TRANSPORT NETWORK OF INDIA

Transport or transportation is the movement of humans, animals and goods from one location to another. Transport is an essential component with which people not just connect with each other, but also progress. To fulfill the increase in demand for safe, reliable, environmental friendly, economical and efficient transport system, road infrastructure becomes crucial. Transport of passengers and goods is vital to satisfy the mobility needs, which is commensurate with today's lifestyle characterized by social interactions and reliable goods distribution nationwide. The transportation system of any country works as the backbone of the nation's economy.

ROAD TRANSPORT

Road transport is vital to the economic development and social integration of the country. Easy accessibility, flexibility of operations, door-to-door service and reliability have earned road transport an increasingly higher share of both passenger and freight traffic vis-à-vis other transport modes. Transport sector accounts for a share of 6.4 per cent in India's Gross Domestic Product (GDP).

The bulk of domestic freight and passenger traffic is carried by Indians roads. Spanning over 5.23 million kilometers, Indian roadways have been able to traverse into hitherto unreachable areas carrying 65 per cent of domestic freight and 87 per cent of passengers. Road mobility in India has risen from around 3400 billion passenger-km in 2004-05 to over 8000 billion passenger-km in 2012-13 and is touching to a figure of 11000 currently. The number of registered vehicles in India is constantly rising, ramping up the pressure on the fragile road infrastructure. At the end of 2013, the number of registered vehicles in India was 182 million. This figure is expected to grow three-fold by 2035. Consequently, road congestion, air and noise pollution, travel safety, lack of skilled manpower, poor or lack of infrastructure are some of the challenges which confront the roadways sector. The intervention of technology in the road transportation sector can help in easing the pressures on each of the problem areas listed above. In order to ease out congestion issues, Intelligent Transport Systems need to be invested in. Technologies for traffic management, freight information systems, electronic toll collections, vehicle to infrastructure communication, intelligent speed management, incident detection and GPS and navigation systems are increasingly available. Intermodal transportation mechanisms are in dire need to be smoothened. With emission norms being gradually standardized and implemented in vehicles, technology solutions for emission reduction span from engine downsizing to alternative combustion to alternative fuels. While in the short term, shifting from petroleum products to natural gas seems desirable, in the long run biofuels (preferably 3rd generation), synthetic fuels, fuel cell vehicles, use of solar powered vehicle would serve as sustainable alternatives. Shifting to electric and hybrid electric vehicles would also aid in fuel efficiency and emissions reduction. Besides all these, fuel efficiency would also benefit from innovation in vehicle design as well as through the use of advanced friction reduction light weight materials.

Points to remember:

i. Roads in India have been classified as National Highways (NH), State Highways (SH), Major District Roads, and Rural Roads
ii. The National Highways Authority of India (NHAI), which is an autonomous body under the Ministry of Transport, The National Highways Authority of India (NHAI) was operationalized in 1995. The NHAI is responsible for the development, maintenance, and

operation of National Highways. The National Highways constitute only 2.7per cent of the total road length, but carry about 40 per cent of the road traffic

iii. State Highways are constructed and maintained by the state governments.
iv. Border road and International highways maintained by Central Government
v. About 80 per cent of the total road length in India are categorized as rural roads
vi. NH 44 - 3,745 km (2,327 mi) from Srinagar to Kanyakumari. It is the longest national highway in India
vii. Golden Quadrilateral comprises the National Highways connecting the four metro cities, Delhi, Mumbai, Chennai and Kolkata. The component has a total length of 5846km

Important highways of India

National Highways name	Route	Distance
NH-44	Srinagar to Kanyakumari	3,745
NH-27	Porbandar in Gujarat to Silchar in Assam	3507
NH-48	New Delhi to Chennai	2807
NH-52	Sangrur in Punjab to Ankola in Karnataka	2317
NH-30	Sitarganj in Uttarakhand to Ibrahimpatnam in Andhra Pradesh	2040
NH-6	Meghalaya, Assam, Mizoram (Zorabat-Shillong- Badarpur-Kolasib- Aizawl- Badarpur,-Panchgram)	1873
NH-53	Hajira in Gujarat to Paradip Port in Odisha	1781
NH-16	Kolkata to Chennai	1711
NH-66	Panvel in Maharashtra to Kanyakumari	1622
NH-19	Delhi to Kolkata	1435
NH-1	URI- Baramulla-Kargil, Srinigar - Leh	534
NH-21	Jaipur-Agra-Bareilly	465

RAILWAYS

Railways in India was once the major mode of transportation catering to almost 55% of the mobility needs. The share has gone down substantially as the growth of road transport overtook the growth of railways. Railways have by far very low emissions and energy requirement compared to automobiles. In developed countries railways cater to almost 60% of freight transportation which eases out the stress on highways. Aptly considered the lifeline of India, railways remains the preferred mode of transport of the common man in India. Compared with road transport, it is inexpensive, fuel efficient and environment friendly. With a total route of almost 65,000 kms, India boasts of the second largest rail network in the world. However, railway is also technologically one of the least developed modes of transport in India. In the 66

years of independence, only 21.5 per cent of new route kms have been added and the maximum commercial speed has only increased from 80-100 km/h to 140 km/h (while average speed is much lower at 110 km/h). This starkly contrasts with the global picture where commercial speeds in excess of 300 km/h have been consistently maintained by trains in Germany, China, France, South Korea, Taiwan, Spain, Japan, Italy, Belgium and the UK. The technological gap between India and the developed world is also considerable in heavy and long freight operations, axle load capacity, Payload to Tare Weight ratio of wagons, braking systems, intelligent adhesive control systems, signaling and traffic management, and passenger comfort. The status of indigenous technologies in this sector is still relatively undeveloped. Hence, reliance on foreign technologies is imminent. Unlike some of the more sensitive areas like defence and space, railways technologies are available for sourcing from outside and technological partnerships with the best in the world are possible. However, high costs may be a prohibitive factor. A rational strategy would be to import technology initially followed by indigenous development for long term sustenance. One of the major problem areas in the sector is the non-availability of separate tracks for passengers and freight. Having dedicated tracks for each of these functions would increase the speed and efficiency of the railways immensely. Besides, short term, medium term and long term goals with regard to the issue areas mentioned above have been identified in the report to help strategize the technological leap that India railways so badly needs. Finally, fuel efficiency and emission control ought to go up in priority. Electric locomotives and other equipments must be designed to minimize energy waste and maximize regenerative capacity. Smart railway energy grids and piezo-electric power derived from floors of station area made of piezoelectric crystals need to be developed to better utilize energy. Moreover, alternative fuels such as hydrogen fuel cells and other renewable sources of energy must become the focus of research and development activities. The report also focuses on the futuristic train technologies which include high speed bullet trains, magnetic levitation (maglev) trains, evacuated tube transport (Hyper loop).

Points to remember:

i. Railways was introduced to India in 1853
ii. The first railway line in India between Mumbai to Thane was constructed during the rule of Lord Dalhousie
iii. The total length of Indian Railways network is 67368 km
iv. Konkan Railways line runs parallel to the Arabian Sea
v. Gorakhpur railway station has the world's longest railway platform
vi. Mumbai is the busiest suburban railway network in India
vii. Vivek Express (Dibrugarh to Kanyakumari) is the longest train route in the Indian Subcontinent
viii. Ahmedabad Mumbai Central Double Decker Express is the India’s first double Decker train
ix. First female loco pilot of the Indian Railways in India is Surekha Shankar Yadav
x. The Railway network is divided into 17 zones. The 17 zones are their respective headquarters are given below:

Zonal Railways	Headquaters
Central railway	Mumbai CST
Eastern railway	Kolkata
East Central Railway	Hajipur
East Coast Railway	Bhubaneswar
Northern Railway	New Delhi
North Central Railway	Prayagraj
North Eastern Railway	Gorakhpur
North Frontier Railway	Maligaon, Guwahati
North Western Railway	Jaipur
Southern Railway	Chennai
South Central Railway	Secunderabad
South Eastern Railway	Kolkata
South East Central Railway	Bilaspur
South Western Railway	Hubballi
Western Railway	Mumbai
West Central Railway	Jabalpur
Kolkata metro Railway	Kolkata

WATER TRANSPORT

Water transport is the most economical and environmental friendly of all the modes of transport. The value of fuel consumed by water transport is 30 per cent of the fuel consumed by road and the emissions are one sixth of that by road and 50 per cent of that by railways. Consequently, over 90 per cent of the volume and 70 per cent of the value of global trade is transported through waterways. For India, with over 7500 km of coastline alongwith 13 major and 200 minor & intermediate ports and 14,500 km of navigable rivers and canals, water transport is a very conducive mode for both passenger and freight transport. In 2012, India's maritime trade was US$794 billion. However in terms of relative output India's share of maritime trade is declining. In 1950's, maritime trade accounted for over 90 per cent of total India's international trade. It reduced to 30 per cent in the 1990s and only 8 per cent currently. India's international trade has declined from over 90 percent in the 1950s, to 30 percent in the early 90s, to less than 9 percent presently. The share of inland shipping is a meager 1percent, while coastal shipping constitutes 7 percent of the total domestic cargo movement in India. This pales in comparison to 57 per cent and 34 per cent by roads and railways respectively. But the increasing delays in transporting goods due to high road and rail congestion is going to force the adoption of waterways as a preferred mode of transport and will provide impetus to the growth of coastal and inland shipping network in India in the future. There are number of factors, contributed to the relative slow growth of the maritime dimension of India's trade. First, India's shipping industry has not caught up with India's burgeoning trade. Slow growth of tonnage in India has led to gradual decline in share of Indian companies. Thus, India's trade remains heavily dependent on foreign shipping companies for transportation needs. Second,

India has not had an integrated transport policy to promote inter-modal coordination leading to sub-optimal use of resources and their allocation to different sectors of transport. Third, although India's overall share in global shipbuilding industry was miniscule, India had made good progress in shipbuilding in the 10th plan (2002-2007) by increasing its global share in commercial shipbuilding from 0.12 per cent to 1.3 per cent. Fourth, India lacks adequate port infrastructure to accommodate large size vessels. Moreover, India does not have any transshipment hub ports in the country and thus is dependent on feeder services from international hub ports in other countries for its cargo and goods. Consequently, not only does India miss on potential revenue from transshipment hubs, but it also ends up paying more charges for additional handling. With the increasing trend of the international trade activities and also the dependence of India for the import of oil and gas, emission from the maritime sector are bound to increase. Therefore, there is a need to identify the new and advanced technologies to reduce the emissions. The future of maritime transport lies in the development of "greener ships" with zero emission by fully harnessing the technological advancements. Safety and security aspects of maritime transportation will also need to be addressed simultaneously. New benchmarks like Energy Efficiency Design Index (EEDI) and Ship Energy Efficiency Management Plan (SEEMP) have been introduced to make ships about 30 per cent more efficient. On engineering aspects, new technologies for hull and propellers, hull coating, hull air lubrication system, use of hybrid lightweight material for ship construction and improvement of propeller efficiency are being developed. Moreover, alternate fuels such as bio-fuels, LNG, solar energy, wind energy and fuel cells are exciting areas of research on which India must invest in the medium to long term. Having successfully launched a nuclear submarine, Arihant, India could make use of nuclear fuel, especially in the short to medium term. Using shore electricity when the ship is in port offers huge potential for emission reduction. Navigation technology is another area where India has shown potential, especially with the Indian Regional Navigational Research Satellite System (IRNSS). Other key futuristic technology includes hydrogen as an alternative fuel, use of nanotechnology, 3-D navigation charts and shipping across the Arctic.

Water transport can be divided into two major categories − Inland waterways and Oceanic waterways.

- **Inland Waterways Authority** was set up in 1986 for the development, maintenance, and regulation of national waterways in the country.
- **Ocean transport** is the most important water transport because it has certain advantages overland carriage. The sea offers a ready-made carriageway for ships which, unlike the roadway or railway, requires no maintenance.
- Water surfaces are two-dimensional and, although sea-going vessels frequently keep to shipping lanes, ships can travel, within a limited number of constraints, in any direction.

Zone	State	Port	Features
Eastern Coast	Tamil Nadu	Chennai	Artificial Port Second busiest port
Western Coast	Kerala	Kochi	Sited in the Vembanad lake Exports of spices and salts
Eastern Coast	Tamil Nadu	Ennore	India's First corporatized port
Eastern Coast	West Bengal	Kolkata	India's only major Riverine port Situated on Hugli river Known as Diamond Harbour
Western Coast	Gujarat	Kandla	Known as Tidal Port Acknowledged as Trade Free Zone Largest port by volume of cargo handled.
Western Coast	Karnataka	Mangalore	Deals with the iron ore exports
Western Coast	Goa	Mormugao	Situated on the estuary of the river Zuari
Western Coast	Maharashtra	Mumbai Port Trust	Largest Natural Port and harbour In India The busiest port in India
Western Coast	Maharashtra	Mumbai Port Trust	Largest Natural Port and harbour In India The busiest port in India
Western Coast	Maharashtra	Jawaharlal Nehru Port Trust (JNPT) also known as Nhava Sheva, Navi Mumbai	Largest Artificial Port It is the Largest Container Port in India.
Eastern Coast	Odisha	Paradip	Natural Harbor deals with the export of iron and aluminium
Eastern Coast	Tamil Nadu	Tuticorin	A major port in south India deals with the fertilizers and petrochemical products
Eastern Coast	Andhra Pradesh	Visakhapatnam	Deepest port of India deals with the export of iron ore to Japan. Amenities for building and fixing of ships are available

AIR TRANSPORT

Air Transport is one of the most technology intensive industry and have transformed the human aspirations of mobility and made this world truly flat by destroying distances. Air transport has consistently exhibited high level of growth in India over the last decade. Between 2006-07 and 2015-2016, passenger traffic grew by a CAGR of ten per cent. Significantly, the figures for passenger traffic are expected to undergo a threefold leap from 150 million passengers in 2011-12 to about 450 million in 2020, catapulting India's aviation market from 9th to 3rd position within a decade. Growing urbanization, robust middle class, increasing affordability and accessibility of air transport and increased global business connectivity, among other things, have contributed to these salubrious projections. Nevertheless, the challenges that lay ahead of the Indian air transport industry are daunting. This growing demand for air transport has already lead to congestion in the air transport system at the major airports. Airspace and airport congestion not only lead to economic losses but raises many issues related to environment and safety. Increasing air congestion, carbon emissions and high fuel costs are significant impediments in full fructification of this industry. Further, in India, the increasing numbers of passengers have not brought in profits, resulting in the airline industry suffering from chronic accumulated losses as well as capacity constraints due to limited aviation infrastructure (airspace and airports) to meet the demands of increased

traffic. Shortage of skilled workforce, chronic delays in existing projects and riskier post 9/11 security scenario are other issues which the air transport industry and its technology development faces in India.

In the civil aviation sector, India has been excessively dependent on imported technologies. The primary thrust of public sector units like HAL, DRDO, BEL and ISRO has been on developing technologies for defence sector. Consequently, despite there being a dedicated agency in National Aeronautical Laboratory (NAL) for developing aerospace technologies, design and aircraft building in the civilian sector, India has remained a laggard in aircraft design and manufacture. However, with the Government's "Make in India" initiative and opening up the sector for FDI, lot of big industrial houses have entered in the fray. In the last two decades Indian technology companies have made significant progress in providing software engineering services to the global aerospace majors, Indian companies are recognized for their capabilities to meet the very stringent quality requirements of the sector. Almost all the major global aerospace companies have set up engineering and design centers in India, to take advantage of the local talent, and also for the long term business interest. India has embarked upon a serious technology drive to upgrade its Air Navigation Services (ANS) infrastructure and technologies including radar surveillance systems, reduced separation requirements in performance based airspace design. A satellite based augmentation system for GPS signal, GAGAN will eliminate the need for ground based radio navigation aids which are costly, difficult to maintain, and have limited range. By 2035, India should aim to garner 5 per cent of global share of the aerospace supply chain. The guiding vision should be of a safe, sustainable and scalable air transport system through development of most efficient technologies available. The roadmap for technological priorities strategize in short term, medium term and long term perspectives, which includes the futuristic technologies like include high speed aircraft, cryogenic planes, pilotless aircraft, stealth technology, new materials like composites, avionics, radar, nano-technology, superior control and other futuristic technologies.

- Air transport in India marked its beginning in 1911 with the commencement of airmail over a little distance of 10 km between Allahabad and Naini.
- **Pawan Hans** is the helicopter service operating in hilly areas and is widely used by tourists in north-eastern regions.
- The coastline of India is dotted with 12 Major Ports and about 200 Non-major Ports. The Major Ports are under the purview of the center while the Non-major Ports come under the jurisdiction of the respective State Governments.

PIPELINE TRANSPORT NETWORK

Pipeline transport network is a new arrival on the transportation map of India. In the past, these were used to transport water to cities and industries. Now, these are used for transporting crude oil, petroleum products and natural gas from oil and natural gas fields to refineries, fertilizer factories and big thermal power plants. Initial cost of laying pipelines is high but subsequent running costs are minimal. It rules out trans-shipment losses or delays. This entry gives the lengths and types of pipelines for transporting products like natural gas, crude oil, or petroleum products.

Some of the important pipelines are briefly described as under:

1. Naharkatia-Nunmati-Barauni Pipeline:

This was the first pipeline constructed in India to bring crude oil from Naharkatia oilfield to Nunmati. It was later extended to transport crude oil to refinery at Barauni in Bihar. It is 1,167 km long. It is now extended to Kanpur in U.P. The pipeline between Naharkatia and Nunmati became operative in 1962 and that between Nunmati and Barauni in 1964. Construction work on pipeline from Barauni to Kanpur and Haldia was completed in 1966. It has a number of pumping stations and subsidiary pipelines.

i. Nunmati-Siliguri pipeline transport oil from Nunmati (Guwahati) in Assam to Siliguri in West Bengal.
ii. Lakwa-Rudrasagar-Barauni pipeline has been constructed to carry crude oil from Lakwa and Rudrasagar to oil refinery at Barauni.
iii. Barauni-Haldia pipeline, completed in 1966, transports refined petroleum products to Haldia port and bring back crude oil to Barauni refinery.
iv. Barauni-Kanpur pipeline carries refined petroleum products from Barauni to Kanpur.
v. Nunmati-Bangaigaon section of this pipe is used to transport raw materials for Bongaigaon petro-chemical complex.
vi. Haldia-Rajbandh-Maurigram pipeline has been constructed to meet the requirements of southern part of West Bengal.

2. Mumbai High-Mumbai-Ankleshwar-Kayoli Pipeline:

This pipeline connects oilfields of Mumbai High and Gujarat with oil refinery at Koyali. A 210 km long double pipeline connects Mumbai with Mumbai High. It provides facilities for transporting crude oil and natural gas. Ankleshwar-Koyali pipeline was completed in 1965. It transports crude oil from Ankleshwar oilfield to Koyali refinery.

3. Salaya-Koyali-Mathura Pipeline:

An important pipeline has been laid from Salaya in Gujarat to Mathura in U.P. via Viramgram. This is 1,256 km long pipeline which supplies crude oil to refineries at Koyali and Mathura. From Mathura, it has been extended to the oil refinery at Panipat in Haryana and further to Jalandhar in Punjab. It has an offshore terminal for imported crude oil.

4. Hajira-Bijapur-Jagdishpur (HBJ) Gas Pipeline:

This pipeline has been constructed by Gas Authority of India Limited (GAIL) to transport gas. It is 1,750 km long and connects Hazira in Maharashtra to Bijapur in M.P. and Jagdishpur in U.P. It carries 18 million cubic metres of gas everyday to three power houses at Kawas (Gujarat), Anta (Rajasthan) and Auraiya (U.P.) and to six fertilizer plants at Bijapur, Sawai Madhopur,. Jagdishpur, Shahjahanpur, Aonla and Babrala.

Each of the fertilizer plants has a capacity of producing 1,350 tonnes of ammonia per day. The construction of this pipeline is a unique engineering feat and has been completed at an estimated cost of over Rs. 1,700 crore. The pipeline passes through 343.7 km long rocky area, 56.3 km long forest area, besides crossing 29 railway crossings and 75 big and small rivers.

This is the world s largest underground pipeline and has brought about a big transformation in the economy of Gujarat, Madhya Pradesh, Rajasthan and Uttar Pradesh. It has been extended upto Delhi so that enough gas is made available to meet the growing demand of the capital city.

5. Jamnagar-Loni LPG Pipeline:

This 1,269 km long pipeline has been constructed by Gas Authority of India Limited (GAIL) at the cost of Rs. 1,250 crore. It connects Jamnagar in Gujarat to Loni near Delhi in U.P. and passes through the states of Gujarat, Rajasthan, Haryana and U.P. This is the longest LPG pipeline of the world.

It is like transporting 3.5 lakh LPG gas cylinders across 1,269 km every day and its capacity is being increased to 5.0 lakh cylinder per day. It will result in net saving of Rs. 500 crore per year by eliminating road tanker movement and lead to reduction of about 10,000 tonnes of pollutant emission per year.

This is the first time that cross-country pipeline has been used to transport LPG adding to availability of supplies, safety in transportation and wider distribution. LPG is received at various points along the route for bottling in Ajmer and Jaipur (Rajasthan), Piyala (Haryana), Madanpur Khadar (Delhi) and Loni (U.P.). Phase-I of the pipeline was completed in 2001 and Phase-II was completed in 2003. Its capacity will be expanded from the current level of 1.7 million tonnes to 2.5 million tonnes.

6. Kandla-Bhatinda Pipeline:

This 1,331 km long pipeline is proposed to be constructed for transporting crude oil to the proposed refinery at Bhatinda. It is to be constructed by IOC at the estimated cost of Rs. 690 crore.

Apart from the above mentioned important pipelines, several other pipelines have also been laid in different parts of the country. Construction of some of them has already been completed while others are at different stages of completion. In Gujarat, a number of pipelines carry crude oil, gas and refined products to refineries and markets.

Important pipelines include the Kalol-Sabarmati Crude Pipeline, the Nawgam-Kalol-Koyali Crude Pipeline, the Cambay-Dhiwaran Gas Pipeline, the Ankleshwar- Uttaran Gas Pipeline, the Ankleshwar-Vadodara Associated Gas Pipeline, and the Koyali-Ahmedabad Products Pipeline. Mumbai is an important centre for petroleum products. As such, it is joined with Pune and Manmad by pipelines. The Haldia-Kolkata pipeline caters to the needs of Kolkata and its neighbouring areas.

The Gas Authority of India Ltd. (GAIL) has drawn up an ambitious plan at the cost of Rs. 10,000 crore for the “near term” which includes projects for integrating the gas pipeline network through capacity expansion and adding new pipelines.

Some of the pipelines for which the preliminary work has been completed are the Dahej-Vijaipur pipeline, 300 km north-south Gujarat pipeline, Dehej- Hazira-Uran pipeline (400 km), Kochi-Mangalore-Bangalore pipeline (900 km) and Phase III of pipeline network in Andhra Pradesh.

A 600 km Vishakhapatnam-Secunderabad pipeline of 1.1 million tonnes capacity would also be put at the cost of Rs. 490 crore. Some of the other proposed pipelines include the Kanpur-Bina, Mangalore-Chennai, Vijayawada-Vishakhapatnam, and Haldia-Budge Budge pipelines.

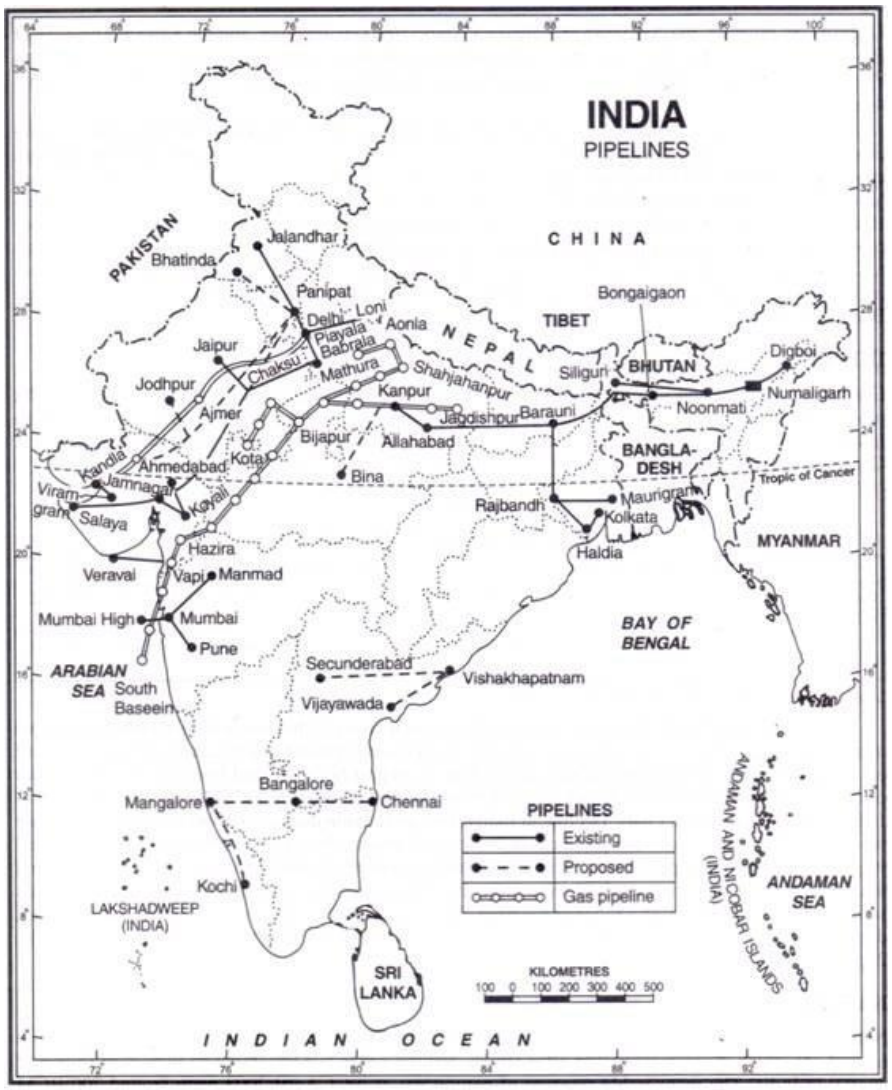

FIG. 26.7. India : Pipelines