		
Rajasthan	0.4	9.2
Uttarakhand	13.5	1.0
Uttar Pradesh	0.5	13.4
Sub Total (NR)	**47.0**	**30.9**
WESTERN		
Madhya Pradesh	2.8	8.6
Chhattisgarh	1.3	8.9
Gujarat	0.6	6.1
Maharashtra	3.1	43.0
Goa		
Sub Total (WR)	**7.8**	**66.6**
SOUTHERN		
Andhra Pradesh	2.6	26.4
Telangana	1.3	8.8
Karnataka	4.4	7.6
Kerala	2.5	1.2
Tamil Nadu	1.8	16.5
Sub Total (SR)	**12.6**	**60.5**
EASTERN		
Jharkhand	0.3	1.5
Bihar	0.1	
Odisha	2.8	4.8
West Bengal	0.8	5.5
Sikkim	6.1	
Sub Total (ER)	**10.1**	**11.8**
NORTH EASTERN		
Meghalaya	2.0	
Tripura		
Manipur	0.6	
Assam	0.6	0.3
Nagaland	0.3	
Arunachal Pradesh	50.4	0.7
Mizoram	1.9	5.6
Sub Total (NER)	**55.9**	**6.5**
ALL INDIA	**133.4**	**176.3**

Source: PIB, ICRA Analytics

5.4 Rise in Hydropower Construction Investments (FY2026-FY2032)

The importance of hydropower and its untapped potential has led to various initiatives from the government's end to develop the segment further. Hydroelectric projects with aggregate 15GW capacity are currently under construction. It is estimated to increase from 42GW to 67GW by FY2032, marking a more than 50% increase. Despite various challenges like difficult terrain, remote location, ecological and environmental issues, natural disasters, R&R issues and cross-border conflicts, the GoI has taken many initiatives to develop the hydropower sector to its full potential. This paves the way for significant investment and development, leading to further rise in Hydropower Construction Investments in the coming years.

Table 11: Key Projects in the Hydropower Sector in India (as in July 2024)

Sl. No.	Name of the Project (Executing Agency)	State / UT	District	I.C. (No. X MW.)	Cap. Under Execution (MW)	River/Basin	Date of finish/ commissioning	% Physical Progress
1	Subansiri Lower (NHPC)	Arunachal Pradesh/Assam	Lower Subansiri, Ar.Pradesh / Dhemaji, Assam	8x250	2000	Subansiri/ Brahmaputra	2026-27 (May'26)	93.20
2	Parbati St. II (NHPC)	Himachal Pradesh	Kullu	4x200	800	Parbati/Beas/ Indus	2024-25 (Dec'24)	97.58
3	Dibang Multipurpose Project (NHPC)	Arunachal Pradesh	Lower Dibang Valley	12x240	2880	Dibang/ Brahmaputra	2031-32 (Feb'32)	11.70
4	Ratle (RHEPPL / NHPC)	UT of Jammu & Kashmir	Kishtwar	4x205 + 1x30	850	Chenab/Indus	2026-27 (Dec'26)	14.00
5	Pakal Dul (CVPPL)	UT of Jammu & Kashmir	Kishtwar	4x250	1000	Marusadar/ Chenab / Indus	2026-27 (Sept'26)	55.00
6	Kiru (CVPPL)	UT of Jammu & Kashmir	Kishtwar	4x156	624	Chenab/ Indus	2026-27 (Sept'26)	37.00
7	Tehri PSS (THDC)	Uttarakhand	Tehri Garhwal	4x250	1000	Bhilangna/ Bhagirathi/Ganga	2024-25 (Oct'24)	97.00
8	Polavaram (APGENCO/ Irrigation Dept., A.P.)	Andhra Pradesh	East & West Godavari	12x80	960	Godavari/EFR	2025-26 (Mar'26)	23.70
9	Upper Sileru PSP (APGENCO)	Andhra Pradesh	Alluri Sitharamaraju	9x150	1350	Sileru/Godavari	2028-29 (Feb'29)	Initial stage of construction
10	Pinnapuram (Greenko AP01 IREP Private Limited)	Andhra Pradesh	Kurnool	4x240+2x120	1200	Pennar Basin	2024-25 (Dec'24)	90.80

Source: CEA; ICRA Analytics

5.5 Overview of canals in India

India boasts an extensive inland waterway network, around 14,500 KM of which is navigable, comprising of canals, rivers, creeks, and backwaters. The rural agricultural sector is highly dependent on this network for their irrigation needs. Canals serve as an important water source and are more densely populated in more fertile regions with perennial sources of water. This form of irrigation is mostly seen in the northern river belts and the costal and delta regions of India. Rocky and uneven surfaces make canal use impractical. Thus, it is less prevalent in the peninsular plateau and northern mountainous regions of the country. Due to their immense importance, the government has taken various measures to create and maintain the waterway and canal network.

Apart from irrigation, these river and canal networks are also widely used to move cargo in various parts of the country. As per a recent report by the government, more than six-fold increase in cargo movement on National Waterways (NW) since FY2014 has been observed, with total traffic increasing from 18.1 million metric tonnes (MMT) in FY2014 to 133.0 MMT in FY2024. The GoI intends to further improve cargo traffic, with a target to reach 200 MMT by FY2030 and 500 MMT by FY2047. In FY2016, 106 new NWs were declared, with operational waterway numbers increasing from 3 in FY2016 to 26 in FY2024.

The GoI is taking significant measures to maintain and develop the waterways in India. The century old law which previously governed the segment was replaced by the Inland Vessels Act, 2021. The Jal Marg Vikas Project (JMVP) was also launched in FY2018 to consolidate the capacity of NW1 (Ganga - Bhagirathi-Hooghly River system), covering a length of 1,390 KM and a financial outlay of Rs. 5,369 crores. The GoI has also opened the Indo-Bangladesh Protocol Route, and linked NW 1 and NW 2 (Brahmaputra River), boosting trade in the North-East. Various digital initiatives are also being introduced such as IWAI Vessel Tracker, the PANI Portal, CAR-D portal etc. which provided real time tracking and navigation information while also streamlining cargo and passenger data management. Passengers (including tourists) also benefit from ease of transportation through the inland waterway networks. With rise of developed transportation alternatives, potential for tourism also increases, boosting the local economy.

These efforts have resulted in substantial growth in cargo handling and improved regional connectivity, thereby reducing logistics cost and congestion of roadways. The initiatives also lead towards socio-economic upliftment of the local communities, energizing economic activities around the riverbank regions and impacting the overall riverbank ecosystem.

5.5.1 Inter-Linking of Rivers (ILR) Programme

- The National Perspective Plan (NPP) was prepared in FY1980 by the then Ministry of Irrigation (now Ministry of Jal Shakti), promoting inter basin transfer of water from water surplus river basins to water deficit ones, using canals and dams.
- 30 such links, 16 under Peninsular Component & 14 under Himalayan Component, were identified by the National Water Development Agency (NWDA) for the preparation of Feasibility Reports.
- As in February 2024, out of the 30 links which were identified, Pre - Feasibility Reports (PFRs) have been completed for all, while Feasibility Reports (FRs) have been completed for 24 links and Detailed Project Reports (DPRs) completed for 11 links.
- A special committee has been constituted in September 2014 for the inter-linking of rivers (ILR) program, while a Task Force for Interlinking of Rivers was formed in April 2015.
- Three links namely, Ken-Betwa Link Project (KBLP), Modified Parbati- Kalisindh-Chambal (PKC) Link project duly integrated with the Eastern Rajasthan Canal Project (ERCP) and Godavari-Cauvery link project have been identified as priority link projects under the NPP.
- The first ILR project which has been initiated is the Ken-Betwa Link Project (KBLP) among the states of Madhya Pradesh and Uttar Pradesh. The project was approved by GoI in December 2021 with an estimated cost of Rs. 44,605 crore (at year 2020-21 price level). In the Budget FY2025, an allocation of Rs 4000 crore for the interlinking of rivers has been made, implying almost three-fold increase compared to FY2024 revised estimates of Rs 1400 crore, and hinting at a continued thrust of the government on this project.

6. Urban Infrastructure Sector

6.1 Overview

India's urban population has significantly grown from 381 million people in metropolitan regions in FY2010 (31% of total population) to 530.3 million in FY2024 (representing 37% of the total Indian population). According to World Bank's studies, India's urban population is expected to reach 600 million (40% of the total population) by FY2036. Hence, building the essential infrastructure will be key for creating reasonable, climate-resilient, and comprehensive urban areas that drive the economy forward. Indian urban infrastructure is poised for significant growth, driven by the country's rapid urbanisation, government initiatives, technological advancements and participation of the private sector.

The major segments under urban infrastructure- water supply and sanitation, urban waste generation and treatment and metro rail has been discussed in detail.

1. Water Supply and Sanitation (WSS)

- India, possessing ~4% of the world's water resources supports a population of 1.4 billion, which is 18% of the world's total population. The per capita water availability has been declining steadily since FY1951 due to the increase in population. As per the Central Water Commission study, the average annual per capita water availability for FY2021 and FY2031 has been assessed as 1486 cubic meter and 1367 cubic meter respectively. Annual per-capita water availability of less than 1700 cubic meter is considered as water stressed condition whereas annual per-capita water availability below 1000 cubic meters is considered as a water scarcity condition.
- India largely depends on the erratic monsoons for its water requirements which has worsened further due to climate change. Increasing urban population adds further stress to urban water demand and supply. In CY2023, urban population increased to 36.4% of the total population from 35.9% in CY2022. Rapid urbanization leads to unpredictability of water and inadequate management of water resources. It needs adaptive water management strategies including water conservation, efficient water use practices, recycling and reuse, and integrated water resource management.
- The supply of drinking water and sanitation services in urban areas are provided from different sources such as groundwater, surface water and recycled water. According to the Household-level data from the National Sample Survey Office's [NSSO] 76th round survey conducted in FY2018, the main source of drinking water for ~41% of urban households is piped water supply to their houses. This implies that

~59% of the urban households depend on sources like bottled water, community taps, handpumps, tube wells.

- Groundwater is one of the most common sources for rural and urban domestic water supply. However, increasing water stress, lack of sufficient municipal water supply, led to overexploitation and depletion of this resource. In order to improve the management of groundwater in selected states, the government has undertaken a national groundwater program called Atal Bhujal Yojana(ABHY). It has been implemented in 8,220-gram panchayats across seven Indian states. It aims at monitoring and evaluating the water demand and supply while helping the villagers understand the importance of water availability and usage.
- Industry water demand is projected to increase from 67 billion cubic meters (BCM) in FY2025 to 81 BCM FY2050 marking a 21% increase from FY2025 to FY2050. The industrial demand of water increases as commercial and manufacturing sector growth accelerates in India. A huge toll is also placed on India's water bodies especially rivers which are blocked by large scale development ventures. Major river bodies such as Ganga and Yamuna are becoming one of the most polluted rivers in the world due to heavy discharge of untreated sewage and sludge along the tributaries. Indian government is working with World Bank to rejuvenate it by building and maintaining sewage treatment plants along with a network of drains. It would help in sewage treatments before reaching the rivers. As per the survey by Central Pollution Control Board (CPCB) in FY2023, out of 603 rivers in 1920 locations all over the country, 311 were identified as polluted river stretches.
- Another challenge in the urban water supply is the supply leakages. As per estimations, around 25-50% of the water is lost during distribution through the public supply networks in Indian cities.
- Indian government launched various reforms and initiatives to ensure quality drinking water supply in the rural and semi urban areas in efforts to reduce the gap with the urban areas. Under Jal Jeevan Mission (JJM), focus was shifted from providing water at habitation level (included hand pumps and public standposts) to household level through tap water on regular basis. Village Water & Sanitation Committee/Pani Samiti is being established in every village to ensure water conservation, maintain water quality and spread public awareness.
- Water Quality Monitoring & Surveillance enables the provision of clean tap water supply to every rural home and public institution in the rural areas. Testing and monitoring of the water supply and regular water surveillance provides confidence in consuming water directly from tap.
- Department of Drinking Water and Sanitation (DoDWS) and the Ministry of Housing and Urban Affairs (MoHUA) focused on the agenda of providing safe drinking water and improving the sanitation infrastructure in both rural and urban areas. As per Union Budget FY2025, the DoDWS received an allocation of Rs 77,391 crores. This reflected an increase of ~0.5% from the previous year allocation of Rs 77,033 crore. Majority of the portion (Rs 69,927 crore) was allocated for Jal Jeevan Misson, while Rs 7,192 crore was allocated to Swachh Bharat Mission (Gramin) which focuses on improving waste management in rural areas.

2. Urban Waste Generation and Treatment

Union Ministry of Environment, Forests, and Climate Change oversees the Waste Management in India. Each year around 62 million tonnes (mt) of waste is generated in urban areas which comprises of around 377 million people. Out of this, only 43 mt is collected, and rest remains untreated or in landfills. By FY2030, the total waste generated by urban cities is expected to rise to 165 mt, resulting from rapid urbanization and economic growth.

Urban Waste management components:

The urban waste management components can be segregated into the following:

- Segregation of waste
- Biodegradable waste management
- Material Processing
- Plastic waste management
- Construction and Demolition (C&D) waste management
- Sanitary waste management
- Landfill management
- Technological innovation

Currently, the waste management in India faces significant challenges.

- India produces various kinds of waste of which e- waste generation has been a growing concern especially due to rapid advancement in technology and growth.
- India's recycling rate currently stands at only 18 percent, which is well below the global average of 35 percent.
- Only ~30% waste is sorted. Hence, valuable materials like aluminium and plastics instead of being recycled, end up in landfills. Also, only 5% of the total waste generated by the country is being recycled and reused.

6.2 Urban waste treatment

India needs sustainable waste management solutions to solve the environmental issues and achieve further economic growth. Through Swachh Bharat Mission (Urban) [SBM(U)] and AMRUT programs, Ministry of Housing and Urban Affairs (MoHUA) has been working on ensuring complete management of liquid and solid waste (including faecal sludge and plastic waste) in urban areas. Additionally, sewerage infrastructure is created under these programs for better treatment of waste. Although, the government has implemented various policies and regulations, there is a need for responsible practices, along with investment in infrastructure finance, technology, and awareness, to ease the challenges and achieve better management of waste. Some of them are:

- Scientific planning and use of innovative technologies
- Improving waste collection methods
- Waste-to-energy conversion practices
- Improving funding for modernization of landfills
- Introduction of stricter governmental policies and regulations
- Public awareness and education on waste management

6.3 Regulatory framework for water industry in India

Some of the institutions that work together to address the growing scarcity of water in India and manage the water supply needs are:

- Central Water Commission (CWC) oversees the water resources development and management.
- Ministry of Jal Shakti, formulated in 2019, is responsible for water resources, drinking water and sanitation.
- State Water Resources Departments are responsible for implementing water related projects and policies.
- Water Board/Utilities manage the water supply and treatment in urban areas.
- Water regulatory authorities are established in some states, for regulating the water use and allocation of resources.
- National Water Policy 2012 provides detailed guidance for water management and allocation.

Some of the key initiatives/policies taken by the regulatory authorities for water management are:

- **Jal Jeevan Mission (JJM):** Launched by the Indian government in partnership with state governments, the mission aims to provide tap water connections to all rural households by FY2024. As per the latest data, 78% of rural households (15.11 crore) have access to tap water.
- **Atal Mission for Rejuvenation and Urban Transformation (AMRUT) 2.0:** Launched in October 2021, this mission aims to ensure universal water supply coverage in all statutory towns and to make cities "water secure.
- **Namami Gange Programme:** An initiative launched in 2014 to improve the water quality of the Ganga River.
- **National Water Policy (NWP) Revision:** The Ministry of Jal Shakti is revising the 2012 NWP, focusing on water recycling, decentralized wastewater management, and eco-restoration of urban river stretches.
- **National Water Mission (NWM):** A key component of India's National Action Plan on Climate Change, the mission focuses on water conservation, rainwater harvesting, pollution control, water infrastructure, and public awareness on efficient water use.
- **Sahi Fasal Campaign:** Launched in FY2019, this campaign encourages the cultivation of water-efficient crops in water-stressed areas, with workshops held in locations such as Amritsar, Aurangabad, Kurukshetra, and New Delhi.
- **Catch the Rain Campaign:** Under NWM, this initiative promotes the creation of rainwater harvesting structures (RWHS) tailored to local climatic conditions, encouraging the effective storage of rainwater before the onset of the monsoon season.

Regulatory framework for waste management

Waste management framework provides a structured approach covering technical, financial and evaluation aspects of waste management while setting the standards, enforcing regulations for effective urban waste management in India.

- The **Environment (Protection) Act, 1986** allows regulatory authorities to enforce pollution control measures and penalties for non-compliance. Industries must obtain consent before operating in specific areas, adhering to safety standards for effluent discharge.
- The **Central Pollution Control Board (CPCB), 1974**, under the **Water (Prevention & Control of Pollution) Act, 1974**, ensures environmental protection by managing pollution, providing data, technical input for policy formation, and raising public awareness.
- **Ministry of Housing and Urban Affairs (MoHUA)** oversees urban development and waste management.
- **State-level authorities** (State Pollution Control Boards, Urban Local Bodies, etc.) implement waste management at the state level.
- The **Water (Prevention and Control of Pollution) Act, 1974**, addresses water pollution by regulating wastewater discharge. The **Water (Prevention and Control of Pollution) Amendment Bill, 2024** imposes stricter penalties for violations and applies to select regions.
- The **Water (Prevention and Control of Pollution) Cess Act, 1977** levies taxes on wastewater discharge and offers a 25% rebate on cess for installing treatment plants.

6.4 Key Drivers for Water Supply Management

Adoption of water saving technologies, efficient agricultural practices and better infrastructure for water supply and wastewater treatment can improve the overall water supply management. Some of the key drivers for water supply management are:

1. **Increase in population and rapid urbanisation:** As India's population keeps growing, the requirement for water supply also increases, putting pressure on water resources. Furthermore, urbanization and industrialization contribute to water pollution, limiting the water supply from freshwater resources.
2. **Overuse and depletion of groundwater:** Groundwater is one of the largest sources of fresh water. Overexploitation of groundwater for industrial activities, domestic use and irrigation purposes can lower the groundwater table and reduce the surface water supplies.
3. **Agricultural needs:** Inefficient water management in agriculture reduces the availability of water and declines the quality of water. Excess irrigation pollutes the surface and groundwater as it induces nutrient and pesticides losses.
4. **Inefficient use of water:** Inefficient water use is driven by poor infrastructure, outdated pipelines, and lack of water-saving technologies. Water leakage, often caused by cracked and worn-out pipes, leads to significant wastage. Implementing advanced leak detection technologies and strengthening the water supply system can mitigate these losses.
   .
5. **Water energy nexus:** Harnessing energy requires huge amount of water just as power is needed for water treatment and supply. Renewable energy sources are integrated in water pumps, water supply and distribution systems and wastewater treatment plants thereby reducing emissions.
6. **Government policies:** Coordination between different government agencies and states is required for proper water supply management across all states and cities.
7. **Climate change:** Change in monsoons and increased frequency of extreme weather events also impacts the water supply and availability.
8. **Technological advancements:** Modern technologies such as Digital Water Management, leveraging AI, IoT sensors, and advanced meters, are revolutionizing water supply management. Advanced wastewater treatment methods like oxidation processes, adsorption/biosorption, and biological/anaerobic treatments enhance efficiency. Additionally, water-saving technologies facilitate the repurposing of water, addressing critical challenges like aging infrastructure, inefficient waste treatment, water leakage, and inconsistent or contaminated water supply. These innovations are optimizing operations, maintenance, and monitoring of water networks, driving improvements across the sector.
9. **Public awareness and education:** The government has introduced multiple initiatives and schemes for raising public awareness and educate the citizens regarding water supply management like Jal Shakti Abhiyan, Jal Jeevan Mission, National Water Mission etc. These initiatives help engage local

communities through outreach programs and build awareness while encouraging collective ownership in water conservation efforts.

6.5 Storm water drainage

Storm water drainage systems are used to protect urban areas against flooding in a phased manner. These need to be planned and then employed in a structured manner, keeping design, operation, maintenance, rainfall analysis, construction and economies in mind. In India, these projects are prioritized, coming behind only drinking water supply and sewerage projects in most cases. Urban flooding might be caused by heavy rainfall, high intensity rainfall, unplanned urbanization which becomes unable to support excess population growth, incorrect disposal of storm run-off etc. This can be mitigated if the storm water drainage system is properly developed along with accurate rainfall intensity analysis and strategic planning and implementation, protecting both property and citizens' lives.

The flood control and mitigation measures usually fall under the purview of the state government and Urban Local Bodies/Urban Development Authorities at city level, while the GoI supports the efforts through schematic interventions/ advisories, financial and technical support. The GoI has also published various documents and advisory guidelines:

- Urban and Regional Development Plans Formulation and Implementation (URDPFI) Guidelines, 2014
- Standard Operating Procedure (SOP) for Urban Flooding
- River Centric Urban Planning Guidelines in 2021
- Creation of Rainwater Harvesting Parks (by MoHUA)

Furthermore, under the AMRUT Mission, storm water drainage is a key component. As reported by the states, currently 772 Storm Water Drainage projects worth Rs. 2,140 crore have been completed, resulting in elimination of 3,556 water logging points. Additionally, 69 projects worth Rs. 878 crore are currently under the implementation stage across 19 States/ Union Territories (UTs), estimated to tackle another 372 water logging points.

AMRUT 2.0 also aims at rejuvenation of water bodies and wells, by harvesting rainwater through storm water drains into water body (which is not receiving sewage or effluents). Under the mission, 2,713 water body rejuvenation projects worth Rs. 5,432 crore have been approved till date.

6.6 Key Drivers for Wastewater Treatment

India requires a multi-faceted approach involving government initiatives, private sector participation, efficient technologies and enhanced public awareness for improving the wastewater treatment in India. Some of the key drivers for wastewater treatment are:

1. **Persistent water scarcity:** Urban water scarcity is an emerging systemic risk driven by the growing population. Hence, conservation of water, recycling and reuse of water after wastewater treatment becomes necessary.
2. **Compliance with regulatory requirements:** Both Industries and individuals are required to comply with the laws, regulations and standards set for wastewater discharges. Furthermore, rules and regulations should be monitored regularly to check whether they meet current needs. In case where upgradations are required, they should also be duly revised by the required bodies, to align with new standards.
3. **Leveraging technological advancements:** Wastewater treatment can be effectively done using advanced treatment processes and innovative technologies such as Ultrasonic reactors, Electrocoagulation and electrooxidation, Photocatalytic oxidation and so on.
4. **Climate change impacts and environmental protection:** The wastewater treatment not only helps in reducing the impacts of climate change but also helps in protecting the environment by preventing pollution of water bodies, soil and so on.
5. **Promoting circular economy:** Circular economy considers wastewater as a valuable resource instead of a nuisance. Water reuse and recycling is suitable for irrigation and industrial activities, thereby reducing the demand for freshwater sources.
6. **Better health of citizens:** Wastewater treatment reduces the risk of water borne diseases and protects human health.

6.7 Metro Rail Segment Overview

The GoI has undertaken various initiatives to revolutionize the country's infrastructure landscape, including the expansion of India's Metro Rail system, which has transformed urban commuting. Since FY2014, the metro network has expanded from 248 KM to an impressive 945 KM by FY2024. Approximately 1 crore passengers benefit from the metro network daily. The system, which initially started from 5 cities before FY2014 has expanded to 21 cities across the country in FY2024, with 939 KM of lines under construction in 26 additional cities. This number has further increased in the current fiscal after the recent approval of 3 new projects, pushing the under-construction network to 1,018 KM in the country. Furthermore, the introduction of 'Namo Bharat', the state-of-the-art train to be operated on the 48.15 KM Delhi-Meerut Regional Rapid Transit System (RRTS) corridor, highlights India's commitment towards the development and modernization of urban infrastructural development.

Table 12: Metro rail network details in brief details (as on FY2024)

Metro Network	**Area under routes (in KM)**
Total metro network (before FY2014)	248
Total metro network (as of FY2024)	945
Under construction (as of Aug 2024)	1018
Metro Network operational cities	**No. of cities**
Metro network operational in (FY2024)	21
Additional cities metro network is under construction in (FY2024)	26

Source: Ministry of Housing and Urban Affairs (MoHUA), PIB, ICRA Analytics

6.8 Metro Projects in India

India has come a long way in terms of urban infrastructure and transportation and the metro rail system has played a crucial role in this development. The first ever metro network was the Kolkata Metro Rail system which started in October 1984. Currently, the Delhi Metro Rail boosts the largest and busiest urban metro rail network in India. A list of key metro rail networks across the country is provided as under:

Table 13: Key Metro Rail Projects (as in August 2024):

Metro network	**Location**	**Operational route (in KM)**	**Operational Stations**	**Under construction route (in KM)**	**Operators**
Delhi Metro	Delhi-NCR	392.4	288	112.4	DMRC
Bangalore Metro	Karnataka	73.8	70	174.9	BMRCL
Chennai Metro	Tamil Nadu	54.1	41	118.9	CMRL
Nagpur Metro	Maharashtra	40.0	38	43.8	Maha-Metro
Kochi Metro	Kerala	30.8	25	11.2	KMRL
Mumbai Metro	Maharashtra	46.5	42	146.1	MMOPL, MMRCL
Ahmedabad Metro	Gujarat	40.0	33	28.3	GMRC
Lucknow Metro	Uttar Pradesh	22.9	21	11.1	UPMRCL
Pune Metro	Maharashtra	29.7	25	36.8	Maha-Metro
Agra Metro	Uttar Pradesh	6.0	6	29.4	UPMRCL
Kanpur Metro	Uttar Pradesh	9.0	9	23.4	UPMRCL
Gurgaon Rapid Metro	Haryana	12.9	11	28.5	RMRG (now DMRC)
Hyderabad Metro	Telangana	69.0	57	70.0	HMRL
Jaipur Metro	Rajasthan	12.0	11	-	JMRC
Kolkata Metro	West Bengal	64.1	45	41.9	Metro Railway & KMRC
Navi Mumbai Metro	Maharashtra	11.1	11	-	CIDCO
Noida Metro	Uttar Pradesh	29.7	21	-	NMRC

Source: Metro Rail websites of different states and cities, PIB, ICRA Analytics

Note: DMRC- Delhi Metro Rail Corporation; BMRCL-Bangalore Metro Rail Corporation Limited; CMRL- Chennai Metro Rail Limited; MAHA-Metro- Maharashtra Metro Rail Corporation Limited; KMRL- Kochi Metro Rail Ltd; MMOPL- Mumbai Metro One private Limited; MMRCL- Mumbai Metro Rail Corporation Limited; GMRC- Gujarat Metro Rail Corporation Limited; UPMRCL- Uttar Pradesh Metro Rail Corporation Ltd; HMRL- Hyderabad Metro Rail Limited; JMRC- Jaipur Metro Rail Corporation Limited; KMRC- Kolkata Metro Rail Corporation; CIDCO- City and Industrial Development Corporation; NMRC- Noida Metro Rail Corporation Ltd

6.9 Progress of Key Metro Projects Across the Country

Apart from existing metro rail network, the GoI with collaboration with state governments and PPPs have further planned to develop the metro rail network. An additional capacity of 1018 KM is under construction with plans to build the network in 26 more cities. This will be a key milestone in the urban infrastructure segment. A list of key projects under construction and consideration are listed below along with their progress as in august 2024:

Table 14: Key under-construction and approved Metro Projects of India (as in August 2024):

Metro network	Location	Date	Network (in KM)	Physical progress	Financial progress	Operators
Delhi Metro-Phase-IV (3 Priority Corridors)	Delhi-NCR	2019	65.2	49%	44%	DMRC
Delhi Metro-Phase-IV (2 Corridors out of 3 Remaining Corridors)	Delhi-NCR	2024	47.2	-	-	DMRC
Gurugram metro-Millennium City Centre to Cyber City Gurugram	Haryana	2023	28.5	-	-	GMRL
Bangalore Metro Rail Project Phase-2	Karnataka	2014	73.1	92%	97%	BMRCL
Bangalore Metro Rail Project Phase-2A & 2B	Karnataka	2021	58.2	36%	38%	BMRCL
Bangalore Metro Rail Project Phase 3	Karnataka	2024	44.7	-	-	BMRCL
Chennai Metro Rail Project-Phase II	Tamil Nadu	2019	118.9	-	-	CMRL
Nagpur Metro Rail Project Phase-II	Maharashtra	2022	43.8	-	-	Maha-Metro
Kochi Metro Rail Project Phase II	Kerala	2022	11.2	4%	4%	KMRL
Mumbai Metro Line-3	Maharashtra	2012	33.5	90%	77%	MMOPL, MMRC & MMMOCL
Ahmedabad Metro Rail Project Phase-2	Gujrat	2019	28.3	65%	56%	GMRC
Surat Metro Rail Project-2 corridors	Gujrat	2017	40.4	47%	40%	GMRC
Pune Metro Rail Project Phase-1	Maharashtra	2012	33.3	99%	87%	Maha-Metro
PCMC-Nigdi Extension of Pune Metro Rail Project	Maharashtra	2023	4.4	-	-	Maha-Metro
Pune Metro Line-3	Maharashtra	2018	23.3	-	-	Maha-Metro
Pune Metro Rail Project Phase-1-Line-1 B extension	Maharashtra	2024	5.46	-	-	Maha-Metro
Noida-Greater Noida Metro Rail Project	Uttar Pradesh	2017	29.7	-	-	NMRC
Bhopal Metro Rail Project	Madhya Pradesh	2018	27.9	25%	29%	MPMRCL
Indore Metro Rail Project	Madhya Pradesh	2018	31.6	38%	36%	MPMRCL
Patna Metro Rail Project	Bihar	2019	32.5	37%	25%	PMRC
Agra Metro Rail Project	Uttar Pradesh	2019	29.4	34%	32%	UPMRCL
Kanpur Metro Rail Project	Uttar Pradesh	2019	32.4	65%	63%	UPMRCL
Hyderabad Metro Rail Project- Phase II	Telangana	2024	70	-	-	HMRL
Bhubaneswar Metro	Odisha	2023	26	-	-	BMRCL
Meerut Metro	Uttar Pradesh	2019	38.6	-	-	UPMRCL
Thane Metro Project	Maharashtra	2024	29	-	-	Maha-Metro

Source: PIB, Metrorail guy, ICRA Analytics

Note: DMRC- Delhi Metro Rail Corporation; BMRCL-Bangalore Metro Rail Corporation Limited; CMRL- Chennai Metro Rail Limited; MAHA-Metro- Maharashtra Metro Rail Corporation Limited; KMRL- Kochi Metro Rail Ltd; MMOPL- Mumbai Metro One private Limited; MMRCL- Mumbai Metro Rail Corporation Limited; GMRC- Gujarat Metro Rail Corporation Limited; UPMRCL- Uttar Pradesh Metro Rail Corporation Ltd; HMRL- Hyderabad Metro Rail Limited; JMRC- Jaipur Metro Rail Corporation Limited; KMRC- Kolkata Metro Rail Corporation; CIDCO- City and Industrial Development Corporation; NMRC- Noida Metro Rail Corporation Ltd

6.10 Trend in Investments in Metro Rail Network and Smart Cities Projects

The metro rail projects are primarily financed by the central government in the form of grants, equity, subordinate debt, pass through assistance etc. along with state governments and private players in some cases. India also receives foreign investments in the metro rail sector, mainly in the form of loans with flexible arrangements.

- The European Investment Bank (EIB) approved a US$ 450 million loan for a 23 km metro line and 80 metro cars in Lucknow.
- The Japan International Cooperation Agency (JICA) has sanctioned loans totalling JPY 3.7 trillion (US$ 23.5 billion) for metro projects in multiple Indian cities, including Delhi, Mumbai, Kolkata, Chennai, Bengaluru, Ahmedabad, and Patna. Recent agreements include JPY 84.2 billion (US$ 536.45 million) for Mumbai Metro Line 3 and JPY 103 billion (US$ 655.3 million) for Delhi Metro Phase 4.
- The Asian Infrastructure Investment Bank has invested in metro projects such as the Kochi Metro Phase II, Mumbai Metro Line 5, and Chennai Metro Rail Phase 2.
- Germany's KfW Development Bank provided EUR 500 million for the Nagpur Metro project.
- Foreign technical assistance has played a key role in India's metro development, with companies like Mitsubishi Electric India, Nippon Signal, Hyundai Rotem, Siemens, Bombardier, and Alstom providing advanced technologies.
- Siemens plans to invest Rs. 186 crore to build a metro train manufacturing facility in Aurangabad by 2028, positioning the region as an export hub for metro turnkey projects.

6.11 Smart cities

The smart cities mission, since its inception in June 2015, has been a novel experiment in the urban development landscape of India, driving economic growth and improving the quality of life of people. By FY2030, India is expected to accommodate 40% of its total population in cities, which will contribute approximately 75% to the GDP. This trend requires comprehensive development of physical, institutional, social and economic infrastructure, thereby increasing the need for smart cities. Under the mission, 100 cities were initially targeted to be developed within the duration of FY2015 to FY2020. This timeline has further been extended till 31st March 2025, within which time all ongoing projects need to be completed.

The GoI has implemented unique solutions under the smart city mission like competition among cities for selection of 100 smart cities, formation of special purpose vehicles (SPVs) for the smart cities, stakeholder driven project selection, digital solutions for improved urban governance, third-party impact evaluation by premier academic and professional institutes etc.

As on 20th August 2024, the 100 Cities have completed 7,239 projects (90% of total projects) amounting to Rs.1,45,293 crore as part of the Mission. The balance 778 projects (10% of total projects) amounting to Rs. 18,996 crore are also at advanced stages of completion. As per latest reports, the Mission has an allocated GoI budget of Rs. 48,000 crore for the 100 cities, of which Rs. 46,585 crore (97% of the allocated GoI budget) has already been released. Out of this released fund, 93% have been utilized till date.

The smart cities mission aims to provide clean and sustainable environment incorporating modern technologies and to create a replicable model which can be implemented easily to other cities as well. Some basic urban planning and management features include:

- Adequate power supply
- Improved sanitation (including waste and water)
- Adequate water supply
- Smooth urban mobility and transportation
- Affordable housing
- Health and educational development
- Safety and security of citizens
- Robust IT connectivity and digitalization
- Sustainable environment

Smart cities also stress on green and open spaces, encompassing parks, playgrounds, and recreational spaces which enhance the quality of life, reduce negative effects of urban heat and promote eco-balance. Furthermore, the cities also try to incorporate renewable and green energy sources like EV and solar infra, green hydrogen, alternative fuels etc. to reduce emissions and increase sustainable practices.

6.12 Overview of Share of PPP Model in Metro Projects

Central government is the primary financier of metro rail projects along with state governments. But recently, the government has tried to boost private participation in this sector. The Metro Rail Policy 2017 mandates the involvement of public private partnership (PPP) in some form or the other in a metro project like operation and maintenance or fare collection. Due to this, PPP mode has become important for current metro rail projects.

PPP model has become an increasingly popular mode in the urban infrastructure segment. Key PPP metro projects are given below.

- Pune Metro Line III is a recent under-construction metro project which is being developed in PPP mode spanning 23.3 KM.
- Hyderabad Metro's three lines is one of the largest PPP projects in Metro sector globally.
- The Phase IV expansion of the Delhi Metro has also been developed under this model, which aims to connect various parts of the city with the outskirts.
- The Bangalore metro's Phase II aims at adding extensions to existing lines and the addition of new lines, which was significantly financed by the PPP model.

6.13 Key announcements and latest metro projects

The Union Minister for Housing and Urban Affairs recently announced the approval of three major Metro Rail projects by the Union Cabinet, highlighting the government's role in urban planning and infrastructural development:

- Bengaluru Metro Project (Phase 3): 44.65 KM expansion comprising two corridors with an estimated cost of Rs.15,611 crore and to be operational by FY2029.

- Thane Metro Project: 29 KM network to reduce congestion on the roads of Thane, with an estimated cost of Rs. 12,200 crore and to be operational by FY2028.

- Pune Metro Project: 5.5 KM route aimed to improve urban mobility in the city, with an estimated cost of Rs. 2955 crore. and to be operational by FY2028.

With the approval for the 3 new lines, the metro lines under construction now stands at 1,018 KM in India. Additionally, India also ranks 3rd globally in terms of operational Metro network length, following countries like China and USA.

Various initiatives to boost domestic manufacturing like Make in India and Atmanirbhar Bharat has led to development of four state-of-the-art manufacturing facilities of metro coaches in India, which has provided over 1,000 Metro coaches in the last five years.

India's expertise in metro rail system has led to the country acting in advisory capacity in international landscape. The Delhi Metro Rail Corporation (DMRC) is currently engaged in implementing a metro rail system in Bangladesh, while also providing consultancy services in Jakarta. Other countries like Israel, Saudi Arabia (Riyadh), Kenya, and El Salvador have shown interest to partner with DMRC too, to develop metro rail systems in their cities.

7. Road Infrastructure in India

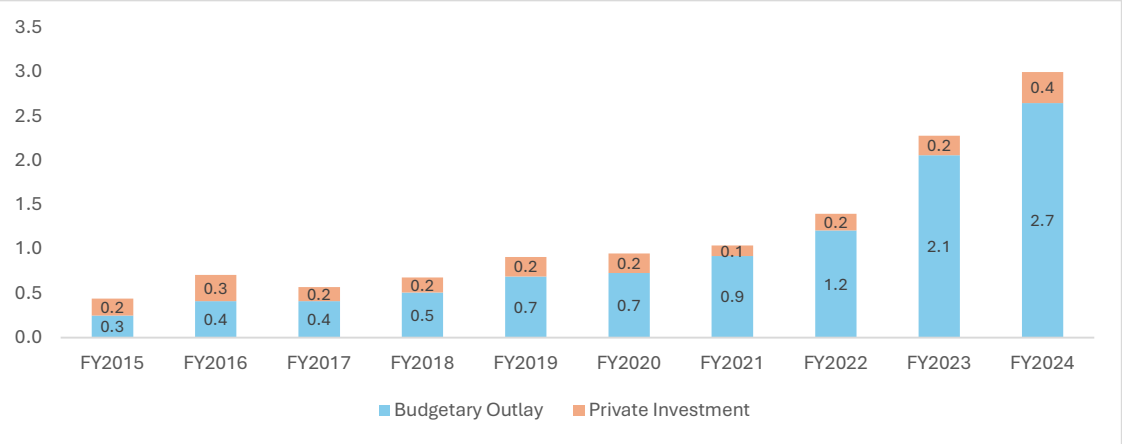
Public Private Partnership (PPP) model initiatives: The government is taking initiatives to attract and involve the private sector participation into making significant investments in the construction of infrastructures in India. Some of the initiatives include government bearing the cost of project feasibility study, shifting of utilities, environmental clearances and so on. The sector has drawn its highest-ever investment from the private sector in FY2024. Some of the popular models under PPP initiatives are:

a. VGF- Viability gap funding addresses the funding gap, making the project viable for private sector participation. In order to bridge the gap, the government provides a grant typically upto 20% of the project cost. The VGF grant is repaid by the private sector partner through annuity payments or other agreed mechanisms. This has been used successfully for various infrastructural projects including highways, roads, port and airports.

b. HAM- Under this the government: private sector has a 40:60 ratio and thereby sharing the risk of execution. This method has reduced the element of risk, increased investment, improved quality and faster execution.

c. Skill development- This involves collaborative efforts between the government and private sector to develop skills relevant to infrastructure development and operations. This includes training programs, capacity building, transferring of knowledge, apprenticeships, certification programs and so on. By focusing on skill development, PPP projects in India can create a sustainable and skilled workforce, supporting infrastructure growth and economic development.

Chart 13: Government and Private investment along with total capital outlay in road transport



Source: Economic Survey 2023-2024, ICRA Analytics

7.4 Key budget announcements for the roads sector

As per Union Budget FY2025, the following are the key takeaways for Road and Highway sector:

1. **Budget Allocation**: MoRTH's capital outlay increased by 3% to ₹2.72 trillion in FY2025 BE from ₹2.65 trillion in FY2024 RE, supporting Bharatmala Pariyojana and NIP.
2. **NHAI Funding**: Allocation remains at ₹1.68 trillion, with no new borrowings to manage debt levels.
3. **PMGSY Phase IV**: Launched to provide all-weather connectivity to 25,000 rural habitations, with allocation rising to ₹190 billion in FY2025 BE from ₹170 billion in FY2024 RE.
4. **Asset Monetisation**: NHAI realised ₹317 billion in FY2024 (90% of ₹350 billion target) and aims to raise ₹500 billion in FY2025 through a dedicated Asset Monetisation Cell.
5. **CRIF Allocation**: Increased to ₹273 crore in FY2025 BE from ₹256 crore in FY2024 RE for road transport and safety.
6. **Sustainable Infrastructure**: GoI continues to prioritise green initiatives, clean energy, and sustainable transport, aligning with its net-zero 2070 vision.

7.5 Growth drivers and emerging trends for the road sector

India's road and highway infrastructure is experiencing a substantial growth and is projected to showcase robust growth till FY2030. The major growth drivers are as discussed below:

1. Rapid Urbanisation: The increase in urban population leads to an increase in vehicle ownership supported by rising income and better standard of living. This increase led to a surge in demand for efficient transportation infrastructure including extensive road networks, thereby contributing to the development of road sector.

2. Economic growth: As the economy grows, the demand for transportation and goods also increases, which requires a sound road infrastructural development. The logistics and transportation sector are dependent closely on the road and highway sector. Better road infrastructure would boost trade and commerce by reducing transportation costs and time.

3. Government initiatives: As the government prioritizes and undertakes the implementation of various projects like Bharatmala Pariyojana, PMGSY, better focus on the growth of road construction and connectivity takes place ensuring overall growth.

4. Public Private Partnership (PPP) model: It enables the private sector to participate in the road infrastructural development investments and thereby contribute to overall growth of the sector.

5. Technological advancements: As India embraces digital advancements such as intelligent traffic management and automated toll collection, better efficiency and safety of road operations will contribute to the growth of overall road infrastructure.
6. Foreign investments: Increase in influx of foreign capital as the international investors recognize the growth potential of road and highway sector.
7. Multimodal transportation: Integrating Road infrastructure with other modes of transport such as railway, airport and ports would enhance the movement of goods and people, reducing costs and making it more efficient.
8. Smart Cities Mission: It is an initiative by the government to develop 100 smart cities across the country. The mission has led to the development of
    - Intelligent Transportation Systems
    - Smart traffic management
    - Energy efficient streetlights
    - Dedicated bus lanes
    - Pedestrian friendly infrastructure
    - Green corridors including tree-lined roads, green roofs and walls, urban forests.
9. Sustainable Development: It focuses on creating environmentally friendly, socially responsible and economically viable transportation infrastructure. It includes Green Highways, recycling of asphalt in road construction and use of other eco-friendly materials, conservation of water, climate resilient road designs to withstand the climate change and so on.
10. Rural Connectivity: It aims at connecting the rural areas with the urban regions, thereby improving the accessibility to larger urban markets, education, healthcare and employment opportunities. Prioritising this would help India bridge rural-urban divide, fostering an inclusive growth and development.

7.6 Challenges for the road and highway sector

Despite the significant growth, the road sector faces certain challenges that block its growth and development. They are as discussed below:

1. Funding constraints: The scale of investment required is much more than the funding from government budgetary allocation and private sectors, thereby leading to delays and slowdowns in project implementation.
2. Land Acquisition issues: Acquisition of land for road projects could involve lengthy legal proceedings, disputes and resistance from the landowners thereby slowing down the project implementation.
3. Bureaucratic delays: Multiple approvals, compliance requirements and slow decision making can delay the project implementation. Private investors hesitate to invest in such cases as it increases the project timeline and administrative costs.
4. Quality control and safety concerns: India's roads are considered among the unsafe roads globally with a high accident rate. Hence ensuring quality construction and maintenance of the roads can also contribute to one of the challenges in the road and highway sector. Most of the times, the roads are inadequately maintained leading to deterioration and reduction of its lifespan.
5. Environmental concerns: Construction of roads involve deforestation and pollution, thereby creating environmental impacts. Roads are also vulnerable to climate change- extreme weather conditions which call for resilient design and construction practices.
6. Lack of standardisation: Roads created across the states vary from one to another due to lack of consistency including inconsistent road designs.
7. Technological gaps: The road and highway sector face significant challenges in bridging technological gaps which includes
    - outdated construction techniques

- inadequate adoption of advanced technologies
- lack of skilled workforce
- incompatibility between different systems and technologies
- vulnerability to cyber threats and inadequate research and development

8. Maintenance and upgradation: Some of the road and highways are old and deteriorating, requiring regular maintenance and upgradation. However, insufficient allocation of funds for maintenance, lack of regular inspections and poor-quality construction using substandard materials remain key areas of concern for the road and highway sector. This leads to safety risks, traffic congestions and economic losses.

Addressing these challenges is crucial as it will help tap into the immense potential of the road and highway sector.

7.7 Outlook on investments in national and state highways (FY19-FY24)

In the last ten years, India's road network has witnessed a growth of ~60%. Some of the investments made by NHAI to build smart highways are discussed as below:

- **National Highways Infra Trust (NHIT):** As of March 2024, NHIT raised funds for 889 km of highways at an enterprise value of ₹16,000 crore, marking NHAI's largest monetization. The government targets constructing 65,000 km of national highways by FY2025 at ₹5.35 lakh crore.
- **E-Vehicle Infrastructure & Road Safety:** Since FY2021, the government has invested in charging stations every 40-60 km, aiming for 700 stations covering 35,000-40,000 km by FY2023. Mandates on sleep detection sensors and fixed driving hours for trucks were also introduced to enhance road safety.
- **Major Expressways & Digital Initiatives:** The ₹1 lakh crore, 29.6 km, eight-lane **Dwarka Expressway** was inaugurated in March 2024. NHAI launched the **'Rajmargyatra'** app in FY2023 for highway information and complaint filing. **'One Vehicle, One FASTag'** was introduced to streamline toll collection.
- **Wayside Amenities & OFC Infrastructure:** NHAI plans to develop 900 **Wayside Amenities (WSAs)**, with 322 sanctioned and 50 operational. In FY2024, 162 WSAs were approved. Additionally, NHAI is enhancing **10,000 km of Optic Fibre Cables (OFC)** by FY2025.
- **Multimodal Logistics Parks (MMLPs):** A ₹46,000 crore investment is planned for 35 MMLPs, expected to handle 700 MMT of cargo.
- **State Highway Development Programs:**
    - **Maharashtra:** The **MSRIP Phase 1**, funded by the Asian Development Bank, aims to improve state highways, enhance remote area connectivity, and reduce interstate disparities.
    - **Madhya Pradesh:** A **World Bank-funded project** focuses on improving rural connectivity, road safety, and climate resilience while supporting industrial corridors.

These initiatives reflect a comprehensive approach to strengthening India's highway infrastructure and logistics ecosystem.

The government has actively integrated new technologies and initiatives while setting ambitious infrastructure targets. Increased budget allocations and private sector collaboration have driven investments. As of February 2024, 567 out of 1,825 projects are PPP road projects. The 100% FDI policy has further attracted global partnerships, boosting sector growth.

8. Tunnelling

8.1 Overview

In the past few years, growth of infrastructure coupled with rapid urbanization has increased the tunnel requirements. The demand for tunnel construction has been crucial for the development of better urban mass transit systems, road and rail infrastructure, hydropower projects and water and sewerage systems. Methods such as New Austrian Tunnelling Method (NATM), tunnel boring method (TBM) are being adopted by the sectors for efficient tunnel construction.

8.2 Sector-wise tunnel projects: completed, under construction and upcoming

Tunnel construction projects across various sectors are given below:

Railways:

In the past few years, more than 650 railway tunnels have been constructed comprising a length of over 250 km. As in May 2024, railway sector has more than 370 tunnels with a length of ~330 km either under implementation, under bidding or under planning stage.

Few under construction key projects are:

- Mumbai-Ahmedabad High Speed Rail Corridor Project which has 8 tunnels of a length of 26 km
- Jiribam-Tupul-Imphal Railway Line Project which includes 50 tunnels of a length of more than 70 km
- Rishikesh-Karanprayag New Rail Project, which includes 17 tunnels of a length of 105 km

Udhampur-Srinagar-Baramulla Rail Link project which includes 38 tunnels of a length of 272 km
Key achievements:

- Rapuru Railway Tunnel in Andhra Pradesh with a length of 6.65 km is the first and longest electrified railway tunnel in India.
- India's longest rail tunnel was inaugurated in Jammu, which has a length of 12.77 km, and falls under Udhampur-Srinagar-Baramulla Rail Link.

Upcoming projects:

- National High Speed Rail Corporation Limited in partnership with Afcons Infrastructure Limited is set to construct India's first undersea rail tunnel of a length of 7 km. It will be a part of Mumbai-Ahmedabad bullet train project which comprises of 21 km long tunnel network.
- Dimapur – Kohima new railway line project- would include 21 tunnels of length 31 Km. It would facilitate transportation and help in local development.
- The Sivok – Rangpo new rail link project connecting Sivok (West Bengal) and Rangpo (Sikkim) is about 45 kms long and includes 14 tunnels, 13 major bridges, 9 minor bridges and 5 stations. The length of the longest tunnel (T-10) is 5.3 km.

Roads:

Table 15: List of road tunnel projects across the country

Year	Tunnel Name	Location	Length	Status
2023	Mumbai Coastal Road Tunnel	Mumbai	2.07 Kms	Completed
2023	Z-Morh tunnel	Jammu and Kashmir	6.5 Kms	Completed
2023	Nechiphu Tunnel	Arunachal Pradesh	500 m	Completed
2023	Marog Tunnel	Jammu and Kashmir	645 m	Completed
2023	Zojila Tunnel	Jammu and Kashmir	14.15 Kms	Ongoing
2024	Sela Tunnel	Arunachal Pradesh	980 m	Ongoing
2024	Shinkula Tunnel	Ladakh	4.1 Kms	Ongoing
2024	Goregaon – Mulund Link Road Tunnel	Maharashtra	6.3 Kms	Ongoing
2024	Thane Borivali Twin Tunnel	Maharashtra	11.8 Kms	Ongoing

Source: IMARC Group, ICRA Analytics

As of May 2024, India's road segment has over 210 tunnels spanning ~460 km at various stages of implementation. Of these, 100 tunnels (150 km) are under construction, 90 tunnels (250 km) are in the planning stage, and 20 are under bidding. With rapid urbanization, road tunnels enhance connectivity, reduce travel time, and optimize land use for commercial and residential developments. Notable projects include the **Sela Pass Tunnel** (inaugurated in March 2024) for all-weather access to Tawang, the **Atal Tunnel** (8.82 km) in Himachal Pradesh—the world's longest highway tunnel, and the **Zojila Tunnel** (14.2 km) in Ladakh—Asia's longest all-weather tunnel.

Upcoming projects:

- Assam's Tunnel project under Brahmaputra River by National Highways and Infrastructure Development Corporation (NHIDC) is under bidding stage. The total length of the project would be a length of ~34.6 km connecting Gohpur village on NH-52 and Numaligarh village on NH-715.
- Construction of twin tube unidirectional tunnel with a total length of 10.8 km connecting Sheshanag to Panchtarni under Ganesh top hill is under bidding stage.

Metro:

Increase in urbanisation has also increased the metro services across the country, leading to an expansion in metro tunnels. As in May 2024, more than 70 metro tunnels with a length of ~220 km are under different stages of construction. 40 tunnels are under construction with a length of more than 120 km while 20 are under planning stage which consist of a length of 80 km, and the remaining are under bidding stage.

Upcoming projects:

- Paroul (New Chandigarh) to Sector 28 (Panchkula)- covering 26 stations of a length of 32.2km, Sukhna Lake (Chandigarh) to Zirakpur ISBT (via Mohali ISBT and Chandigarh Airport) covering 29 station of a length of 36.4 km.
- Guwahati Metro Phase 1 Routes proposed- MG Road to Khanapara covering a length of 10 km.
- Thane Metro Route with an underground tunnel of 2-3 kms. It is popularly known as Thane Integral Ring Metro and was approved by India's Central Government in August 2024. It is expected to be completed by FY2029.

Hydro:

It is the largest segment under tunnelling industry. As in May 2024, hydro segment has more than 800 tunnels consisting of a length of 900 km under different stages of construction. Of this, 600 tunnels (more than 500 km length) are under planning stage, 100 tunnels (more than 200 km length) are under construction and the balance are under bidding stage.

Upcoming projects:

- Stage I of the Luhri Hydro Electric Project consisting of 2 tunnels of a length of ~38.6 km, developed on the Satluj river, in the Shimla and Kullu districts of Himachal Pradesh. It is expected to be commissioned in April 2026.
- Stage II of the Parbati Hydro Electric Project consisting of 6 tunnels of length of ~35km, planned on Parbati river in Himachal Pradesh, India. It is expected to be commissioned in December 2024.

Irrigation, water supply and sewerage:

As in May 2024, water supply and sewerage has more than 40 tunnels with a length of ~300 km under different stages of completion. Of this, 20 tunnels are under construction, 9 tunnels are planning stage and remaining are under bidding stage. In the irrigation sector, there has been a rise in tunnel construction. The sector has more than 60 tunnels with a length of 560 km, of which 20 tunnels of a length of 140 km are under construction while over 30 tunnels with a length of more than 400 km are under planning stage and remaining are under bidding stage.

Upcoming projects:

- Sleemanabad Carrier Canal Tunnel Project located at Madhya Pradesh is one of the key under construction projects as it has a length of 12 km long tunnel and is projected to be completed by December 2024.
- Kaleshwaram irrigation project of a length of 56 km is one of the key ongoing projects in irrigation sector.

1. Irrigation tunnelling:

Tunnelling assumes a vital part in India's irrigation infrastructure, particularly in areas with challenging terrains like mountains or regions with restricted surface water accessibility. Tunnels are built to divert water from rivers, reservoirs, or other sources to agricultural fields, making it possible to water crops even in remote or dry areas. Advanced concrete lining and reinforcement methods are utilized in irrigation tunnels to ensure their structural integrity and long-life span. This helps prevent leaks and collapse, ensuring a consistent flow of water.

Key Projects:

- Narmada Valley Project: This project incorporates several tunnels that channel water from the Narmada River to dry spell inclined regions in Gujarat, Madhya Pradesh, and Maharashtra. The tunnels make sure that water gets to areas that are hard to irrigate using traditional methods.
- Tehri Dam and Irrigation Tunnel: Located in Uttarakhand, the Tehri Dam is one of India's largest hydroelectric projects. It also includes tunnels that divert water for irrigation purposes, helping to irrigate large areas of land in the surrounding states.

2. Water supply Tunnelling:

Water supply tunnelling is essential for transporting water to metropolitan and rural regions, especially in areas where surface pipelines are not feasible because of geological hindrances or where there is a need to safeguard land surface for different purposes. Tunnelling permits safe and secure transportation of water over long distances, often from reservoirs or treatment plants to distribution networks.

Key Projects:

- Mumbai Water Supply Project: Mumbai, one of India's largest cities, relies heavily on tunnelling for its water supply. Several tunnels, including the Vaitarna and Bhatsa tunnels, bring water from distant reservoirs to the city, ensuring a consistent water supply for millions of residents.
- Bangalore Water Supply: Bangalore's Cauvery Water Supply Scheme includes tunnels that transport water from the Cauvery River to the city. These tunnels help address the city's growing water demand due to rapid urbanization.

3. Sewerage Tunnelling:

With the rapid development of India's urban areas, sewage management remains critical. Tunnelling provides a solution by assisting the development of large-diameter sewer lines that can transport wastewater to treatment plants. This is especially important in urban areas where there is limited surface area and a high risk of contamination.

Key Projects:

- Delhi Sewer Tunnelling: The Delhi Jal Board has implemented several sewage tunnelling projects to upgrade the city's aging sewer network. These tunnels help divert sewage away from residential areas and transport it to modern treatment plants.
- Mumbai Sewerage Disposal Project: Mumbai's vast sewerage system includes deep tunnels that collect and transport wastewater to treatment facilities. This project is part of the city's efforts to modernize its sewage infrastructure and reduce the pollution of local water bodies.

8.3 Technological Trends

The tunneling sector in India has a robust pipeline of projects across hydro, irrigation, road, and railway sectors. Various techniques are used based on project requirements, including conventional methods like Drill-and-Blast Method (DBM), Tunnel Boring Machines (TBM), New Austrian Tunneling Method (NATM), and micro-tunneling, alongside modern techniques such as sequential excavation and ground freezing.

Tunneling Techniques & Applications

- **DBM:** Preferred for its adaptability, particularly in the Himalayan region, where TBM setup is challenging. It is widely used in the hydro sector (470 km of tunnels) and irrigation (22 km). Innovations like blast fragmentation modelling, remote monitoring, and vibration assessments enhance accuracy and cost-efficiency. However, worker safety risks and complex geological conditions lead to delays and cost overruns.
- **TBM:** Suitable for urban settings due to minimal ground disturbance and lower lining costs. Used primarily in metro and water supply projects, notable examples include Mumbai's Coastal Road (12.2m TBM) and the Mumbai-Ahmedabad bullet train (India's first underwater rail tunnel, 13.1m TBM). Challenges include geotechnical uncertainties, skilled labour shortages, and logistical hurdles in mobilization.

- **NATM:** Effective in uncertain geological conditions, using deformation monitoring to optimize support systems. Applied in hydro projects, metro rail, and approach roads.
- **Micro-tunneling:** A trenchless method used for pipelines beneath roads and waterways, first deployed in Mumbai's sewage project and later in Delhi and Kolkata. It faces challenges due to soil-dependent performance and structural limitations.

Modern Innovations in Tunneling

Advanced materials such as fiber bolts, self-drilling rock bolts, and steel/fiber-reinforced anchors enhance tunnel strength. Technologies like ground freezing, integrated control systems, wireless communication, and advanced geological investigations improve efficiency.

Outlook

DBM is expected to remain dominant due to its flexibility and resilience in challenging conditions, despite the rise of advanced tunneling technologies.

8.4 Challenges faced by the industry

The tunnelling industry in India faces several significant challenges that impact the efficiency, safety, and success of tunnelling projects. Here are few key challenges:

1. **Geological and environmental challenges**

India's varied geology acts as significant challenge during tunnelling. The unpredictable nature of the geological strata can lead to difficulties in excavation, increased wear and tear on equipment, and unexpected delays. Also, water resources and natural habitats can be negatively impacted by tunnelling projects, especially in environmentally sensitive areas.

2. **Technological and equipment limitations**

Modern technologies like TBM are still inaccessible with limited application in specific areas because of significant expenses and a lack of technical expertise. Equipment can frequently fail due to the harsh conditions of tunnelling. Ensuring the timely maintenance and accessibility of spare parts, particularly in remote or difficult-to-access regions, represents a challenge that can cause project delays.

3. **Financial constraints and project management**

Tunnelling projects are capital-intensive and frequently subject to cost overruns because of unexpected land conditions, delays in project approvals, and escalating material expenses. Delays in land procurement, acquiring environment clearances, and other regulatory approvals can slow down tunnelling projects.

4. **Safety and skilled labour shortages**

Risks inherent in tunnelling include flooding, collapses, and exposure to hazardous gases. In any case, maintaining high safety standards is challenging, especially in projects where cost-cutting measures may compromise worker safety. Also, due to a lack of such skilled labour in India, project execution may be suboptimal, and accidents may occur more frequently. The industry faces significant challenges in terms of training and retaining skilled workers.

Addressing these challenges is crucial for the successful execution of tunnelling projects in India. It requires a combination of advanced technology, efficient project management, skilled labour, and a strong commitment to safety and environmental sustainability.

8.5 Outlook

Despite various challenges, the tunnel industry has the potential to transform itself into a promising sector. It is expected to experience significant growth in the coming years, driven by increased investment in infrastructure development across various sectors.

Few key growth drivers are given below:

- Gati Shakti Master Plan, Jawaharlal Nehru National Urban Renewal Mission, Pradhan Mantri Krishi Sinchayee Yojana, Interlinking of Rivers program and other schemes of the government play an important role in providing an incentive to the tunnelling sector.

- Public Partnership model promotes private investments in infrastructure thereby drawing the interest of many foreign and private players in tunnel construction projects.
- Rapid urbanisation with the requirement of better road and rail connectivity are increasing the scope of tunnel projects while several tunnel construction opportunities are upcoming in hydropower segment, roads and railway projects.

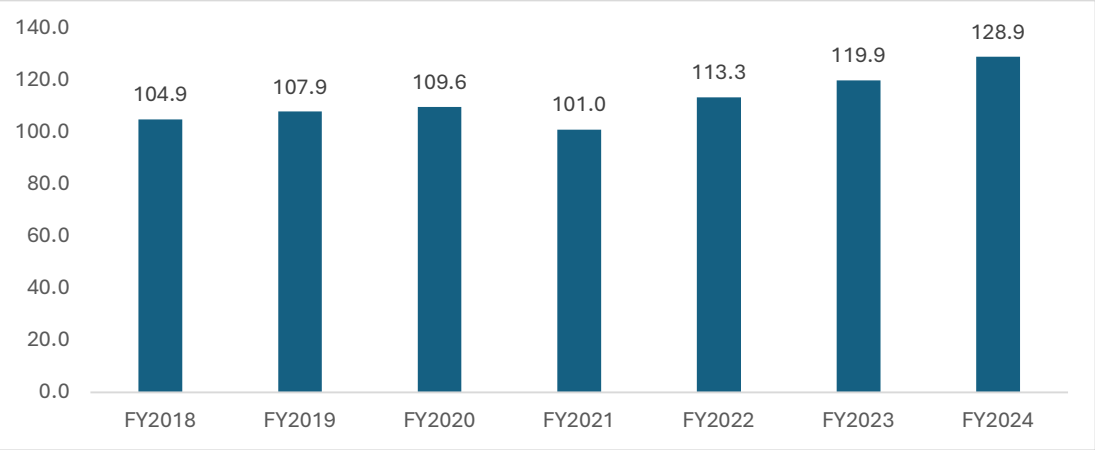
9.Mining sector in India

9.1 Overview

India holds an advantageous position with respect to the minerals and mining sector. Its strategic location also allows it to explore export opportunities. As of FY2024, India boasted of 1,426 reporting mines of which 564 were reporting mines of metallic minerals and remaining mines of non-metallic nature stood at 862. Since minerals are a fundamental raw material for most industries, the growth and development of this sector is extremely essential. India has abundant mineral resources, which serves to advance the nation's mining sector.

The total value of mineral production (excluding atomic and fuel minerals) during FY2024 was recorded at Rs. 1, 92,734 crore, which was a ~2.0% increase from the previous year. The value of metallic minerals was recorded at Rs. 1,10,785 crore which is ~57.5% of the total value. Non-metallic minerals (including minor minerals) value stood at Rs. 81,949 crore or 42.5% of the total.

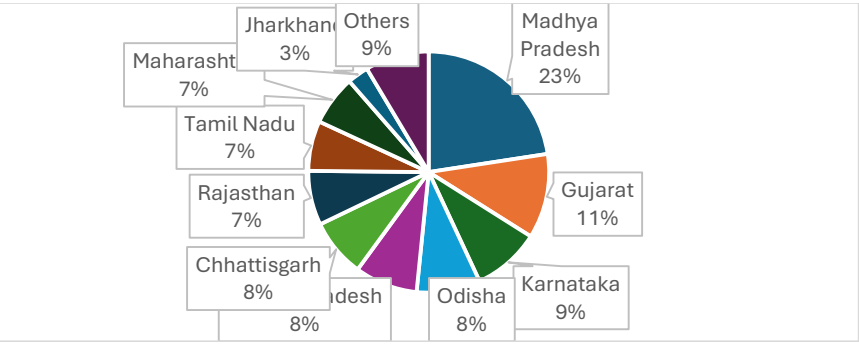
Chart 14: Index of Mineral Production



Source: Ministry of Mines; ICRA Analytics
Base 2011-12=100

The 1,426 reporting mines in India are distributed across the country, Madhya Pradesh having the highest number of mines at 322, followed by Gujrat (162) and Karnataka (130). A brief table is provided with the number of mines spread across different states:

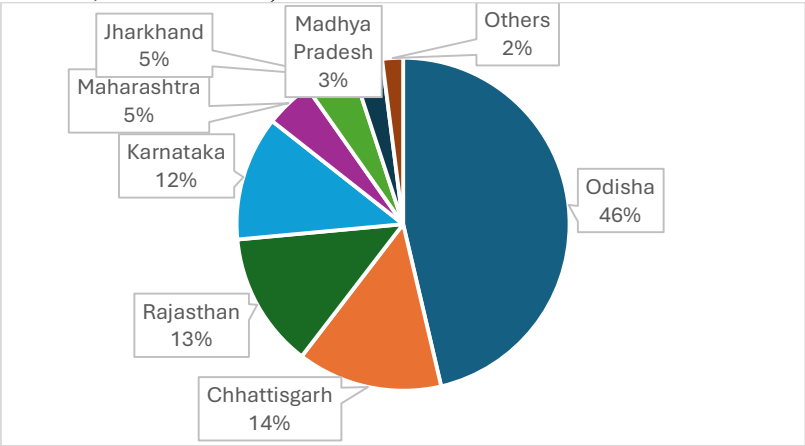
Chart 15: State-wise distribution of mines in India:



Source: Ministry of Mines; ICRA Analytics

In FY2024, the bulk of estimated mineral productions (amounting to ~97.5% of the total) came from only 8 out of the 19 states. The figure below provides detailed analysis of the same.

Chart 16: Share of States in Value of Estimated Mineral Production FY2024 (excluding atomic, fuel minerals, minor minerals)



Source: Ministry of Mines; Statutory returns submitted to IBM; ICRA Analytics

9.2 Global contribution and rank of India

As per World Mineral Production, 2017- 21, published by British Geological Survey, India ranks 2nd in steel (crude/liquid) and aluminium (primary) globally in term of quantity, followed by 3rd in chromite ores & concentrate and zinc (slab). India's ranks 4th in iron ore, 5th in bauxite, 7th in manganese ore, 11th in copper (refined), 12th in lead (refined), 17th in magnesite and 19th in apatite & rock phosphate. Further details are provided in the table below:

Table 16: Contribution and Rank of India in World Production of Principal Minerals & Metals (2021):

Sector	Unit	Production quantity globally	Production quantity of India#	Contribution (%)	India's rank in world order (US$)
Metallic Minerals					
Bauxite	'000 tonnes	342600	22495	6.6	5th
Chromite	'000 tonnes	35100	3785	10.8	3rd
Iron ore	million tonnes	3108	254	8.2	4th
Manganese ore	'000 tonnes	56200	2347	4.2	7th
Industrial Minerals*					
Magnesite	'000 tonnes	34300	113	0.3	17th
Apatite & Rock phosphate	'000 tonnes	222000	1395	0.6	19th
Metals					
Aluminium (primary)	'000 tonnes	67000	4016	6.0	2nd
Copper (refined)	'000 tonnes	24800**	484	2.0	11th
Steel (crude/liquid)	million tonnes	1915	120	5.6	2nd
Lead (refined) (estimated)	'000 tonnes	14400***	191	1.3	12th
Zinc (slab)	'000 tonnes	14000	775	5.5	3rd

Source: Ministry of Mines; ICRA Analytics

Notes: *Minerals declared as minor minerals not included; **Figures relate to both primary and secondary refined copper; ***Figures relate to both primary and secondary refined lead; # figures relate to FY2022

9.3 Self-reliance in minerals and mineral based products

Minerals are essentially the primary mineral raw materials that are supplied to industries like iron and steel, cement, and so on. India has largely been self-sufficient in major minerals such as bauxite, chromite, iron ore, kyanite, limestone, sillimanite, etc. Despite significant production, a few metals/minerals are also imported to fulfil the demand either for mixing with locally accessible mineral raw materials or to meet special requirement for manufacturing of exceptional qualities of mineral based items. Magnesite, manganese ore, rock phosphate, and other items are imported to meet domestic demand as they are deficient in India. India imports raw uncut stones for their value-added re-exports in order to meet the domestic Cutting and Polishing Industry's rising demand for uncut diamonds, emeralds, and other precious and semi-precious stones.

Table 17: Degree of Self-sufficiency in Principal Minerals & Metals for FY2021(P):

Sl. No.	Commodity	Demand/Domestic Consumption ('000 tonnes)	Supply/Domestic supply ('000 tonnes)	Order of self-sufficiency (%)
Minerals*				
1	Bauxite	25124	22495	90
2	Chromite	4028	3785	94
3	Iron ore	234000	254000	100
4	Kyanite	9	10	100
5	Limestone	408182	392760[(a)]	96
6	Magnesite	618	113	18
7	Manganese ore	8734	2347	27
8	Rock phosphate (including apatite)	11053	1395	13
9	Sillimanite	3	5	100
Metals				
10	Aluminium (primary)	2896	4016	100
11	Copper (Cathode)	868[(b)]	484	56
12	Lead (primary)	186[(c)]	191	100
13	Zinc	640[(d)]	775	100

Source: Ministry of Mines; ICRA Analytics
Note: *Minerals declared as minor minerals not included; P: Provisional
a. Excludes production of limestone as a minor mineral, calcite & chalk and includes lime shell, limekankar & marl.
b. Based on production of copper cathode and imports & exports of copper & alloys.
c. Based on production of lead (primary), and imports & exports of lead & alloys.
d. Based on production of zinc (ingots) and imports & exports of zinc & alloys

9.4 Production Trends

Metallic Minerals

The estimated value of metallic minerals is Rs. 1.1 lakh crore in FY2024. Amongst the principal metallic minerals, iron ore contributed Rs. 0.9 lakh crore or 80.9%, zinc concentrate contributed Rs. 8,216 crore or 7.4% and chromite contributed Rs. 3,735 crore or 3.4%.

- **Bauxite**: Estimated production in FY24 stood at 21.9 million tonnes, declining by 8.2% YoY. Odisha and Jharkhand are the key producing states.
- **Chromite**: Production in FY24 was 3.6 million tonnes, registering a 23.8% YoY decline. Odisha accounts for 100% of the country's production.
- **Copper Concentrate**: Estimated production in FY24 was 111.7 thousand tonnes, down 1% YoY. Rajasthan and Madhya Pradesh are the major producers.
- **Primary Gold**: FY24 production stood at 1,341 kg, reflecting a ~6.2% YoY decline. Karnataka contributed 99% of total output, with the remaining 1% from Jharkhand.
- **Iron Ore**: Estimated production in FY24 was 252.2 million tonnes, down 2.4% YoY. Key producing states include Odisha, Karnataka, and Chhattisgarh.
- **Lead & Zinc Concentrate**: Lead concentrate production in FY24 stood at 340 thousand tonnes (-9.6% YoY), while zinc concentrate was 1,529 thousand tonnes (-8.5% YoY). Rajasthan is the sole producer.
- **Manganese Ore**: FY24 production reached 3.1 million tonnes, marking an 8.3% YoY growth. Madhya Pradesh, Maharashtra, and Odisha are the leading producers.

Non-Metallic Minerals:

The estimated value of metallic minerals is Rs. 12,601 crore in FY2024. Limestone was the leading non-metallic mineral contributing 91.2% to the total estimated value in FY2024. It was followed by Phosphorite which contributed 7.7% to the total.

- In FY2024, limestone's estimated production stood at 407 million tonnes, which increased by 0.3% as compared to FY2023. Mention the key states producing limestone.

- In FY2024, magnesite's estimated production stood at 118 thousand tonnes, which increased by 10% as compared to FY2023. Magnesite is mainly produced in the states Tamil Nadu and Uttarakhand.

- In FY2024, phosphorite's estimated production stood at 1,375 thousand tonnes, which decreased by 30.5% as compared to FY2023. Phosphorite was mainly produced in the state Rajasthan (90%) followed by Madhya Pradesh (10%).

Table 18: List of successful auctions since 2015, as on 31.03.2024:

States	FY2016	FY2017	FY2018	FY2019	FY2020	FY2021	FY2022	FY2023	FY2024	Total
Andhra Pradesh	-	1	2	2	-	-	4	11	3	23
Chhattisgarh	3	-	2	-	-	2	2	20	6	35
Gujarat	-	-	3	-	-	4	3	2	6	18
Jharkhand	2	1	1	3	-	-	-	-	3	10
Karnataka	-	7	-	7	4	1	8	11	6	44
Madhya Pradesh	-	1	-	5	2	5	4	29	22	68
Maharashtra	-	-	2	1	10	-	9	6	10	38
Odisha	1	2	2	-	25*	1	9*	10	-	48
Rajasthan	-	3	2	1	2	-	7	8	31	54
Tamil Nadu	-	-	-	-	-	-	-	-	-	-
Telangana	-	-	-	-	-	-	-	-	-	-
Uttar Pradesh	-	-	-	-	-	-	-	4	3	7
Goa	-	-	-	-	-	-	-	4	5	9
Total	**6**	**15**	**14**	**19**	**43***	**13**	**46***	**105**	**95**	**354**

Source: Ministry of Mines, ICRA Analytics
*Note: 2 Iron Ore Blocks auctioned in FY2020 in Odisha were forfeited. The same have been re-auctioned in September 2021. Therefore, in total 356 mineral blocks were auctioned but in actual, the net figure is 354.

Table 19: Mineral-wise Auction Summary as on 31.03.2024

Minerals	FY2016	FY2017	FY2018	FY2019	FY2020	FY2021	FY2022	FY2023	FY2024	Total
Limestone	4	5	10	5	4	9	18	20	35	110
Iron Ore	1	7	2	9	17	1	13*	33	24	106
Iron Ore & Manganese	0	0	0	0	6	0	1*	2	1	9
Gold	1	1	1	1	0	2	2	5	4	17
Manganese	0	1	0	1	3	0	3	18	11	37
Diamond	0	1	0	0	1	0	-	-	-	2
Bauxite	0	0	1	0	5	1	5	14	8	34
Graphite	0	0	0	3	2	0	1	5	1	12
Chromite	0	0	0	0	3	0	-	-	-	3
Copper	0	0	0	0	2	0	-	-	2	4
Kyanite	0	0	0	0	0	0	1	-	-	1
Rock Phosphate	0	0	0	0	0	0	1	3	-	4
Copper & Gold	0	0	0	0	0	0	1	-	-	1
Phosphorite	0	0	0	0	0	0	0	3	2	5
Ni, Cr and associated P GE	0	0	0	0	0	0	0	2	-	2
Glauconite (Potash)	0	0	0	0	0	0	0	0	2	2
Base metal	0	0	0	0	0	0	0	0	5	5
Total	**6**	**15**	**14**	**19**	**43**	**13**	**46***	**105**	**95**	**354**

Source: Ministry of Mines, ICRA Analytics
*Note: 2 Iron Ore Block auctioned in FY2020 in Odisha was forfeited. The same were re-auctioned in September 2021. Therefore, in total 356 mineral blocks were auctioned but in actual, the net figure is 354

9.5 Overview of mining regulations and compliance framework in India

1. **The Ministry of Mines** is the apex body operated by GoI. It is responsible for setting regulations governing the mining sector, formulating of policies, functioning and overall administration of mines and minerals in the country. It comprises of the following departments:

- The Geological Survey of India (GSI)
- The Indian Bureau of Mines
- The Controller of Mining Leases
- The Directorate General of Mines Safety

2. **Mines and Minerals (Development & Regulation) Act (MMDR)**:

- The MMDR Act, 1957, regulated India's mining sector, requiring leases for mining operations. The allocation followed a discretionary "first come, first serve" approach, lacking transparency. Lease renewal issues hindered large-scale investment.
- The MMDR Amendment Act, 2015, introduced auction-based allocation to eliminate discretion and enhance transparency.
- The Minerals Laws (Amendment) Act, 2020, ensured seamless transfer of valid clearances for two years post-auction, allowing states to auction blocks before lease expiry to sustain mineral production.
- The MMDR Amendment Act, 2021, aimed to expand mineral production, streamline mine operations, attract investment, and accelerate exploration and auctions.
- The MMDR Amendment Act, 2023, introduced an exploration license for deep-seated and critical minerals, encouraging private sector participation. It also delisted six atomic minerals to boost exploration, crucial for India's net-zero commitments.
- The MMDR Act empowers the Central Government to regulate environmental protection, ensuring sustainable mineral development.

3. **Offshore Areas Minerals (Development & Regulation) Act, 2002 (OAMDR Act):** It is administered by the Ministry of Mines. It is responsible for the regulation of the mines and development of mineral resources in the territorial waters, continental shelf, exclusive economic zone and other maritime zones of India. The Act specifies provisions that ensure a deterrent punishment and fine in case there is a breach of safety standards. It also ensures prevention and control of pollution, thereby protecting marine environment.

4. **Offshore Areas Mineral Concession Rules, 2006:** It lays down the process for obtaining renewal of the permits, license or lease. Section 35 of the act provides rules that prescribe the safety measures that need to be followed in leased offshore areas and also includes guidelines on protection of marine environment.

5. **Mines Act, 1952:** This act was introduced with the aim of consolidating the laws and regulations of labour and safety in mines. It is a welfare legislation that regulates the safety of labours while carrying out mining operations, regular inspection of mines and systematic management of mines. It also regulates the working conditions by laying out the basic provisions for health and safety of people employed in mines.

6. **Mine Rules, 1955:** The rules include the provision for engaging a medical officer for examination of the labours employed at mines. It ensures basic health and sanitation provisions and welfare amenities for the labours and their families. It also specifies the clearance requirements, approvals and permits necessary for exploring or mining an area such as Environment and Forest Clearance, Wildlife Clearance, Landowner's Consent and so on.

7. **Indian Bureau of Mines (IBM):** The Indian Bureau of Mines (IBM) was established in 1948, acting as a multi-disciplinary government organisation under the Ministry of Mines. IBM promotes conservation, scientific development of mineral resources and aims to protect the environment in mines other than coal, petroleum & natural gas, atomic minerals and minor minerals. The organisation aims for optimum utilisation of both on-shore and off-shore mineral resources of the country, while also maintaining a central database for exploration, prospecting, mines and minerals of the country in the form of National Mineral Information Repository.

8. **National Mineral Exploration Trust (NMET):** The NMET was formed by GoI in August 2015, with the objective to expedite mineral exploration in the country. NMET operates on a two-tier structure, where the apex body is the Governing Body, chaired by the Minister of Mines, holding the overall control of the Trust. The holder of mining lease or a prospecting licence-cum-mining lease transfer money (an amount equivalent to 2% of royalty paid) to the NMET Fund. The Trust's main objective is to support regional and detailed mineral exploration.

9. **The Forest (Conservation) Act, 1980:** The Forest Conservation Act 1980 was established with the objective of helping conserve India's forests. It severely restricts and regulates the de-reservation of forests or use of forest land for non-forest purposes without the prior approval of Central Government.

The Act also lays down the circumstances and pre-requisites for the de-reservation of forest land for non-forest purposes. Since mining has great environmental impact in and around its sites, the act helps minimize the potential negative impacts from this sector for the Indian ecosystem.

10. **Pradhan Mantri Khanij Kshetra Kalyan Yojana (PMKKKY):**
    a. It is an initiative taken by the Indian government that ensures welfare of the community affected by the mining related operations. It uses the funds generated by District Mineral Foundations (DMFs).
    b. It aims at implementing various developmental and welfare projects/programmes in the areas affected by mining.
    c. It also ensures minimisation of the adverse effects of mining with regards to the environment, health and socio-economic aspects.
    d. It guarantees long-term sustainable livelihoods for the affected people in mining areas.

11. **Mining Surveillance System (MSS):** The MSS has been developed by Ministry of Mines & Indian Bureau of Mines (IBM) with assistance from Bhaskaracharya Institute for Space Applications and Geo-informatics (BISAG), Gandhinagar and Ministry of Electronics and Information Technology (MeitY). It is a satellite-based monitoring aimed to check illegal mining activities around mining leases and establish responsive mineral administration through automatic remote sensing detection technology. The system follows the basic idea of mineral continuity around the leased mines and checks a region of 500 meters around the existing mining lease boundary in search of unusual activity which is likely to be illegal mining. These discrepancies are then flagged as a trigger and forwarded to respective State Governments for verification through field visit, thus helping to curb illegal mining activities.

    MSS being an innovative digital system, incorporates latest satellite images and superimposes digitized mining leases (boundary), there by combining advanced digital techniques to effectively combat illegal mining practices. Since this data is also available to the public at large, it builds a holistic, transparent and participatory system, which enables general citizens to report unusual mining activities too.

The Ministry of Mines developed a credible system of evaluation of mining footprints and instituted the Sustainable Development Framework (SDF) for taking up mining activity under its umbrella, encompassing inclusive growth, without adversely affecting the social, economic and environmental well-being, at present and also in future generation. Further, to implement the Sustainable Development Framework (SDF), Ministry has evolved a system of Star Rating of Mines. The Star Rating is being implemented as per the provisions of Rule 35 of Mineral Conservation and Development Rules'2017 through the Indian Bureau of Mines (IBM), a subordinate office of the Ministry of Mines.

10.Competitive landscaping

10.1 Brief Profile of LCC Projects and its peer companies

1. LCC Projects Limited

LCC (Laxmi Construction Company) was established as partnership firm in 2004 and was incorporated as LCC Projects Private Limited in 2017. Company focuses on irrigation and water management business. Headquartered at Ahmedabad, Gujarat, company has a presence with a wide network of offices situated in [11] states, as of September 30, 2024. Company is into construction of dams, barrages, weirs, hydraulic structures, canals, pipe distribution networks, lift irrigation works, water treatment and supply, and other infrastructure development projects.

The company is currently exploring new avenues,

1. Renewable Energy (Solar)
2. Sewerage Network & Treatment (STP)
3. Waste Water Treatment
4. Railways i.e. metro
5. River Linking
6. Desalination

Currently company has unexecuted Order Book of INR 7918.57 crores (as on Sep 30, 2024) which is 2.33 times of Projected FY25 turnover of INR 3400.00 Crores. The company is one of the fastest growing multidisciplinary large corporate EPC companies from Gujarat, in terms of growth in turnover as of FY2024, poised to undertake infrastructure projects across 11 states in India. The company is one of the leading multidisciplinary EPC companies in India, in terms of market share, in the irrigation and water supply projects segment, as of six months period ended September 30, 2024.

The company has its in-house design and engineering team specializing in developing solutions for projects with geographical and technical complexities. Government authorities provide project scopes and specifications, and the team prepares detailed structural and architectural designs for approval.

Below are few such projects

i. Canal and PDN Work, SSNNL, Gujarat
LCC Constructed Distributary Canals including its Minors (UGPL), Sub Minors (UGPL) off taking from subbranch canal including O & M for Five years. (Package-I-II-III-IV-V)(KBC).

ii. Canal Work, SSNNL, Gujarat
LCC Constructed Dudhai Sub-Branch canal reach from 11.430 to 23.025 km [Earth work, C.C. Lining, Structures, service Road Gate work, Control Cabins and its operation & Maintenance work for 5 years] (Package-DIR-II).

iii. Dam Construction, Sitanagar, WRD , MP
LCC was involved in construction work of composite gravity dam and pressurised Micro irrigation system of SitaNagar irrigation Project.

iv. Irrigation Work, SSNNL, Gujarat
LCC has constructed underground pipeline network of more than 20000 km and developed more than 2,00,000 CCA in state of Gujrat.

v. Metro Rail work, GMRC
Ahmedabad Metro Rail Project Phase-I The company was involved in construction of metro rail station and other ancillary work at Metro Station Paldi and Old high court station, and Metro Station at Shreyas Nagar & Rajiv Nagar in Ahmedabad, Gujarat.
Construction of paldi station includes RCC works, Arch. Works, PHE works Entry - Exit Structures, Viaduct (Portal & I - Girder)
Construction of 11.6 km viaduct and various stations under Surat metro rail project.

vi. Dam Construction, WRD, Narsinghgarh

LCC was involved in Construction Of Composite Gravity Dam On River Parbati, Madhya Pradesh Of Least Gross Capacity Of 172.54 Mcm.

vii. **Long Syphon Canal, SSNNL , Gujarat**
LCC Constructed long Canal Syphon between Ch. 215.272 Km to 217.217 Km. and C.R. At Ch. 215.235 Km. of Kachchh branch canal (Earth work, C.C. Lining, Structures, gates & Stop logs, services road control cabin and O & M work for 5 Year. It is one of the longest of its type.

viii. **Dam Construction**, **WRD, Sagar**
LCC Constructed composite gravity dam on River Bina of Gross Capacity of 270.10 MCM for sagar district of Madhya Pradesh (Madia Dam).

ix. **Irrigation Work, SSNNL , Gujarat**
LCC was involved in Supplying, Installing & testing of UGPL system of sub minor for Irrigation through kundiesin Chakarea for SSP Command of various Sub Minors under jurisdiction of Executive Engineer, N P Canal Dn. No. 4A, Dabhoi with five years maintenance (Package-10)

x. **Irrigation, VIRDC, Maharashtra**
LCC was involved in construction of Pipe Line Distribution Network for command area of 7109 Ha. including detailed designing with construction as per approved design, formation of WUA (Water user association), handing over the command area to WUA, maintaining the whole system for a period of 60 months after completion, out of which first 3 years irrigation with WUA and next 2 years handing over the area to WUA and irrigation with them for GURUKUNJ LIS Tq. Tiwasa Dist. Amravati.

xi. **Canal Work, WRD, Madhya Pradesh,**
LCC was involved in construction of cement concrete lining of Tawa Left Bank Main Canal from R.D. 45780M. to 90240M. Of Tawa Project, Hosangabad.

xii. **Irrigation, WRD, Odisha,**
LCC was involved in extension of Harabhangi Irrigation Project 3763Ha GCA (2800Ha CCA) in Seragada & Aska Block of Ganjam District (Extension through U.G.P.L. (Gravity flow) under Nabakrushan Choudhury Secha Unnayan Yojana, ERM)

xiii. **Water Supply Work, GWSSB, Gujarat**
LCC was involved in design and construction of WTP @ LakhondHW, RCC U/G Sump, Pump House at various places & Civil Works & Providing, Supplying, Lowering, Laying & Jointing Pipeline & Supply, Installation, Testing & Commissioning of Pumping Machinery with Operation & Maintenance of All type Machineries for 5 Yrs. under Banni Regional Water Supply Scheme Taluka –Bhuj of District Kachchh

Currently Companies Order Book comprises over [40] projects of which

- **a.** Sidhi Bansagar Multi-Village Scheme (₹ 13,864.90 million)
- **b.** Sondwa Lift Micro Irrigation Project (₹ 13,954.11 million)
- **c.** Gandhi Sagar 1 Multi-Village Scheme (₹ 10,490.00 million)

are our top 3 projects (based on project value)

Further, certain of our notable executed projects include the construction of Tawa Left Bank Canal, Parbati Dam Project, Dudhai Sub Branch Canal Project and AKOT Lift Irrigation Scheme which have been covered above.

Company Business

LCC has its presence in below mentioned sectors

i. **Irrigation and Water management business**

The company over a period have developed relationship with clients I.e. Irrigation department, of various States Government owing to the trust that the company have been able to build over the years on account of successful execution of the projects. The company executes various irrigation and water management projects which includes is construction of dams, barrages, weirs, hydraulic structures, canals, pipe distribution networks, lift irrigation works, water treatment and supply. Significant part of company present revenue is derived from irrigation and water management business.

ii. Waste water management

The company foresees this as one of the big opportunity since water stress has become a recurring worry in India as a result of the rapid and uncontrolled growth in water demand for household, agricultural, and industrial requirements. More than half of the country's population is expected to be urban by 2050. This would challenge water management given the exponential increase. Furthermore, insufficient and restricted wastewater treatment facilities endanger water quality and public health.

iii. Renewable Energy

Given the continued government focus to tap the renewal energy potential, there is focus of the government to tap the solar energy potential of the country. The company has developed significant EPC capabilities over a period of time to execute these projects and is well poised to tap on to the potential of Solar Energy business particularly on (EPC) Execution, Procurement and Commissioning as one of the segment of renewable energy. Presently the company continues to bid for the solar EPC contracts and shall continue to explore such projects in future.

iv. Metro Rail

Metro Rail network in all the urban cities are one of the focus areas of the Government to decongest and ease the urban metro and non-metro city traffic. The government of India through various Metro Rail Corporation is working simultaneously across Indian City to develop metro train network. The company at present is looking forward to tap on to this opportunity. The company has successfully executed few projects for Gujarat Metro Rail Corporation Ltd pertaining to construction of metro stations and would continue to focus on more opportunity in future through various Metro Rail Corporation across various urban cities.

v. Coal Mining

The company at present is handling coal extraction and mining project at Bishrampur Coal Mining site (Under South Eastern Cola Fields) and Public Sector Undertaking in the state of Chhattisgarh. The work involves removal of overburden (top soil and layers of rocks) and extraction of coal and piling of coal a designated collection area. The company is executing this project under long term contract of 7 years.

Technological Capabilities

LCC has projects such as lift irrigation, water supply, underground pipeline network for Irrigation, Micro Irrigation, Canal Network, Dam & Barrage Construction etc.

Company uses technologies like IOT, SCADA, Water Gems, Water Hammer, KY Pipe, E-Survey (used on Hydraulic and Surge Design), Staad-pro (used in structural design) and AutoCAD for design planning and for design data base, Geographic Information System for mapping and analysing topographic data, soil testing equipment for soil investigation and GPS technology for precise location data. Company is using all these advanced resources for preparation of economical and feasible design solution for execution considering budget and financial profit of company.

Company has Electro-Mechanical, Electrical team which work in the field of water sector like Large Pumping station for lifting of water, Automation SCADA system for remotely operation of system, water treatment technology including filtration, chlorination and purification methods, monitoring and control systems for water treatment plants.

Company is involved in project execution like Excavation, Backfilling, Pipeline laying, Pipeline welding – jointing, and Construction of Structures like Intake well Pump House, Elevated Storage Reservoirs, Sumps with using reliable and advanced technologies.

2. Enviro Infra Engineers Ltd.

Enviro Infra Engineers Ltd, was incorporated in 2009. Company is engaged in the design, construction, operation, and maintenance of water and Waste-Water Treatment Plants (WWTPs), development of Sewage Treatment Plants (STP), and Common Effluent Treatment Plants (ETP) and water supply projects (WSSPs) for government agencies/entities.

Company Business

EIEL operations are broadly divided into the following categories:

i. Sewerage treatment Plants
ii. Common Effluent Treatment Plant
iii. Water Treatment Plant
iv. Sewerage Schemes- Designed to collect, transport, and treat wastewater and sewage to protect public health and the environment
v. Water Supply Schemes- Methods and infrastructure needed to deliver safe and reliable drinking water to communities.
vi. Operations and Maintenance (O&M) for ensuring facilities and equipment function efficiently and effectively over their operational lifespan.

3. Vishnu Prakash R Punglia Ltd.

Vishnu Prakash R Punglia Ltd, was incorporated in 1986. Company is an integrated infrastructure development company having vast experience in executing major infrastructure projects for Central and State Governments, Local Bodies, Public Sector Companies, World Bank Projects, and Private Bodies across more than 12 States & Union territories in India. Company's principal business operations are Infrastructure Development Works on EPC mode including their operation and maintenance activities.

Company Business

VPRPL operations are broadly divided into the following categories:

vii. Water Sector which includes works like Water dams, Water Tanks, Reservoirs, Water Treatment Plants, Water supply schemes, Overhead tanks, Pipelines, Irrigation Channels etc.,
viii. Sewerage Sector which includes activities like Sewerage treatment Plants, Sewer Tank drain,
ix. Railway Sector, which includes all Railway works like Railway Tracks, Railway Stations and allied buildings, Platforms and Bridges
x. Road Sector, which includes Development of roads and highways, bridges and Flyovers
xi. Tunnelling Works
xii. Buildings and Warehouses Works
xiii. Multi-dimensional Smart City Projects.
xiv. Automation work involving PLC and SCADA.

4. JWIL Infra Ltd

JWIL Infra Ltd, was incorporated in 2006. Company is a distinguished entity within the OP Jindal Group. It stands as a comprehensive water management enterprise. Specializing in turnkey solutions for projects encompassing drinking water, irrigation, wastewater, and industrial effluent treatment. JWIL has its business across diverse geographies, including India, Africa, and South Asia.

Company Business

JWIL Infra operations are broadly divided into the following categories:

i. Irrigation Projects
ii. Water Supply and Distribution Management
iii. Waste Water Solution
iv. Operations and Maintenance

10.2 Financial benchmarking of key peers in the sector- This section covers some of the operational and financial key performance indicators of LCC Projects and its competitors.

Particulars	LCC Projects				Enviro Infra Engineers Ltd				Vishnu Prakash R Punglia Ltd.				JWIL Infra			
Consolidated financials	**FY2022**	**FY2023**	**FY2024**	**H1FY25**	**FY2022**	**FY2023**	**FY2024**	**H1FY25**	**FY2022**	**FY2023**	**FY2024**	**H1FY25**	**FY2022**	**FY2023**	**FY2024**	**H1FY25**
Presence in segments	*Irrigation, water supply, metro rail and industrial projects, mining*				*Sewerage treatment, Common Effluent Treatment, Water Treatment Plant*				*Water supply, Sewerage Sector, Railway, Road Sector- highways and bridges, Tunnelling Works, Buildings and Ware Houses, Smart City Projects, Automation work involving PLC and SCADA*				*Drinking water, Irrigation, Wastewater and Industrial Effluent Treatment*			
Order book as on March 31st (in Rs Mn)	19,624.89	43,842.00	62,689.68	73,474.24	1,698.64	14,966.86	21,225.86	19,576.00	38,127.37	34,844.89	47,169.57	50,865.00	NA	37,000.00	40,000.00	Not available
Revenue from operations (Rs Mn)	7,808.96	12,252.67	24,389.12	14,681.13	2,235.25	3,381.02	7,289.15	4,181.94	7,856.13	11,684.04	14,738.65	5,914.00	7,933.92	9,448.23	21,687.98	
Growth in Revenue from Operations (%)	NA	56.91%	99.05%	NA	NA	51.26%	115.59%	NA	NA	48.73%	26.14%	NA	NA	19.09%	129.55%	
EBITDA (in Mn)	862.75	1,277.77	2,413.65	2,039.62	521.19	852.48	1,784.12	1,177.18	886.41	1,596.43	2,186.71	822.00	835.64	1,034.06	2,249.53	
EBITDA Margin	11.05%	10.43%	9.90%	13.89%	23.32%	25.21%	24.48%	28.15%	11.28%	13.66%	14.84%	13.90%	10.53%	10.94%	10.37%	
PAT (in Mn)	353.34	682.17	1,219.97	1,179.49	345.49	553.39	1,085.70	663.35	448.47	906.43	1,221.85	384.96	359.72	451.77	1,220.27	
PAT Margin (%)	4.52%	5.57%	5.00%	8.03%	15.46%	16.37%	14.89%	15.86%	5.71%	7.76%	8.29%	6.51%	4.53%	4.78%	5.63%	
Total Debt (in Mn)	1,175.36	2,892.77	4,216.94	6,616.58	181.12	645.44	2,335.95	3,760.90	1,765.77	2,503.74	3,955.17	5,623.32	1,859.04	1,730.78	3,426.42	
Total Debt to Equity	0.61	1.11	1.10	1.32	0.25	0.51	0.80	1.05	1.11	0.80	0.55	0.74	0.93	0.74	0.95	
Return on Equity	18.30%	26.11%	31.87%	23.59%	48.24%	43.74%	37.16%	18.50%	28.26%	28.82%	16.95%	5.07%	18.04%	19.33%	33.84%	
Return on Capital Employed	25.56%	21.92%	27.63%	16.45%	58.08%	44.62%	32.78%	15.45%	25.19%	27.03%	18.58%	6.01%	21.14%	24.84%	31.51%	
Net Worth (Rs Mn)	1,931.07	2,612.25	3,828.25	5,000.56	716.23	1,265.14	2,921.84	3,585.83	1,586.90	3,145.07	7,210.64	7,594.00	1,993.76	2,336.61	3,605.67	

Source: Company annual reports, ICRA Analytics

Formulae used:

1. Growth in Revenue from Operations is calculated as a percentage of Revenue from operations of the relevant period/year less Revenue from operations of the preceding period/year, divided by Revenue from operations of the preceding period/year
2. EBITDA is calculated as Profit/(loss) before tax for the period/year add finance cost, depreciation and amortisation expenses
3. EBITDA Margin is calculated as EBITDA divided by Revenue from operations
4. Profit after tax is Profit after tax reported in the Restated Consolidated Financial Information
5. PAT Margin is calculated as Profit after tax reported in the Restated Consolidated Financial Information divided by Revenue from Operations
6. Total Debt is calculated as sum of Long-Term borrowings and Short-Term borrowings.
7. Total Debt to equity is calculated as Total Debt divided by Total Equity (excluding non-controlling interest).
8. Return on Equity is calculated as Profit after tax after share of profit/(Loss) of Associate divided by Net Worth. Net worth has been defined means the aggregate value of the paid-up share capital and other equity less non-controlling interest.
9. Return on Capital Employed is calculated as EBIT divided by Capital employed. EBIT is calculated as Profit/(loss) before tax for the period/year as increased by finance cost. Capital employed is defined as total debt (Long Term borrowings + Short Term borrowings) plus Net Worth as on the last date of the reporting period.
10. Net worth is calculated as Total Equity less non-controlling interest.

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