6.4 Railways

6.4.1 Sector Overview

The CBIC Area has a dense railway network comprising 2,806 route km, all of which is broad gauge (1,676 mm) – please see a network illustration in Figure 6.4.1. The network is maintained and operated by three zonal railway organizations under the Ministry of Railways (MOR). The largest component of the network is that of the South Western Railway (1,285 route km), operated from a base in Hubli, Karnataka. The Southern Railway, based in Chennai, operates 950 route km and the South Central Railway, with a headquarters in Secunderabad, operates 566 route km within the CBIC boundary. Passengers dominate the traffic on this network, particularly on the Southern Railway portion which generates most of its revenue from passenger traffic.

The network consists of a central east-west route of 675 km linking Chennai with Chitradurga, via Bengaluru, plus another 21 routes generally running north and south from Chennai or Bengaluru.

The network has the following functions:

- It connects inland industrial centres with east coast ports in Chennai, Ennore, Krishnapatnam, and, in the future, with new ports in Kattupalli and (possibly) Duggirajapatnam

- It connects the CBIC area to the major cities of India

- It connects the inland industrial centres of CBIC with other manufacturing centres located outside the CBIC Area.

In particular, the CBIC railway network provides some important trunk line connections between:

- Chennai and Gudur Junction (a "Golden Quadrilateral" connecting Chennai with Delhi and Kolkata);

- Chennai, Renigunta and Nandalur (also a "Golden Quadrilateral" connecting Chennai with Hyderabad and Mumbai);

- Chennai-Salem, Chennai-Villupuram and Bengaluru-Mysore (links with major cities and with agricultural areas in the south);

- Bengaluru and Dharmavaram (links to Hyderabad, Mumbai and Delhi, as well as the steel producing region around Bellary); and

- Bengaluru and Chitradurga/Rayadurga (links to Mangalore Port to the southwest and Bellary to the north).

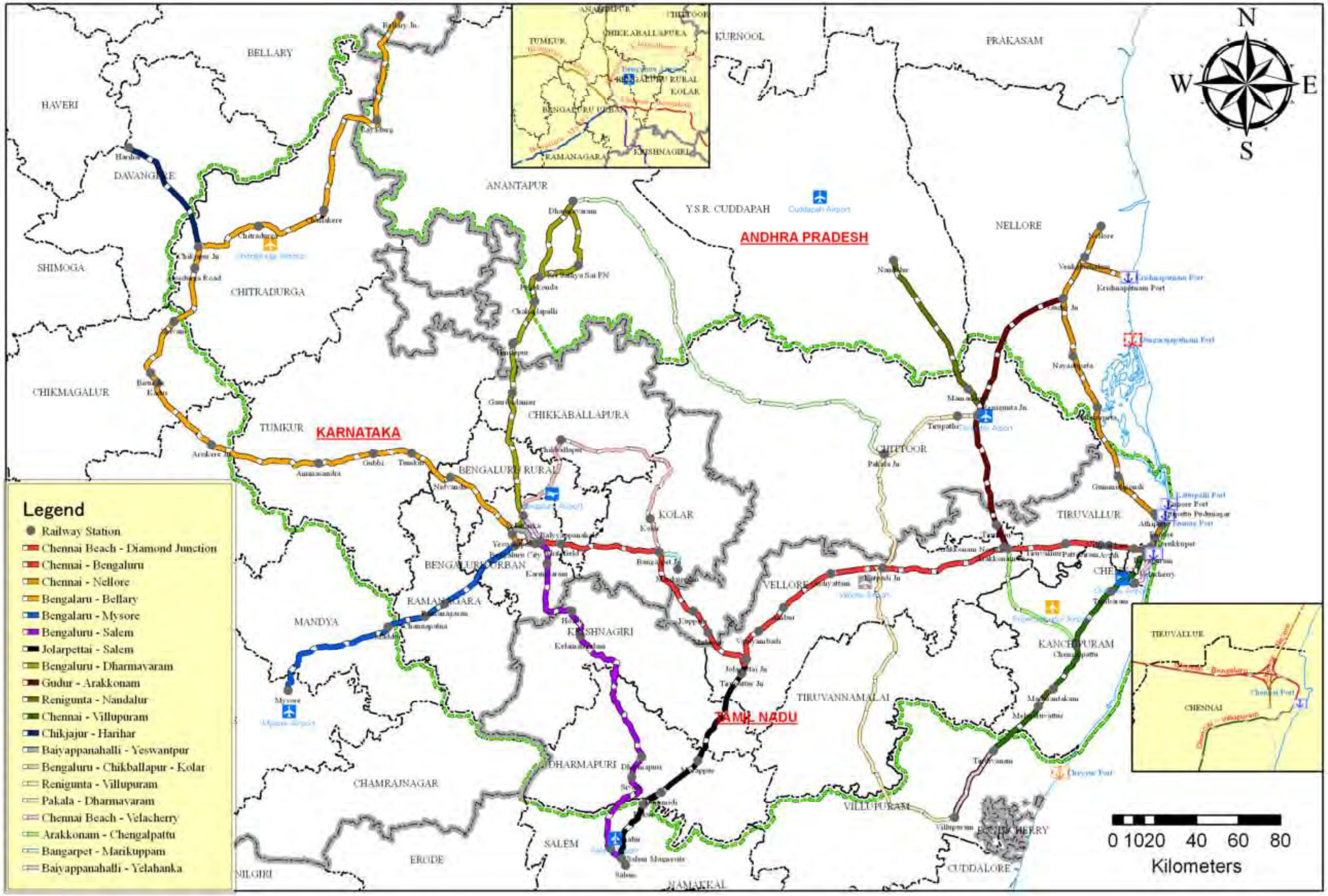
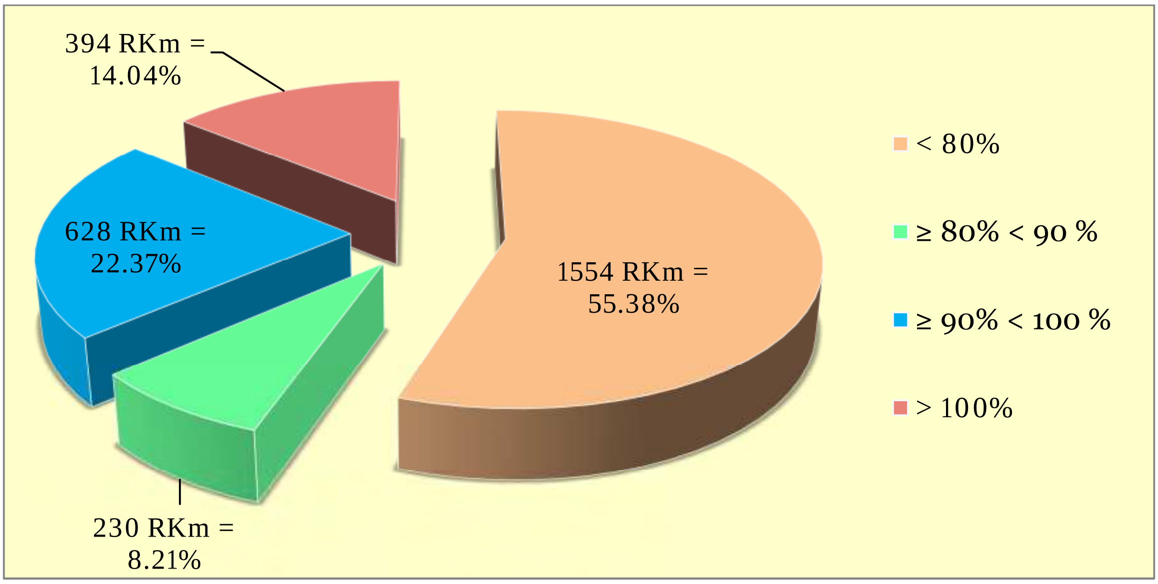


Figure 6.4.1 Railway network within the CBIC area

In Interim Report 1, 20 routes and 66 line sections were identified within the CBIC railway network. This has been revised to 22 routes and 66 line sections.

A key conclusion of Interim Report 1 was that nearly 40 per cent of this network in terms of route km had either already reached or was fast approaching capacity saturation. This has been subsequently revised to just under 37% (as shown in Source: Zonal railways

Figure 6.4.2). *Capacity saturation occurs when the number of trains each way per day exceeds 90 per cent of the estimated daily train capacity (i.e. the maximum number of trains which can operate in each direction per day on the line section).*[96]



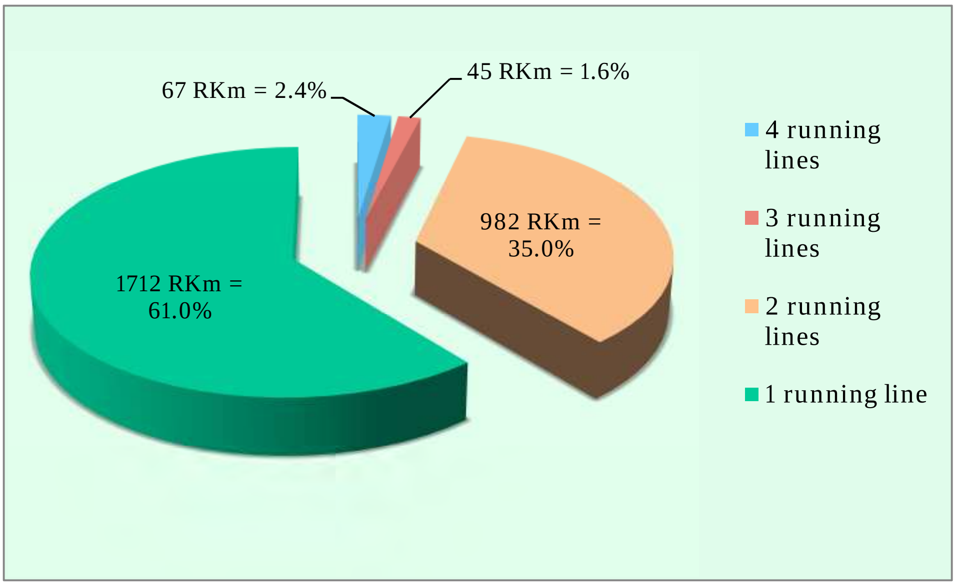
Source: Zonal railways

Figure 6.4.2 Line capacity utilisation on CBIC railway network (by route km)

Capacity shortages are particularly critical in the line sections near Chennai, owing to the fact that long distance passenger and freight trains share the track with suburban passenger services. Between Chennai and Gudur Junction, five out of eight operating sections, accounting for 33% of the route km on this line, have already exceeded 90 per cent of their estimated capacity. Similarly, four out of eight sections on the Southern Railway portion of the Chennai-Bengaluru route (between Chennai and Jolarpettai), accounting for 60 per cent of route km, have already exceeded 90% of their estimated train capacity.

The traffic/capacity relationship has been aggravated by the fact that some 61% of the network's route km is equipped only with a single running line, while another 35% has only two running lines (please see Figure 6.4.3). In the Chennai suburban area, traffic on a few sections with 4 running lines has already exceeded capacity and will require some form of efficiency improvements or the addition of fifth and sixth running lines. Further strong traffic growth could well require the addition of even more running lines, but this could prove difficult, owing to the non-availability of land in urban areas.

[96] In the case of single line sections, line capacity is a function of the time taken by the slowest train to pass through the longest block section, since only one train can occupy the section at a time. In the case of multiple running lines, line capacity is determined on the basis of the minimum headway (train intervals) permitted by the signalling system.



Source: Zonal railways

Figure 6.4.3 Distribution of route-km by number of running lines

The Ministry of Railways is attempting to relieve capacity shortages where these are most critical by adding running lines, but with passenger traffic growing by about 3.5 per cent per annum and freight traffic by more than 7 per cent per annum, is struggling to keep up. Of course, the addition of running lines is but one means of relieving line capacity shortages, but it has greater potential for relief than other measures (such as electrification, increased axle loads, etc.) in the present operating context of the CBIC railway network.

Summary of the existing situation and issues

i. The 22 routes and 66 sections of the CBIC rail corridor cover 2806 Route Kilometres. 61% of the CBIC corridor is currently single-line only; only 4% or 112 km have more than 2 lines. 37% (1022 km) of the CBIC corridor has a level of track utilisation higher than 90%, which implies a very high level of congestion. Congestion is pronounced in some sections around Chennai, where a suburban rail service shares the tracks with long distance passenger and freight services.

ii. A more detailed analysis of possible solutions to deal with congestion are listed in Chapter 6.4.3; however as stated, the addition of running lines presents the most potential for congestion relief.

iii. Additionally, the upgrading of Absolute Block Signalling (ABS) to Automatic Signalling will also improve utilisation. Only around 440 Km, or around 16% of the network, (all of which is within Southern Railways) runs on Automatic Signalling. Beyond marginal improvements, these sections will require additional lines if an increase in capacity is needed.

iv. South Western and South Central Railways' sections are under ABS and can be upgraded to Automatic Signalling; however beyond this, additional lines will be required for further increases in capacity.

v. Other measures to improve efficiency such as back loading of wagons and combining empty wagons can also be considered and are explained in detail in Chapter 6.4.3 (i). Indian Railways already carry out these improvements but it is likely that there will scope for further implementation of such measures.

vi. This should be considered also in view of the very low share of Rail in freight movements within the CBIC corridor. As indicated in Chapter 6.3.1.3, the share of rail in container traffic within the CBIC area is around 5%. It is assumed that this share will increase, and that the necessary operational and policy changes required for this will be implemented. Additionally, rail does not participate in the current movement of cars to Ennore port for exports. It is expected that this will also be addressed. This is discussed in detail in Chapter 6.4.2 (iii) and Chapter 6.4.4 (iv).

6.4.2 *Demand Forecast*

The railway demand forecast has been prepared at three levels.

First, the daily number of trains (both freight and passenger) operating on all of the 66 line sections comprising the CBIC network was projected for 20 years up until 2032/33, in order to assess the timing, scale and cost of future line capacity expansion.

Second, passenger and freight volume flows (number of passengers and freight tonnage) on the principal route between Chennai and Bengaluru were projected over the same 20 year period, in order to estimate the potential to divert traffic to the proposed Dedicated Freight Corridor (DFC) and High Speed Passenger Railway (HSR).

Third, the future tonnages of cargo moving by rail to and from individual east coast ports were estimated to establish the volumes that would be available to support the improvement of rail connectivity to the ports.

(i) Growth scenarios

Two scenarios were initially considered: one (known as the "Business as Usual" scenario or BAU) reflecting growth which might be expected to occur in the absence of the accelerated industrial development of the corridor and the other (the "Business Induced" scenario or BIS) reflecting the faster growth which might be expected to result from such development. Forecasts were carried out for both the BAU and BIS cases. The forecasting process involved calculation of future volumes by applying valid growth rates to base year data. The year 2012/13 was adopted as the base year for all forecasts. The rates used for forecast expansion were the BIS rates estimated by the project economists for GRDP (Gross Regional Domestic Product) in the CBIC area.

However, since some proportion of the demand for railway services is generated from outside of the CBIC area, it was necessary to compute a weighted average of the GRDP for CBIC and the national GDP for use as the forecast expansion factor for freight traffic. A GDP rate forecast by Standard Chartered Bank for 2014-2030 (6.7 %) was used for the latter.

In the absence of adequate railway Origin-Destination data, it was necessary to assume the internal/external proportions to be used in calculating a weighted average expansion factor. These assumptions were: internal, 67% and external, 33%.

In the case of passenger traffic, it was found that the actual rate realised by the growth of total passenger volume in all three zonal railways (about 10% per annum) was significantly higher than the rate used by the zonal railways to expand the number of passenger trains in their forward capacity analysis (3.5% per annum). This analysis covers the five year period from 2012/13-2017/18.[97] The ratio of the BIS population forecast rate to the BAU rate was used to derive a passenger train expansion rate in the BIS case, thus:

1. Population CAGR (20 years) – BAU case: 1.36%
2. Population CAGR (20 years) - BIS case: 1.89%
3. Ratio (2)/(1) : 1.392
4. Passenger train expansion factor BIS case : 3.5% x 1.392 = 4.87%

(Source: JICA Study Team, Socioeconomic Forecasts) CBIC project economists)

[97] One of the reasons for the variance between passenger volume growth and the projected growth in daily passenger train flows is passenger train loads have been increasing at levels considerably in excess of 100% of design seating and standing passenger capacity. Occasionally train capacity is increased by adding carriages to standard passenger train consists, but such action cannot keep pace with the burgeoning growth in demand, which is a reflection of cheap fares.

The forecast expansion factors are summarised in Table 6.4.1 below.

Table 6.4.1 Expansion factors used for train and traffic volume forecasts

Item	BAU	BIS
GRDP (CBIC)	7.69%	11.42%
GDP (India)	6.70%	6.70%
Pass. Train exp. Factor	3.50%	4.87%
Freight train exp. factor	7.36%	9.86%
Export/Import traffic		
Containers - TEU	10.20%	14.50%
Containers - tonnes	10.00%	14.60%
Cars – units & tonnes	10.20%	14.50%
Break-bulk (excl. cars)	5.10%	9.10%
Coal	11.10%	13.10%
Other dry bulk	4.40%	8.10%

Sources: (1) JICA Study Team

(2) Standard Chartered Bank

(ii) Train Forecasts

Forecasts of daily train numbers by line section, for all 66 sections of the CBIC network, were generated as an extension of the 5 year forward capacity analysis of the three zonal railways. Table 6.4.2 provides an example of the methodology used in this case and the results of the capacity deficit analysis are given in Chapter 6.4.3.

For the forecast, the "Business as Usual" growth rate was applied up until 2017/18, and the "Business Induced" rate as from 2018/19 when it was assumed that the planned industrial investments would be in place throughout the corridor.

When the daily train number increases to 90% of estimated train capacity, it is assumed that planning for capacity expansion would begin either by upgrading the signalling or by adding a running line. Based on feedback from MoR on initial estimates, the analysis has assumed that a double line with automatic signalling can run 100 trains/day in each direction. Additionally, as part of a sensitivity analysis, the same exercise was repeated considering a lower value of 90 trains/day also.

If it is not possible to make signalling improvements (on sections where automatic signalling is already in place) another running line would be needed. It has been assumed that the line would be sanctioned and built over 5 years as is shown in Table 6.4.2. In the example shown, on-going capacity relief would require the addition of 2 running lines to the existing 2 in the section over 20 years. This would mean that nearly 122 km of running lines would be added to the section, equivalent to 200% of the section's route-km.

Table 6.4.2 Sample train forecast sheet (Arakkonam-Katpadi section), BIS case

No.	From / to	Route-Km	No. running tracks	Year	Capacity with maintenance block of 4 hours	Average Number of Trains in each direction				Utilisation (%)	Expansion	Length
						Pass	Goods	Others	Total			
23	**Arakkonam - Katpadi**	**60.89**	**2**	2012-13	76	37.0	18.6	3.5	59.1	78%		
				2013-14	76	38.3	20.0	3.5	61.8	81%		
				2014-15	76	39.6	21.4	3.5	64.6	85%		
				2015-16	76	41.0	23.0	3.5	67.5	89%		
				2016-17	76	42.5	24.7	3.5	70.6	93%	Improvements	
				2017-18	100	43.9	26.5	3.5	73.9	74%		
				2018-19	100	46.1	29.1	3.5	78.7	79%		
				2019-20	100	48.3	31.9	3.5	83.7	84%		
				2020-21	100	50.7	35.0	3.5	89.2	89%		
				2021-22	100	53.2	38.4	3.5	95.0	95%	Planning and construction of a 3rd line (over 5 years)	60.89
				2022-23	100	55.7	42.1	3.5	101.3	101%		
				2023-24	100	58.5	46.2	3.5	108.1	108%		
				2024-25	100	61.3	50.7	3.5	115.5	115%		
				2025-26	100	64.3	55.6	3.5	123.4	123%	Addition of 3rd line	
				2026-27	150	67.4	61.0	3.5	131.9	88%		
				2027-28	150	70.7	66.9	3.5	141.1	94%	Planning and construction of a 4th line (over 5 years)	60.89
				2028-29	150	74.1	73.4	3.5	151.0	101%		
				2029-30	150	77.8	80.5	3.5	161.7	108%		
				2030-31	150	81.5	88.3	3.5	173.3	116%		
				2031-32	150	85.5	96.9	3.5	185.9	124%	Addition of 4th line	
				2032-33	200	89.7	106.3	3.5	199.4	100%		
										TOTAL		**121.78**

Growth factors for forecasting:		
	Scen: BAU	Scen: BIC
All India GDP	6.70%	6.70%
GRDP (CBIC)	7.69%	11.42%
Weighting (GDP)	33.0%	33.0%
Weighting (GRDP)	67.0%	67.0%
Weighted average growth factor (freight)	7.36%	9.86%
Composite rate for BCN (grain+other)	6.00%	6.00%
Composite rate for pax traffic (GDP/capita)	3.50%	4.87%

Sources: (1) Base data: Zonal Railways (2) Forecast expansion factors: JICA socioeconomic forecasts.

(iii) Freight and passenger volume forecasts on the Chennai-Bengaluru route

a. *Freight forecast*

A comprehensive forecast should take into account not only the underlying or "normal" growth of existing railway traffic on the route, but also the potential for diversion of road freight traffic to the railway and for the generation of new or induced traffic by the planned industrial development of the corridor. Unfortunately such a comprehensive forecast was not possible, owing to:

- The lack of an Origin-Destination breakdown of railway freight tonnages, by commodity;
- An absence of information on long distance movement of road freight within the corridor; and
- Information gaps related to the increased production to be expected from new manufacturing to be established at specific locations within the proposed priority nodes.

To an extent, the assumption of induced growth in the BIS case will compensate for an absence of information on new production capacity within CBIC, but if the same growth rates are to be applied to road freight volumes without any allowance for a modal shift from road to rail, the result will be an overestimate of the freight volume moving in the corridor. *Given these deficiencies, it can be concluded that any forecast of normal railway traffic will be grossly inadequate as a basis for planning a Dedicated Freight Corridor for CBIC.*

Consequently, the way forward for this project should allow for a comprehensive, unified transport demand forecast to be prepared. Such a forecast would involve the proper integration of demand forecasts for all transport modes and provide a platform for a modal split analysis as a means of distributing demand among the different modes.

Forecasting base

The zonal railways do not compile traffic data by Origin-Destination and assembly of this data for all 22 routes in the CBIC area would have required the laborious tabulation of OD tonnages on a station by station basis. Instead, the zonal railways were able to extract from the Freight Operations Information System details of peak day train flows by type of wagon and by direction for each line section in the 2012/13 base year.

A forecasting base was established by converting daily train/wagon flow data to annual tonnages, by broad commodity group. For this purpose, average wagon payloads were estimated by assuming that BOXN (bogie open) wagons are loaded to 90% of their payload capacity, that BLCA (container flat) wagons and new car wagons would be loaded to their full capacity (2 TEU and 12 cars respectively) and that all other wagons would be loaded to 75% of their payload capacity. The assumed number of wagons per train was as advised by the zonal railways and the assumed number of operating days was 360 per year. Details of these assumptions are given in Table 6.4.3 and Table 6.4.4 which also contain the tonnage, train numbers, TEU and car forecasts by direction of working for the BAU and BIS cases. *Overall tonnage forecasts by commodity for the BIS case are summarised in Figure 6.4.4, Figure 6.4.5 and Figure 6.4.6.*

Because the most commonly used wagon types, notably BOXN (bogie open) and BCN (bogie covered van), can carry multiple commodities, it was not possible to relate wagon types to specific commodities, unless such a relationship is suggested by the origin or destination of the train or "rake". For example, trains of BCN wagons moving from the south to Chennai along the Villupuram line can be safely assumed to carry food grains. Similarly BOXN rakes moving from Chennai to Salem can be safely assumed to carry coal, and so forth.

Since the objective of the forecast was also to estimate future flows of empty trains moving in the opposite direction to loaded train flows, all wagon types, except for container wagons, were assumed to be backhauled empty to their originating stations. In many cases it was observed that flows of loaded trains were balanced in the opposite direction by smaller numbers of empty trains, suggesting that train lengths are increased in the empty running direction to reduce the pressure on limited line capacity.

There are significant opportunities for the back-loading of general purpose wagons, such as the BCN, which can carry, interchangeably, all types of bagged commodities. The Indian Railways has recently been investigating the application of freight rate incentives to maximize back-loading opportunities and reduce empty running. In view of the desirable effects on line capacity relief, it is suggested that the Railway should re-double its efforts to achieve a better utilisation of both its rolling stock and its line capacity through commercial pricing incentives.

Containers and cars

These commodity groups represent major new freight traffic opportunities for rail in the CBIC area.

In the case of container traffic, CONCOR data related to the throughput of the Whitefield ICD were used to establish a forecasting base for international containers. For 2012/13, the total throughput was indicated as 102,807 TEU (6971 TEU of which were domestic containers).[98] All of this volume was assumed to have moved by rail to/from Chennai, the international containers to/from Chennai Port and the domestic containers to/from the Tondiarpet ICD, via the Korukkupet Goods Terminal. *Import and export container flows were assumed to be balanced in terms of TEU but not in terms of tonnage*. Container throughput data provided by Chennai Port indicate that in 2012/13 approximately 25% of the export TEU throughput was of empty containers. It was necessary, therefore, to adjust the container tonnage figure to allow for the empty container proportion in the throughput of export containers.

[98] CONCOR website: http://www.concorindia,com

Table 6.4.3 Forecast of rail freight volume moving between Chennai and Bengaluru in the "Business as Usual" case

Growth factors for forecasting:			
	Scen: BAU		
All India GDP	6.70%		
GRDP (CBIC)	7.69%		
Weighting (GDP)	33.0%		Growth rate
Weighting (GRDP)	67.0%		cont&cars
Weighted average growth factor	7.4%		10%
Composite rate for BCN (grain)	6.0%		

Wagon Type	Loading condition/Direction	Estimated av.payload (tonnes/TEU /cars)	Wagons/ train	Forecasting base: Data for 2012/13 Trains/ day	Trains/ year	Tonnes/TEU/ cars/year	Volume forecast (tonnes/TEU/cars) 2017/18	2022/23	2027/28	2032/33	Forecast number of trains per day 2017/18	2022/23	2027/28	2032/33
	LOADED													
BCN	DOWN (Chennai-Bengaluru)	46	58	2.8	1014	2,690,649	3,838,173	5,475,099	7,810,151	11,141,070	4.0	5.7	8.2	11.7
BOXN	DOWN (Chennai-Bengaluru)	58	59	0.4	136	462,182	659,297	940,477	1,341,578	1,913,741	0.5	0.8	1.1	1.6
BTPN	DOWN (Chennai-Bengaluru)	41	50	0.4	139	281,475	401,520	572,763	817,038	1,165,493	0.6	0.8	1.1	1.6
BLCA	DOWN (Chennai-Bengaluru) - TEU	2	45	1.6	571	51,418	82,809	133,365	214,786	345,915	2.6	4.1	6.6	10.7
NMG	DOWN (Chennai-Bengaluru) - no.cars	5	25		0	0								
Fut.Auto wag	DOWN (Chennai-Bengaluru) - no.cars	12	27		0	0	0	0	0	0	0.0	0.0	0.0	0.0
BFNS	DOWN (Chennai-Bengaluru)	47	50	1.9	699	1,625,175	2,318,289	3,307,007	4,717,398	6,729,301	2.8	4.0	5.6	8.0
Total tonnes	DOWN (Chennai-Bengaluru)			**5.5**	**1988**	**5,059,481**	**7,217,279**	**10,295,346**	**14,686,164**	**20,949,605**	**7.9**	**11.2**	**16.0**	**22.9**
Total TEU	DOWN (Chennai-Bengaluru)			**1.6**	**571**	**51,418**	**82,809**	**133,365**	**214,786**	**345,915**	**2.6**	**4.1**	**6.6**	**10.7**
Total cars	DOWN (Chennai-Bengaluru)			**0.0**	**0**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
	EMPTY													
BCN	DOWN (Chennai-Bengaluru)	0	50	3.8	1,376	0	0	0	0	0	5.1	6.8	9.2	12.3
BOXN	DOWN (Chennai-Bengaluru)	0	58	0.4	129	0	0	0	0	0	0.5	0.7	1.0	1.5
BTPN	DOWN (Chennai-Bengaluru)	0	50	0.4	145	0	0	0	0	0	0.6	0.8	1.2	1.7
BLCA	DOWN (Chennai-Bengaluru) - TEU	2	45	0.0	0	0	0	0	0	0	0.0	0.0	0.0	0.0
NMG	DOWN (Chennai-Bengaluru) - no.cars	0	25		0	0								
Fut.Auto wag	DOWN (Chennai-Bengaluru) - no.cars	0	27		0	0	0	0	0	0	0.4	0.7	1.1	1.8
BFNS	DOWN (Chennai-Bengaluru)	0	50	2.1	752	0								
Total tonnes	DOWN (Chennai-Bengaluru)			**4.6**	**1,650**	**0**	**0**	**0**	**0**	**0**	**6.2**	**8.4**	**11.4**	**15.4**
Total TEU	DOWN (Chennai-Bengaluru)			**0.0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.0**	**0.0**	**0.0**	**0.0**
Total cars	DOWN (Chennai-Bengaluru)			**0.0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.4**	**0.7**	**1.1**	**1.8**

Wagon Type	Loading condition/Direction	Estimated av.payload (tonnes/TEU /cars)	Wagons/ train	Forecasting base: Data for 2012/13 Trains/ day	Trains/ year	Tonnes/TEU/ cars/year	Volume forecast (tonnes/TEU/cars) 2017/18	2022/23	2027/28	2032/33	Forecast number of trains per day 2017/18	2022/23	2027/28	2032/33
	LOADED													
BCN	UP (Bengaluru-Chennai)	46	50	2.3	821	1,878,038	2,513,238	3,363,279	4,500,826	6,023,121	3.1	4.1	5.5	7.3
BOXN	UP (Bengaluru-Chennai)	58	58	0.4	161	537,869	767,262	1,094,489	1,561,273	2,227,133	0.6	0.9	1.3	1.9
BTPN	UP (Bengaluru-Chennai)	41	50	0.8	292	591,300	843,481	1,203,214	1,716,367	2,448,374	1.2	1.7	2.4	3.4
BLCA	UP (Bengaluru-Chennai) - TEU	2	45	1.2	438	39,439	63,516	102,293	164,744	265,323	2.0	3.2	5.1	8.2
NMG	UP (Bengaluru-Chennai) - no.cars	5	25		-	0		0	0	0	0.0	0.0	0.0	0.0
Fut.Auto wag	UP (Bengaluru-Chennai) - no.cars	12	27			0	50,000	80,526	129,687	208,862	0.4	0.7	1.1	1.8
BFNS	UP (Bengaluru-Chennai)	47	50	0.8	288	669,600	955,175	1,362,543	1,943,649	2,772,588	1.1	1.6	2.3	3.3
Total tonnes	UP (Bengaluru-Chennai)			**4.3**	**1,562**	**3,676,806**	**5,079,156**	**5,660,982**	**7,778,466**	**10,698,628**	**4.8**	**6.6**	**9.1**	**12.5**
Total TEU	UP (Bengaluru-Chennai)			**1.2**	**438**	**39,439**	**63,516**	**102,293**	**164,744**	**265,323**	**2.0**	**3.2**	**5.1**	**8.2**
Total cars	UP (Bengaluru-Chennai)			**-**	**-**	**-**	**50,000**	**80,526**	**129,687**	**208,862**	**0.4**	**0.7**	**1.1**	**1.8**
	EMPTY													
BCN	UP (Bengaluru-Chennai)	0	50	1.6	586	0	0	0	0	0	2.3	3.3	4.7	6.7
BOXN	UP (Bengaluru-Chennai)	0	58	0.5	162	0	0	0	0	0	0.6	0.9	1.3	1.9
BTPN	UP (Bengaluru-Chennai)	0	50	1.3	480	0	0	0	0	0	1.9	2.7	3.9	5.5
BLCA	UP (Bengaluru-Chennai) - TEU	2	45	0.4	133	11,979	19,292	31,070	50,039	80,589	0.6	1.0	1.5	2.5
NMG	UP (Bengaluru-Chennai) - no.cars	0	25		0	0	0	0	0	0	0.0	0.0	0.0	0.0
Fut.Auto wag	UP (Bengaluru-Chennai) - no.cars	0	27		0	0	0	0	0	0	0.0	0.0	0.0	0.0
BFNS	UP (Bengaluru-Chennai)	0	50	2.1	752	0	0	0	0	0	3.0	4.3	6.1	8.6
Total tonnes	UP (Bengaluru-Chennai)			**5.5**	**1,980**	**0**	**0**	**0**	**0**	**0**	**7.8**	**11.2**	**16.0**	**22.8**
Total TEU	UP (Bengaluru-Chennai)			**0.4**	**133**	**11,979**	**19,292**	**31,070**	**50,039**	**80,589**	**0.6**	**1.0**	**1.5**	**2.5**
Total cars	UP (Bengaluru-Chennai)			**0.0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.0**	**0.0**	**0.0**	**0.0**

Table 6.4.4 Forecast of rail freight volume moving between Chennai and Bengaluru in the “Business Induced” case

Growth factors for forecasting:			
	Scen: ACC		
All India GDP	6.70%		
GRDP (CBIC)	11.42%		
Weighting (GDP)	33.0%	Growth rate	
Weighting (GRDP)	67.0%	cont&cars	
Weighted average growth factor	9.86%		13%
Composite rate for BCN (grain)	6.0%		

Wagon Type	Loading condition/Direction	Estimated av.payload (tonnes/TEU/cars)	Wagons/ train	Forecasting base Data for 2012/13 Trains/ day	Trains/ year	Tonnes/TEU/ cars/year	Volume forecast (tonnes/TEU/cars) 2017/18	2022/23	2027/28	2032/33	Forecast number of trains per day 2017/18	2022/23	2027/28	2032/33
	LOADED													
BCN	DOWN (Chennai-Bengalaru)	46	58	2.8	1014	2,690,649	3,838,173	6,142,401	9,829,963	15,731,335	4.0	6.4	10.3	16.5
BOXN	DOWN (Chennai-Bengalaru)	58	59	0.4	136	462,182	659,297	1,055,102	1,688,528	2,702,228	0.5	0.9	1.4	2.2
BTPN	DOWN (Chennai-Bengalaru)	41	50	0.4	139	281,475	401,520	642,571	1,028,335	1,645,691	0.6	0.9	1.4	2.3
BLCA	DOWN (Chennai-Bengalaru) - TEU	2	45	1.6	571	51,418	82,809	155,268	291,128	545,867	2.6	4.8	9.0	16.8
NMG	DOWN (Chennai-Bengalaru) - no.cars	5	25		0	0								
Fut.Auto wag	DOWN (Chennai-Bengalaru) - no.cars	12	27		0	0	0	0	0	0	0.0	0.0	0.0	0.0
BFNS	DOWN (Chennai-Bengalaru)	47	50	1.9	699	1,625,175	2,318,289	3,710,063	5,937,382	9,501,861	2.8	4.4	7.1	11.4
Total tonnes	DOWN (Chennai-Bengalaru)			**5.5**	**1988**	**5,059,481**	**7,217,279**	**11,550,137**	**18,484,208**	**29,581,114**	**7.9**	**12.6**	**20.2**	**32.3**
Total TEU	DOWN (Chennai-Bengalaru)			**1.6**	**571**	**51,418**	**82,809**	**155,268**	**291,128**	**545,867**	**2.6**	**4.8**	**9.0**	**16.8**
Total cars	DOWN (Chennai-Bengalaru)			**0.0**	**0**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
	EMPTY													
BCN	DOWN (Chennai-Bengalaru)	0	50	3.8	1,376	0	0	0	0	0	5.1	6.8	9.2	12.3
BOXN	DOWN (Chennai-Bengalaru)	0	58	0.4	129	0	0	0	0	0	0.6	0.9	1.5	2.4
BTPN	DOWN (Chennai-Bengalaru)	0	50	0.4	145	0	0	0	0	0	0.6	1.0	1.7	2.6
BLCA	DOWN (Chennai-Bengalaru) - TEU	2	45	0.0	0	0	0	0	0	0	0.0	0.0	0.0	0.0
NMG	DOWN (Chennai-Bengalaru) - no.cars	0	25		0	0								
Fut.Auto wag	DOWN (Chennai-Bengalaru) - no.cars	0	27		0	0	0	0	0	0	0.4	0.8	1.5	2.8
BFNS	DOWN (Chennai-Bengalaru)	0	50	2.1	752	0								
Total tonnes	DOWN (Chennai-Bengalaru)			**4.6**	**1,650**	**0**	**0**	**0**	**0**	**0**	**6.3**	**8.8**	**12.3**	**17.3**
Total TEU	DOWN (Chennai-Bengalaru)			**0.0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.0**	**0.0**	**0.0**	**0.0**
Total cars	DOWN (Chennai-Bengalaru)			**0.0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.4**	**0.8**	**1.5**	**2.8**

Wagon Type	Loading condition/Direction	Estimated av.payload (tonnes/TEU/cars)	Wagons/ train	Forecasting base Data for 2012/13 Trains/ day	Trains/ year	Tonnes/TEU/ cars/year	Volume forecast (tonnes/TEU/cars) 2017/18	2022/23	2027/28	2032/33	Forecast number of trains per day 2017/18	2022/23	2027/28	2032/33
	LOADED													
BCN	UP (Bengalaru-Chennai)	46	50	2.3	821	1,878,038	2,513,238	3,363,279	4,500,826	6,023,121	3.1	4.1	5.5	7.3
BOXN	UP (Bengalaru-Chennai)	58	58	0.4	161	537,869	767,262	1,227,884	1,965,039	3,144,741	0.6	1.0	1.6	2.6
BTPN	UP (Bengalaru-Chennai)	41	50	0.8	292	591,300	843,481	1,349,861	2,160,244	3,457,135	1.2	1.9	3.0	4.7
BLCA	UP (Bengalaru-Chennai) - TEU	2	45	1.2	438	39,439	63,516	119,093	223,300	418,690	2.0	3.7	6.9	12.9
NMG	UP (Bengalaru-Chennai) - no.cars	5	25		-	0		0	0	0	0.0	0.0	0.0	0.0
Fut.Auto wag	UP (Bengalaru-Chennai) - no.cars	12	27			0	50,000	93,750	175,783	329,593	0.4	0.8	1.5	2.8
BFNS	UP (Bengalaru-Chennai)	47	50	0.8	288	669,600	955,175	1,528,610	2,446,303	3,914,930	1.1	1.8	2.9	4.7
Total tonnes	UP (Bengalaru-Chennai)			**4.3**	**1,562**	**3,676,806**	**5,079,156**	**5,941,025**	**8,626,109**	**12,624,997**	**4.8**	**7.0**	**10.1**	**14.7**
Total TEU	UP (Bengalaru-Chennai)			**1.2**	**438**	**39,439**	**63,516**	**119,093**	**223,300**	**418,690**	**2.0**	**3.7**	**6.9**	**12.9**
Total cars	UP (Bengalaru-Chennai)			**-**	**-**	**-**	**50,000**	**93,750**	**175,783**	**329,593**	**0.4**	**0.8**	**1.5**	**2.8**
	EMPTY													
BCN	UP (Bengalaru-Chennai)	0	50	1.6	586	0	0	0	0	0	2.6	4.2	6.7	10.7
BOXN	UP (Bengalaru-Chennai)	0	58	0.5	162	0	0	0	0	0	0.7	1.2	1.8	3.0
BTPN	UP (Bengalaru-Chennai)	0	50	1.3	480	0	0	0	0	0	2.1	3.4	5.5	8.7
BLCA	UP (Bengalaru-Chennai) - TEU	2	45	0.4	133	11,979	19,292	36,173	67,825	127,172	0.7	1.3	2.4	4.6
NMG	UP (Bengalaru-Chennai) - no.cars	0	25		0	0	0	0	0	0	0.0	0.0	0.0	0.0
Fut.Auto wag	UP (Bengalaru-Chennai) - no.cars	0	27		0	0	0	0	0	0	0.0	0.0	0.0	0.0
BFNS	UP (Bengalaru-Chennai)	0	50	2.1	752	0	0	0	0	0	3.3	5.3	8.6	13.7
Total tonnes	UP (Bengalaru-Chennai)			**5.5**	**1,980**	**0**	**0**	**0**	**0**	**0**	**8.8**	**14.1**	**22.5**	**36.1**
Total TEU	UP (Bengalaru-Chennai)			**0.4**	**133**	**11,979**	**19,292**	**36,173**	**67,825**	**127,172**	**0.7**	**1.3**	**2.4**	**4.6**
Total cars	UP (Bengalaru-Chennai)			**0.0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.0**	**0.0**	**0.0**	**0.0**

From CPT container tonnage and TEU data, an average tonnage of 19.29 was calculated for export containers. Assuming that the tare weight of a TEU is 2.4 tonnes, the average tonnage per export TEU was re-calculated as 0.25 x 2.4 + 0.75 x 19.29 = 15.07 tonnes. The average tonnage per TEU for export and import containers combined was then re-calculated at 17.3 in 2012/13. The unit container tonnage figures provided by the Chennai Port Trust seem to be on the high side when compared with averages typically encountered in Asia of about 11-12 tonnes per TEU. It is possible that the CPT tonnages include the tare weights of containers, which is not the case across Asia.

The recalculated container tonnages were used to convert the TEU forecast to a tonnage forecast. Application of slightly higher growth rates than those adopted for the port throughput forecasts was considered necessary in order to reflect an expectation of an increasing rail share of port container throughputs. If the faster growth of the BIS case is realised, the TEU volume carried by rail could be expected to grow to 1.09 million, and the container tonnage to 18.76 million, by 2032/33.

It is likely that the port orientation of the container traffic moving on the Chennai-Bengaluru route will change as the Port of Chennai (currently the only handling port for containers to/from Whitefield) encounters capacity constraints. What is not so certain is whether (and which) high priority industrial nodes will in future generate container traffic for rail. The annual container handling capacity of the Whitefield ICD has been estimated at 1.08 million TEU. Thus, the current utilisation of this capacity stands at less than 10% (102,000 TEU/1,080,000 TEU).[99] It is likely, therefore that the terminal will begin to encounter capacity constraints towards the end of the forecast period. In addition, it is likely that some, or all, of the priority nodes will require their own cargo consolidation and clearance facilities, suggesting a need for rail in future to serve new ICDs in the CBIC area.

In the case of car traffic, the railway has a strong opportunity to participate in the future haulage of cars for export from the Toyota factory, and indeed from the premises of other automotive manufacturers in the Bengaluru area. In 2013, Toyota committed an investment of Rs. 900 crore to expand its car output from 210,000 to 310,000 units per year.[100] The General Manager (Transportation) of Ennore Port Limited has indicated that last year Toyota moved 24,000 export cars through his port, which is a small volume as compared with the exports of other car manufacturers through the port (e.g. Nissan with 100,000 units). Toyota is likely to be using rail for domestic distribution but there are currently no rail connected car unloading facilities in Ennore Port.

Toyota export cars are currently moving to Ennore Port by road, possibly on trailers carrying 6 cars. Toyota's competitiveness on regional markets would be improved if its consignments to the port could switch to rail, but this will require the construction of rail- connected loading and unloading facilities at either end, as well as the allocation of efficient auto-carrying wagons to the traffic. The Indian Railways has a commitment as part of its Car Carrying policy to produce and introduce to traffic new bi-level wagons, each carrying up to 12 cars.

The rail haulage of export cars from Bengaluru to Ennore Port is expected to commence by 2017/18 with 50,000 units transported in that year. This volume is expected to grow in the BIS case to about 330,000 units by 2032/33.

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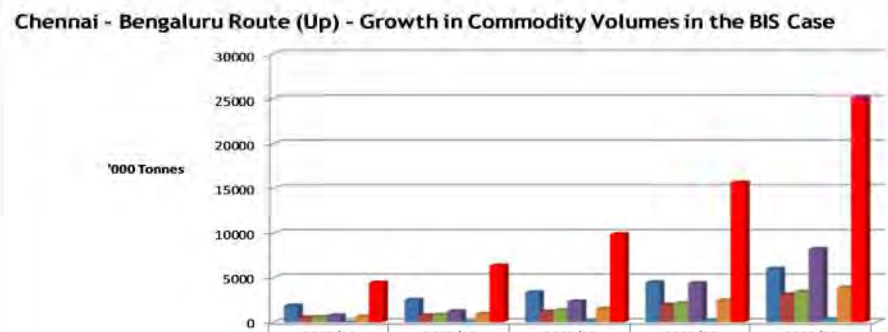
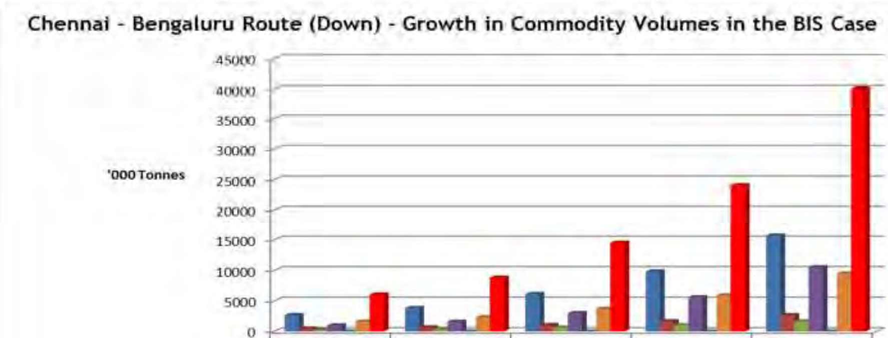
99 Based on information received from the Assistant Operations Manager of the CONCOR Whitefield Terminal (telephone contact 14 February 2014), the current Container Yard capacity is 9,000 TEU. Assuming an average container dwell time of 3 days, the CY stack would turn 120 times per year, resulting in an annual throughput capacity of 9,000 x 120 = 1,080,000 TEU.

100 Press Trust of India, *Toyota to invest Rs 900 Cr to increase production in India,* 06 September 2012.



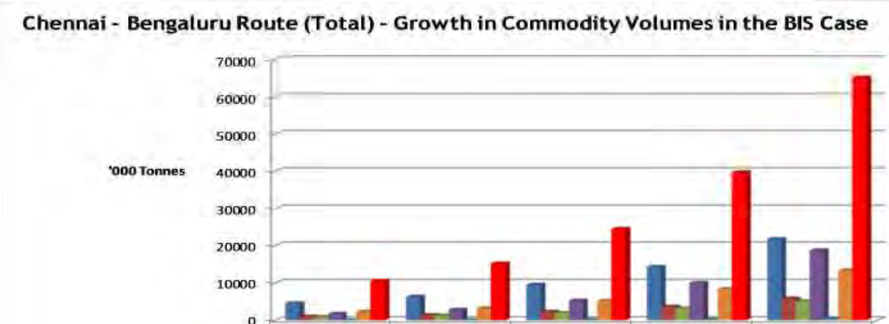
	2012/13	2017/18	2022/23	2027/28	2032/33
Breakbulk/bagged products	1878	2513	3363	4501	6023
Dry bulk (Coal/dolomite/limestone)	538	767	1228	1965	3145
POL/edible oil	591	843	1350	2160	3457
Containers	775	1248	2339	4387	8225
Cars	0	50	94	176	330
Other (e.g. steel)	670	955	1529	2446	3915
Total tonnes (Up)	4452	6376	9903	15635	25095

Figure 6.4.4 Chennai-Bengaluru freight tonnage forecasts (BIS case) - Up Direction



	2012/13	2017/18	2022/23	2027/28	2032/33
Breakbulk/bagged products	2691	3838	6142	9830	15731
Dry bulk (Coal/dolomite/limestone)	462	659	1055	1689	2702
POL/edible oil	281	402	643	1028	1646
Containers	992	1598	2997	5619	10535
Cars	0	0	0	0	0
Other (e.g. steel)	1625	2318	3710	5937	9502
Total tonnes (Down)	6051	8815	14547	24103	40116

Figure 6.4.5 Chennai-Bengaluru freight tonnage forecasts (BIS case) - Down Direction



	2012/13	2017/18	2022/23	2027/28	2032/33
Breakbulk/bagged products	4569	6351	9505	14331	21754
Dry bulk (Coal/dolomite/limestone)	1000	1426	2283	3654	5847
POL/edible oil	872	1245	1993	3188	5103
Containers	1767	2846	5336	10006	18760
Cars	0	50	94	176	330
Other (e.g. steel)	2295	3273	5239	8383	13417
Total tonnes (Up and Down)	10503	15191	24450	39738	65211

Figure 6.4.6 Chennai-Bengaluru freight tonnage forecasts (BIS case) - Both Directions

b. *Passenger forecast*

Data compiled at the zonal level for the three railways operating on the CBIC railway network show that total passenger trips have been growing much faster than the numbers of passenger trains operated on the network (please see Table 6.4.5 below). Between 2008/09 and 2011/12 (the latest year for which data are available), total passenger trips on all three railways grew at a compound rate of 10.2%, from 726.7 to 973.7 million, when the forward capacity analysis indicates an expected annual increase in the number of passenger trains to be operated of only about 3.5%. One reason for this is to be found in the dominance of unreserved trips in the total number of passenger trips in the three railway zones. In 2011/12 unreserved trips accounted for more than 88% of all trips in the three zones, leading to the conclusion that the number of passengers without seat reservations overwhelmed the seating and standing capacity on offer.

Table 6.4.5 Trend in number of passenger trips, 3 zonal railways

Zonal Railway	Year	1st Class AC (1A)	Executive Chair Car (ECC)	2nd Class AC (2A)	3rd Class AC (3A)	1st Class (FC)	AC Chair Car (CC)	Sleeper Class (SL)	Second Sitting (2S)	Total Reserved	Unreserved (II)	Total
Southern Railway (Non Suburban)	2008-09	127,800	20,100	1,907,600	4,949,800	271,700	1,458,100	27,240,400	6,864,100	42,839,600	265,337,800	308,177,400
	2009-10	133,300	28,300	1,975,500	5,424,300	254,100	1,556,600	28,392,400	7,953,600	45,718,100	284,024,900	329,743,000
	2010-11	165,600	31,100	2,273,000	6,123,700	303,600	1,783,900	31,534,000	8,619,400	50,834,300	323,893,500	374,727,800
	2011-12	219,000	33,100	2,682,000	7,045,400	315,600	2,459,300	35,048,700	10,209,800	58,012,900	359,177,400	417,190,300
	CAGR	19.7%	18.1%	12.0%	12.5%	5.1%	19.0%	8.8%	14.2%	10.6%	10.6%	10.6%
South Western Railway	2008-09	37,800	35,300	737,100	1,639,500	25,100	676,100	10,382,300	1,539,400	15,072,600	121,480,800	136,553,400
	2009-10	46,700	33,200	804,700	2,048,800	23,200	632,700	13,515,400	1,992,100	19,096,800	135,379,200	154,476,000
	2010-11	64,300	38,300	943,400	2,418,500	27,300	763,800	12,394,300	2,194,100	18,844,000	151,984,000	170,828,000
	2011-12	74,300	40,500	961,100	2,476,000	29,900	857,200	12,356,000	2,512,800	19,307,800	161,718,300	181,026,100
	CAGR	25.3%	4.7%	9.2%	14.7%	6.0%	8.2%	6.0%	17.7%	8.6%	10.0%	9.9%
South Central Railway	2008-09	81,600	1,200	1,292,600	2,525,800	27,900	575,800	19,931,200	1,825,100	26,261,200	255,718,700	281,979,900
	2009-10	81,600	-	1,377,600	3,011,400	29,100	647,500	21,145,800	2,497,500	28,790,500	269,946,200	298,736,700
	2010-11	96,700	-	1,599,500	3,839,400	20,800	781,100	23,600,000	3,318,900	33,256,400	314,285,300	347,541,700
	2011-12	103,900	3,800	1,679,100	4,194,800	27,400	946,000	24,866,300	4,039,900	35,861,200	339,666,500	375,527,700
	CAGR	8.4%	46.8%	9.1%	18.4%	-0.6%	18.0%	7.7%	30.3%	10.9%	9.9%	10.0%
SR, SWR and SCR combined	2008-09	247,200	56,600	3,937,300	9,115,100	324,700	2,710,000	57,553,900	10,228,600	84,173,400	642,537,300	726,710,700
	2009-10	261,600	61,500	4,157,800	10,484,500	306,400	2,836,800	63,053,600	12,443,200	93,605,400	689,350,300	782,955,700
	2010-11	326,600	69,400	4,815,900	12,381,600	351,700	3,328,800	67,528,300	14,132,400	102,934,700	790,162,800	893,097,500
	2011-12	397,200	77,400	5,322,200	13,716,200	372,900	4,262,500	72,271,000	16,762,500	113,181,900	860,562,200	973,744,100
	CAGR	17.1%	11.0%	10.6%	14.6%	4.7%	16.3%	7.9%	17.9%	10.4%	10.2%	10.2%

Source: Annual Statistical Statements of Indian Railways

Forecasts of passenger trips between Chennai and Bengaluru were prepared for the main purpose of estimating the number of passengers which might be attracted to the proposed High Speed Railway (HSR) from existing premium day-time services.

For this purpose, a request was made to the three zonal railways to provide the trend over the past 5 years in passenger numbers by class of travel for the major railway routes in the corridor.

With the exception of the Southern Railway, the zonal railways were unable to provide the requested data, essentially for the same reason that they were unable to provide OD tonnage data for freight traffic (i.e. the need to compile data from each and every station). The Southern Railway was able to provide data in respect of passenger trips from Chennai to Bengaluru, but only for the current year. Excluded from this data set were passengers boarding and alighting at intermediate stations, since the data are based on ticket sales for passenger trips from Chennai stations to Bengaluru.

The forecasting method involved:

- Doubling the number of passengers travelling in reserved seats from Chennai to Bengaluru in the base year to allow for passengers travelling in the other direction (from Bengaluru to Chennai);

- From the zonal railway historical data (Table 6.4.5), computing weighted average compound annual growth rates which were then applied to selected BAU and BIS growth rates to derive forecast expansion factors for each class of travel;

- Applying these expansion factors to the base data to derive forecasts of passenger numbers by class for the 20 year forecast period, from 2013/14 to 2032/33; and

- Extracting the forecast numbers for the premium classes of travel, to provide estimates of the passenger number which might transfer to HSR services after allowing for a six year construction period.

The BAU and BIS rates assumed for the expansion of passenger volumes from the base year are the same as assumed for the freight forecast (viz. 7.36% for the BAU case and 9.86% for the BI case). It was assumed that only first and second class passengers travelling on air conditioned day services would divert to the HSR. As with freight and capacity forecasts, the Induced case utilised BAU growth rates for the first 5 years and accelerated growth rates subsequently.

The resulting estimates are given in Table 6.4.6 for the BIS case. They show that the transferable volume in the BIS case would grow from 2.7 million to nearly 15.0 million over the timeframe of the study.

It has to be acknowledged that the massive investment likely to be required for the HSR project would require a comprehensive demand analysis to be conducted considering, in addition to the potential for passenger transfer from existing rail services, the transfer of traffic from other modes (bus, car and air), as well as the potential of the project to generate new traffic.

Table 6.4.6 Passenger Traffic Estimates between Chennai and Bengaluru in the BIS Case

Projection of Passenger Volumes for Chennai - Bangalore Traffic in the Business Induced Case (BIC) Scenario

Class of Travel		1st Class AC (1AC)	2nd Class AC (2AC)	3rd Class AC (3AC)	Chair Car (CC)	Executive Chair Car (ECC)	Potential Transfer Traffic to HSR	Second Class (SL)	Second Sitting (2S)	Total Reserved
Growth Rate (BAU)		13.97%	7.50%	8.69%	10.54%	6.61%		5.33%	9.87%	
Growth Rate (BIC)		18.72%	10.05%	11.64%	14.12%	8.86%		7.14%	13.22%	
MAS - SBC in 2013/14		6,345	52,089	94,262	6,62,295	41,923		4,87,473	4,98,993	18,43,378
Total Route traffic		12,689	1,04,177	1,88,523	13,24,591	83,846		9,74,945	9,97,985	36,86,757
Base Year	2012/13	11,134	96,909	1,73,451	11,98,291	78,647		9,25,610	9,08,333	33,92,374
Year 1	2013/14	12,689	1,04,177	1,88,523	13,24,591	83,846	Construction Period for a High-Speed Railway Line	9,74,945	9,97,985	36,86,757
Year 2	2014/15	14,462	1,11,990	2,04,906	14,64,203	89,388		10,26,910	10,96,486	36,86,757
Year 3	2015/16	16,482	1,20,390	2,22,712	16,18,530	95,296		10,81,644	12,04,709	36,86,757
Year 4	2016/17	18,785	1,29,419	2,42,066	17,89,123	1,01,596		11,39,296	13,23,614	36,86,757
Year 5	2017/18	21,409	1,39,125	2,63,102	19,77,696	1,08,311		12,00,020	14,54,255	36,86,757
Year 6	2018/19	25,417	1,53,107	2,93,727	22,56,947	1,17,907		12,85,702	16,46,508	57,79,314
Year 7	2019/20	30,175	1,68,495	3,27,917	25,75,628	1,28,354	27,03,982	13,77,501	18,64,176	64,72,244
Year 8	2020/21	35,823	1,85,428	3,66,086	29,39,307	1,39,726	30,79,033	14,75,854	21,10,620	72,52,845
Year 9	2021/22	42,529	2,04,064	4,08,698	33,54,337	1,52,106	35,06,443	15,81,230	23,89,644	81,32,608
Year 10	2022/23	50,491	2,24,572	4,56,271	38,27,969	1,65,582	39,93,551	16,94,130	27,05,555	91,24,571
Year 11	2023/24	59,943	2,47,142	5,09,381	43,68,478	1,80,253	45,48,731	18,15,091	30,63,229	102,43,517
Year 12	2024/25	71,164	2,71,980	5,68,673	49,85,307	1,96,223	51,81,531	19,44,688	34,68,188	115,06,224
Year 13	2025/26	84,486	2,99,314	6,34,866	56,89,233	2,13,609	59,02,842	20,83,539	39,26,682	129,31,729
Year 14	2026/27	1,00,302	3,29,395	7,08,765	64,92,552	2,32,535	67,25,087	22,32,304	44,45,790	145,41,642
Year 15	2027/28	1,19,079	3,62,499	7,91,265	74,09,301	2,53,137	76,62,438	23,91,690	50,33,523	163,60,494
Year 16	2028/29	1,41,370	3,98,930	8,83,368	84,55,494	2,75,565	87,31,059	25,62,457	56,98,955	184,16,140
Year 17	2029/30	1,67,834	4,39,023	9,86,192	96,49,410	2,99,980	99,49,390	27,45,416	64,52,357	207,40,213
Year 18	2030/31	1,99,253	4,83,144	11,00,985	110,11,906	3,26,558	113,38,465	29,41,439	73,05,358	233,68,645
Year 19	2031/32	2,36,553	5,31,700	12,29,140	125,66,788	3,55,492	129,22,279	31,51,458	82,71,127	263,42,257
Year 20	2032/33	2,80,836	5,85,136	13,72,212	143,41,218	3,86,988	147,28,206	33,76,472	93,64,570	297,07,432
Potential Traffic / Year transferrable to HSR at the end of year 20							**147,28,206**			

c. *Forecast of rail – port traffic*

Forecasts of rail tonnages by broad commodity moved into and out of the four main east coast ports were prepared for both scenarios. Summaries for each of the five commodities for which forecasts were prepared in the "Business Induced" scenario are given in Figure 6.4.7.

The assumptions underlying these forecasts are as follows:

- Containers

The base year TEU volume transported by rail to/from the CONCOR Whitefield terminal was projected at slightly more than the rates of throughput growth used for port throughput forecasts. This was to allow for growth in the rail share of port container traffic. Rail hauled container volume is expected to be handled exclusively at Chennai Port until 2022/23, after which port capacity restrictions will arise. At that time (2027/28 in the BAU case and 2024/25 in the BI case), rail hauled volume will be directed to the other ports in addition to Chennai. Based on the port forecasts, rail volume was distributed to the four ports in the following proportions:

Chennai – 43.8%; Ennore – 21.9%; Kattupalli – 15.6%; Krishnapatnam – 18.6%

- Cars

It was assumed that by 2017/18 Ennore Port would capture most of the car exports from the east coast and that facilities for unloading cars from rail would by then be available in the port. Exports from the Toyota plant in Bengaluru through Ennore Port are running at around 24,000 cars per year. It is expected that by 2017/18 rail could capture this traffic, starting at about 50,000 cars per year.

- Break-bulk (other than cars)

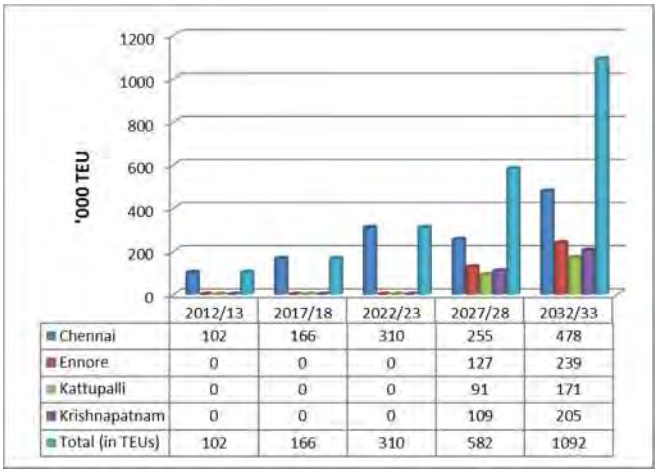
Break-bulk was assumed to include bagged products carried in BCN (covered) wagons. In 2012/13 a total of 533.000 tonnes was moved by rail to and from Chennai Port. Port capacity data indicates that the share of Ennore Port in this traffic is likely to increase. Consequently, it was assumed that by 2027/28, 16% of break-bulk tonnage would be moved by rail through Ennore Port and the balance through Chennai Port.

- Coal

Daily train data, supplemented by information received from the ports, were used to estimate the volumes of coal (both thermal and coking coal) currently moved by rail from Ennore and Krishnapatnam Ports - to Salem and Raichur in the case of Ennore Port and to Raichur and Bellary in the case of Krishnapatnam Port. These volumes were expanded to future years at the BAU and BI growth rates determined in the port forecast.

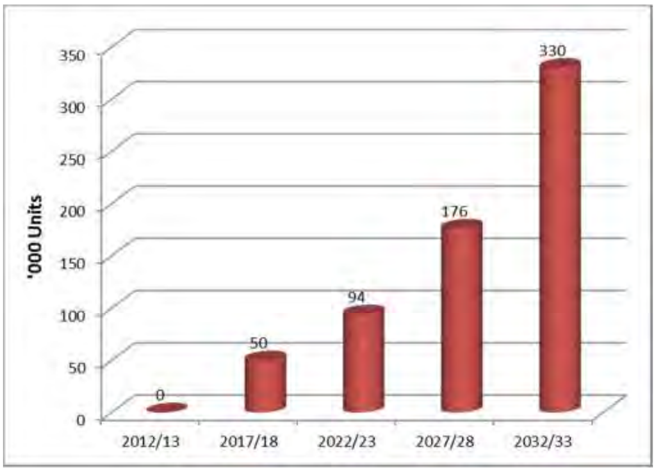
- Other Dry Bulk

Commodities such as limestone and dolomite dominate this category which is moved by rail in BOXN open wagons from Chennai Port to Bengaluru (limestone) and Bellary (dolomite). Daily train data, supplemented by information received from the port were used to assess the tonnages moving respectively to Bengaluru and Bellary. These tonnages were expanded to future years at the BAU and BIS growth rates determined in the port forecast.

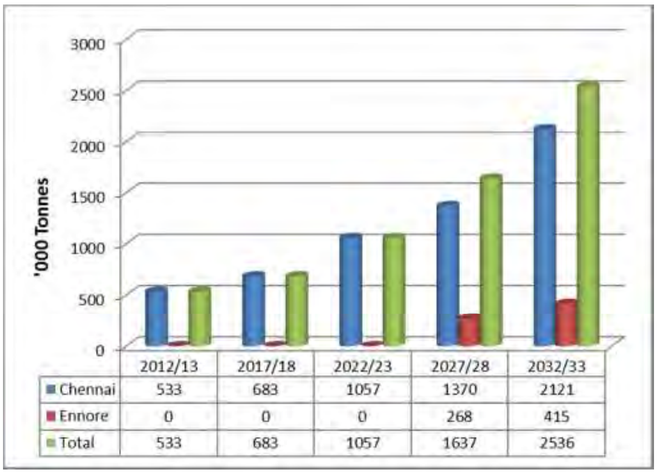


	2012/13	2017/18	2022/23	2027/28	2032/33
Chennai	102	166	310	255	478
Ennore	0	0	0	127	239
Kattupalli	0	0	0	91	171
Krishnapatnam	0	0	0	109	205
Total (in TEUs)	102	166	310	582	1092

(A) Growth in Container Traffic

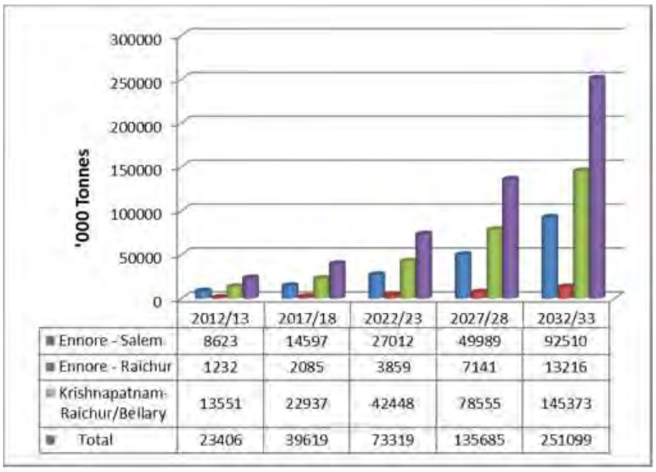


(B) Growth in Car Export Traffic



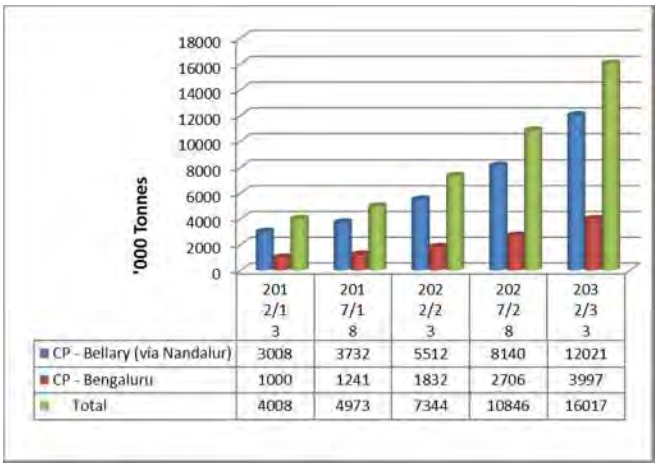
	2012/13	2017/18	2022/23	2027/28	2032/33
Chennai	533	683	1057	1370	2121
Ennore	0	0	0	268	415
Total	533	683	1057	1637	2536

(C) Growth in Break-bulk Traffic



	2012/13	2017/18	2022/23	2027/28	2032/33
Ennore - Salem	8623	14597	27012	49989	92510
Ennore - Raichur	1232	2085	3859	7141	13216
Krishnapatnam-Raichur/Bellary	13551	22937	42448	78555	145373
Total	23406	39619	73319	135685	251099

(D) Growth in Coal Traffic



	201 2/1 3	201 7/1 8	202 2/2 3	202 7/2 8	203 2/3 3
CP - Bellary (via Nandalur)	3008	3732	5512	8140	12021
CP - Bengaluru	1000	1241	1832	2706	3997
Total	4008	4973	7344	10846	16017

(E) Growth in Non-Coal Dry Bulk Traffic

Figure 6.4.7 Projected growth in Rail Traffic by Commodity to and from CBIC Ports (BIS Case)

6.4.3 *Demand/Supply Gaps*

As indicated in Chapter 6.4.1, nearly 37% of the CBIC railway network, in terms of route-km, is already capacity saturated. Capacity saturation can be said to have occurred when the daily number of trains passing through a line section has reached 90% or more of its estimated daily train capacity.

An analysis of the current utilisation of route capacity was undertaken on the basis of information provided by the three zonal railways operating on the CBIC network. The results of this analysis were reported in Interim Report 1. Since railway route capacity utilisation is a dynamic concept, it was necessary to examine the effect of alternative rates of traffic growth on the utilisation of capacity on the 66 line sections comprising the CBIC railway network. For this purpose, forecasts of the daily number of trains passing per direction through each line section were prepared and the methodology discussed in Chapter 6.4.2(ii). In this Chapter, the results of this demand vs. capacity analysis are presented.

(i) Methods for expanding railway route capacity or improving capacity utilisation

Before measures are taken to expand route capacity, it is highly desirable to exhaust all possible means of improving capacity utilisation, such as:

- Increasing train lengths up until the available length in crossing/passing loops and sidings (On the CBIC network it is understood that the standard loop length is 850 metres, enough to accommodate 75 BOXN or 52 BCN wagons);
- Providing freight rate incentives to encourage the back-loading of general purpose wagons (such as BCNs) which would otherwise run empty; or
- Combining rakes of empty wagons in order to reduce train numbers.

It is understood that the Indian Railways has proactively applied these measures, although it is likely that there is scope for further action.

If there is no alternative but to expand railway route capacity, this may be done in a number of different ways, including:

- Electrification, to increase train acceleration and reduce running times;
- Increasing axle loads of rolling stock and track (where necessary);
- Increasing motive power in order to permit heavier and longer trainloads;
- Addition of train passing/crossing loops on single line sections;
- Lengthening of crossing/passing loops and sidings;
- Improving Signalling to allow shorter headways (e.g. upgrading Absolute Block Signalling to Intermediate Block Signalling or to Automatic Signalling);
- Introducing in-cab, or moving block, signalling; and
- Addition of running lines in an operating or block section;

Electrification of the network is advancing. Most of the Southern and South Central Railway sections are already electrified and electrification is underway on several non-electrified lines of the South Western Railway.

Electrification can increase a section's capacity, but has only a limited impact (increasing train numbers by only 2-3 per day). Its main benefits are related more to cost efficiency and reduced environmental impacts.

Increasing axle loads is likely to be a longer term solution, since new rolling stock would have to be provided across the entire Indian Railways system and infrastructure re-construction would take even longer.

It should be noted that replacement of the ABS (Absolute Block Signalling) system with state-of-the-art cab signalling represents a quantum leap. This is not only because the cost of the new technology signalling system is several orders of magnitude higher than that of the system it would replace, but because a major part of the locomotive fleet in India would have to be modified to accept the new system. In this context it should be borne in mind that locomotive resources are pooled and deployed to each zonal railway on the basis of need. Thus adoption of a new technology system is likely to be a very long term solution, perhaps beyond the planning horizon for the CBIC Study.

However, upgrading sections to Intermediate Block or Automatic Signalling can produce some improvements in capacity. The available data suggested that Automatic Signalling produces a 20 to 30% capacity increase. It may not eliminate the need for additional expansion but will delay the need for new running lines.

One additional possibility that can be considered within the Chennai suburban area is the segregation of suburban EMU traffic from long distance passenger and freight traffic. This is already in effect on the Chennai – Villupuram Route, where suburban services run on a dedicated double line from Chennai Beach up to Tambaram. The dedicated lines have much higher capacities (due to the near homogeneity of the services). This is a possible solution for congestion within the Chennai suburban area on the Chennai – Bengaluru line, which is already a quadruple line with automatic signalling between Chennai and Arakkonam. Segregating two lines for suburban services is likely to increase the capacity for suburban services; however it may have impacts on the mainline timetable, since long distance passenger and freight trains would now be restricted to two lines instead of four. The potential for segregation on both the Chennai – Bengaluru and Chennai – Nellore lines should be judged in this context. It has not been possible to undertake a detailed analysis of the impacts of segregation but it could be considered as an alternative where constraints make it difficult to add running lines.

Thus, in the present context of the CBIC network, it is likely that besides upgrading the signalling to Automatic working, the addition of running lines provides the most effective solution for route capacity expansion and this is recognised in the Ministry of Railways infrastructure investment program.

In the longer term, but within the time horizon of the CIBC project, consideration should be given to the possibility that a Dedicated Freight Corridor could be justified between Chennai and Bengaluru, with options to extend further to Krishnapatnam and Goa. A pre-feasibility study of this project was undertaken by RITES but the study has not yet been finalized to the satisfaction of the Ministry of Railways. If the DFC project could be justified it would avoid the need to expand route capacity in the parallel routes of the corridor, since the DFC would remove freight traffic from these lines.

A similar observation may be made about the proposed development of a High Speed Rail Corridor between Chennai and Bengaluru. If this project were to proceed, it would have to be asked whether it would remove passenger traffic from the existing routes, in which case it might also avoid the need to expand their capacity.

(ii) Results of forward utilisation vs. capacity analysis

Forecasts of daily train numbers in both the BAU and BI cases were compared with existing capacity train numbers to determine the timing and length in km of additional running lines required on each line section. Additional running line requirements were identified when forecast train numbers each way on each line section reach 90% of estimated capacity and additional signalling improvements were not possible. The base assumption for this analysis is that a double line can run 100 trains/day in each direction.

This analysis takes into account existing commitments by the Ministry of Railways to add running lines in various sections, as well as line expansion work which is already underway. The resulting requirement for additional running lines *over and above existing commitments* is shown in Table 6.4.7 for the BAU case and the Table 6.4.8 for the BIS case; the tables also indicate when capacity saturation is reached on each route.

Table 6.4.7 Estimated route capacity expansion (in km) (BAU case)

Year	Chennai-Nellore	Athipattu-Ennore Port	Venkatchalam-K Port	Gudur-Arakkonam	Arakkonam-Chengalpattu	**Chennai-Bengaluru**	Chennai Beach-Diamond Junction	Jolarpettai-Salem	Bengaluru-Salem	Chennai-Villupuram	Chennai Beach-Velachery	Renigunta-Villupuram	Bengaluru-Mysore	Bengaluru-Rayadurga	Bengaluru-Dharmavaram	Baiyappanahalli-Yelahanka	Baiyappanahalli-Yeswantpur	Bengaluru-Bangarpet (via Kolar)	Bangarpet-Marikuppam	Chikjajur-Harihar	Pakala-Dharmavaram	Renigunta-Nandalur	**CBIC Total**
2012-13		0.0		0.0	0.0			0.0	0.0		0.0						0.0	0.0	0.0	0.0	0.0	0.0	**547.8**
2013-14	22.4	0.0		0.0	0.0	26.8		0.0	0.0		0.0						0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
2014-15	0.0	0.0		0.0	0.0	0.0	8.6	0.0	0.0	133.6	0.0		138.0	68.3	12.4	15.7	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
2015-16	0.0	0.0	18.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	104.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
2016-17	**38.3**	0.0	0.0	0.0	0.0	**17.4**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**120.5**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**176.3**
2017-18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**96.2**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**96.2**
2018-19	0.0	0.0	0.0	0.0	0.0	**3.9**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**3.9**
2019-20	**25.2**	0.0	0.0	0.0	0.0	**83.7**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**108.9**
2020-21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**195.8**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**195.8**
2021-22	0.0	0.0	0.0	0.0	0.0	**16.7**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**46.6**	0.0	0.0	**15.1**	0.0	0.0	0.0	0.0	0.0	**78.4**
2022-23	0.0	0.0	0.0	0.0	0.0	**78.3**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**78.3**
2023-24	**2.2**	0.0	0.0	0.0	0.0	**1.4**	0.0	0.0	0.0	**4.3**	0.0	0.0	0.0	0.0	**41.5**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**49.4**
2024-25	**38.3**	0.0	0.0	0.0	0.0	**3.9**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**42.2**
2025-26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**3.3**	0.0	**29.1**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**32.5**
2026-27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**116.7**	0.0	0.0	0.0	0.0	0.0	0.0	**53.1**	0.0	0.0	0.0	**16.0**	0.0	0.0	0.0	**185.8**
2027-28	**0.7**	0.0	0.0	0.0	0.0	**16.7**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**17.4**
2028-29	**35.2**	0.0	0.0	**11.3**	**62.5**	**113.6**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**222.6**
2029-30	**27.4**	0.0	0.0	0.0	0.0	**26.8**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**54.3**
2030-31	0.0	0.0	0.0	0.0	0.0	**66.2**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**85.4**	**151.6**
2031-32	**18.0**	0.0	0.0	0.0	0.0	**46.9**	0.0	0.0	0.0	**30.7**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**95.5**
2032-33	0.0	0.0	0.0	**53.6**	0.0	**10.5**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**64.1**
20 year Total	**207.7**	**0.0**	**18.0**	**64.9**	**62.5**	**512.9**	**8.6**	**120.0**	**195.8**	**197.8**	**0.0**	**104.0**	**138.0**	**211.1**	**227.5**	**15.7**	**15.1**	**0.0**	**16.0**	**0.0**	**0.0**	**85.4**	**2200.9**
Above Committe	**185.3**	**0.0**	**0.0**	**64.9**	**62.5**	**486.0**	**0.0**	**120.0**	**195.8**	**64.2**	**0.0**	**0.0**	**0.0**	**142.8**	**215.1**	**0.0**	**15.1**	**0.0**	**16.0**	**0.0**	**0.0**	**85.4**	**1653.1**
Route km	174.4	6.0	18.0	149.3	62.5	353.6	10.8	120.0	195.8	162.8	19.3	274.1	138.0	325.7	227.5	15.7	15.1	148.2	16.0	59.6	227.4	85.4	2805.2
Exp./route	106%	0%	0%	43%	100%	137%	0%	100%	100%	39%	0%	0%	0%	44%	95%	0%	100%	0%	100%	0%	0%	100%	59%

Indicates capacity saturated routes for which running line expansion already committed or in progress (548 km)	Note: Capacity saturation occurs when the number of trains each way exceeds 90% of estimated daily train capacity.
Indicates capacity saturated routes requiring running line expansion over and above existing commitments (1653 Km)	

Observations on capacity saturation in the BAU Case

- It is extremely important to note that existing utilisation levels are so high in certain sections that they would suffer constraints even if future growth was along the lines of the BAU case itself.
- Table 6.4.7 shows that of the network's 22 routes, 10 are already exceeding their capacity, another 1 will be capacity saturated by 2020/21, 1 more route will be saturated by 2021/22, 1 more route by 2025/26, another 1 by 2026/27, 2 additional routes by 2028/29 and 1 other route by 2030/31.
- Assuming that signalling efficiency can be improved to allow a double line with automatic signalling to run 100 trains a day each way, 5 out of the 22 routes will not require any capacity expansion within the 20 year forecast period.
- Over and above the capacity expansion to which the MoR is already committed, a requirement to add 1,653 km of running lines to the existing route length of 2,806 km over the forecast period has been identified (i.e. 59% of current route length).
- Even at BAU growth levels, the Chennai – Bengaluru route would need nearly 486 km (excluding the 26.8 km committed) or 137% of its current length. More than half of this additional capacity will be required in the sections between Arakkonam and Jolarpettai. This indicates the extremely high utilisation levels on this corridor, especially since Arakkonam, Katpadi and Jolarpet are all major junctions with a lot of through traffic from other lines.

Table 6.4.8 Estimated route capacity expansion (in km) (BIS case)

Year	Chennai-Nellore	Athipattu-Ennore Port	Venkatchalam-K Port	Gudur-Arakkonam	Arakkonam-Chengalpattu	**Chennai-Bengaluru**	Chennai Beach-Diamond Junction	Jolarpettai-Salem	Bengaluru-Salem	Chennai-Villupuram	Chennai Beach-Velachery	Renigunta-Villupuram	Bengaluru-Mysore	Bengaluru-Rayadurga	Bengaluru-Dharmavaram	Baiyappanahalli-Yelahanka	Baiyappanahalli-Yeswantpur	Bengaluru-Bangarpet (via Kolar)	Bangarpet-Marikuppam	Chikjajur-Harihar	Pakala-Dharmavaram	Renigunta-Nandalur	**CBIC Total**
2012-13		0.0		0.0	0.0			0.0	0.0		0.0						0.0	0.0	0.0	0.0	0.0	0.0	547.8
2013-14	22.4	0.0		0.0	0.0	26.8		0.0	0.0		0.0						0.0	0.0	0.0	0.0	0.0	0.0	0.0
2014-15	0.0	0.0		0.0	0.0	0.0	8.6	0.0	0.0	133.6	0.0		138.0	68.3	12.4	15.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2015-16	0.0	0.0	18.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	104.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2016-17	38.3	0.0	0.0	0.0	0.0	17.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	120.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	176.3
2017-18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	96.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	96.2
2018-19	25.2	0.0	0.0	0.0	0.0	87.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	112.8
2019-20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	195.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	195.8
2020-21	0.0	0.0	0.0	0.0	0.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	46.6	0.0	0.0	15.1	0.0	0.0	0.0	0.0	0.0	78.4
2021-22	2.2	0.0	0.0	0.0	0.0	62.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	106.0
2022-23	0.0	0.0	0.0	0.0	0.0	17.4	0.0	0.0	0.0	4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.7
2023-24	38.3	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41.7
2024-25	0.0	0.0	0.0	11.3	0.0	3.9	0.0	116.7	0.0	29.1	0.0	0.0	0.0	0.0	53.1	0.0	0.0	0.0	16.0	0.0	0.0	0.0	230.2
2025-26	35.9	0.0	0.0	0.0	62.5	96.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	194.6
2026-27	25.2	0.0	0.0	0.0	0.0	43.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	68.8
2027-28	2.2	0.0	0.0	0.0	0.0	109.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	85.4	196.8
2028-29	18.0	0.0	0.0	53.6	0.0	27.9	0.0	0.0	0.0	30.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	130.1
2029-30	54.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	54.9
2030-31	0.0	0.0	0.0	0.0	0.0	3.9	0.0	120.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	124.0
2031-32	0.0	0.0	0.0	11.3	0.0	183.3	0.0	0.0	0.0	29.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	223.8
2032-33	60.4	0.0	0.0	1.4	0.0	16.7	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	81.1
20 year Total	**323.0**	**0.0**	**18.0**	**77.6**	**62.5**	**712.9**	**11.1**	**240.1**	**195.8**	**226.9**	**0.0**	**104.0**	**138.0**	**211.1**	**227.5**	**15.7**	**15.1**	**0.0**	**16.0**	**0.0**	**0.0**	**85.4**	**2680.6**
Above Committed	**300.6**	**0.0**	**0.0**	**77.6**	**62.5**	**686.1**	**2.6**	**240.1**	**195.8**	**93.3**	**0.0**	**0.0**	**0.0**	**142.8**	**215.1**	**0.0**	**15.1**	**0.0**	**16.0**	**0.0**	**0.0**	**85.4**	**2132.8**
Route km	174.4	6.0	18.0	149.3	62.5	353.6	10.8	120.0	195.8	162.8	19.3	274.1	138.0	325.7	227.5	15.7	15.1	148.2	16.0	59.6	227.4	85.4	2805.2
Exp./route	172%	0%	0%	52%	100%	194%	24%	200%	100%	57%	0%	0%	0%	44%	95%	0%	100%	0%	100%	0%	0%	100%	76%

Indicates capacity saturated routes for which running line expansion already committed or in progress (548 km)

Indicates capacity saturated routes requiring running line expansion over and above existing commitments (2133 Km)

Note: Capacity saturation occurs when the number of trains each way exceeds 90% of estimated daily train capacity.

Sources: Base year utilisation and capacity data –Zonal Railways; Forward analysis – JICA Study Team

<u>Observations on capacity saturation in the BIS case</u>

- Table 6.4.8 shows that of the network's 22 routes, 10 are already exceeding their capacity, another 1 will be capacity saturated by 2019/20, while another 1 will exceed its capacity before 2020/21, 1 more route by 2023/24, 2 more routes by 2024/25, 1 additional route by 2025/26 and 1 more by 2027/28.

- Again, assuming that a double line with automatic signalling can run 100 trains a day each way, 5 out of the 22 routes will not require any capacity expansion within the 20 year forecast period.

- Over and above the capacity expansion to which the MoR is already committed, a requirement to add 2133 km of running lines to the existing route length of 2,806 km over the forecast period has been identified (i.e. 76% of current route length).

- The Chennai-Bengaluru route will require the addition of 686 km of running lines over the forecast period (excluding the 26.8 km committed), equivalent to 194% of its route length. Again, more than half of this additional capacity will be required in the sections between Arakkonam and Jolarpettai.

MoR are also constructing or planning to build a number of new lines in the CBIC area. Due to the lack of Origin – Destination data it was not possible to identify how much existing traffic would shift to the new lines but it is likely that the identified expansion requirements would be reduced once the new lines are in operation.

Figure 6.4.8 illustrates the locations of the capacity expansion required in the BIS case in 5 year periods. It will be observed that major routes have been coloured orange indicating that capacity increments will be required before 2017/18, above what is already committed.

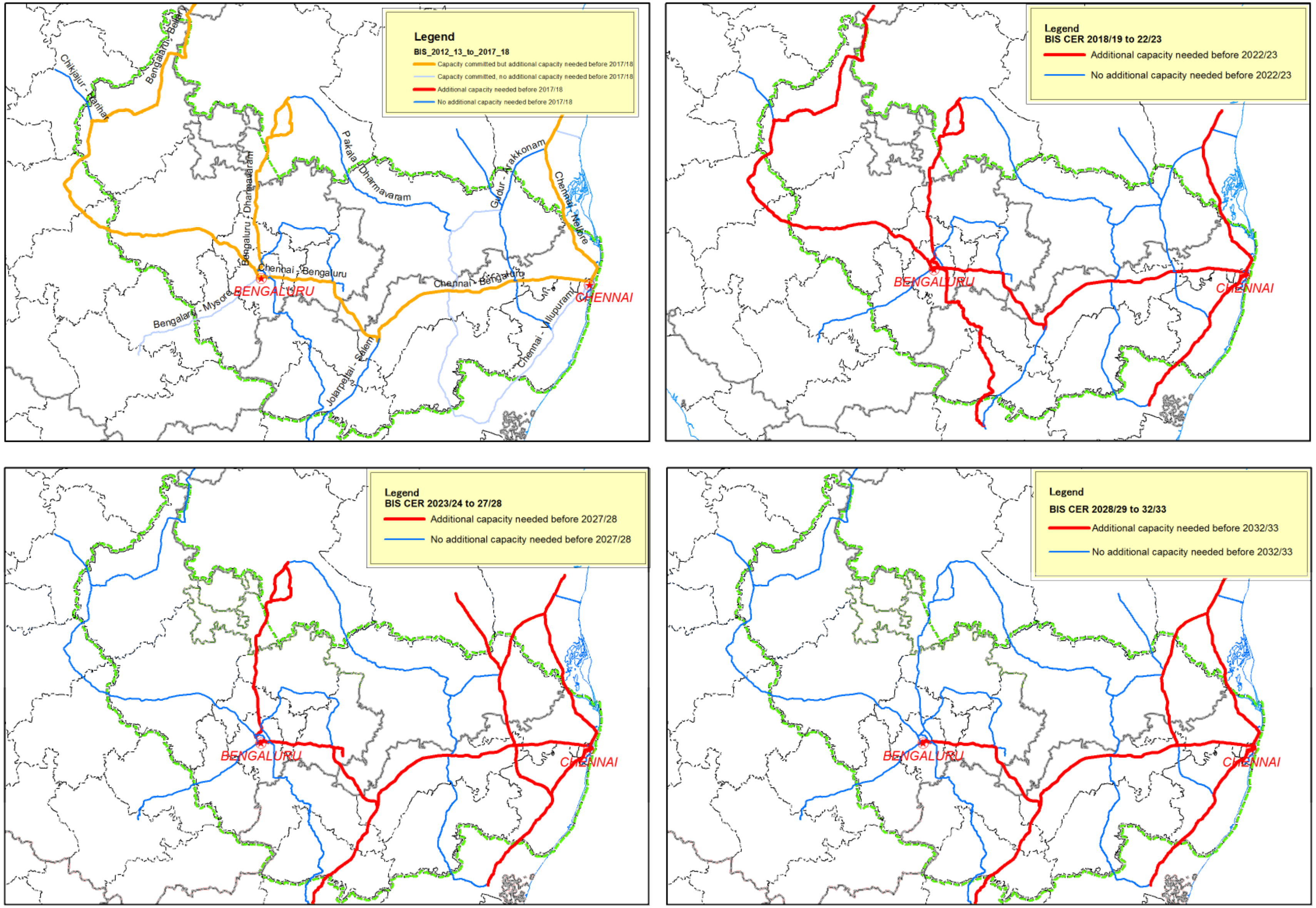


Figure 6.4.8 Capacity Expansion required in 5-year periods (BIS Case)

(iii) Summary of Results and Sensitivity Analysis

The results of the capacity analysis are summarised below.

Table 6.4.9 Summary of Capacity Expansion (D/L = 100 trains/day)

Business Case	Short Term (km)	Medium Term (km)	Long Term (km)	Total (km)
BAU	272.4	465.2	915.4	1653.0
BIS	272.4	514.6	1345.7	2132.7

The results indicated above are for the base analysis which assumed that a double line with automatic signalling could run 100 trains/day in each direction. However, depending on the operating conditions for each section, the actual capacity may vary. As part of a sensitivity analysis, a lower capacity value of 90 trains/day was assumed and the expansion required calculated. The results for this are indicated below.

Table 6.4.10 Summary of Capacity Expansion (D/L = 90 trains/day)

Business Case	Short Term (km)	Medium Term (km)	Long Term (km)	Total (km)
BAU	385.2	439.8	984.0	1809.0
BIS	385.2	594.0	1460.8	2440.0

As can be seen, assuming a lower value in turn increases the capacity expansion required across the CBIC network. In the BAU Case, an additional 156 track kilometres over 20 years would be required (1809 km instead of 1653 km). The BIS case would require 2440 km, 307 kilometres more than in the initial analysis (2133 km).

The base case of a 100 trains/day represents the maximum capacity of a double line with automatic signalling. For the purposes of this analysis, it was assumed that the efficiency of all sectors could be improved to attain this figure. The practical capacity of a section may vary as it may be affected by a number of factors including the existing timetable, speed restrictions, length of blocks, existence of passing loops and sidings etc. The results for the main route in the CBIC area, the Chennai – Bengaluru main line, are indicated below.

Table 6.4.11 Capacity Expansion for the Chennai – Bengaluru Route

Capacity of Double Line	Business Case	Short Term (km)	Medium Term (km)	Long Term (km)	Total (km)
100 Trains/day	BAU	17.4	182.6	286.1	486.1
	BIS	17.4	184.0	484.7	686.1
90 Trains/day	BAU	105.0	100.3	318.8	524.1
	BIS	105.0	100.3	577.0	782.3

As is the case with the network as a whole, assuming a lower capacity of 90 trains/day increases the capacity expansion requirement for both the BAU and BIS cases. When assuming 100 trains/day, the short term requirement for the Chennai – Bengaluru line is considerably lower; this is because it is assumed that the efficiency of the existing lines can be improved before considering adding new lines. However, if the capacity of a double line is assumed to be 90 trains/day there will be increased short term requirements on the Chennai – Bengaluru main line because most sections are already near this capacity.

6.4.4 *Infrastructure Development Strategy*

Railway development strategy proposed for CBIC

Six strategies are proposed for the development of railway infrastructure within CBIC:

(i) *Expand railway route capacity* to satisfy increased freight and passenger demand

(ii) *Connect the railway to industrial nodes* being proposed for accelerated development

(iii) *Improve railway connectivity* of major east coast ports

(iv) *Apply rolling stock and commercial strategies* to attract high potential freight customers to rail

(v) *Consider construction of a Dedicated Freight Corridor* (DFC) between Chennai/Ennore/Krishnapatnam and Bengaluru (with provision for future extension to Goa)

(vi) *Consider construction of a High Speed Passenger Railway* (HSR) between Chennai and Bengaluru

(i) Expansion of railway route capacity

As indicated in Chapter 6.4.3(ii), realisation of "Business Induced" growth will require the addition of running lines to all but five routes in the CBIC railway network. Altogether, 2,133 km of additional running lines will need to be constructed over the 20 year forecast period (2012/13-2032/33) to satisfy freight and passenger demand which would be generated due to the accelerated development of the CBIC area.

Again, it should be noted that 1,653 km of additional running lines would be required anyway even if accelerated growth was not realised across the same time period.

(ii) Connection of the railway to all high priority industrial nodes

The existing CBIC railway network passes through all 8 high priority industrial nodes identified by the JICA study team, these being:

- Ponneri
- Hosur
- Bidadi
- Tumkur
- Mulbagal (Kolar)
- Hindupur
- Kalikiri
- Krishnapatnam

However, the locations of major industries and multimodal logistics centres within these nodes have yet to be identified; hence it is not yet possible to plan access lines and sidings to connect with these sites.

New lines proposed for improved rail access to industrial nodes are shown in Figure 6.4.9. They include:

- A link line between Avadi (Chennai-Bengaluru mainline) and Guduvancheri (Chennai-Villupuram mainline) to serve a dry port and industries (mainly car production) in Sriperambadur, Irungadukottai and Oragadam. This line, including a spur line to connect with the Hyundai plant at Irungadukottai, will have a length 73 km with a capital cost estimated at Rs. 893.41 Crore in 2013/14 prices. A final alignment survey is underway and detailed cost estimates are being prepared. Construction can be expected by 2017/18. The line will facilitate the domestic distribution of cars manufactured at the Hyundai, Renault/Nissan and Ford plants, but is too close to Chennai to permit economic rail haulage of export cars to the ports.

- A direct rail link between Tumkur and Chitradurga, to be provided as part of a new single track, non-electrified line between Tumkur and Davangere. The line will have a length of 200 km and a capital cost estimated at Rs. 1,837.58 Crore in 2011/12 prices. Construction has yet to start but completion is expected by 2017/18. The line may be expected to reduce rail haulage costs (and ultimately, freight charges) for domestic distribution of output from plants in the Tumkur node.

- A direct rail link between Tumkur and Rayadurga. This line will be single track and non-electrified with a length of 212 km. The most recent available cost estimate for this project is Rs. 970.34 Crore in 2007/08 prices. Construction has started and completion is expected by 2017/18. As in the case of the Tumkur – Davangere line, this line may be expected in the longer term to reduce rail haulage costs and charges, for the benefit of industry to be attracted to Tumkur.

- A direct rail link between Whitefield and Kolar. This line will be single track and non-electrified with a length of 53 km and a capital cost of Rs. 354 Crore. It will provide a connection between the Whitefield Freight Terminal and the proposed new industrial node at Kolar. Initial planning is underway and it is likely that the line would be constructed within the period 2018/19 – 2022/23. In the longer term, the line could be part of a Bengaluru-Cuddapah railway route.

- Jolarpettai-Hosur Line. This project is currently at the initial proposal stage, but is intended to provide a direct connection between the high priority industrial node proposed for Hosur and the Bengaluru-Chennai mainline (giving it access to the Gateway ports). It is likely to be around 90 km long; however, no cost estimates are available.

Additionally, a number of other lines are also in various stages of construction or planning. These include:

- Tindivanam – Nagari Line (under construction)
- Bengaluru – Hassan Line (under construction)
- Bengaluru – Chamrajanagar Line (under construction)
- Tindivanam – Tiruvannamalai Line (committed)
- Chikballapur – Gowribidanur Line (under study)
- Chikballapur – Puttaparthi Line (under study)
- Dharmapuri – Morappur Line (under study)

These lines do not serve any CBIC area nodes or ports but are included in the map below, which indicates all projects currently under construction, committed or under study within the CBIC Area. The costs of these new lines have not been included in the estimates given in Chapter 6.4.7.

Note: The alignments of 'new lines' shown in Figure 6.4.9 are for representative purposes only. Exact alignments may vary.

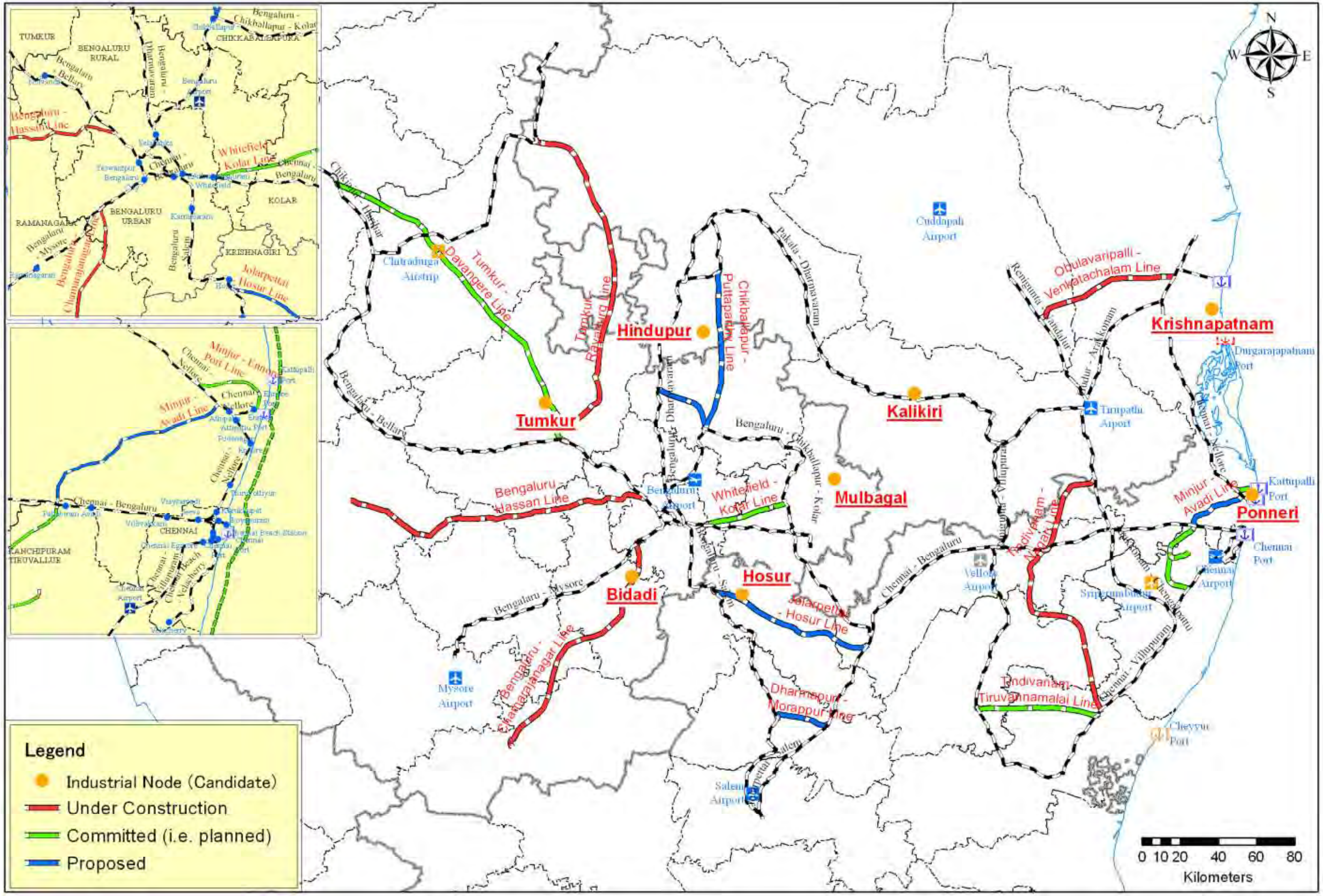


Figure 6.4.9 New lines committed, planned or proposed for the CBIC Area

(iii) Improving rail connectivity of major east coast ports

Improvement of the rail connectivity of major east coast ports will be a prerequisite for a modal shift of container, break-bulk and (possibly) POL traffic from road to rail. This improvement will be achieved in two ways: through capacity expansion of existing access lines to Chennai and Krishnapatnam ports and through the construction of new lines to improve access to Ennore Port from the north and Bengaluru and to Krishnapatnam Port from Bengaluru.

Details of projects underway, committed or proposed are as follows:

- Chennai Port rail capacity expansion

Rail access to Chennai Port is currently provided by two running lines between Chennai Beach and Korukkupet. Traffic on these lines is currently equal to 113% of capacity and rail evacuation capacity is estimated to be restricted to approximately 10 million tonnes per annum (the cargo volume moved into or out of the port by rail in 2012/13).

The Railways are committed to constructing an additional two running lines in the section between Chennai Beach and Korukkupet. This is expected to increase daily capacity from 43 to 143 in each direction, but *the benefits of this capacity expansion will only be realised when improvements to the internal port rail layout can be made* to allow full length container trains (45 BLCA) to access Container Terminals I and II in the port.

At the growth rate expected in the BAU scenario (7.36% per annum), this expansion will provide sufficient capacity up until 2032/33, but if the accelerated growth of the BIS case is realised, the line will be close to saturation by 2032/33, possibly requiring a fifth running line in the years beyond. In this case, land availability is likely to become a problem, since no more land is available in the railway ROW; the ChPT had to make land available for construction of the 3rd and 4th running lines.

Construction work is yet to commence, but can be expected to be complete by 2017/18. Based on cost estimates provided by MoR, the cost of capacity expansion between Chennai Beach and Korukkupet is expected to be of the order of Rs. 76.00 Crore.

- Krishnapatnam Port rail capacity expansion

Rail access to Krishnapatnam Port is provided by an 18 km long single track non-electrified line which branches off from the Chennai-Nellore mainline at Venkatachalam. The line has been in operation since 2010; work to double and electrify the line has been completed at an estimated cost of Rs. 87.00 Crore and is awaiting operational clearance. With growth at the level of the BAU forecast, this expansion will provide sufficient capacity up until 2032/33, but in the accelerated scenario some additional improvements such as automatic signalling may be required.

- Extension of Krishnapatnam Port access line to Obulavaripalli on the Renigunta-Nandalur mainline

Construction of this line would allow traffic between the p0rt and stations to the northwest to by-pass the congested Gudur-Renigunta section and improve port access for traffic to/from Bellary/Hospet. The line will have a length of 113 km and a cost, estimated at 2006/07 prices, of Rs. 930 Crore. The line is currently being constructed and is likely to be completed by 2017/18.

In the longer term, it could form part of a direct Bengaluru-Krishnapatnam line (via Cuddapah). A later, more detailed appraisal of projects identified in this report should consider all feasible options for a direct Bengaluru-Krishnapatnam rail connection, including the possibility of routing a DFC via Krishnapatnam.

- Northern access line to Ennore Port

The current access line to Ennore Port enters the port from the south, from a junction on the Chennai-Nellore mainline between Athipattu and Athipattu Pudunagar stations. The line is linked to the coal handling yard, but not to the site of the future container terminals. Approximately 8 trains per day haul coal out of the port to Salem and Raichur, with a routing through Chennai. Construction of a northern access line with a length of 12 km, entering the Chennai-Nellore mainline near Anupampattu would increase capacity, provide better access for northbound traffic from the port and provide access to the future container terminals. The capital cost of this project is estimated at Rs. 150 Crore and construction is likely to be completed before 2017/18.

- Ennore Port-Avadi Line (ORR alignment)

This line would follow the alignment of Phase 2 of the Outer Ring Road but unlike the road would run at grade for its entire length of 32 km. It will be a double track electrified line which will occupy up to 22 metres of the width of the highway ROW. A preliminary estimate of the cost is Rs. 7.5 Crore per km or Rs. 240 Crore in total.

The railway project will be financed by Ennore Port Ltd. Its major benefit would be to permit all traffic proceeding from the Bengaluru-Chennai line to the Chennai-Nellore line, or vice-versa, to by-pass Chennai. If the project can be developed under a BOT contract, it is likely that it can be completed and in service within about 4 years.

Consideration should be given to routing the proposed DFC via the Outer Ring Road alignment to terminate in Ennore Port, with a possibility of extension to Krishnapatnam Port.

It is important to recognize that the mere connection of ports to rail ***will not of itself realise a modal shift of port traffic from road to rail.*** Owing to the fact that in most ports (even in the most recently developed ports such as Krishnapatnam) container loading/unloading sidings are located far from the container stacks, rail will incur double handling penalties. This is because movement of containers between the rail sidings and the container stacks will be done by port prime movers and trailers. Very often, rail can suffer a penalty of three container lifts to every one for road. In Chennai Port, CONCOR pays an additional charge of Rs. 1,100 per container handling to cover the cost of additional lifts.

Wherever not precluded by existing port development, action must be taken to eliminate double handling of containers between the rail sidings and container stack in ports. An opportunity is presented in new port developments, such as the proposed Multipurpose Terminal in Chennai Port, to opt for a port layout which would place railway tracks and a dual lane roadway in the middle of a container stacking area, rather than to the outside. With this arrangement large portal cranes would span the rail tracks the roadway and the container stacks and containers would be lifted directly from wagons and road trailers into the container stack.

(iv) Application of rolling stock and commercial strategies to attract new traffic to rail

Containers and cars represent new high potential traffic opportunities for rail. Realisation of these opportunities will depend upon the application of commercial pricing strategies, as well as the introduction of new efficient rolling stock, with the objective of minimizing customer logistics costs.

a. Containers

Within the corridor, containers are currently moved by rail exclusively on behalf of CONCOR which pays an access charge to IR. There is no evidence that containers are moving long distances by road to the port, although this possibility cannot be discounted. It is important, therefore, that access charges allow the charges of CONCOR, and of future private operators, to remain competitive with the charges of road transport operators.

Subject to the constraints of structure and moving gauges between Chennai and Bengaluru, consideration should be given to introducing double stack container wagons in the corridor, as they have the potential to reduce rail haulage costs by about 40%. Such an initiative should certainly be considered in the context of the proposed Chennai-Bengaluru DFC.

b. Cars

A substantial new traffic opportunity for rail exists in the haulage of cars manufactured in the CBIC area. The Indian Railways has an Auto Freight Policy[101] and plans to introduce into service new bi-level auto-carrier wagons within the first quarter of the current year. These wagons will be operated in rakes of 27, each rake carrying 318 small cars. They will replace NMG wagons which were converted from old passenger stock and could carry only 125 cars per rake. They will have a considerable advantage over auto-carrying trailer trucks which can carry only 6-8 cars each.

Notwithstanding rail's potential advantages over road in terms of the efficient long–haul movement of cars, it will be necessary to maintain rail haulage charges at a competitive level with road charges if there is to be a significant modal shift of this traffic from road to rail.

(v) Consideration of a Dedicated Freight Corridor

a. Studies commissioned by the MoR

The Chennai-Bengaluru DFC project is one of two such projects currently being considered by the Ministry of Railways to link Chennai to the west. The other is a DFC linking Chennai with Goa, via a more northerly alignment.

RITES has recently undertaken a Pre-feasibility Study of the Chennai-Bengaluru project. This involved an assessment of its commercial potential and did not include an investigation of its alignment issues. The Chennai-Goa project, on the other hand has already been subjected to a Preliminary Engineering and Technical Study, or PETS, an essential feature of which is an alignment survey. Consequently, a proposed alignment has yet to be determined for the Chennai-Bengaluru DFC, although it was suggested in meetings with DFCCIL personnel that the DFC would follow existing railway alignments wherever possible and would have connections to both Chennai and Ennore Ports, either directly or through "'feeders".[102]

The Ministry of Railways released a copy of the PFS for the Chennai-Bengaluru project to the JICA Study Team in early March 2014 as RITES had to conclude the study to the satisfaction of the MOR.

b. Probable benefits of the DFC

The DFC is likely to have significant benefits for the development of manufacturing industry in the CBIC Area.

These benefits are likely to flow in the form of substantially reduced rail haulage costs which will ultimately result in reduced haulage charges, which will increase the competitiveness of industries in the corridor.

Reduced unit haulage costs are likely to be generated by:

- Increased average speeds - the DFC can be expected to double the current average speeds of freight trains, from 25 km per hour to 50-60 km per hour which will halve running time between Chennai and Bengaluru from 14.32 hours to 7.16 hours;

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[101] Auto Freight Train Operator Scheme, Freight Marketing Circular No 2 of 2013, Indian Railways (http://www.indianrailways.gov.in/railwayboard/uploads/directorate/traffic_comm/Freight-Mktg-2k13/FM_02.pdf).

[102] Meeting with HD Gujrati, Director Operations and Business Development. DFCCIL, Delhi 22 November 2013.

- Increased train lengths – the DFC could accept up to 100 wagons per train, when the current average is about 54; and

- Possible introduction of double stack container wagons which would reduce unit haulage costs by at least 40%

In addition, the transfer of freight traffic to the DFC will release capacity on the existing Chennai-Bengaluru line in two ways, by:

- Reducing the number of trains per day on the route; and

- Increasing average passenger train speeds

c. Effect of a DFC on capacity expansion requirements

As part of this analysis, an exercise to identify the potential effects of a Dedicated Freight Corridor on the main line was undertaken. This is a theoretical exercise that is intended to provide a quantitative idea of how much capacity expansion a Dedicated Freight Corridor could save. It is based on the following assumptions:

- The Dedicated Freight Corridor will be completed by 2022/23, allowing for full operations from 2023/24 onwards.

- The freight projections in this report have identified the number of trains running between Chennai and Bengaluru in each 5-year period. It is assumed that a percentage of the freight trains running on the Chennai – Bengaluru line in 2022/23 will transfer immediately to the newly completed DFC.

- The analysis has considered two cases – one where 50% of the through-freight transfers to the DFC and one where 80% transfers to the DFC.

- The impact on the main line in terms of capacity will be an increase in the number of trains each section can handle by a factor of 1.5 (i.e. every freight train that shifts to the DFC can be replaced by 1.5 passenger trains on the main line). This is due to the higher average speeds of passenger trains, allowing more trains to be run in the place of the freight trains that have been shifted to the DFC.

The results of the two cases and a comparison with a scenario where the DFC is not built are indicated below. If the DFC is not built, the capacity expansion will be along the lines indicated earlier in Table 6.4.7 and Table 6.4.8.

Table 6.4.12 Reduction in Capacity Expansion for Chennai – Bengaluru main line due to construction of a Dedicated Freight Corridor

Growth Case	Capacity required in Kilometres for 20-year period up to 2032/33		
	Dedicated Freight Corridor not built	Dedicated Freight Corridor built by 2023	
		50% of Freight transferred	80% of Freight transferred
Business As Usual	486.1	352.4	321.7
Business Induced Scenario	686.1	483.3	426.4

The results indicate that a Dedicated Freight Corridor would reduce the need for capacity expansion in both the BAU and BIS cases.

If 50% of the through-freight is transferred to a DFC, the capacity expansion needed on the main-line would come down by nearly 134 km in the BAU case and 203 km in the BIS case. If 80% of the freight is transferred, the BAU requirement would be lower by around 164 km, while the BIS case would need 260 km less than if it was not built.

It should be kept in mind that this considers only the transfer of through freight between Chennai and Bengaluru. Other freight traffic (from other origins and destinations) also uses the main line (such as Ennore – Salem traffic) and it is possible in theory that the DFC could attract some of this traffic also, depending on the connectivity of feeder routes and spur lines. However, as noted below, the practicality of such feeder services needs to be examined, as the feasibility will depend on the distances.

d. Concept and alignment options

The efficiency of DFC operation will be promoted if the DFC route can be terminal to terminal, e.g. from Chennai/Ennore Ports and from the main Goods Yard at Korukkupet to the Whitefield Container Terminal near Bengaluru. Feeder lines to/from the DFC may not be a practical alternative due to short rail hauls and the need to have transfer facilities in terminals.

The possibility of extending the DFC to Krishnapatnam port is worthy of detailed consideration. There may be an option to route the DFC via the Outer Ring Road alignment with branches terminating at Ennore and Krishnapatnam ports.

There is some doubt that the existing railway ROW will have sufficient width to accommodate a DFC. The land take for the DFC might be minimized if it could be aligned to run beside highways, with an obvious candidate being the proposed Chennai-Bengaluru Expressway. If the Expressway does proceed, it is understood that a reservation of 20 m width could be available for DFC development along the expressway alignment. In this situation, the DFC would have to run at grade and, as necessary, through cuttings to ease gradients.

Comparative technical standards are as follows:

Table 6.4.13 Design Standards for Expressways and Dedicated Freight Corridors

Standard	Expressway	DFC
Length	270 km	Not Available
ROW width	90 m (70 m for Expressway and Service roads)	13-5 m (min in cutting for double track DFC)
Curve radii (min)	1,000 m	292 m (700 m recommended)
Gradient (max) ruling grade for DFC	3%	0.5%

e. Potential demand for a Chennai-Bengaluru DFC

It has not been possible as part of this study to undertake a comprehensive assessment of the potential demand for the DFC. In addition to accommodating through freight traffic transferred from the existing line, the DFC can be expected to divert long distance freight from road, as well as to generate new traffic in combination with accelerated industrial growth in the corridor.

In the "Business as Usual" case, through freight volume on the Chennai-Bengaluru line was forecast to grow from 10.5 million tonnes in 2012/13 to 46.5 million tonnes in 2032/33. In the "Business Induced" case, through freight volume was expected to reach 65.2 million tonnes by 2032/33. These forecasts are considered to underestimate the potential demand for a DFC since they include only "normal" freight traffic and exclude traffic diverted from road and generated traffic.

It is uncertain whether a Year 20 traffic volume of 65 million tonnes will be sufficient to justify the likely level of investment in a Chennai-Bengaluru DFC project. Although the required level of investment has not yet been established with any confidence, information provided to the consultants by the MoR suggests that a higher level of traffic might be needed to justify investment in the project.[103]

For this reason, **it is essential that a comprehensive forecast, which is inclusive of potential freight volume from all sources of demand for a DFC is undertaken during a later stage of this project**.

(vi) Consideration of a High Speed Railway

A High Speed Railway has been proposed for the Chennai-Bengaluru corridor but the JICA Study Team has not been given access to any technical reports related to the HSR.

Given the relatively short distance between Chennai and Bengaluru (360 km by rail), commuter travel between the two cities would be made possible by an HSR offering speeds of the order of 300-350 km per hour.

Based on very limited passenger data provided by the Southern Railway, a preliminary passenger traffic forecast was prepared, the details of which were outlined in Chapter 6.4.2(iii)b.

In generating this forecast it was assumed that only first and second class passengers travelling on air conditioned day services would divert to the HSR.

As is also the case with the DFC project, consideration of the High Speed Railway should include a comprehensive demand analysis, which in addition to assessing the level of traffic transferred from existing passenger services should also assess the level of traffic diverted from other modes (bus, car and air), as well as the level of generated demand.

[103] Meeting with the Director, Perspective Planning, MOR Delhi 22 November 2013

6.4.5 *Development Goals and Target Performance Indicators*

Development Goals

The goal of proposed capacity expansion projects is to reduce congestion on all lines within the CBIC network to less than 90% and to maintain utilisation levels below that figure.

Project Targets

Capacity utilisation is a quantifiable measure of performance. As stated earlier, *"Capacity saturation occurs when the number of trains each way per day exceeds 90 per cent of the estimated daily train capacity (i.e. the maximum number of trains which can operate in each direction per day on the section)"*.

It is assumed that capacity is saturated when utilisation reaches 90%. *Therefore additional capacity is required at that point. The target is to keep utilisation below 90*%. The projects proposed in this report are on the basis of identification of length of running lines needed to achieve this target. This is summarised in the earlier Table 6.4.7 and Table 6.4.8; Table 6.4.17 and Table 6.4.18 in Chapter 6.4.7 give a breakdown of the investment required on a year-on-year, route-by-route basis to keep levels below 90%.

6.4.6 *Development Plan and Suggested Projects*

The Development Plan proposed for the Railway sub-sector includes three different projects and one study with different objectives:

- An on-going project involving the expansion of route capacity on the 66 line sections comprising the CBIC railway network;
- A project to improve rail connections to high priority industrial nodes; and
- A project to improve the rail connectivity of major east coast ports
- A study to examine the economic feasibility of the DFC project and High Speed Railway project

The first project is given highest priority since the network already faces a severe capacity shortage, with traffic on more than 37 per cent of the network having exceeded capacity. Unless there is a continuous infusion of capital for the construction of additional running lines, the railway will never keep up with the growth of demand. The cost of capacity expansion the BIS case over 20 years (Rs. 11,194 Crore) reflects a need to add nearly 2,133 km of running lines to the network (above the 548 km already committed), equal to 76 per cent of its route length. For the purpose of assessing the demand – capacity relationship, traffic was assumed to grow at the accelerated rate of the Business Induced case, i.e. 9.86% for freight and 4.87% for passengers. The costs of new line construction projects were based on the unit costs of recent projects.

Table 6.4.14 List of Railway Subsector Projects

No	Project Title	Status	Project Cost		Priority[1]
			(Rs. Crore)	(US $ Mn)	
RL1	Committed Capacity Expansion (548 km)	On-going	2,485	407	A
RL2	Route Capacity Expansion (BAU Case)	Proposed (2013/14-2032/33)	8,649	1,418	A/B
RL3	Route Capacity Expansion (BIS Case)	Proposed (2013/14-2032/33)	11,194	1,835	A/B
RL4	New Line Construction – node connections	New	4,055	665	A/B
RL5	New Line Construction – port connections	New	1,320	217	A/B
RL6	Study on Comprehensive Demand Analysis for DFC project and/or High Speed Railway project	New	-	-	A

1/ "A" refers to projects for implementation before or by 2018; "B" refers to projects for implementation from 2019 to 2033.

6.4.7 *Phasing Plan*

The phasing of the Route Capacity Expansion project reflects the need to add running lines whenever traffic on a line section reaches 90 per cent of its estimated capacity in terms of the maximum daily number of trains which can be operated. Table 6.4.17 and Table 6.4.18 below provide a summary by route of the timing of the capital expenditure needed to support the capacity expansion project. The summary was used as the basis for compiling the phasing plan in Table 6.4.15.

The likely timing of expenditure on New Line Construction projects was estimated on the basis of information provided by the MoR and zonal railways.

Table 6.4.15 Summary of Phasing Plan for Railway Subsector Projects (Rs. Crore)

Category	Currency	Short (2013/14 – 2017/18)	Mid (2018/19 – 2022/23)	Long (2023/24 – 2032/33)	Total
Study on Comprehensive Demand Analysis		To be done in the short term	-	-	-
Route Capacity Expansion (548 km Committed) (Estimated Cost)	Rs (Cr)	2,485			2,485
	US $ (Mn)	407			407
Additional Route Capacity Expansion (BIS Case)	Rs (Cr)	1382	2687	7,125	11,194
	US $ (Mn)	227	440	1,168	1,835
New Line Construction – node connections	Rs (Cr)	3,701	354		4,055
	US $ (Mn)	607	58		665
New Line Construction – port connections	Rs (Cr)	1,320			1,320
	US $ (Mn)	216			216
Total	Rs (Cr)	8,888	3,041	7,125	19,054
	US $ (Mn)	1,457	498	1,168	3,123

Note: All costs indicated in USD are simple conversions in 2014 prices

Table 6.4.16 Detailed Phasing Plan for Railway Subsector Projects

S.No	Category	Short Term (2013/14 to 2017/18)	Medium Term (2018/19 to 2022/23)	Long Term (2023/24 to 2032/33)
A	**Route Capacity Expansion**			
1	*Committed increase in capacity*	• 548 km of new running lines committed (in both cases). • Will reduce congestion on lines including Chennai - Bengaluru, Chennai -		

S.No	Category	Short Term (2013/14	Medium Term	Long Term
		Nellore, Bengaluru - Rayadurga and Bengaluru - Dharmavaram • Will increase capacity of rail access to Chennai and Krishnapatnam Ports		
2	*Additionally required capacity*	• In both cases, 272 km of new running lines are required before 2017/18 over and above committed capacity. • This is required to reduce congestion on major lines within the CBIC area.		
3	*Additionally required capacity*		• In the BAU case, 465 km of new running lines will be required between 2018/19 and 2022/23. • In the BIS case, 515 km of new running lines will be required between 2018/19 and 2022/23. • This will be required to reduce congestion on major lines within the CBIC area.	
4	*Additionally required capacity*			• In the BAU case, 916 km of new running lines will be required between 2023/24 and 2032/33. • In the BIS case, 1346 km of new running lines will be required between 2023/24 and 2032/33. • This will be required to reduce congestion on all major lines within the CBIC area and improve access into Ports.

S.No	Category	Short Term (2013/14	Medium Term	Long Term
B	**New Line Construction - Node Connectivity**			
1	New Lines under construction including: • Tumkur - Davangere Line • Tumkur - Rayadurga Line New Lines planned including: • Avadi - Sriperambadur - Guduvancheri Line	• Improved access to Tumkur node • Improved access to existing industrial hubs at Sriperambadur and Oragadam		
2	New Lines planned and proposed, including: • Whitefield - Kolar Line • Jolarpettai - Hosur Line		• Improved access to Kolar and Hosur nodes	
C	**New Line Construction - Port Connectivity**			
1	New Lines under construction including: • Obulavaripalli - Venkatachalam Line	• Improved access to Krishnapatnam Port from Bellary allowing traffic to bypass congested sections between Renigunta and Gudur.		
2	New Lines planned including: • Ennore - Minjur Line (Northern Rail Link) • Minjur - Avadi Line	• Improved access to Ennore Port from Chennai - Nellore main line • Improved access to Ennore Port from Chennai - Bengaluru main line, allowing traffic to bypass congested sections of inner Chennai rail network		

Table 6.4.17 Estimated Capex profile for route capacity expansion (BAU scenario)

Year	Chennai-Nellore	Athipattu-Ennore Port	Venkatchalam-K Port	Gudur-Arakkonam	Arakkonam-Chengalpattu	**Chennai-Bengaluru**	Chennai Beach-Diamond Junction	Jolarpettai-Salem	Bengaluru-Salem	Chennai-Villupuram	Chennai Beach-Velachery	Renigunta-Villupuram	Bengaluru-Mysore	Bengaluru-Rayadurga	Bengaluru-Dharmavaram	Baiyappanahalli-Yelahanka	Baiyappanahalli-Yeswantpur	Bengaluru-Bangarpet (via Kolar)	Bangarpet-Marikuppam	Chikjajur-Harihar	Pakala-Dharmavaram	Renigunta-Nandalur	**CBIC Total**
2012-13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
2013-14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
2014-15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
2015-16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
2016-17	**203.1**	0.0	0.0	0.0	0.0	**92.3**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**638.8**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**934.1**
2017-18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	447.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**447.9**
2018-19	0.0	0.0	0.0	0.0	0.0	**20.7**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**20.7**
2019-20	**133.6**	0.0	0.0	0.0	0.0	**443.3**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**576.9**
2020-21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**1037.6**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**1037.6**
2021-22	0.0	0.0	0.0	0.0	0.0	**88.6**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**217.0**	0.0	0.0	**70.1**	0.0	0.0	0.0	0.0	0.0	**375.8**
2022-23	0.0	0.0	0.0	0.0	0.0	**415.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**415.0**
2023-24	**11.8**	0.0	0.0	0.0	0.0	**7.4**	0.0	0.0	0.0	**22.9**	0.0	0.0	0.0	0.0	**219.8**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**261.8**
2024-25	**203.1**	0.0	0.0	0.0	0.0	**20.7**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**223.8**
2025-26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**17.7**	0.0	**154.4**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**172.1**
2026-27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**618.5**	0.0	0.0	0.0	0.0	0.0	0.0	**281.5**	0.0	0.0	0.0	**74.5**	0.0	0.0	0.0	**974.5**
2027-28	**3.8**	0.0	0.0	0.0	0.0	**88.6**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**92.4**
2028-29	**186.5**	0.0	0.0	**59.9**	**331.1**	**602.3**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**1179.8**
2029-30	**145.3**	0.0	0.0	0.0	0.0	**142.2**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**287.5**
2030-31	0.0	0.0	0.0	0.0	0.0	**350.8**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**452.6**	**803.4**
2031-32	**95.1**	0.0	0.0	0.0	0.0	**248.4**	0.0	0.0	0.0	**162.7**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**506.2**
2032-33	0.0	0.0	0.0	**283.8**	0.0	**55.6**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**339.4**
20 year Total	**982.2**	**0.0**	**0.0**	**343.7**	**331.1**	**2575.8**	**0.0**	**636.2**	**1037.6**	**340.0**	**0.0**	**0.0**	**0.0**	**664.9**	**1140.1**	**0.0**	**70.1**	**0.0**	**74.5**	**0.0**	**0.0**	**452.6**	**8648.9**

Capex profile summary - BAU case (no DFC, no HSR)

	Rs.crore
Short term (2013/14 - 2017/18)	1382.0
Medium term (2018/19-2022-23)	2425.9
Long term (2023/24-2032/33)	4841.0
Total	8648.9

Note

Assumed unit costs per track-km:

	Rs. Crore
Doubling plus electrification:	5.94
Doubling of electrified line:	5.30
Doubling of non-electrified line:	4.66

Table 6.4.18 Estimated Capex profile for route capacity expansion (BIS scenario)

Year	Chennai-Nellore	Athipattu-Ennore Port	Venkatchalam-K Port	Gudur-Arakkonam	Arakkonam-Chengalpattu	**Chennai-Bengaluru**	Chennai Beach-Diamond Junction	Jolarpettai-Salem	Bengaluru-Salem	Chennai-Villupuram	Chennai Beach-Velachery	Renigunta-Villupuram	Bengaluru-Mysore	Bengaluru-Rayadurga	Bengaluru-Dharmavaram	Baiyappanahalli-Yelahanka	Baiyappanahalli-Yeswantpur	Bengaluru-Bangarpet (via Kolar)	Bangarpet-Marikuppam	Chikjajur-Harihar	Pakala-Dharmavaram	Renigunta-Nandalur	**CBIC Total**
2012-13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
2013-14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
2014-15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
2015-16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
2016-17	**203.1**	0.0	0.0	0.0	0.0	**92.3**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**638.8**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**934.1**
2017-18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**447.9**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**447.9**
2018-19	**133.6**	0.0	0.0	0.0	0.0	**464.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**597.6**
2019-20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**1037.6**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**1037.6**
2020-21	0.0	0.0	0.0	0.0	0.0	**88.6**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**217.0**	0.0	0.0	**70.1**	0.0	0.0	0.0	0.0	0.0	**375.8**
2021-22	**11.8**	0.0	0.0	0.0	0.0	**330.1**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**219.8**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**561.6**
2022-23	0.0	0.0	0.0	0.0	0.0	**92.3**	0.0	0.0	0.0	**22.9**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**115.2**
2023-24	**203.1**	0.0	0.0	0.0	0.0	0.0	0.0	**17.7**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**220.8**
2024-25	0.0	0.0	0.0	**59.9**	0.0	**20.7**	0.0	**618.5**	0.0	**154.4**	0.0	0.0	0.0	0.0	**281.5**	0.0	0.0	0.0	**74.5**	0.0	0.0	0.0	**1209.6**
2025-26	**190.3**	0.0	0.0	0.0	**331.1**	**510.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**1031.3**
2026-27	**133.6**	0.0	0.0	0.0	0.0	**230.8**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**364.4**
2027-28	**11.8**	0.0	0.0	0.0	0.0	**578.5**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**452.6**	**1042.9**
2028-29	**95.1**	0.0	0.0	**283.8**	0.0	**147.9**	0.0	0.0	0.0	**162.7**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**689.5**
2029-30	**290.7**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**290.7**
2030-31	0.0	0.0	0.0	0.0	0.0	**20.7**	0.0	**636.2**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**656.9**
2031-32	0.0	0.0	0.0	**59.9**	0.0	**971.4**	0.0	0.0	0.0	**154.4**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**1185.8**
2032-33	**320.0**	0.0	0.0	**7.6**	0.0	**88.6**	**16.2**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**432.5**
20 year Total	**1592.9**	**0.0**	**0.0**	**411.3**	**331.1**	**3635.9**	**16.2**	**1272.3**	**1037.6**	**494.5**	**0.0**	**0.0**	**0.0**	**664.9**	**1140.1**	**0.0**	**70.1**	**0.0**	**74.5**	**0.0**	**0.0**	**452.6**	**11194.0**

Capex profile summary -BIS case (no DFC, no HSR)

	Rs.crore
Short term (2013/14 - 2017/18)	1382.0
Medium term (2018/19-2022-23)	2687.7
Long term (2023/24-2032/33)	7124.3
Total	11194.0

Note

Assumed unit costs per track-km:

	Rs. Crore
Doubling plus electrification:	5.94
Doubling of electrified line:	5.30
Doubling of non-electrified line:	4.66

6.5 Urban/Public Transport

6.5.1 *Sector Overview*

6.5.1.1 Urban Transport in Chennai Metropolitan Area (CMA)

6.5.1.1.1 Current Urban Transport System in Chennai

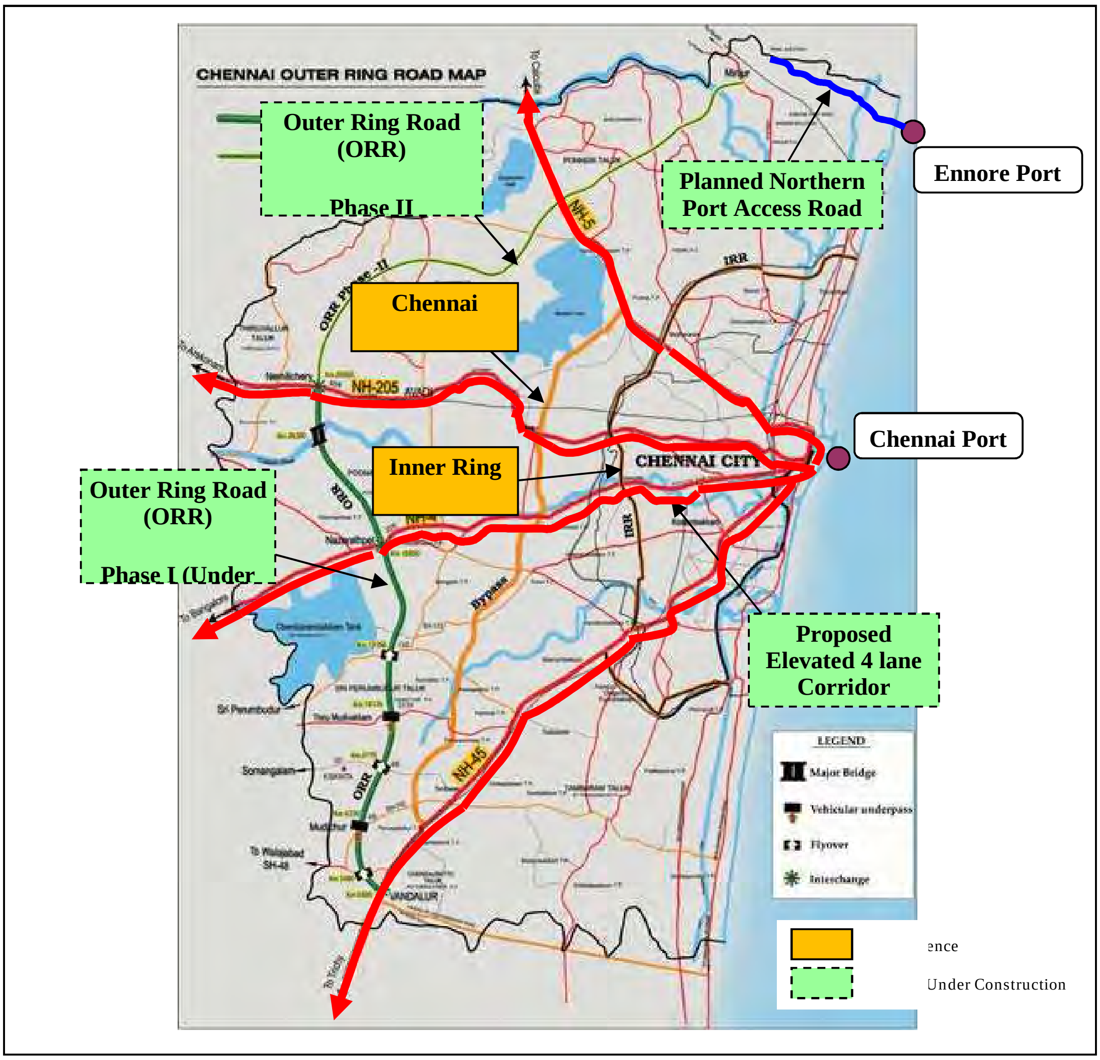
(1) Existing Urban Road Network in CMA

Chennai has four major National Highways that originate within the city. These include NH 4 (Chennai to Mumbai), NH 5 (Chennai to Kolkata), NH 45 (Chennai to Theni) and NH 205 (Chennai to Anantapur).

The Inner Ring Road (IRR) was originally proposed in 1968 as a city bypass and the central portion, linking NH 45 , NH 4 and NH 5 was constructed first in the 1980s. Subsequently the 8.1 km northern arm, extending the road upto TPP Road in Minjur was completed. The southern arm is under progress. The growth of the urban area eventually covered the IRR; a new ring road, the 32-km long access-controlled Chennai Bypass was subsequently constructed and opened in phases from 2008.

As Chennai has expanded year by year, the Chennai Bypass and the Inner Ring Road have been absorbed into the urbanized area. Hence, the Outer Ring Road (ORR) Project has been promoted and Phase I (South section: 29.7 km) is under construction.

Additionally, within the city, new roads to improve connectivity to the Ports at Chennai and Ennore are being constructed. The Ennore - Manali Road Improvement Project will upgrade the existing road to Ennore to Highway standard. The Madhuravoyal - Port Expressway is an elevated access-controlled road proposed to connect the dry port at Sriperambudur to Chennai Port. The project is currently ongoing.



Source: Chennai Metropolitan Development Authority (CMDA)

Figure6.5.1: Main Road Network in Chennai Metropolitan Area

(2) Bus Transportation in Chennai Metropolitan Area

■ Tamil Nadu State Transport Corporation Ltd.

The Tamil Nadu State Transport Corporation (TNSTC) is the state-owned intracity bus operator in Tamil Nadu. It is the second largest government-owned bus corporation in India, behind only the Andhra Pradesh State Road Transport Corporation.

Serviceswithin the CBIC Area

The CBIC area has two primary urban centres, Chennai and Bengaluru, and there is a very high volume of bus traffic between these two locations. However, this route is served by SETC directly and TNSTC's Villupuram division tends to run services to towns like Vellore, Tirupati, Kanchipuram and Chittoor which also see signifcant trip generation and attraction. Tirupati is the site of a major temple and thus is connected by bus to many desinations within the CBIC area and beyond. Kanchipuram is also a major temple town. It is reported that the transport department of Government of Tamil Nadu has intention to increase number of operations of inter-city buses in the CBIC region.

1. State Express Transport Corporation Ltd.

Services within the CBIC Area

State Express Transport Corporation (SETC) runs services between Chennai and Bengaluru within the CBIC area. As SETC focuses only on routes longer than 300km, a lot of the towns and urban areas within the CBIC area are linked by TNSTC services instead.

2. Metropolitan Transport Corporation (Chennai) Ltd.

Metropolitan Transport Corporation (MTC) is responsible for intra-city bus services within the Greater Chennai area. Its current fleet strength is 3,652 buses and it covers 765 routes, which are spread out across the Chennai Metropolitan Area and beyond in some cases.

Services of MTC within the CBIC area are restricted to CMA and peripheral destinations. The MTC does not operate services beyond those limits.

(3) Railway System in Chennai Metropolitan Area

3. Southern Railway

Southern Railways (SR) operates a suburban railway system which connects the city centre to northern, western, and southern areas by three radial routes. SR also runs the Mass Rapid Transit System (MRTS), a metro-like rail service, which connects Chennai Beach to Velachery in southern Chennai. A metro network is currently under construction and is due to partially open in 2014.

The suburban railways run from the city centre to several destinations along the three major lines. The three routes cover destinations within the CBIC area. The Lines run from Chennai Beach to Chengalpattu, Chennai Central to Nellore and Chennai Central to Tiruttani. The establishment of these lines played a key role in developing urban growth and commuter traffic in the Chennai Metropolitan Area.

SR also operate MRTS which is metro-like rail service within the Chennai area. MRTS is an elevated railway line that connects Chennai Beach with Velachery, passing through mainly residential and commercial areas with a connection to the IT hub on the Rajiv Gandhi IT Expressway. The MRTS line is being extended up until the existing suburban line at St Thomas Mount station, where one line of the Chennai Metro will also terminate.

New Proposals and On-going Projects

The Chengalpattu to Arakkonam line is partially electrified from Chengalpattu to Tirumalpur; further electrification is planned and if completed upto Arakkonam, it will be possible to run orbtial services on this route also. Work is also underway to add capacity on existing lines by adding running lines.

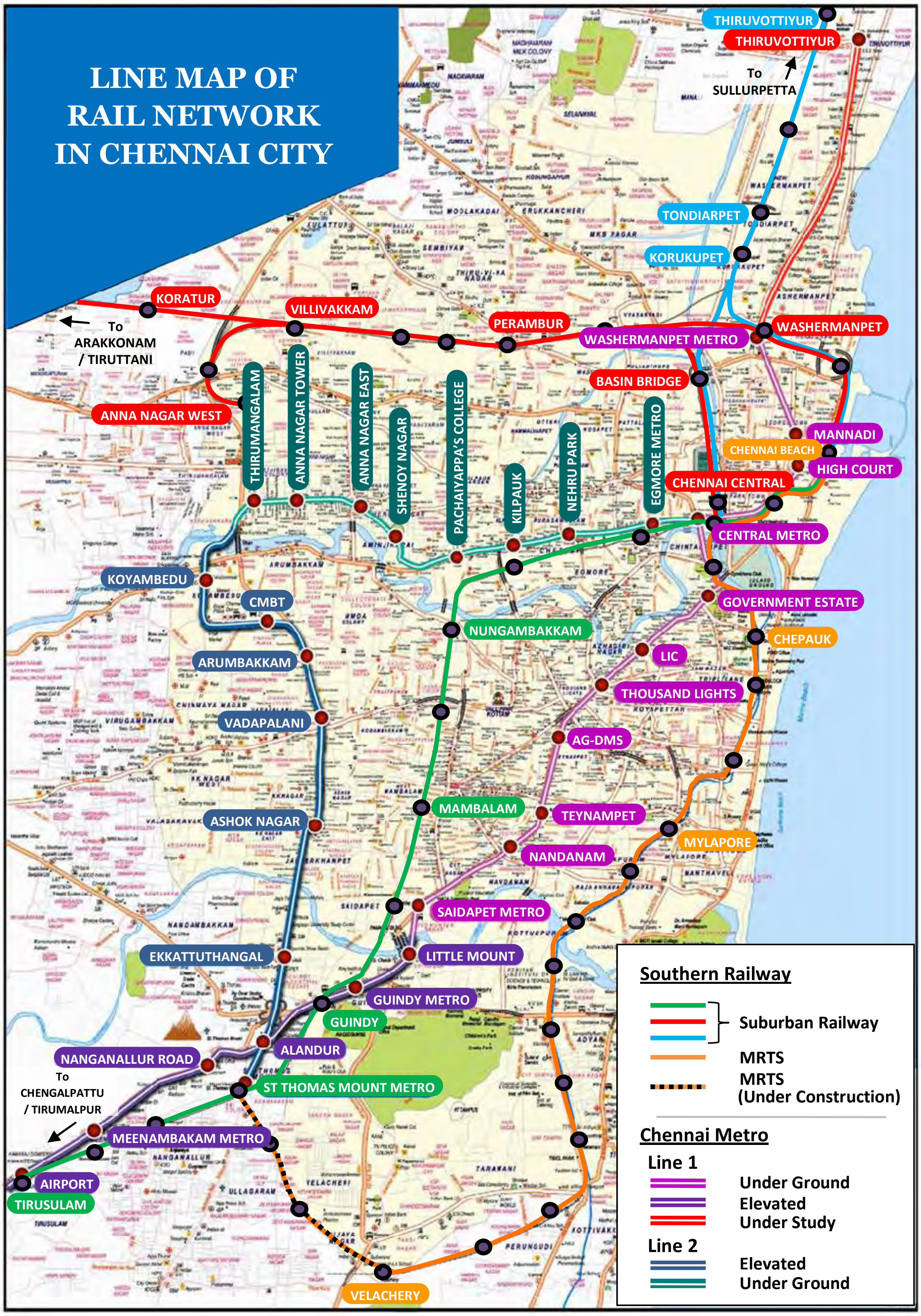


Figure6.5.2: Rail Network in Chennai City

Source: Compiled from Chennai Metro Rail Website

4. Chennai Metro

Chennai Metro is a planned 45-km metro system, which will be partially underground and partially elevated. The Chennai Metro is overseen by Chennai Metro Rail Limited which is a joint-venture between the state and central governments. The first two lines have been sanctioned; construction work began in 2009 and the first stretch is scheduled to open in 2014. Line 1 will run from Washermanpet to Chennai Airport and Line 2 from Chennai Central to St Thomas Mount Railway Station. Both lines will offer an interchange at Chennai Central and Alandur. The system will integrate with the existing suburban and MRTS railway at Chennai Central and at St.Thomas Mount. The fare system is still under consideration.

Planned Projects

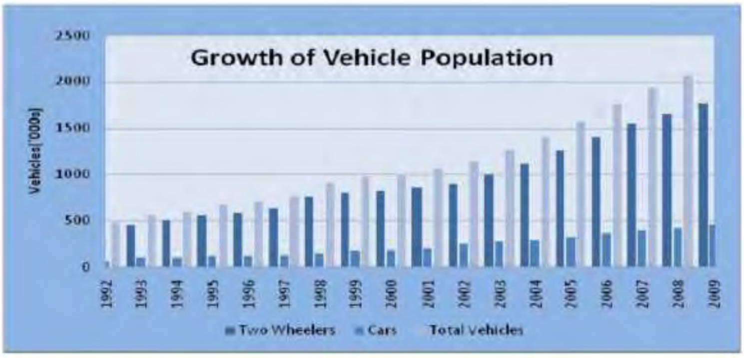
Chennai Metro Rail proposed a total of seven corridors initially of which two corridors were selected to be built in the first phase. The first phase is in the construction stage and future phases have yet to be planned. Additionally the government has begun planning for a Monorail system to supplement the Metro in Chennai.

6.5.1.1.2 Summary on Major Issues and Problems in CMA

The major current issues that need to be addressed are the following:

(1) Growth in Motor Vehicle Population

The vehicle population in Chennai has grown steadily every year, with the major share being the increase in two-wheelers. As can be seen in the graph below, the number of two-wheelers has more than tripled in the 15-year period from 1992 onwards. The number of cars has also increased year-on-year with the current volume being close to 500,000 vehicles (source: Chennai Comprehensive Transport Study (CCTS).

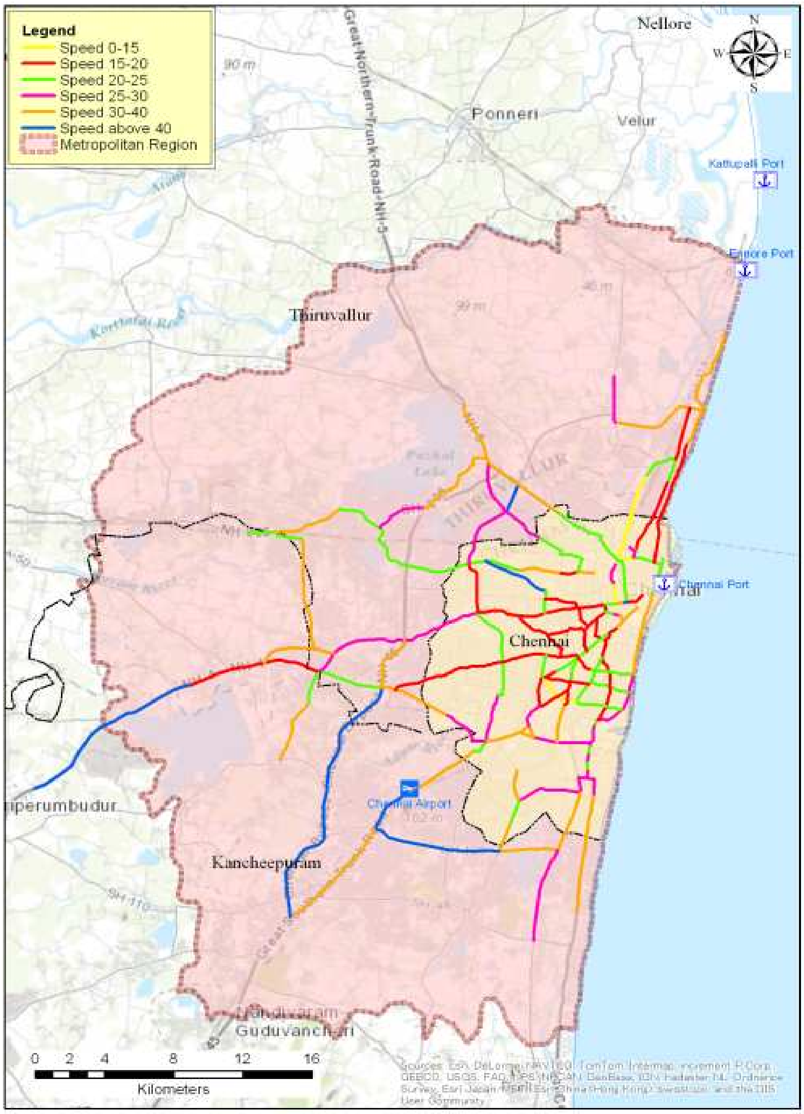


Source: Chennai Comprehensive Transportation Study (CCTS), Chennai Metropolitan Development Authority, August 2010

Figure6.5.3: Growth of Motor Vehicles in Chennai

(2) Road Traffic

Capacity of almost all roads in the present network system is reduced due to the rapid growth of car ownership and lack of properly designed intersections. The volume capacity ratio (=congestion rate: V/C) on many of the links during peak hour is more than one. V/C ratios are 1.4 to 2.6 in and around the CBD. As a result, travel speed in peak hour is 10 km/hour in the CBD and 18 km/hour in other major roads (from CCTS).



Source: Chennai Comprehensive Transportation Study, Chennai Metropolitan Development Authority, August 2010

Figure6.5.4: Average Speed in Peak Hours on Selected Corridor

(3) Road Network Configuration

Although the Inner Ring Road (IRR) and the Chennai Bypass already exist, the present road network configuration in CMA is radial predominant. Due to this network pattern, most of the radial arterial roads leading to the CBD are severely congested. As the Chennai urban area has expanded year by year, the Chennai Bypass became an urban road and the on-going Outer Ring Road (ORR) will be covered by densely populated areas soon.

(Note: The Outer Ring Road Phase 1 (South section) is under construction and 80% of land acquisition for the Phase 2 (North section) was finished)

(4) Public Transport

The share of bus transport has declined from 38.6 in 1995 to 26% in 2008 and the share of train is only 4-5%. On the other hand, the share of fast two wheelers has increased from 7% in 1995 to 25% in 2005. The most important issue for the public transport system in CMA is poor inter-modal transfers from bus to rail and vice versa. Possible causes on the low share of public transportation isthat bus network and railway systems are not well combined as a total public transport system. The feeder services to/from raiway stations by buses are not effectively functioned due to poor inter modal facilities.

Table 6.5.1: Modal Share

	Mode	1995 (%)	2008 (%)
Modal Share (All trips)	Bus	38.6	26
	Train	4.1	5
	Car/ Taxi	1.5	6
	Fast two wheeler	7	25
	Auto rickshaw	2.2	4
	Bicycle	14.2	6
	Cycle rickshaw & others	2.9	
	Walk	29.5	28
Total		100	100

Source: Chennai Comprehensive Transportation Study, August 2010, CMDA

(5) Freight Traffic

There are many container freight stations and inland container depots around the Chennai Port and the Ennore Port. In addition, industrial parks and special economic zones are located or planned near the ports and outer ring road under construction and along the proposed new peripheral ring road. As access roads from the industrial areas to the ports are limited at present, the transportation bottlenecks especially the last mile connectivity to the Chennai Port and the Ennore Port is the most critical issue for the industrial development in CMA.

(6) On-Street Parking

It is reported in the Second Master Plan (Draft MP-II) that the parking shortage is acute in the CBD area. The demand for parking in CBD is 1.5 to 2 times the supply. It is reported that the on-street parking has led the loss in the road capacity about 15% to 60%.

(7) Traffic Accidents

It is reported that an average 625 persons die on City roads annually with 35/10,000 vehicles of fatality rate. At the same time, 42% of road accidents involve pedestrians and 10% cyclists (Draft MP-II). The conflicts between fast moving vehicular traffic and bicycles and pedestrians traffic are one of reasons of traffic accidents, Also, inadequate enforcement of traffic rules and insufficient regulatory measures have result in the accidents.

6.5.1.2 Urban Transport in Bengaluru Metropolitan Area (BMA)

6.5.1.2.1 Current Urban Transport System in BMA

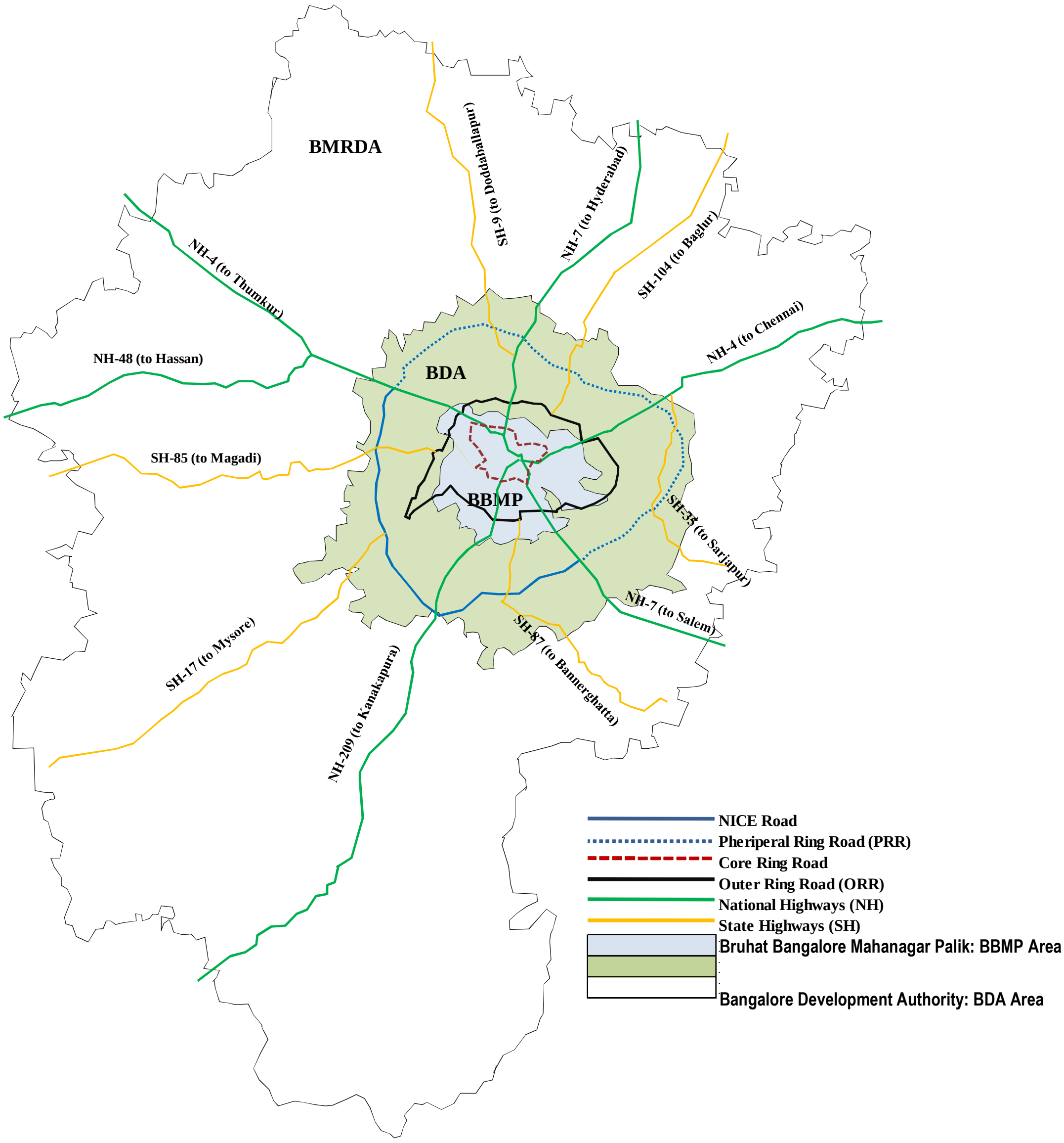
(1) Urban Road Network

Bengaluru is connected by three National Highways, two of which pass through the city and one of which originates there. There is a proposal for a Commuter Railway system to be established. A metro system, initially consisting of two lines, is under construction with a small section opened to the public in 2011.

Two National Highways pass through Bengaluru, NH 4 (Chennai to Mumbai) and NH 7 (Varanasi to Kanyakumari). NH 209 begins at Bengaluru and passes through a part of CBIC area before terminating at Dindigul. Additionally, NH 48 begins at Nelamangala, near Bengaluru and terminates at the port city of Mangalore.

Due to the radial spread of the city, a number of ring roads have been planned to allow traffic to bypass the congested city centre. The 62-Km long Outer Ring Road was opened in phases in the late 1990s. The Nandi Economic Corridor Enterprises (NICE) Ring Road has also been constructed as the southern portion of a new Peripheral Ring Road which is being planned.

The Stage Highway between Bengaluru and Mysore is being upgraded to an expressway and will link to the NICE Road. A portion of NH 7, linking Bengaluru to Hosur, has been supplemented by an access-controlled elevated expressway which was built under BOT scheme.



Source: JICA Study Team

Figure6.5.5: Main Road Network in Bengaluru Metropolitan Region

(2) Bus Transportation in Bengaluru Metropolitan Area

Karnataka State Road Transport Corporation (KSRTC) and Bangalore Metropolitan Transport Corporation (BMTC) were established in Karnataka State as governental bus service operators to provide intercity and intra urban bus service in CBIC area, respectively.

Karnataka State Road Transport Corporation

KSRTC was set up in 1961 to operate bus services across the state of Karnataka. It is a fully state-owned operator. In 1997, services in Bengaluru were hived off into BMTC which became responsible for all services within the city and urban area. KSRTC oversees all the bus services in 6 north-eastern districts, and it also operates buses to destinations outside the state, linking to cities and towns in all the neighbouring states.

Bangalore Metropolitan Transport Corporation

BMTC was created in 1997, when it was decided to create a separate authority for city buses. Services of Karnataka State Road Transport Corporation in Bengaluru were reorganised under the BMTC, which later became the first public transport operator in the country to run A/C Volvo buses. The BMTC runs more than 6600 buses everyday.

(3)Railway System in Bengaluru Metropolitan Area

Bengaluru does not have a commuter rail service at present although there have been proposals for such a system to supplement the existing public transport network which is based around bus services run by the BMTC. Bengaluru is also constructing a metro system known as the Namma Metro, which consists of 2 lines. A small section of this network was opened in 2011.

South Western Railway

South Western Railway (SWR) zone of Indian Railways is responsible for rail operations in much of Karnataka. There have been proposals to implement a suburban rail service on the SWR network in Bengaluru. The state government of Karnataka has asked Rail India Technical and Economic Services (RITES) to prepare a detailed project report on commuter services being run on two routes (Bengaluru - Ramanagara and Bengaluru - Malur). The first of those routes is on the route from Bengaluru to Mysore and the second is on the Bengaluru to Chennai route. Both routes would be within the CBIC area when implemented. The Bangalore Suburban Rail Corporation is being set up to oversee execution.

Namma Metro

Namma Metro is the agency responsible for constructing and operating the metro system for Bengaluru. It is a joint venture between the state and central governments. The initial phase of the project covers two lines, with a central interchange at the Kempegowda Bus Stand Metro Station to allow passengers to transfer to long distance bus services and local BMTC services. The station will also offer connectivity to the adjacent City Railway Station (The section from MG Road Station to Bayappanahalli Station is now under operation).

Source: Namma Metro Website

Figure6.5.6: Namma Metro Network

Planned Projects

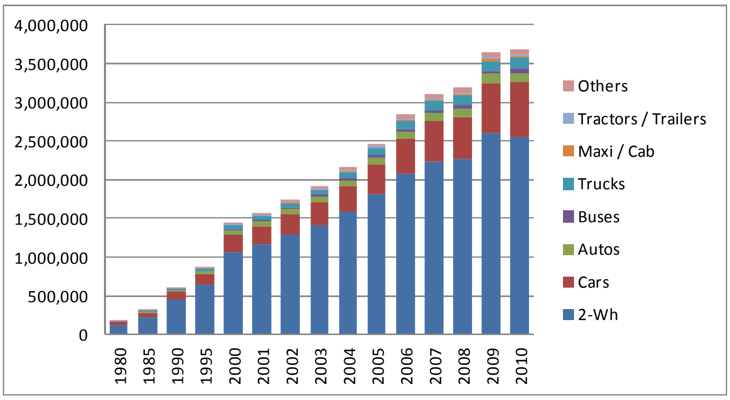
Work is ongoingto complete the remainder of phase 1 of Namma Metro, including the underground section in the city centre. Namma Metro is planning to build two more lines and increase the length of the current two lines in future phases.

6.5.1.2.2 Summary on Major Issues and Problems in BMA

The major issues regarding the transport system in Bengaluru are summarized as below:

(1) Growth in motor vehicle population

As can be seen in the graph detailed below, there has been a constant increase in the vehicle population every year for the past 20 years. The growth has been significant in the first 10 years of the 21st century. The number of two-wheelers in 2010 is 150% more than the one in 2000. The second biggest rise has been in the number of cars, with the total exceeding 600,000. Those increases are due to the growing economic activities or through traffic from new residential locations in the surrounding areas of BMA.



Source: Bengaluru Traffic Police Web Site and RTO, Bengaluru

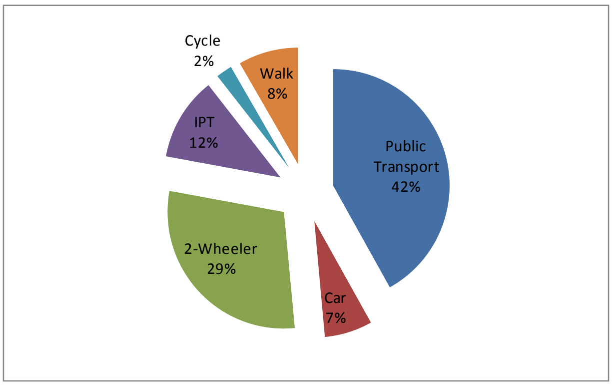
Figure6.5.7: Growth of Motor Vehicles in Bengaluru

(2) Insufficient road network capacity

Road network capacity in BMA is not sufficient. Width of most of the major roads is four lanes or less. Volume/ Capacity Ratios on the roads are more than 1.0. Average traffic speed in peak hour is about 13.5 km/hour. As widening of the existing roads is very difficult in densely populated city centre, appropriate traffic management measures including the Intelligent Transport System (ITS) are necessary.

(3) Decline in the share of public transport

Modal share of public transport is about 42% at present. However, this share is continuously declining in the past two decades. On the other hand, shares of private modes of two wheelers and cars in the travel demand are very high.



Source: Comprehensive Traffic and Transportation Plan for Bengaluru, Karnataka Urban Infrastructure Development and Finance Corporation, June 2011

Figure6.5.8: Modal Split with Walk Trips

(4) High Parking demand

Parking is also a critical issue in Bengaluru. Parking demand should be reduced by providing better public transport system.

(5) New rail services connecting Bengaluru City with suburban towns

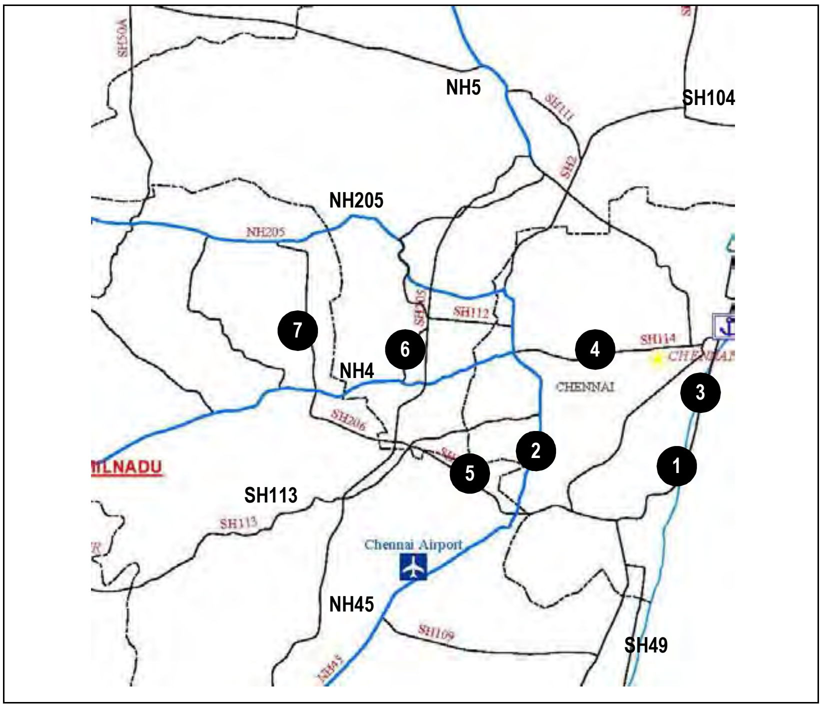
In order to mitigate the concentration to the Bengaluru City, major development has been proposed in the suburban satellite towns. This will surely increase interaction between Bengaluru and these satellite towns. In situations where there are many areas without access to railway lines connecting with Bengaluru, new commuter rail services should be developed.

6.5.1.3 Analysis of Current Infrastructure Gaps and Bottlenecks

6.5.1.3.1 Volume/ Capacity Ratio on Road Network

(1) Chennai Metropolitan Area

Screen line survey was carried out in Chennai Comprehensive Transportation Study. Traffic count survey result on urban arterial roads is as shown in Table 6.5.2. V/C (Volume/ Capacity Ratio) value is more than 1.0 at all survey locations.



Source: Chennai Comprehensive Transportation Study, Chennai Metropolitan Development Authority, August 2010

Figure6.5.9: Location Map of Traffic Survey

Table 6.5.2: Traffic Survey Result in Chennai Metropolitan Area

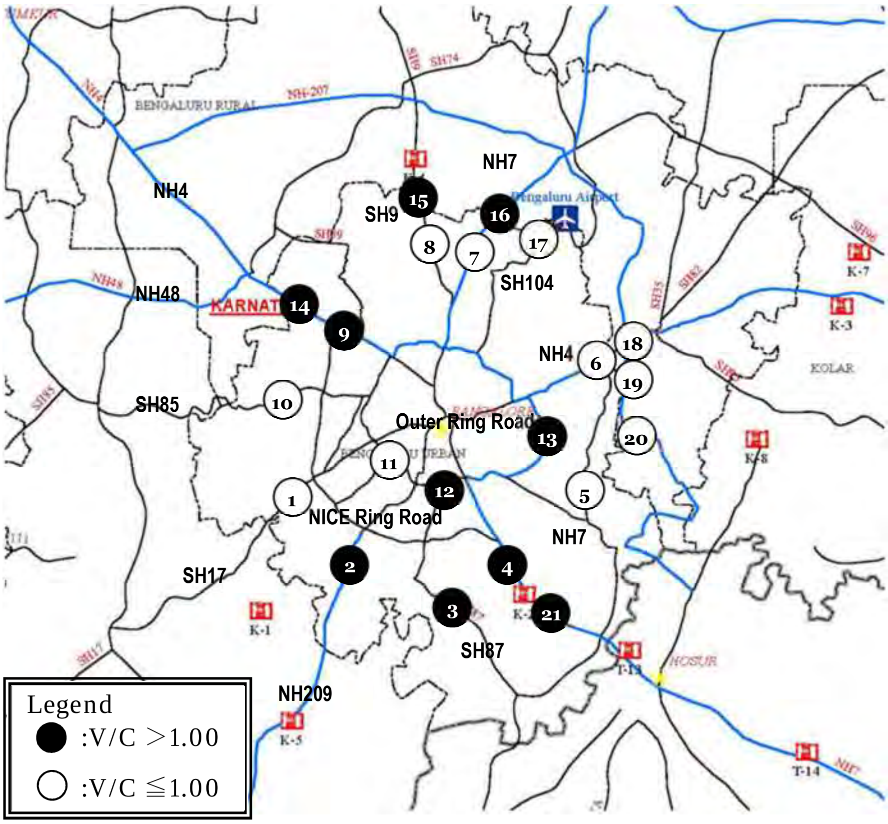
No.	Location	Surveyed Traffic Volume (pcu)	Number of Lanes	V/C	Remarks
1	Durgabhai Deshmukh Road near Sathya Studio	139,633	6	2.33	24hour (2008)
2	Jawaharlal Nehru Road Crossing Adyar River near Ekkattuthangal	116,161	4	2.58	24hour (2008)
3	Kamaraj Salai at Napier Bridge	96,375	6	1.61	24hour (2008)
4	Periyar EVR Salai near Aminjikarai Market	82,388	6	1.37	24hour (2008)

No.	Location	Surveyed Traffic Volume (pcu)	Number of Lanes	V/C	Remarks
5	Mount Poonamallee Road near MIOT Hospital	80,279	4	1.78	24hour (2008)
6	Bridge at Vanagaram - Ambattur Road	29,243	2	1.67	24hour (2008)
7	Bridge at Avadi- Poonamallee Road	38,719	2	2.21	24hour (2008)

Source: JICA Study Team, based on Chennai Comprehensive Transportation Study, Chennai Metropolitan Development Authority, August 2010

(2) Bengaluru Metropolitan Area

Two traffic survey results carried out in 2006 and 2012 are shown in Table 5.3.3. Traffic volumes on NH7 (to/from Hosur), Outer Ring Road, NH4 (to/from Tumkur), Kanakapura Road have already exceeded the capacity.



Source: 1-13 : Comprehensive Traffic and Transportation Plan for Bengaluru, Karnataka Urban Infrastructure Development and Finance Corporation, June 2011

14-21: Construction of Eight lane Peripheral Ring Road to Bangalore City (Draft Final Report), Bangalore Development Authority, 2013

Figure6.5.10: Location Map of Traffic Survey

Table 6.5.3: Traffic Survey Result in Bengaluru Metropolitan Area

ID	Road Name	Surveyed Traffic Volume (pcu)	Number of Lanes	V/C	Remarks

ID	Road Name	Surveyed Traffic Volume (pcu)	Number of Lanes	V/C	Remarks
1	Mysore Road	5,372	4	0.12	24 hours(2006)
2	Kanakapura Road	27,781	2	1.59	24 hours(2006)
3	Bannerghatta Road	19,339	2	1.11	24hours(2006)
4	Hosur Road	78,006	6	1.30	24hours(2006)
5	Sarjapura Road	11,933	4	0.27	24hours(2006)
6	Old Madras Road	39,999	6	0.67	24hours(2006)
7	Bellary Road	27,468	6	0.46	24hours(2006)
8	Doddaballapur Road	21,440	4	0.48	24hours(2006)
9	Tumkur Road	62,401	6	1.04	24hours(2006)
10	Magadi Road	14,152	4	0.31	24hours(2006)
11	Outer Ring Road (near Kamakya)	38,026	6	0.63	12hour(8:00-20:00) (2006)
12	Outer Ring Road (BTM Layout Bus Stop)	86,609	6	1.44	12hour (8:00-20:00) (2006)
13	Outer Ring Road (near Maratha Halli)	83,183	6	1.39	16hour (6:00-22:00) (2006)
14	NH-4, BangaloreTumkur Road	90,794	6	1.51	AADT (2012)
15	SH-9, Doddaballapura Bangalore Road	20,465	2	1.17	AADT (2012)
16	NH-7, Bangalore Bellary Road	67,595	6	1.13	AADT (2012)
17	Hennur-Bagalur Road	9,902	4	0.22	AADT (2012)
18	NH-4, Bangalore - Kolar Road	56,897	6	0.95	AADT (2012)
19	KR Puram- Whitefield Road	16,087	4	0.36	AADT (2012)
20	SH-35, Between Hosakote - Sarjapura Road	16,832	2	0.96	AADT (2012)
21	NH-7, Bangalore - Hosur Road	68,580	6	1.14	AADT (2012)

Source: 1-13: Comprehensive Traffic and Transportation Plan for Bengaluru, Karnataka Urban Infrastructure Development and Finance Corporation, June 2011

14-21: Construction of Eight lane Peripheral Ring Road to Bangalore City (Draft Final Report), Bangalore Development Authority, 2013

6.5.1.3.2 Area Coverage Gaps in Public Transport

(1) Chennai Metropolitan Area

Suburban railways operated by Southern Railway are operated alongside important radial corridors of NH4, NH45 and NH5. Development potential band is fully covered by two hours access coverage area and one hour access coverage area covers part of north and west development potential band. As for access coverage for southern area where industrial investment has been promoted, one hour access coverage is very limited.

(2) Bengaluru Metropolitan Area

In case of the Bengaluru Metropolitan Area, the extension of future METRO network is planned up to the Peripheral Ring Road. However, many satellite towns are already located beyond the Peripheral Ring Road. Under this situation, alternative sub-urban commuter railway system will be necessary to connect such satellite towns with Bengaluru.

6.5.2 *Demand Forecast*

6.5.2.1 Future Demand Forecast for CMA

(1) Future Population

The Chennai Comprehensive Transportation Study (CCTS) prepared by the Chennai Metropolitan Development Authority (CMDA) estimated future population up to 2026 in CMA as below:

Table 6.5.4: Future Demographic Projection

Forecast Input Variables	Population		Growth Ratio ('26/'08)	Average Annual Growth Rate ('08-'26)	CBIC Study Estimates Growth Rate of CMA to 2033 (Tentative)	2033 Population (*)
	2008	2026				
City	4,746,766	5,855,332	1.23	1.2%	-	-
CMA (excl. city)	3,520,165	6,726,333	1.91	3.7%	-	-
Total	8,266,931	12,581,665	1.52	2.4%	3.87 % p.a.(*)	15,058,000

Source: (2008 & 2026): Chennai Comprehensive Transportation Study, August 2010, CMDA, (2033): JICA Study Team

Note (*): Tentative estimation by JICA Study Team applying future population growth rate 2026-2033 (accelerated case).

Future population of CMA is forecast to grow by 52% from 2008 to 2026 and the growth rate of CMA outside the city will be higher than the city area. This means the urban area will be expanded toward surrounding areas and trip length will be increased as well.

(2) Projection of Per Capita Trip Rate

The projection of per capita trip rate (PCTR=number of trips per person per day) is shown in the table below:

Table 6.5.5: Projection of Per Capita Trip Rate

Year	PCTR (All Vehicles)	PCTR (Motorized)
2008	1.60	1.06
2016	1.69	1.12
2026	2.14	1.41

Source: Chennai Comprehensive Transportation Study, August 2010, CMDA

As the total population in CMA is expected to increase by 1.52 times from 2008 to 2026 and the per capita trip rate is estimated to increase by 1.33 times (2.14/1.60), total number of trips in CMA will be doubled in 2026 (1.52 x 1.33=2.0)

(3) Proposed Transport Plan and Modal Shares

The CCTS proposed transportation plan for the year 2026 covering all sectors including public transport, road network and traffic management. As a result of combination and implementation all 17 schemes proposed above, the future modal shares are projected as follows:

Table 6.5.6: Projection of Modal Shares

Category	Index	2008 Values	Goals Set 2026	Achievable Goals 2026
Modal Shares (All Trips)	Public Transport (Rail & Buses)	27%	46%	43%
	IPT (Intermediate Public Transport, such as Taxi, Auto rickshaw)	7%	5%	5%
	Private Transport	32%	15%	18%

Source: Chennai Comprehensive Transportation Study, August 2010, CMDA

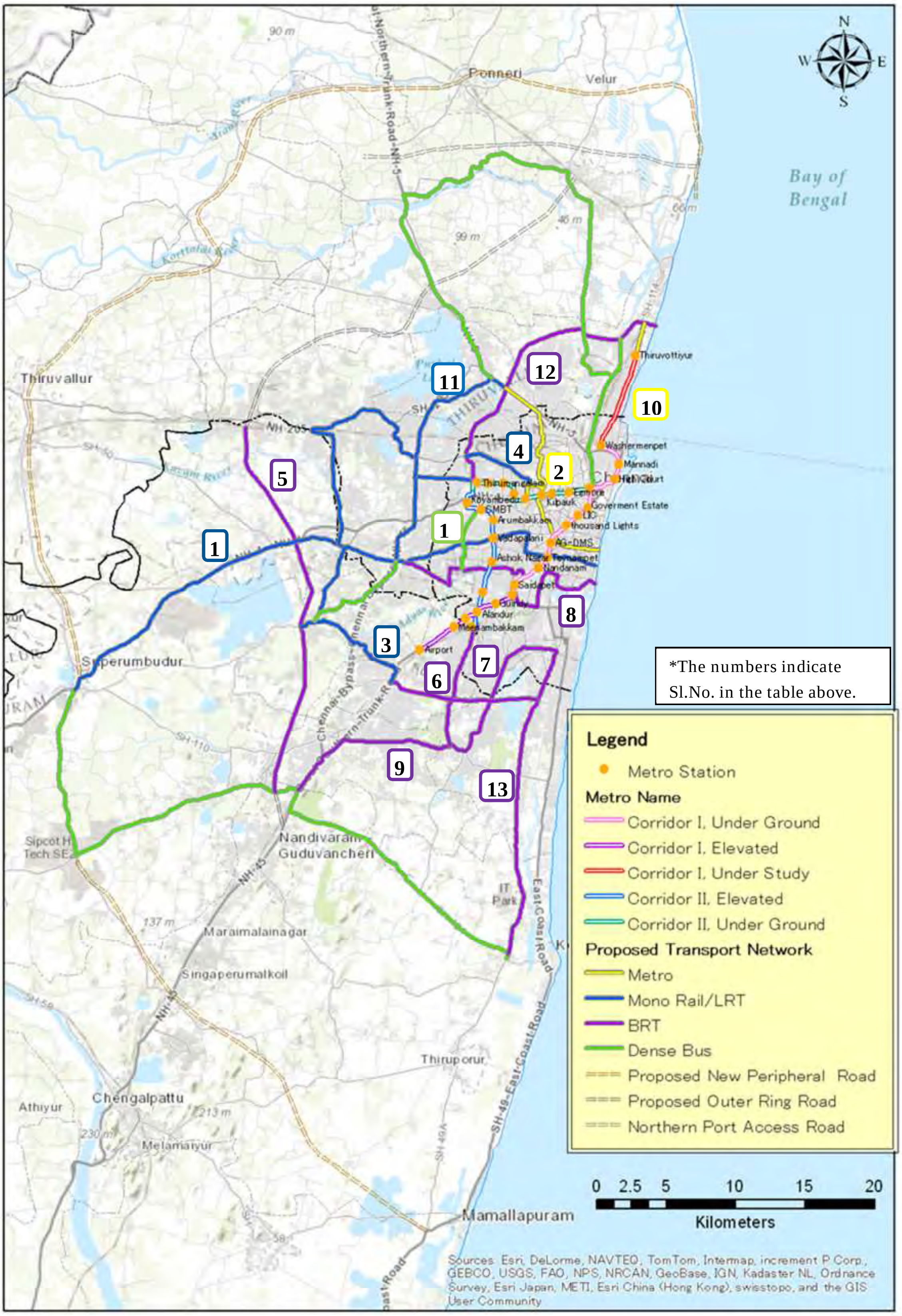
Although the achievable goals are slightly lower than the set goals (targets), the modal share of public transport is expected to increase from 27% in 2008 to 43% in 2026. On the other hand, private transport will reduce its share from 32% in 2008 to 18% in 2026.

The future traffic demand on major public transport corridors in 2026 proposed by CCTS are presented in the Table 6.5.7and combination of all proposed public transport projects is shown in Figure6.5.11.

Table 6.5.7: Future Traffic Demand on Proposed Public Transport Network 2026 (CMA)

Sl. No	From	Via	To	Length (Km)	2016		2021		2026		2033(*)
					System	Demand as PPHPD	System	Demand as PPHPD	System	Demand as PPHPD	Demand as PPHPD
1	Sriperumbudur	Poonamallee, Porur, Arcot Road, T Nagar, Teynampet, Luz Church Road	Luz	42	High Dense Bus	3000	LRT/ Monorail	7000	LRT Monorail	12000	16000
2	Madavaram	GNT Road, Madhavaram High Road, Perambur, Mc Nichols Road, Anna Flyover, Luz	Light house	19	High Dense Bus	6000	Metro	19000	Metro	29000	38000
3	Pallavaram	Kundrathur, Poonamallee, Ambattur, Ambattur Estate	Koyambedu	27	LRT/ Monorail	5000	LRT/ Monorail	7500	LRT/ Monorail	12500	16000
4	Ambattur	CTH Road, Ambattur Industrial Estate, Padi, New Avadi Road	Kilpauk	24	LRT/ Monorail	7000	LRT/ Monorail	8000	LRT/ Monorail	10000	13000
5	ORR from Vandalur	Kundrathur, Nazarethpet, Thandarai	Pattabiram	30	BRT	2000	BRT	4000	BRT	8000	10000
6	Pallavaram	Srinivasapuram, Kilkattalai,Kovilambakkam	Thorapakkam	11	BRT	2000	BRT	4000	BRT	7000	9000
7	St. Thomas Mount	Ullagaram, Nanganallur, Kilkattalai	Medavakkam	11	Elev. BRT	5000	Elev. BRT	7500	Elev. BRT	12000	16000
8	Adyar	Saidapet, Nandambakkam, Mount Poonamallee Road, Porur	NH bypass	16	Elev. BRT	4000	Elev.BRT	5000	Elev.BRT	6000	8000
9	Vandalur	Velachery Road, Medavakkam	Thiruvanmiyur	20	BRT	2000	BRT	3000	BRT	4000	5000
10	Washermenpet	Thiruvottriyur High Road	Wimco Nagar	9	Metro	12000	Metro	18000	Metro	30000	39000
11	NH Bypass from Porur	Maduravoyal, Ambattur, Pudur, Puzhal	Madhavaram	18	BRT	6000	BRT	7000	LRT/ Monorail	10000	13000
12	Tirumangalam	Padi, Eveready, Manali	Wimco Nagar	16	BRT	4000	BRT	5000	BRT	7000	9000
13	Tiruvanmiyur	Kandhanchavadi, Thorapakkam, Mettukuppam,	Kelambakkam	23	BRT	2000	BRT	3000	BRT	5000	7000
14	Nandambakkam	Nesapakkam, Virugambakkam	Koyembedu	7	High Dense Bus	2000	High Dense Bus	4000	High Dense Bus	7000	9000

Source: Chennai Comprehensive Transportation Study, August 2010, CMDA
Note: PPHPD denotes passengers per hour per direction
(*) 2033: Tentative estimation applying future population growth rate 2026-2033 (accelerated case)



Source: Chennai Comprehensive Transportation Study, August 2010, CMDA

Figure6.5.11: Proposed Public Transport Corridors (2026)

6.5.2.2 Future Demand Forecast for BMA

(1) Future Population

According to the "Comprehensive Traffic and Transport Plan in Bengaluru" conducted by Karnataka Urban Infrastructure Development and Finance Corporation in 2010, the future population growth up to 2026 is estimated as shown below: Currently, in 2011, the Bengaluru Metropolitan Area is estimated to have about 8.0 million population and expected to grow to 11.22 million in 2025.

Table 6.5.8: Growth of Future Population in BMA

Year	Population	Growth Ratio (2011 = 1.00)	Annual Growth Rate (%)
2001	6,170,000*	-	-
2011	8,015,000*	-	2.7%
2015	8,840,000*	1.10	2.5%
2025	11,221,000**	1.40	2.4%
2033	13,597,000***	1.70	2.43%

Source: Comprehensive Traffic and Transportation Plan for Bengaluru, June 2011, Karnataka Urban Infrastructure Development

and Finance Corporation

Note (*): Revised Master Plan, (**): Projected for BMA

(***) 2033: Tentative estimation by JICA Study Team applying future population growth rate 2025-2033

(2) Per Capita Trip

The current per capita trip rate in BMA is comparatively lower than that of CMA with the rate of 0.924 trips per person per day in 2011 as shown in the table:

Table 6.5.9: Per-Capita Trip (PCTR) Rates by Purpose in BMA

Trip Purpose	No. of Trips	Percentage (%)	PCTR
Work	1,839,818	29.3	0.271
Education	738,799	11.8	0.109
Others	649,737	10.3	0.096
Non-Home Based	92,347	1.5	0.014
Employer Business	11,748	0.2	0.002
Return	2953,228	47.0	0.434
Total Trips	6,285,677	100.0	0.924
Total Population	6,800,000	-	-

Source: Comprehensive Traffic and Transportation Plan for Bengaluru, June 2011, Karnataka Urban Infrastructure Development

(3) Projection of Future Modal Shares

Future modal share of public transport is projected at 69.8% (excluding walk trips) in 2025 which is about 23% increase compared to 45.7% in 2010 and 6% higher than the case of business as usual in 2025.

Table 6.5.10: Forecast of Modal Share (excluding Walk trips)

Mode	Modal Share (%)		
	2010 (Current)	2025 (Business As Usual)	2025 (With recommended Scenario)
Car+Taxi	7.2	6.4	3.5
Two-Wheeler	34.4	28.0	18.7
Auto rickshaw	12.6	10.8	8.1
Public Transport	45.7	53.9	69.8
Total	100.0	100.0	100.0

Source: Comprehensive Traffic and Transportation Plan for Bengaluru, June 2011, Karnataka Urban Infrastructure Development

(4) Future Traffic Demand for Public Transport Corridors

The future traffic demands on major public transport corridors in 2025 proposed and forecast by the "Comprehensive Traffic and Transportation Plan" are presented in Table 6.5.11 and combination of all proposed public transport projects is shown in Figure 6.5.12.

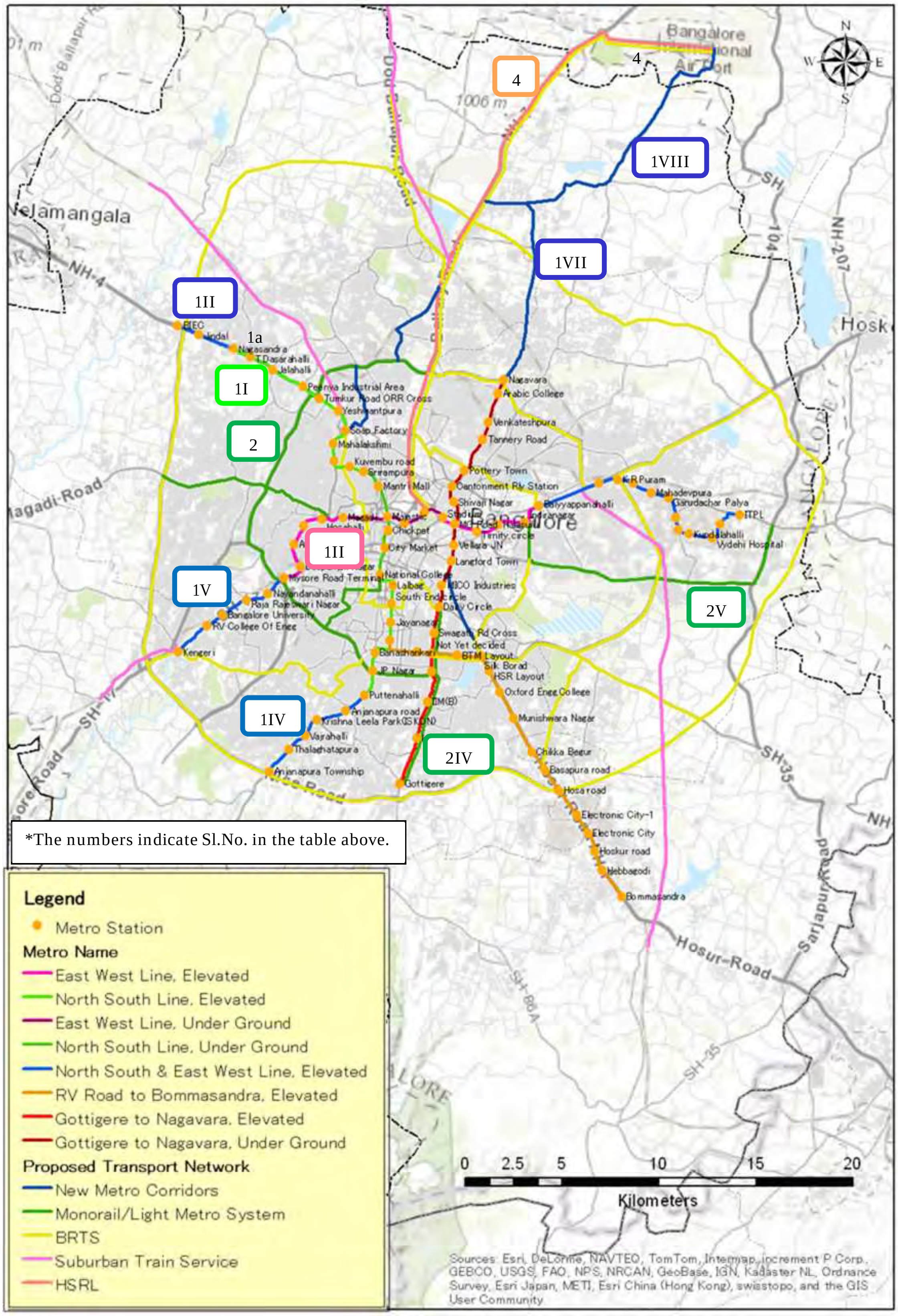
Table 6.5.11: Future Traffic Demand on Proposed Public Transport Network 2025 (BMA)

Sl.No.	Corridor	Max. PPHPD (2025)	Max. PPHPD (2033)*	Length (km)
1	**Metro**			
a	**Metro Corridors-Phase-I**			
I.	Hesarghatta - Puttenahalli Cross	29173	35351	24.2
II.	Baiyyappanahalli - Mysore Road Terminal	30385	36819	18.7
	Total Metro Length (a)	-	-	42.9
b	**Extension of Metro Corridors**			
III.	Extension of Puttenahalli Cross- Hesarghatta line to BIEC	13978	16938	2.7
IV.	Extension of Hesarghatta - Puttenahalli Cross line to PRR	19105	23151	7.4
V.	Extension of Baiyyappanahalli - Mysore Road terminal line to Kengeri	5050	6119	5.9
VI.	Extension of Mysore Road terminal - Baiyyappanahalli line to Whitefield	20230	24514	12.4
	Total Metro Length (b)	-	-	28.4
c	**New Metro Corridors**			
VII.	Electronic City to Srinivasapur	23452	28418	31.8
VIII.	Yeshwantpur to BIA	23577	28570	37.8
	Total Metro Length (c)	-	-	69.6
	Total Metro Length (a+b+c)	-	-	140.9
2	**Light Metro**			
I	Hebbal-JP Nagar (along Western ORR)	14945	18110	31.3
II	Toll Gate to PRR along Magadi Road	10371	12567	9.7
III	National College to Kathriguppe Junction	6147	7449	5.0
IV	Hosur Road-BG Road Junction to PRR	11794	14292	13.8
V	Indira Nagar to White Field	11617	14077	17.2
	Total Light Metro Length	-	-	77.0
3	**BRT**			
I	JP Nagar-Hebbal (along Eastern ORR)	7397	8963	31.7
II	ORR to Hosur Road	12364	14982	13.0
III	Hosur Road to Tumkur Road (Western PRR)	11688	14163	42.9
IV	Tumkur Road to Hosur Road (Eastern PRR)	12219	14807	78.5
V	Along CRR	8582	10399	31.2
VI	Kengeri to JP Nagar	5200	6301	15.9
VII	Domlur Extn to Koramangala	4865	5895	5.6
VIII	Mulur to Maruthinagar	7637	9254	7.1
IX	BIEC to PRR	11519	13958	2.1
X	Cricket Stadium to BIA via Bellary Road	9429	11426	34.0
XI	Yelahanka to PRR along Dodaballapur Road	13185	15977	9.9
XII	KR Puram Metro station to PRR along Old Madras Road	5966	7229	7.7
	Total BRT Length	-	-	279.6
4	**High Speed Rail Link (HSRL)**			
	High Speed Rail Link to BIA	-	-	34.0
	Total Length (km) (Metro + Light Metro + BRT+HSRL)	-	-	531.5

Source: Comprehensive Traffic and Transportation Plan for Bengaluru, June 2011, Karnataka Urban Infrastructure Development and Finance Corporation

Note: PPHPD denotes Passengers per hour per Direction

(*) 2033: Tentative estimation by JICA Study Team applying future population growth rate 2025-2033 (accelerated case)



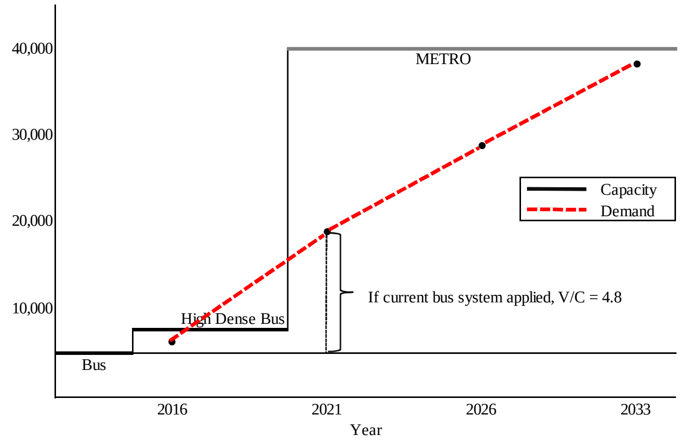
Source: Comprehensive Traffic and Transportation Plan for Bengaluru, June 2011, Karnataka Urban Infrastructure Development and Finance Corporation

Figure6.5.12: Proposed Integrated Public Transport Network (2025)

6.5.3 *Future Demand and Supply Gaps*

(1) Volume/ Capacity Ratio

Unlike the road link capacity, in case of the public transport, there are no appropriate indices to evaluate the demand and supply gaps quantitatively such as volume / capacity ratio (V/C) for each road section. Future public transport modes (such as high dense bus, BRT, LRT/ Monorail and Metro) are selected/ recommended and planned to operate so as to meet the passengers demand in accordance to the forecasted passengers per hour per direction (PPHPD). The following figure shows an example of the Corridor No.2 in Table 6.5.7above.



Source: JICA Study Team

Figure6.5.13: Example of Demand/ Supply Gap (Case of Corridor No.2 in CMA)

(2) Coverage Gaps in Public Transport

On the other hand, demand/ supply gaps in terms of the area coverage of the public transport indicates that supply is not enough to cover the areas which are far from the city centre particularly industrial areas in Sriperumbudur, Oragadam and Mahindra World City in CMA.

Commuter railway system has not been adequately developed in Bengaluru Metropolitan Area. While development of Metro and BRTS system are proposed at about 15km area from urban centre, satellite town areas are proposed at about 30-50km outside from city centre. Development of four suburban commuting railway system with upgrading of existing intercity railway system are proposed. Timely extention of commuter rail system in harmony with suburban area development is essential.

(3) Impacts on Reducing Demand/ Supply Gaps in Public Transport

Traffic demands of public transport on urban arterial road network are predicted by the "Comprehensive Traffic and Transportation Plan for Bengaluru" based on the traffic assignment simulations. According to comparison of traffic demand forecast results between business as usual case in 2025 and recommended scenario case shown in Figure6.5.134, traffic is fairly dispersed and heavy congested links are eliminated in the recommended scenario case.

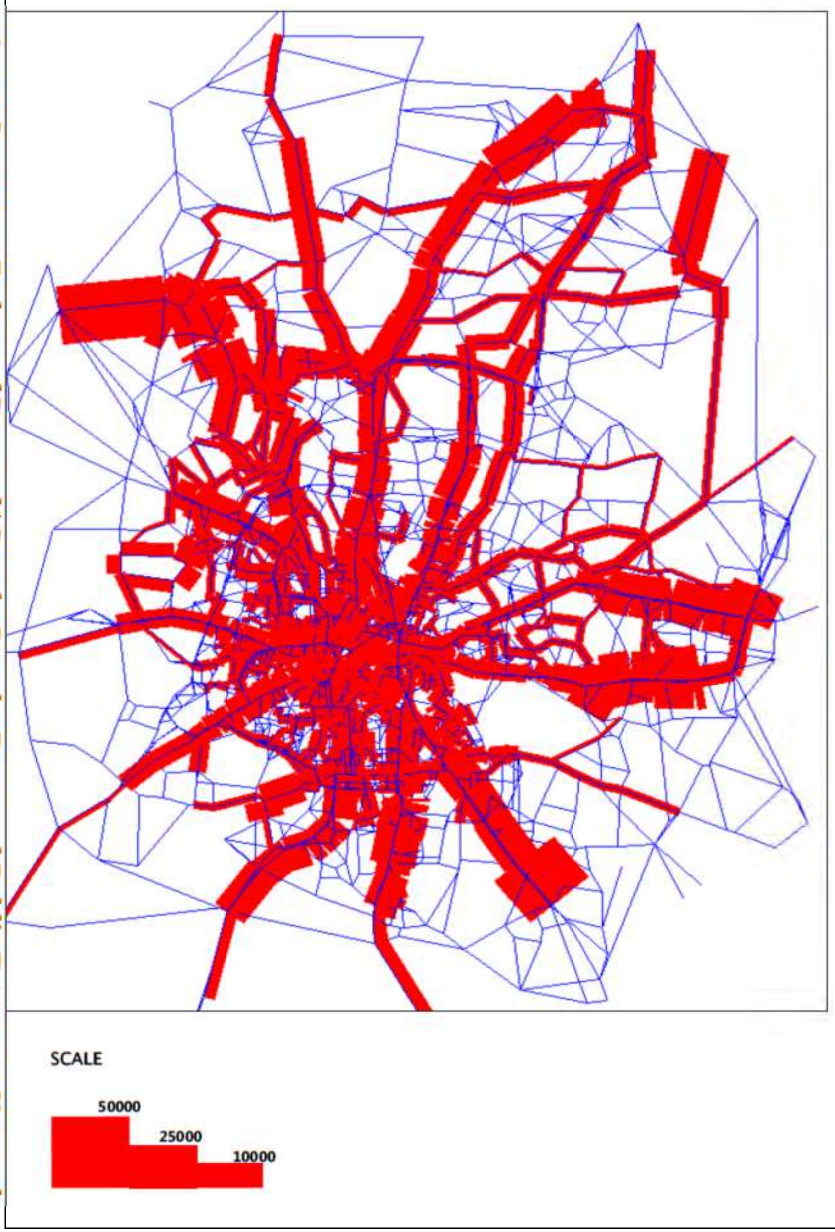
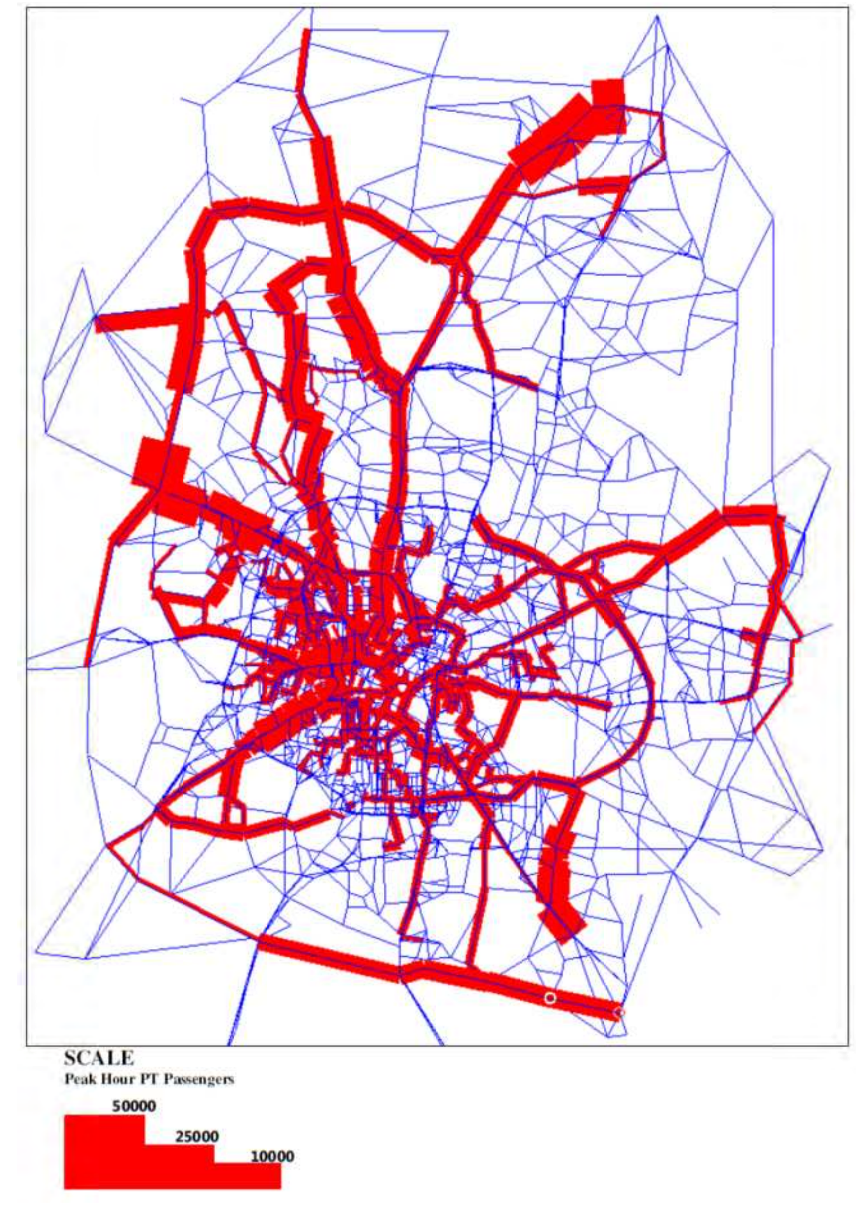
Expected Peak Hour Public Transport Passengers on Road Network in Business as Usual case 2025	Expected Peak Hour Public Transport Passengers on Road Network with Recommended Scenario 2025
	

Figure6.5.14: Impact on Reduce of Demand/ Supply Gaps by Proposed Public Transport Network

Source: Comprehensive Traffic and Transportation Plan for Bengaluru, June 2011, Karnataka Urban Infrastructure Development and Finance Corporation

(4) Supplements note to Demand/ Supply Gap Analyses

As explained above, in case of public transport projects which were proposed in the existing transport Master Plans for both CMA and BMA, public transport modes such as BRT, Mono-rail/ LRT, and Metro, are selected and planned so as to meet traffic demand for main public transport corridors, and hence, future demand/ supply gaps are expected to be avoided by each individual public transport project. On the other hand, regarding the urban road network in CMA and BMA, current demand/ supply gaps (V/C) at main road sections can be estimated based on the results of traffic counting surveys. However, information on V/C ratios of future road network is not provided in the existing transport Master Plans.

The area coverage gaps are more important issues for the two transport Master Plans from a view point of CBIC region development. The planning area of CMA is limited up to the area along the Outer Ring Road (ORR). Although the Chennai Peripheral Ring Road is one of major freight corridors to/from the Ports, its location is planned outside the ORR.

The planning area of BMA is also limited to around the Bengaluru Peripheral Ring Road, and proposal of the Satellite Town Ring Road is not included in the existing transport Master Plan. Considerations should be given for industrial parks and candidate industrial nodes located outside the planning area of BMA. Although the Chennai Peripheral Ring Road and Bengaluru Satellite Town Ring Road are not the projects by the Study Team's own proposals, in order to eliminate the area coverage gaps those are included in the project list of this Comprehensive Integrated Master Plan for CBIC because those are essential projects for the development of the CBIC region in the framework of urban transport.

6.5.4 *Infrastructure Development Strategy*

6.5.4.1 Strategy for Urban Transport Infrastructure Development

The infrastructure development strategy for urban/ public transport sector is set considering the following two aspects. One is to keep consistency with the existing transport master plans for CMA and BMA and another is focusing on the strategy for development of CBIC region.

Development Strategies for CMA and BMA adopted in the existing Urban Transport Master Plans are shown below for reference with their Visions:

Table 6.5.12: Strategy for Urban Transport Development adopted in Existing Transport Master Plans

Strategy for Chennai Metropolitan Area	Strategy for Bengaluru Metropolitan Area
<u>Vision</u> To make Chennai a prime metropolis which will be more liable, economically vibrant and environmentally sustainable and with better assets for the future generation.	**<u>Vision</u>** To realize efficient, people friendly transportation system with minimum travel time and maximum safety and comfort.
<u>Strategy</u>	**<u>Strategy</u>**
<u>1. Land use and Transport Strategy</u> 1) Consideration to environmental sensitivity area. Development toward this area should be restricted. 2) As part of land use planning, large areas to accommodate future activities has been zoned along the Outer Ring Road (ORR). Special incentives for locating employment generating activities along this corridor could be envisaged. <u>2. Road Network Strategy</u> 1) Combination of radial and circumferential roads 2) Designating NH45 and NH4 as Multi –Lane thoroughfares connecting the city area with satellite centres. 3) All committed highway network improvement such as Freight Corridors, elevated corridors and ORR.	1. Extension of mass transport system to provide wide coverage and transport integration with other modes of transport. 2. Provide substantially large network of medium level mass transport system such as BRT to cover the areas beyond the metro network and overloaded corridors. 3. Land-use adjustments and densification of, arterial and corridors along mass transport corridors where possible. 4. Extension of commuter rail system up to the BMRDA's New Town ships and beyond up to Tumkur, Hosur etc. to act as sub-urban service. 5. Rationalization of local bus system and its augmentation. 6. Improvement in traffic management system. 7. Special facilities for pedestrians within the entire network especially in the core areas (provision of pedestrian sky walk/ subways, footpaths and road furniture along the roads where necessary.

Strategy for Chennai Metropolitan Area	Strategy for Bengaluru Metropolitan Area
4) Augmenting capacity of major arterial and multi modal corridors that need capacity improvements. 5) Road network for improved connectivity and mobility including critical missing links. <u>3. Public Transport Strategy</u> 1) Bus augmentation (Rationalization of bus route system, replacement part of the existing bus fleet with modern buses with ITS application. 2) Higher Order Mass Transit Systems (Expansion and introduction of BRT/LRT/Mono-Rail/MRTS or METRO) 3) Intermodal Integration (Intermodal stations, Integrated fare Policy and ticketing, ITS, Park & Ride system, etc.)	8. Diverting through traffic on Peripheral Ring Road. Providing transport hubs at the junctions of Peripheral Ring Road with important radials such as the National Highways and other heavily loaded roads. 9. Improving primary, arterial and other important roads (particularly radial and ring roads) by providing grade separation, junction improvements, adding missing links, widening and other roadside facilities wherever necessary. 10. Institutional strengthening of urban transport organizations.

Source: Chennai Comprehensive Transportation Study, August 2010, CMDA

Comprehensive Traffic and Transportation Plan for Bengaluru, June 2011, Karnataka Urban Infrastructure Development and Finance Corporation

6.5.4.2 Strategy to Support the Development of CBIC in the Framework of Urban Transport

In addition to the above strategies set by the existing transport master plans, further strategies are necessary for the development of CBIC region. Although the public transport deals with mainly passenger movements, the major targets of CBIC is to enhance the industrial development in the region which will generate large freight traffic demand to/from the ports and logistic facilities.

The Chennai Metropolitan Area has two main ports along the east coast. The role of the ports is a gateway for raw material and produced goods through the CBIC region. In addition, many industrial parks and logistic facilities are located around the ports and along the main roads on the outskirt of the metropolitan area. Although the future public transport systems proposed by the transport master plans focused mainly on the CBD and urbanized areas to mitigate current and future traffic congestion, the following are also necessary – to also consider freight traffic coming in and going out of the CBIC region and its ports and other logistic facilities.

Regarding the Bengaluru Metropolitan Area, the candidate Industrial Nodes such as Hosur, Kolar, Ramanagara, and Tumkur are located outside the planning area of BMA together with the nine satellite towns. It is necessary to provide these industrial nodes and satellite towns with strong connectivity via a new ring road.

Considering the above issues, the strategies for the development of CBIC in the framework urban transport are set **<u>focusing on "realization of smooth and reliable connectivity"</u>** as explained below:

(1) Augmentation of capacity of public transport corridors in Metropolitan Area. The strategy and projects proposed by the existing two master plans should be implemented in parallel with the development of CBIC region. The realisation of the two transport master plans is considered to be one of pre-conditions for the development of the CBIC region. At the same time, the candidate nodes and major industrial areas are mainly located outside the planning area of CMA and BMA. Therefore, it is required to focus on transport plans to cover these areas.

(2) To provide smooth connectivity to/from the gateways (Ports) for exports and imports of products and raw materials from existing and planned industrial parks and logistic facilities. At present, it is reported that it takes 6-8 hours to/from Container Freight Stations (CFS) from/to the outskirt of Chennai. At present, as heavy trucks are prohibited to run inside the city from 6 am to 10 pm, they have to wait till night time. This is the highest priority to be addressed for the CBIC development. It is urgently required to ensure 24 hours detour routes for freight movements.

(3) To designate freight movement corridors for heavy trucks avoiding the city centre or, if possible, by providing the elevated highways directly connected with ports for freight vehicles after deep environmental assessments because it passes through the Chennai city centre.

(4) From the aspect of public transport, consideration should also be given to workers who will be commuting to and from the candidate Industrial Nodes. This is an important factor to keep the qualified engineers and other human resources for the realization and sustainable development of Industrial Nodes.

The objectives and strategy for urban/public transport subsector are summarized in the table below:

Table 6.5.13: Summary of Urban/Public Transport Subsector Objective and Strategy

Category	Objective & Strategy	Description
Infrastructure	Objective	• To augment capacity of public transport to mitigate congestion in CBD and surrounding areas • To create the environmental-friendly transport system • To enhance the connectivity to the gateways (ports) from/to the industrial areas and logistic facilities to contribute the development of CBIC region.
	Strategy	• Integration of all public transport modes such as METRO, LRT, BRT, Monorails and Inter-Modal Facilities together with appropriate procedures for Traffic Demand Management (TDM) and introduction of ITS. • Connect the sea ports and all the logistic facilities with industrial areas located inside and outside the metropolitan area by providing new ring roads and direct linkage to the ports by elevated roads. • Establish freight movement corridors for heavy cargo vehicles.
Operations & Management	Objective	• To ensure effective and safety operations of public transport • To maintain transport facilities including roads and public transport in better conditions
	Strategy	• Keep stable fund resources for operation and maintenance in addition to fare revenue. • Application of ITS technology for bus services and traffic control.
Institution	Objective	• To ensure co-ordination among various institutions related to the transport sector so as to realize effective implementation of major planned schemes.
	Strategy	• To strengthen the functions of the Unified Metropolitan Transport Authority (UMTA) in accordance with the recommendation of the National Urban Transport Policy. • Capacity building to create good and sustainable urban transport system covering all related technical fields including the Intelligent Transport System (ITS).

Source: JICA Study Team

6.5.5 *Development Goals and Target Performance Indicators*

For the purpose of evaluation of future urban transport development plans and to confirm its outcomes, the following development goals (targets) and performance indicators are prepared.

Table 6.5.14: Goals and Indicators

Development Goals	Indicators
a) Increase in Mobility (in CBD and surrounding areas)	**Average Speed in Peak Hours** (CMA) 18 km/h (2008)* →30.0 km/h (2026)* (BMA) 13.2 km/h (2010) **→30.0 km/h (2025)
b) Accomplishment of Modal Shift from Private Vehicles to Public Transport	**Modal Share of Public Transport** CMA (% in all trips) 27% (2008) →46% (2026)* BMA (% in motorized vehicles) 45.7% (2010) →69.8% (2025)**
c) Enhancement of Connectivity/ Accessibility to Gateways (sea ports) and Logistic Facilities	**Access Travel Time to/from the Sea Ports** 6-8 hours →Less than 3 hours (via. Proposed Freight Corridors).

Source: (*): Chennai Comprehensive Transportation Study, August 2010, CMDA

(**) Comprehensive Traffic and Transportation Plan for Bengaluru, June 2011,

Note: (CMA): Chennai Metropolitan Area, (BMA): Bengaluru Metropolitan Area

Table 6.5.15: Summary of Urban/Public Transport Subsector Goals and Targets

Indicator	Current Situation	Short-term Target at 2017	Mid-term Target at 2022	Long-term Target at 2032
Average Speed in Peak Hours	18 km/h (CMA) 13 km/h (BMA)	25 km/h (*1)(CMA) 25 km/h(BMA)	30 km/h (*2)(CMA) 30 km/h(BMA)	30 km/h (*2)(CMA) 30 km/h(BMA)
Modal Share of Public Transport	27%(CMA) 45.7% (BMA)	35%(CMA) 50%(CMA)	40%(CMA) 60%(CMA)	46%(CMA) 69.8%(BMA)
Access Travel Time to/from the Sea Ports	6-8 hours via city area	Less than 3 hours	Less than 3 hours	Less than 3 hours

Source: JICA Study Team

Note: (*1): METRO Phase 1 will be opened in 2015. (*2): Many proposed schemes will be completed by 2020.

The ultimate goals of all types of transport infrastructure are to support the daily socio-economic activities in cities providing reliable and smooth transport means for passengers and freight movements. Therefore, increase in mobility in terms of travel speed particularly in peak hours is the most important goal and an indicator. The realization of modal shift from private vehicles to public transport is also a goal through which congestion in the central area will be effectively reduced and travel time will be significantly saved.

Enhancement of connectivity/ accessibility to the gateways and logistic facilities is another goal to handle freight movements inside the city and from/ to the CBIC region. The public transport plans proposed in the existing transport master plans are mainly for passengers' movements. Therefore, another target is necessary for the development of CBIC region.

6.5.6 *Development Plan and Suggested Projects*

6.5.6.1 Chennai Metropolitan Area

(1) Development Plan

Based on the strategy explained in the above section, the development plans for the CMA are presented as below:

1) Formation of the strong trunk road network with a combination of radial and circumferential roads (NH4, NH5, NH45, NH 205, and Chennai Bypass, Outer Ring Road, and proposed Peripheral Ring Road) keeping the smooth connection with the Chennai Port, Ennore Port, Industrial Nodes, logistic facilities, and major industrial zones.

2) Capacity augmentation for access roads to ports

For the purpose of improvement of connectivity to the main ports in Chennai, capacity augmentation projects for access roads are planned or on-going. These projects are summarized as below:

Table 6.5.16: Capacity Augmentation Projects for Port Connectivity

		Current Conditions			After Expansion/ New Construction		
	Route	Current No. of Lanes	Capacity /day (in PCU)	Conversion to No. of Trucks (MAV)	No. of Lanes	Capacity /day (in PCU)	Conversion to No. of Trucks (MAV)
Chennai Port	Route A Via. Ennore Expressway up to IRR	2	11,000	2,400	4	45,000	10,000
	Route B Via. Elevated 4 lane corridor(NH4 up to Port)	-	-	-	4	45,000	10,000
	Route C Via. East Coast Road	4	45,000	10,000	4	45,000	10,000
Ennore Port	Route D Via. NCTPS Road Up to IRR	2	11,000	2,400	4	45,000	10,000
	Route E Via. Northern Port Access Road up to NH5	-	-	-	4	45,000	10,000

Source: JICA Study Team

Note: MAV: Multi Axle Vehicle.

Capacity: Based on IRC64-2008.

3) The public transport services are also to be extended to cover these areas/ facilities above, so as to provide commuting railway modes for workers and for daily business activities to/from the central area.

4) In order to realize the smooth connectivity to/from the sea ports and airports, introduction of Intelligent Transport System (ITS) should be promoted for the proposed ring roads (ETC, for example), intermodal stations, and integrated fare policy and ticketing.

5) Capacity building to create good and sustainable urban transport system covering all related technical fields including the Intelligent Transport System (ITS).

(2) Suggested Projects

The future public transport projects proposed by the “Chennai Comprehensive Transportation Study (CCTS) are presented in Table 6.5.7.

In this section, projects which will contribute to the development of CBIC region are selected among these recommended projects and some additional projects are proposed as shown in the table below and in Figure6.5.165and Figure6.5.176.

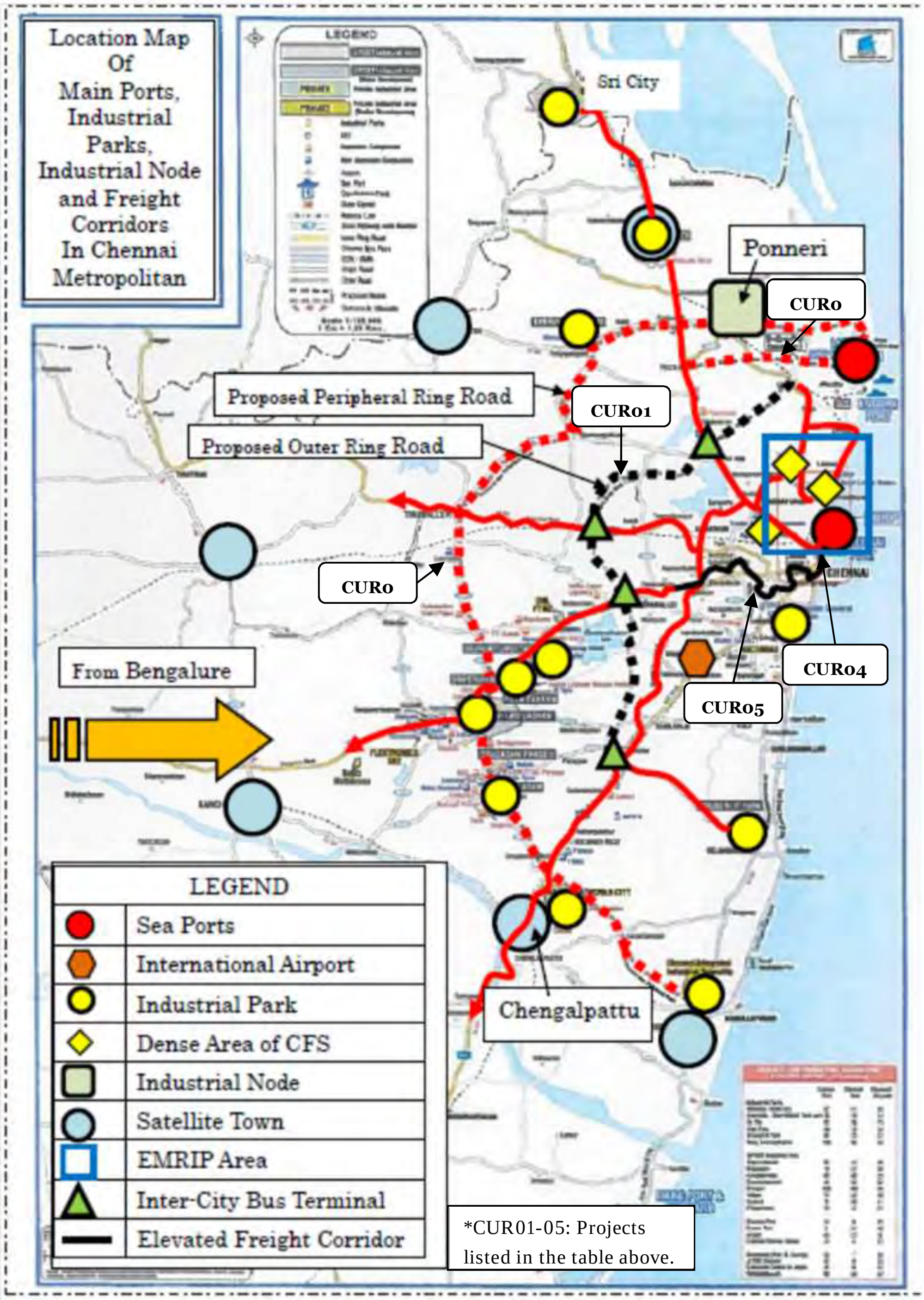
The priority order was decided taking into the urgency of each project from the aspect of connectivity to the Ports and industrial areas. Detailed project information is given in Annex 6.

Table 6.5.17: List of Urban/Public Transport Subsector Projects (Chennai)

No.	Project Title	Status	Project Cost (Million USD)	Traffic Demand	Priority 1/
	Urban Road				
CUR01	Outer Ring Road (Phase I & II)	On-going	386 (Phase I+II)	N.A.	A
CUR02	Peripheral Ring Road (PRR)	DPR prepared	266	N.A.	A
CUR03	Northern Port Access Road	Under Study	70	71,600 pcu (2033), 6 lanes	A
CUR04	Ennore Manali Road Improvement Project (EMRIP) including Bridges	On-going	112	53,000-57,000 pcu (2017), 6 lanes	A
CUR05	Elevated Freight Corridor (along the banks of Cooum River from Chennai Port to Maduravoyal)	On-going	310	43,500 pcu (2033), 4 lanes	A
	Public Transport				
CPT01	BRT (1) on ORR (Phase I section)	Proposed in existing Master Plan	84	8,000 pphpd (2026) 10,000 pphpd (2033)	B
CPT02	BRT (2) on ORR (Phase II section)	Proposed by the Study Team	90	8,000 pphpd (2026) 10,000 pphpd (2033)	B
CPT03	BRT (3) along costal road (Tiruvanmiyur to Kelambakkam IT Corridor)	Proposed in existing Master Plan	65	5000 pphpd (2026) 7000 pphpd (2033)	B
CPT04	LRT/ Monorail (from Sriperumbadur to Luz Church Road via. Poonamallee)	Proposed in existing Master Plan	1,179	12000 pphpd (2026) 16000 pphpd (2033)	B
CPT05	Inter-City Bus Terminals at the intersection of ORR and National Highways. 1) Redhills 3) Varadharajapuram 2) Thirunindravur 4) Vandalur	Proposed in existing Master Plan	150	N.A.	B
	Suburban Trains				
CST01	From Thiruvanmiyur to Mamallapuram (42 km)	Proposed in existing Master Plan	157	20000 pphpd (2026) 26000 pphpd (2033)	B
CST02	From Chengalapattu to Mallapuram (27 km)	Proposed in existing Master Plan	101	20000 pphpd (2026) 26000 pphpd (2033)	C
	Others				
CITS	Introduction of ITS to Ring Roads and inter modal systems	Proposed by the Study Team	50		A
CTR	Capacity Building for Public Transport including ITS	Proposed by the Study Team	3		A

Note: 1/ "A" refers to projects for implementation before 2018, "B" refers to projects for implementation in 2018 – 2022, and, "C" refers to projects for implementation after 2023.

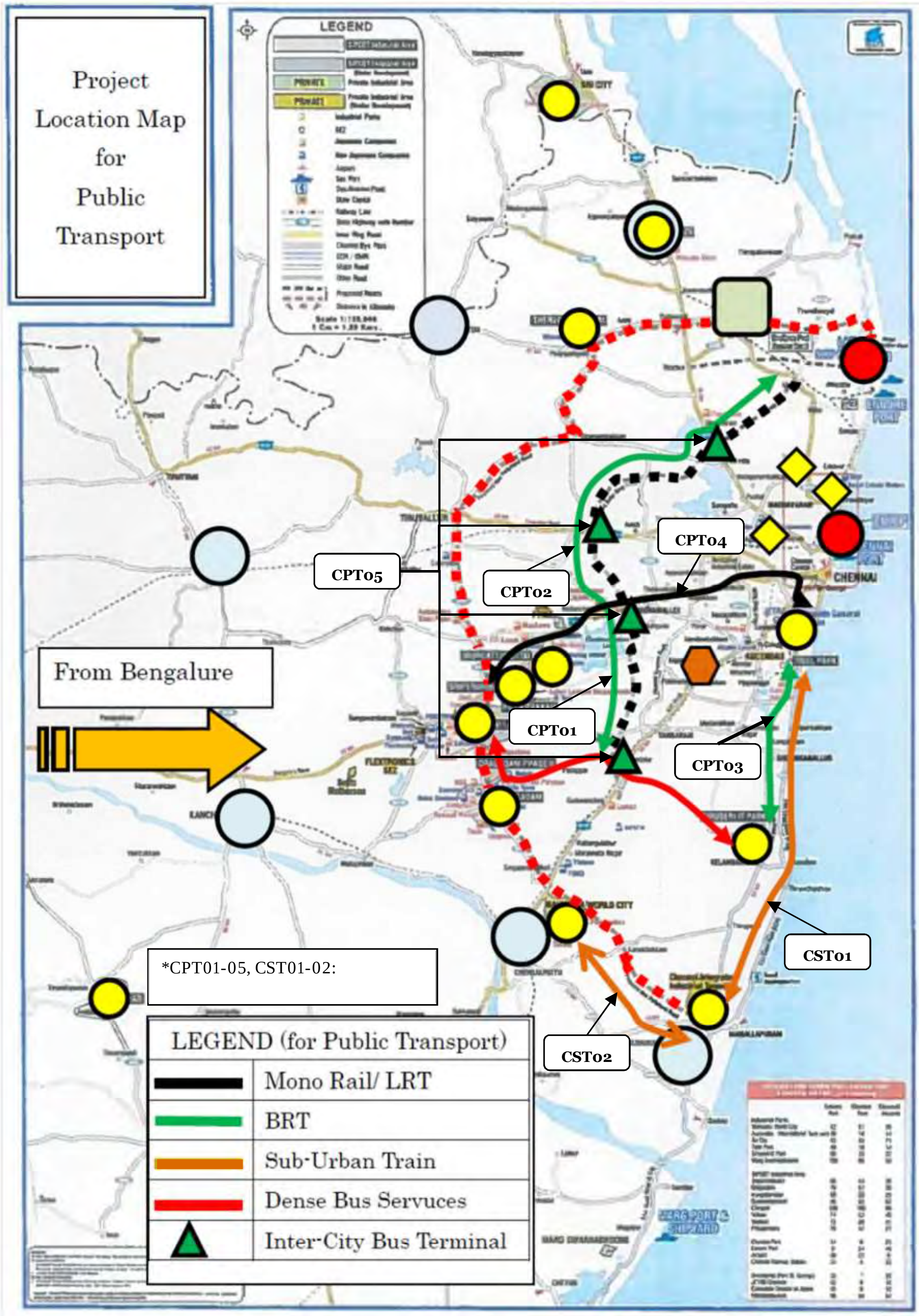
Pphpd : Passenger per hour per direction



Source: JICA Study Team

Base Map: Provided by JETRO

Figure6.5.15: Project Locations and Connectivity to Main Industrial Cores (Chennai)



Source: JICA Study Team
Base Map: Provided by JETRO

Figure6.5.16: Location Map for Public Transport Projects (Chennai)

6.5.6.2 Bengaluru Metropolitan Area

(1) Development Plan

1) In case of the Bengaluru Metropolitan Area (BMA), some industrial parks are located along the planned Peripheral Ring Road (PRR) and others are located near the Satellite Townships outside BMA. The four candidate Industrial Nodes (Hosur, Ramanagara, Tumkur, and Kolar) are also located near the Satellite Townships (Ramanagara is one of the Satellite Townships and also one of the Industrial Nodes). In order to accelerate the development of the Industrial Nodes and industrial zones in Bengaluru, it is necessary to connect these industrial zones by the Satellite Town Ring Road.

2) At present, Bengaluru has no sub-urban train services. As the urban areas are expanding year by year and the Satellite Townships are beyond the Peripheral Ring Road, extension of commuter rail system up to the new townships and beyond up to Tumkur, Hosur, etc.

3) In order to realize the smooth connectivity to/from the airport and effective use of ring roads and Metro network, introduction of Intelligent Transport System (ITS) should be promoted such as ETC for the Outer Ring Road (ORR), Peripheral Ring Road (PRR), intermodal stations, and integrated fare policy and ticketing.

4) Capacity building to create good and sustainable urban transport system covering all related technical fields including the Intelligent Transport System (ITS).

(2) Suggested Projects

Based on the above plans, suggested projects are prepared as shown below. The priority order of each project was decided taking the urgency and contribution to the development of Industrial Nodes and industrial parks. Detailed project information is shown in Annex 6.

Table 6.5.18: List of Urban/Public Transport Subsector Projects (Bengaluru)

No	Project Title	Status	Project Cost (Million USD)	Traffic Demand	Priority[1] /
	Urban Road				
BUR01	Peripheral Ring Road (PRR): Phase I (65 km)	DPR preparation	936	150,000-155,000pcu/day, V/C=0.94-0.97 (2033)(*)	A
BUR02	Peripheral Ring Road (PRR): Phase II (51 km)	Possibility of alternative use of the existing NICE Road	734	N.A.	B
BUR03	Satellite Town Ring Road	On-going (Dobbasapete –Hoskote section)	344	7,100-17,000 pcu/day (2006) 27,000-63,000 pcu/day (2033) (**)	A
BUR04	Widening of NH207 (between NH4 and NH7)	New	79 (Estimation)	N.A.	A
	Public Transport				
BPT01	BRT on PRR (Hosur Road to Tumkur Road: Western PRR), 42.9 km	Proposed in existing Master Plan	112	11,688 pphpd(2025) 14,163 pphpd(2033)	C
BPT02	BRT on PRR (Tumkur Road to Hosur Road: Eastern PRR), 78.5km	Proposed in existing Master Plan	206	12,219 pphpd(2025) 14,807 pphpd(2033)	B
	Suburban Trains				
BST01	Kengeri – Ramanagaram (32 km)	Proposed in existing Master Plan	90	10,000-20,000 pphpd (2033)	B
BST02	Baiyyappanahalli – Hosur (41 km)	Proposed in existing Master Plan	115	10,000-20,000 pphpd (2033)	B

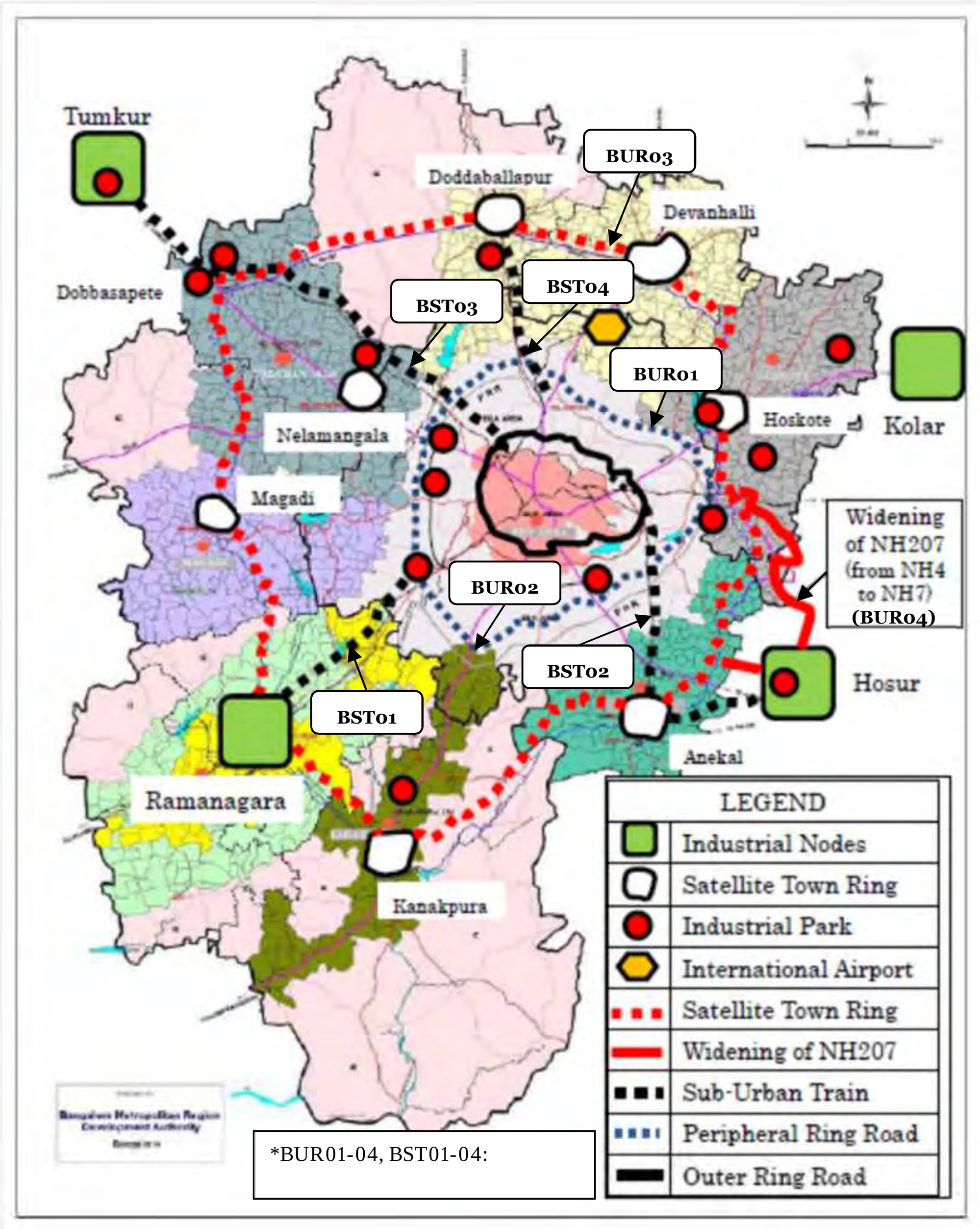
No	Project Title	Status	Project Cost (Million USD)	Traffic Demand	Priority[1/]
BST03	Yeshwantpur – Tumkur (64 km)	Proposed in existing Master Plan	180	10000-20000 pphpd (2033)	B
BST04	Yelahanka – Doddaballapur (24 km)	Proposed in existing Master Plan	67	10000-20000 pphpd (2033)	B
	Others				
BITS	Introduction of ITS to Ring Roads and inter modal systems	Proposed by the Study Team	50		A
BTR	Capacity Building for Public Transport including ITS	Proposed by the Study Team	3		A

Note: 1/ "A" refers to projects for implementation before 2018, "B" refers to projects for implementation in 2018 – 2022, and, "C" refers to projects for implementation after 2023.

Pphpd: Passenger per hour per direction

(*) Source: Draft DPR, Construction of Eight Lane Peripheral Ring Road to Bengaluru, City, (RN-05 Rev R(1))

(**): Estimation applying 5.0% of annual growth rate to 2006 traffic volume



Source: JICA Study Team

Figure6.5.17: Project Locations and Connectivity to Main Industrial Cores (Bengaluru)

(3) Supplement note to the Strategy and Demand/ Supply Gaps and Proposed Projects

Table 6.5.199 Relationship between Strategy and Demand/ Supply Gaps (Bottlenecks) and Projects

Strategy for Infrastructure Development	D/S Gaps (Bottlenecks), Area Coverage Gaps, and poor connectivity to be solved	Project	Project No.
1) Integration of all public transport modes such as METRO, LRT, BRT, Monorail and Inter-Modal Facilities together with appropriate procedures	- Excess demand of private transport -Shortage of public	-Combination of all public transport projects proposed in the existing transport Master Plans for CMA	All public transport projects proposed in the Master Plans, including

Strategy for Infrastructure Development	D/S Gaps (Bottlenecks), Area Coverage Gaps, and poor connectivity to be solved	Project	Project No.
for Traffic Demand Management (TDM) and ITS,	transport services	and BMA	CPT01-CPT05 BPT01, BPT02
	-Area Coverage Gaps in public transport services, particularly for commuting services in suburban areas	-Suburban trains	CST01, CST02 BST01, BST02, BST03, BST04
2) Connect the sea ports and all the logistic facilities with industrial areas located inside and outside the metropolitan area by providing new ring roads and direct linkage to the port by elevated roads. 3) Establish freight movement corridors for heavy cargo vehicles.	-Poor connectivity for freight traffic to/from industrial parks industrial facilities, and gateways (ports) -Area Coverage Gaps (outside planning area)	-Ring Roads -Port access roads -Elevated freight corridor	CUR01, CUR02, CUR03, CUR04, CUR05, BUR01, BUR02, BUR03, BUR04,

Source: JICA Study Team

6.5.7 *Phasing Plan*

The priority projects are selected based on the following criteria:

a) Under the development strategy explained above, projects that contribute to improve "connectivity" to/from the gateways and connectivity between industrial parks and logistic facilities are attached high priority. The smooth connectivity is one of necessary conditions for the development of the whole area of the CBIC region.

b) Introduction of ITS and capacity building are important to operate and manage the priority effectively.

Based on the priority order given in the above tables, the following phasing plans are prepared for both Chennai Metropolitan Area and Bengaluru Metropolitan Area.

Table 6.5.2020: Summary of Phasing Plan for Urban/ Public Transport Subsector (Chennai)

(Unit: Million USD)

Category	Short (-2017)	Mid (2018 – 2022)	Long (2023 – 2032)	Total
Ring Roads Development	652	-	-	652
Port Connecting Roads Improvement/ Construction	492	-	-	492
Public Transport	-	1,568		1,568
Sub-Urban Trains	-	157	101	258
ITS	50	-	-	50
Capacity Building for Public Transport and ITS	3	-	-	3
Total	1,197	1,725	101	3,023

Source: JICA Study Team

Table 6.5.211: Summary of Phasing Plan for Urban/ Public Transport Subsector (Bengaluru)

(Unit: Million USD)

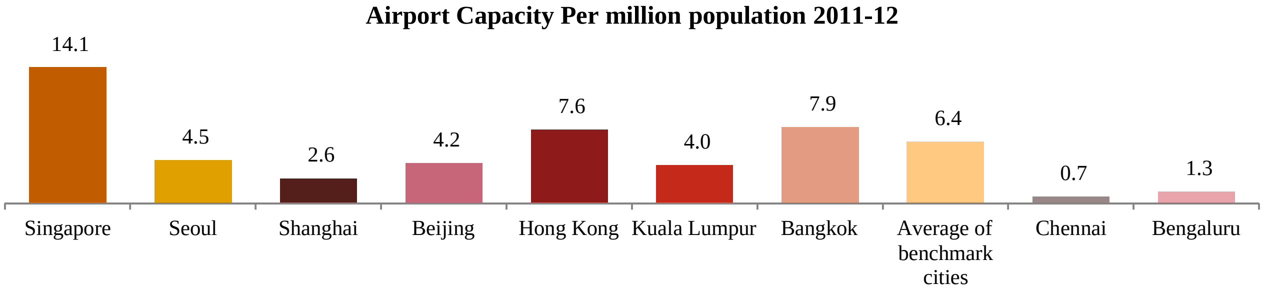
Category	Short (-2017)	Mid (2018 - 2022)	Long (2023 - 2032)	Total
Ring Roads Development	1,280	734	-	2,014
Road Widening	79	-	-	79
Public Transport	-	206	112	318
Sub-Urban Trains	-	452	-	452
ITS	50	-	-	50
Capacity Building for Public Transport and ITS	3	-	-	3
Total	1,412	1,392	112	2,916

Source: JICA Study Team

6.6 Airports

6.6.1 Sector Overview

The proposed corridor region has two international airports at Chennai and Bengaluru and one non-metro airport at Tirupati. Despite the growth witnessed in the passenger and cargo traffic in the region, the air capacity in the region still lags behind the population growth in the major cities of Chennai and Bengaluru. As compared to international cities, the airport capacity per million of the city population is significantly lower than the international average.



Source: *Preliminary Study for the Comprehensive Integrated Master Plan for the Chennai – Bengaluru Industrial Corridor, 2012 PwC Final Report*

The problems in airport infrastructure, in addition to limited air capacity, are further compounded by the lack of sufficient infrastructure facilities at the airports in the region as well as issues related to operational performance of these airports as witnessed in the high dwell time for import and export cargo.

The Chennai Airport takes an average of more than 4 days (as per 2013 data from AAI) for import cargo clearance. The export clearance is completed within 2 days. This high dwell time is also partly due to the government's allowance of 72 hours free period both on exports and imports at the airports in the country. Some of the major reasons for the high cargo dwell time at airports are the time consuming customs and documentation procedures as well as the lack of sufficient infrastructure facilities (like truck docking bays). The average dwell time (import and export) for most of the Indian airports is much higher than the international airports (as shown in the graph below).

Besides, the absence of sufficient cargo handling facilities especially related to handling special cargo, perishable cargo etc. is also likely to hinder the growth of air freight in the corridor region. Like in the case of ports, movement of heavy cargo via airports also suffers from the same problems of city road congestion and travel time restrictions.

Challenges in development of airports

The Central Government, owing to the challenges facing in upgradation of country's airport infrastructure, opened the gateway for the private players to participate from the beginning of 10th Plan (2002-07). The classic examples of such developments are Delhi, Mumbai, Hyderabad and Bengaluru airports. Delhi and Mumbai fall under the Brownfield PPP airports, and Hyderabad and Bengaluru fall under the Greenfield PPP airports. An investment of approximately INR 30,000 crores was brought in as a part of PPP for the four airports mentioned above. Airport Authority of India also continued its effort to modernise and redevelop other airports of the country. It invested about 13,000 Crores in modernization of Kolkata and Chennai airports along with the upgradation of 35 non-metro airports in the country.

It is observed that the improvement in airport infrastructure is focussed on metropolitan and other growing cities. The interior parts of the country are not yet benefitted from aviation industry as the penetration of air transport in these regions is limited. Nearly 80% of the population is handled by top 10 major airports in the country. Remaining traffic is handled by 45 different airports in the country. A gradual shift in future investments targeted at areas that handle smaller proportions of traffic is expected with the anticipated development of non-metro airports by the Airports Authority of India (AAI). However, these interventions require policy changes at the central level in order to incentivize investments in such areas. There is a need to attract investments in the tier 2 & 3 cities where they have existing minimal demand.

1. A comprehensive planning involving all the stake holders would develop an induced demand in these regions. A hub and spoke model can be developed in the long run with airports in metro and regional nodes around forming a hub with this network.

2. New business models can be encouraged for better private participation. Mitigation of demand risk through alternate concession models like provision of subsidies, commercialization of assets, creation of industrial hubs in the region around and development of airport cities and aerotropolis to support the industrial development etc. are potential solutions that need to be examined supported by required policy level changes.

3. Measures to encourage / incentivize airline operators to fly more routes to remote locations could attract the required demand for making the non-metro airports viable.

4. There is a significant amount of funds spent on the modernization and beatification of the airport which is leading to cost overrun. Standardization of the design and specifications, functional airport infrastructure and service quality could curtail investment to some extent. It is observed that, the cost plus model is prevailing with existing airports, hence leading to significant increase in cost. This in turn increases the burden on consumers. Therefore, capping on project cost would also help in resolving the issue of cost overrun.

The interim report 1 highlighted the key bottlenecks in the airport sector in the region, the most important of which are captured in the introduction above. The objectives of the sections covered under this section herein are to assess the future demand and supply of airports in the region and propose broad strategic measures to help improve airport capacity in the region to cater to the anticipated demand.

6.6.2 *Demand Forecast*

The basis for the demand forecast of both passenger and freight traffic is explained in the sections below.

6.6.2.1 Passenger traffic

Air passenger traffic is influenced by a host of economic and social factors covering rising GDP, expanding middle-income group, increase in skilled workforce, rising urbanization, tourism and other important aviation industry related factors such as increase in low cost carriers making air travel cheaper and accessible to the rising middle & upper middle class[104]. The CBIC region is expected to increase its manufacturing output significantly; correspondingly, elements such as urbanization, migration of skilled workforce and business travel are expected to be increase significantly.

The historical growth rates and the growth rates of the Working Group on Civil Aviation Sector (June 2012) have been analyzed for estimation of the future growth rates:

Growth rates of passenger traffic	**Historical CAGR**		**Growth rates of the Report of the Working Group on Civil Aviation**	
	Domestic	**International**	**Domestic**	**International**
Chennai (2006-13)*	5.36%	7.47%	-	-
Bangalore (2006-13)*	5.55%	11.93%	-	-
All India (2010-11 to 2031-32)**	-	-	10%	9%
Sources:* Growth rates based on AAI traffic data; **Report of the Working Group on Civil Aviation, Ministry of Civil Aviation, June 2012				

[104] Report of the Working Group on Civil Aviation Sector, Ministry of Civil Aviation, 2012

The growth rate of traffic in Bangalore has been higher due to commencement of the new airport in the year 2008. The new airport reached the peak design capacity of phase 1 of 12 million passengers in 2012. This explains the pent up demand for air travel in the Bangalore region. The Report of the Working Group on Civil Aviation (June 2012) predicts that the passenger traffic in the country is expected to grow at a CAGR of 10% in the domestic segment and 9% in the international segment during the years 2010-11 to 2031-32. These growth rates have been taken into consideration in line with anticipated rise in GDP growth of 6.5% during the same period, growing urbanization, impetus through plans such as National Manufacturing Plan and anticipated recovery of international markets spurring international travel.

Considering the above growth rates, the growth rates for the accelerated (BIS) scenario have been taken to be 10% and 9% respectively for domestic and international air passenger traffic for the projection period of 20 years. This is in line with the projections of the Ministry of Civil Aviation which considers the impact of national manufacturing plan interventions. The growth rates under the business as usual scenario have been reduced by 2 basis points from the accelerated scenario. Correspondingly, the growth rates for the business as usual (BAU) scenario have been taken to be 8% and 7% respectively for domestic and international air passenger traffic for the projection period of 20 years.

6.6.2.2 Freight traffic

Air cargo growth remains impacted by many drivers such as growing economic activity, manufacturing output linked to future growth plans such as the NMP, growth in passenger fleets and regional trade[105]. The CBIC region is expected to increase its manufacturing output significantly and expected to emerge as a world class manufacturing hub. It is anticipated that the CBIC region would witness significant regional and international trade owing to its projected manufacturing activity.

At present, the key exports from the CBIC airports include garments, pharmaceuticals, electrical & electronic goods, engineering goods and perishables such as fruits and vegetables. Key imports include electrical & electronic items, engineering goods, computer parts, automobile parts and chemicals. It has not been possible to analyze the volume of air cargo traded by commodity due to lack of data availability[106].

An analysis of the historical growth rates and the projected growth rates of the Ministry of Civil Aviation have been undertaken for estimation of the future trends of air cargo growth in the region.

Growth rates of air cargo traffic	Historical CAGR		Growth rates of the Report of the Working Group on Civil Aviation	
	Domestic	International	Domestic	International
Chennai (2006-13)*	10.56%	3.29%	-	-
Bangalore (2006-13)*	4.23%	6.37%	-	-
All India (2010-11 to 2031-32)**	-	-	10%	11%
Sources:* Growth rates based on AAI traffic data; **Report of the Working Group on Civil Aviation, Ministry of Civil Aviation, June 2012				

Though the historical growth rates in Chennai & Bengaluru have been affected due to the recent economic slowdown, the Report of the Working Group on Civil Aviation (June 2012) predicts that the air cargo traffic in the country is expected to grow at a CAGR of 10% in the domestic segment and 11% in the international segment during the years 2010-11 to 2031-32. These growth rates have been taken into consideration in line with anticipated rise in GDP growth and impact of national plans such as the National Manufacturing Plan.

Considering the above growth rates, the growth rates for the accelerated (BIS) scenario have been taken to be 10% and 11% respectively for domestic and international air cargo traffic for the projection period of 20 years. This is in line with the projections of the Ministry of Civil Aviation which considers the impact of national manufacturing plan interventions. The growth rates under the business as usual scenario have been reduced by 2 basis points from the accelerated scenario. Correspondingly, the growth rates for the business as usual (BAU)

[105] Report of the Working Group for Air Cargo Logistics in India, Ministry of Civil Aviation, May 2012
[106]Available data from AAI and publicly available sources have been analyzed

scenario have been taken to be 8% and 9% respectively for domestic and international air cargo traffic for the projection period of 20 years.

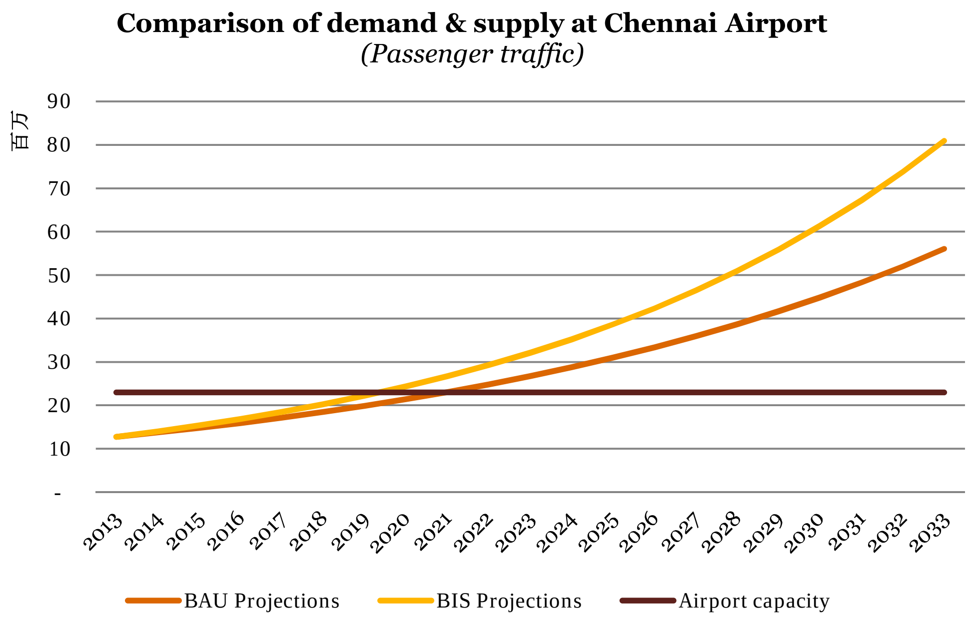
The results of the demand projections under the BAU and BIS scenario for both passenger and air cargo are captured in the forthcoming section for both Chennai and Bengaluru airports. It is to be noted that the airport in Tirupati handles passengers primarily for pilgrimage and tourism segments and hence have not been taken into consideration in the projections.

6.6.3 *Demand/Supply Gaps*

6.6.3.1 Passenger traffic

Chennai airport

Based on the growth rates assumed above, air traffic at Chennai airport is expected to reach its full capacity of handling 23 million passengers per annum by the year 2021 and 2020 under the BAU and BIS scenarios respectively. Due lack of land availability and urbanization around the airport, further expansion of the airport is expected to be challenging. By 2033, Chennai's air passenger traffic demand is expected to reach 56 million under the BAU scenario and to 80 million in the BIS scenario.



Source: JICA Study Team analysis

The gap in demand compared to supply of passenger traffic at Chennai airport is expected to widen significantly to around 33 million in the BAU scenario and around 58 million in the BIS scenario by the year 2033. The demand supply gap in passenger traffic at periodic intervals is captured in the table below.

Demand supply gap at Chennai airport (in million passengers)	2018	2023	2033
BAU scenario	-	(3.7)	(33.0)
BIS scenario	-	(9.1)	(57.9)
Source: JICA Study Team analysis			

Due to challenges in expansion of Chennai airport, an alternative airport for Chennai would be necessary. The proposed airport in Sriperumbudur would be required to be operational by the year 2020-21 to sustain demand in the region.

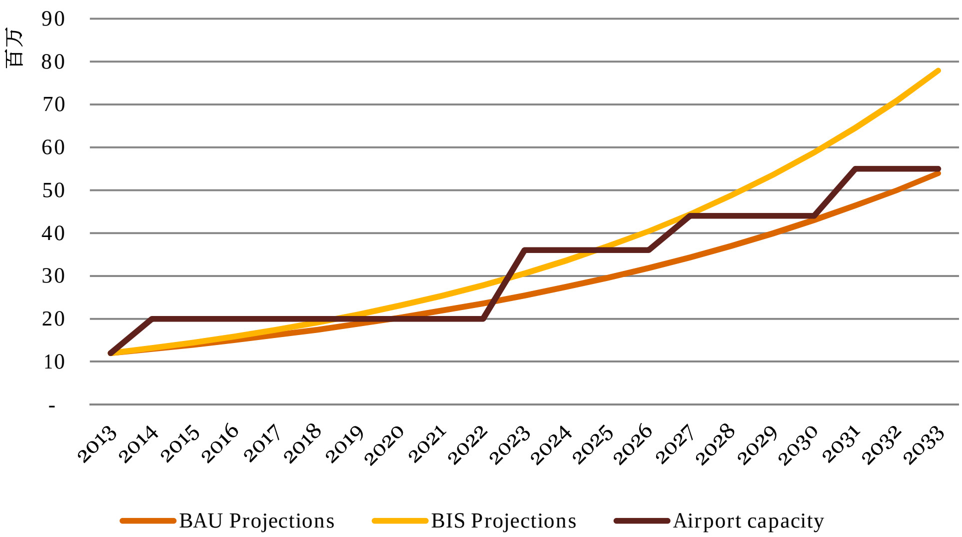
Bangalore airport

The traffic projections for Bangalore airport is expected to hit its capacity of 20 million passengers by 2020 and 2019 in the BAU and BIS scenarios respectively. The master plan of Bangalore airport proposes to add the following capacities during various time periods. The capacity addition has been planned by taking into account a traffic growth rate of 9% on an average.

Phases	Capacity in millions	Cumulative capacity in millions
Existing capacity (Phases 1 & 2)	20	20
Phase 3 (2023)	16	36
Phase 4 (2027)	8	44
Phase 5 (2031)	11	55
Source: Bangalore International Airport Limited, 2013		

By 2034, Bangalore airport's passenger traffic is expected to reach 58 million under the BAU scenario and to 85 million in the BIS scenario.

Comparison of demand & supply at Bangalore Airport
(Passenger traffic)



Source: JICA Study Team analysis

The gap in demand compared to supply of passenger traffic at Bangalore airport is expected to be around 23 million in the BIS scenario by the year 2033. The demand supply gap in passenger traffic at periodic intervals is captured in the table below.

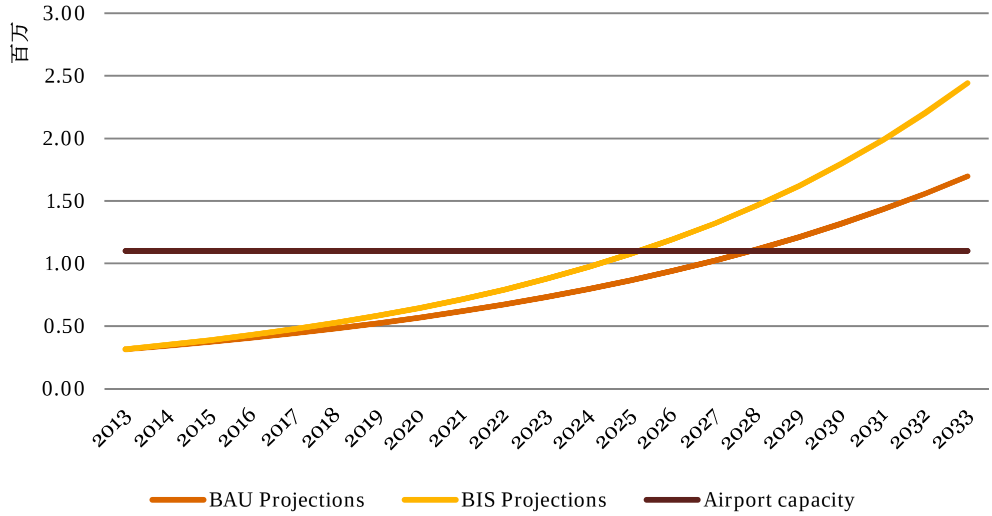
Demand supply gap at Bangalore airport (in million passengers)	2018	2023	2033
BAU scenario	-	-	-
BIS scenario	-	-	(22.9)
Source: JICA Study Team analysis Note: Demand supply gaps are witnessed in the years 2020-22 in BAU & BIS cases and 2025-33 in the BIS case; these gaps could be addressed by advancing the proposed expansion of the airport further discussed below in this section			

6.6.3.2 Freight traffic

Chennai airport

The projected freight traffic for Chennai airport is anticipated to reach 1.7 MT in the BAU scenario and 2.4 MT in the BIS scenario by 2033. Under the BAU scenario, the supply capacity of 1.1 MT at the airport is expected to fall short of demand in the year 2028. The capacity is expected to turn insufficient in the year 2026 under the BIS scenario.

Comparison of demand & supply at Chennai Airport
(Tonnes)



Source: JICA Study Team analysis

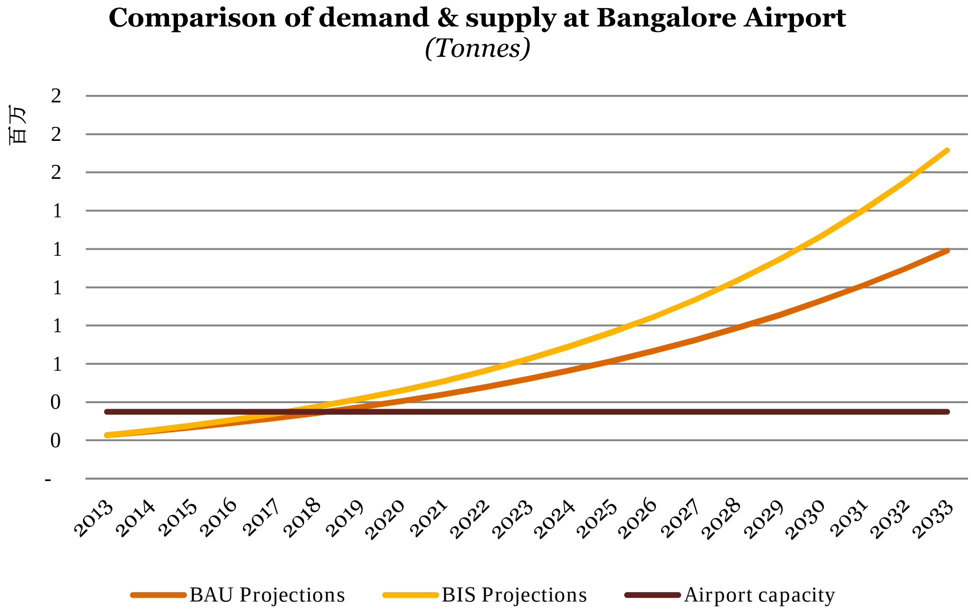
The gap in demand compared to supply of air cargo traffic at Chennai airport is expected to increase to 0.59 MT in the BAU scenario and 1.3 MT in the BIS scenario by the year 2033. The demand supply gap air cargo traffic at periodic intervals is captured in the table below.

Demand supply gap at Chennai airport (MT)	2018	2023	2033
BAU scenario	-	-	(0.59)
BIS scenario	-	-	(1.34)
Source: JICA Study Team analysis			

Given the constraints in expansion of Chennai airport, it is anticipated that the required capacity would need to be built at new airports in the region.

Bangalore airport

The projected freight traffic for Bangalore airport is anticipated to reach 1.2 MT in the BAU scenario and 1.7 MT in the BIS scenario by 2033. The supply capacity of 0.35 MT at the airport is expected to fall short of demand in the year 2019 and 2018 in the BAU and BIS scenarios respectively.



Source: JICA Study Team analysis

The gap in demand compared to supply of air cargo traffic at Bangalore airport is expected to increase to 0.84 MT in the BAU scenario and 1.37 MT in the BIS scenario by the year 2033. The demand supply gap air cargo traffic at periodic intervals is captured in the table below.

Demand supply gap at Bangalore airport (MT)	2018	2023	2033
BAU scenario	-	(0.17)	(0.84)
BIS scenario	(0.02)	(0.27)	(1.36)
Source: JICA Study Team analysis			

Based on the demand supply analysis of air passenger traffic and air cargo in the region, the infrastructure development strategy has been drawn up and discussed in the following sections.

6.6.4 *Infrastructure Development Strategy*

The successful sustenance of the projected economic activity in the CBIC region would be contingent on the presence of critical transport infrastructure, of which airports play an important role. In order to achieve the anticipated gap in supply compared to demand, the strategy for development of airports should be two fold (1) improve the efficiency and capacity of the existing airports to global standards, and (2) create additional world class airports in the region.

1 Improving of the capacity & efficiency at existing airports to global standards over the short to medium term

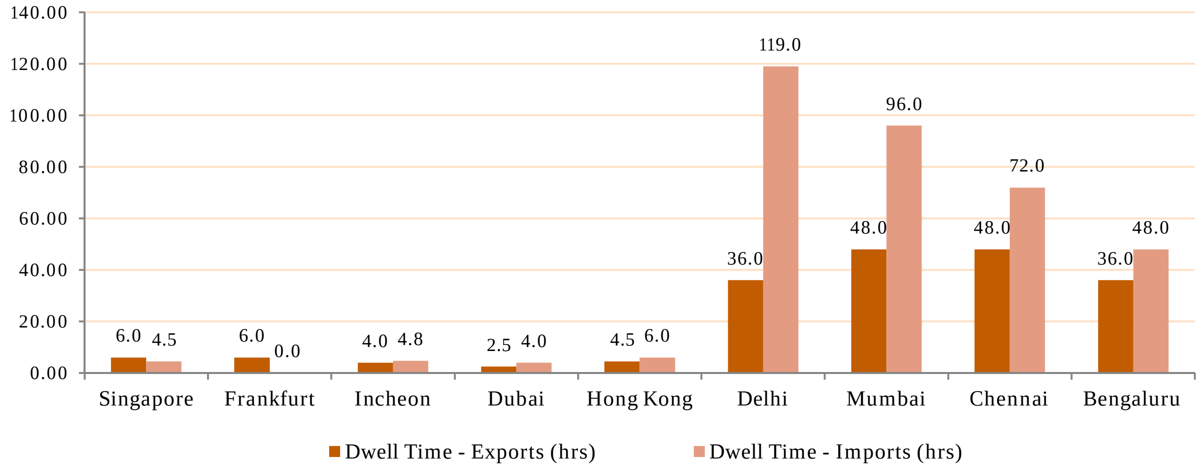
2 Creation of additional world class airports over the medium to long term

mproving the capacity &efficiency of existing airports

While land constraints in Chennai trigger creation of a new airport in the region, efforts should be made to modernize the existing airport to ensure that its performance is maximised. Bangalore airport's ultimate design capacity of 55 million is expected to be built in the year 2030-31. The airport has sufficient capacity to handle the passenger demand up to 2029-30 after which the region's traffic demand surpasses 55 million in the BIS scenario. Timing issues are observed in the pattern of rise in demand compared to the airport's expansion plans. The airport could best cater to demand in the region by advancing its expansion plans by 3-5 years. These suggestions are discussed in the develop plan and suggested projects.

As observed earlier in this section, the dwell time of cargo at Chennai and Bangalore airports are significantly higher when compared to leading international airports. For instance, the dwell time of export cargo in Chennai airport is 48 hours compared to around 4.5 to 6 hours in the airports at Hong Kong, Singapore and Frankfurt. The chart below captures the dwell time of cargo at both Chennai and Bangalore airports compared to the international benchmarks.

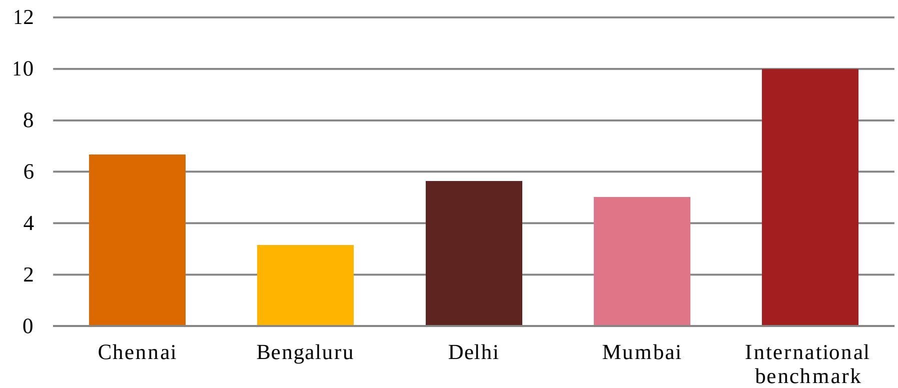
Average Dwell times for Imports and Export clearance, 2012



*Includes 72 hours free period both on Exports and Imports in India
(Source: *Working Group Report on Air Cargo Logistics in India, 2012*, Ministry of Civil Aviation)

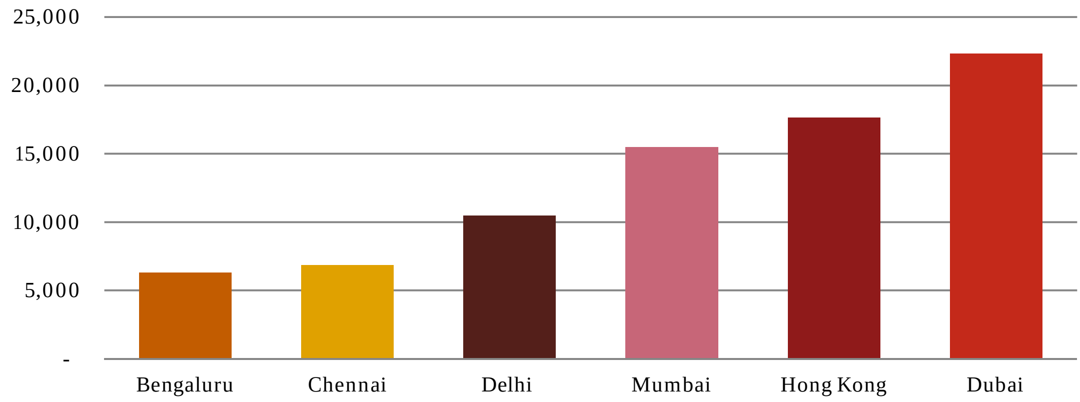
A comparison of the average tonnage handled per square meter shows that Chennai and Bangalore handle about 6.6 and 3.14 tonnes per square meter respectively. This when compared to international benchmark of 10 tonnes per square meter is very low as captured in the following chart.

Comparison of tonnage handled per square meter



Source: Air Cargo Logistics in India - Working Group Report, Ministry of Civil Aviation, 2012

Comparison of traffic handled per truck docking bay (tonnes)



Source: Air Cargo Logistics in India - Working Group Report, Ministry of Civil Aviation, 2012 & JICA Study Team Analysis

International airports that handle increased cargo have created sufficient infrastructure such as truck docking bays and aircraft parking bays for freighter aircrafts. Hong Kong airport has over 230 docking bays when compared to 36 and 46 in Chennai and Bangalore respectively. The traffic handled per truck docking bay compares low for Bangalore & Chennai (around ~6,200-6,500 tonnes) when compared to benchmarks such as Hong Kong and Dubai which handled ~17,600 tonnes and ~22,300 tonnes respectively per docking truck bay at their respective airports.

While interventions in existing airports could face challenges in terms of retrofitting additional physical structures, the possibilities of modernization and efficiency improvement through a high degree of automation should be explored over the short to medium term. Improvements to the operations and infrastructure at existing airports could result in better utilization of the airports leading to additional handling of passengers and air cargo thereby contributing to reduction in the overall gap in airport infrastructure required over the medium to long term. It is however not possible to accurately estimate the additional passenger and cargo handling facility that is possible in the existing airports through such efficiency improvement measures.

Creation of additional world class airports

The CBIC region is expected to witness significant economic growth in the accelerated scenario. Correspondingly, the airport capacity in the region needs to be expanded significantly to cater to the anticipated demand, as the airports of Chennai and Bangalore and not expected to sustain over the short and medium /long term respectively. Accordingly, new airport capacity would need to be created in the Chennai and Bangalore regions.

The various development goals and strategies are discussed in the following sections.

6.6.5 *Development Goals and Target Performance Indicators*

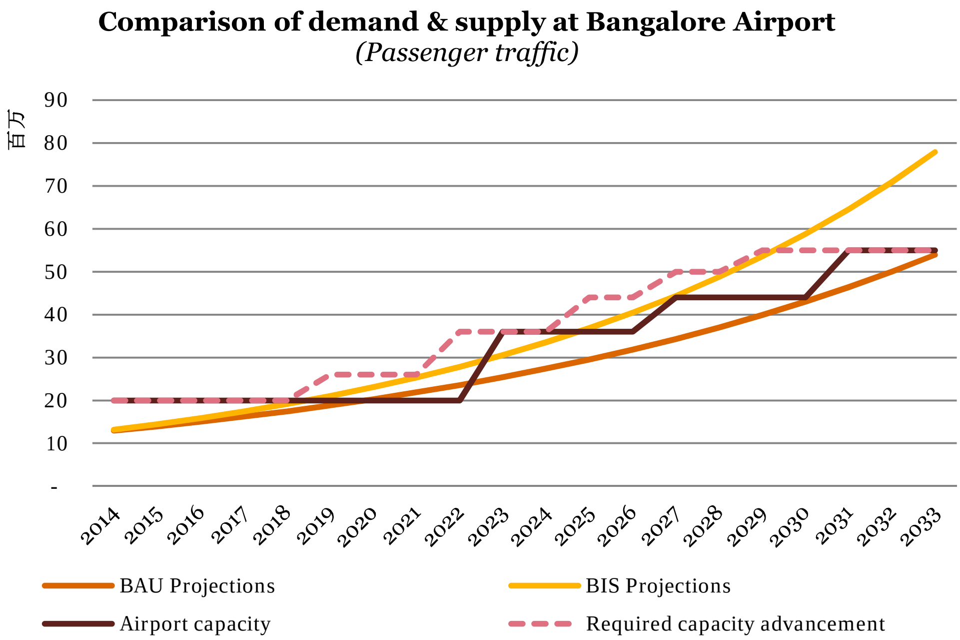
Development goal 1: Improvement of efficiency of Chennai airport

As capacity at Chennai airport is expected to fall short of rising demand by the year 2020, it would be important to evaluate options to maximise the efficiency of Chennai port to handle increased traffic. Challenges in land acquisition could delay development of additional airports; therefore, it would be important to target efficiency improvement. The efficiency improvements at the airport should target handling of increased passengers through infusion of additional possible infrastructure within the airport and target to bring down the cargo dwell time to international benchmarks of roughly 4-6 hours. This would also entail improvement of customs procedures at the airports and management of traffic and cargo within the airports. Further the port could consider modernizing the cargo handling facility to induce a high degree of automation in order to achieve a lower dwell time of cargo.

Development goal 2: Improvement of efficiency & revisiting expansion plans of Bangalore airport

Bangalore airport has sufficient capacity to handle the passenger demand up to 2029-30 after which the region's traffic demand surpasses 55 million in the BIS scenario. Timing issues are observed in the pattern of rise in demand compared to the airport's expansion plans. The airport could improve its ability to cater to the region and minimize demand supply gaps by advancing its expansion plans by 2-3 years. Given that Bangalore airport is a private airport guided by formal regulatory process for planning and approving its capacity expansion, it is expected that that the process would be best placed to carry out a dynamic assessment of developments and time the expansion in accordance to growing demand. The required capacity addition at the airport is captured as under:

Phases (& original plan dates)*	Scheduled capacity in millions *(as per plan)	Required expansion**
Existing capacity (Phases 1 & 2)	20	
Phase 3 (2023)	16	• 6 million by 2019 • 10 million by 2022
Phase 4 (2027)	8	• 8 million by 2025
Phase 5 (2031)	11	• 6 million by 2027 • 5 million by 2029
Source: *Bangalore International Airport Limited, 2013; **JICA Study Team analysis		



Source: JICA Study Team analysis

Similar to the improvements suggested for Chennai airport above, the efficiency improvements at the airport should target handling of increased passengers through infusion of additional possible infrastructure within the airport and target to bring down the cargo dwell time to international benchmarks of roughly 4-6 hours. The port could consider modernizing the cargo handling facility to induce a high degree of automation in order to achieve a lower dwell time of cargo. Given that the airport is under a PPP concession with 26% of the stake jointly owned by Government of Karnataka and Airports Authority of India, these improvement initiatives should be spearheaded by the government and AAI.

Development goal 3: Creation of additional airport capacity

Development goal 3A: Creation of additional airport capacity in the Chennai region

The peak capacity of 23 million passengers of Chennai airport is expected to fall short of rising demand in the years 2020-21, triggering the need for an additional airport in the region. The proposed airport in Sriperumbudur at a distance of 40 kilometres from the existing Chennai airport would need to be operational by 2020-21. ***Considering a time period of 2-3 years for land acquisition and development period of 3-4 years, the efforts for creation of this airport needs to begin immediately.*** It is recommended that a separate study be commissioned at the earliest for development of the proposed airport and also determine its passenger and freight handling capacities.

Development goal 3B: Creation of additional airport capacity in the Krishnapatnam region

Krishnapatnam is at a distance of 200 kilometres from Chennai airport and 134 kilometres from Tirupati airport. According to the plans of the Ministry of Civil Aviation, the annual passenger handling capacity of the airport in Tirupati is expected to be 73,000 by the end of the XII Plan. This expansion would not be sufficient to cater to the air passenger demand expected from Krishnapatnam which is one of the nodes in the CBIC region. Therefore, it is proposed that a new Greenfield airport be developed in Krishnapatnam. It is recommended that a separate study be commissioned for development of the proposed airport and also determine its passenger and freight handling capacities.

Development goal 3C: Creation of additional airport capacity in the Bangalore region

The Bangalore airport's ultimate capacity could sustain rising demand up to the year 2029-30, beyond which a new airport would be required. Further, considering the timing differences in rise in demand compared to the airport's expansion plans, the need for an additional airport could be expected in the year 2024-25. Creation of the new airport could be delayed by a 5 year period should the capacity addition at Bangalore airport happen as per the required capacity expansion shown earlier in this section. However, it would be beneficial to have an additional airport by the year 2024-25 owing to growing demand in the region and reduce over-dependence on Bangalore airport to serve the hinterland.

The prevailing regulations of the Ministry of Civil Aviation prohibit development of additional Greenfield airports within a region of 150 kilometres from an existing airport. The proposed location of Sriperumbudur where an additional airport is expected to be developed to support growing demand in the Chennai region is about 40 kilometres from the existing airport in Chennai. Accordingly, it can be inferred that the Ministry of Civil Aviation regulations would not strictly apply in cases where an existing airport's capacity faces saturation triggering the need for an alternative airport. Accordingly, the potential nodes in the vicinity of Bangalore (within a reach of 150 kilometres) have been shortlisted[107]. The short listed nodes included Mulbagal, Hosur, Bidadi, Tumkur & Hindupur. Among these nodes, the nodes where large scale developments such as the NIMZ were planned have been further shortlisted. These include Tumkur and Mulbagal. Among these locations, the Mulbagal has been chosen as it serves the maximum number of nodes within a range of 150 kilometres. The analysis is captured in the table below:

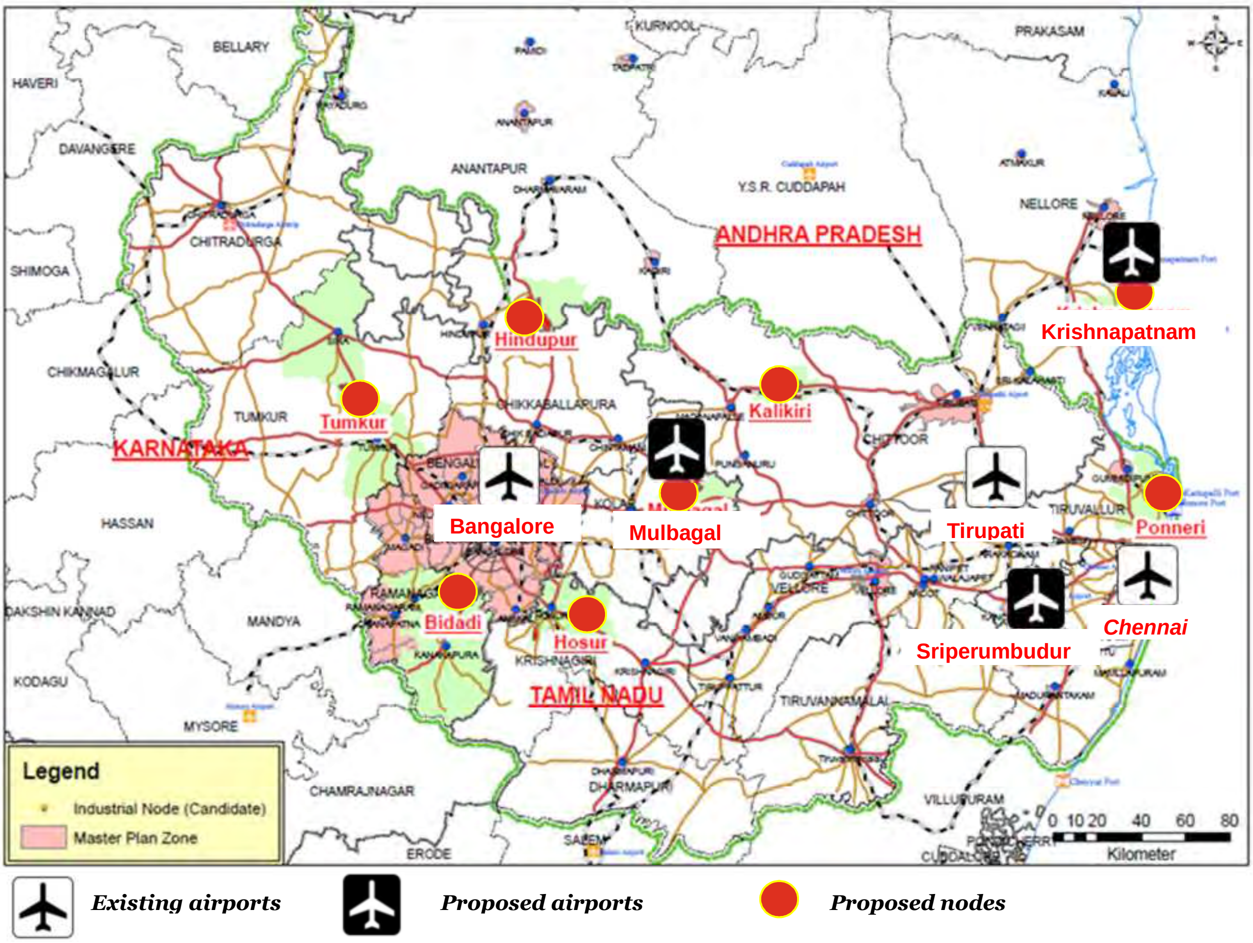
Criteria	Preferred locations
Filter 1: Nodes within a distance of 150 km from Bangalore airport	• Mulbagal – 110 km • Hosur – 75 km • Bidadi – 75 km • Tumkur – 95 km • Hindupur – 100 km
Filter 2: Nodes where large scale developments such as NIMZs are planned; this filter has been used as these locations are expected to develop into integrated townships in future and	• Mulbagal – 110 km • Tumkur – 95 km

[107] The airport at Mysore, falls out of the influence area of the corridor and is not in close proximity to any of the chosen nodes around Bangalore/Tumkur region. Therefore, the analysis of Mysore airport has been excluded as part of the development plan

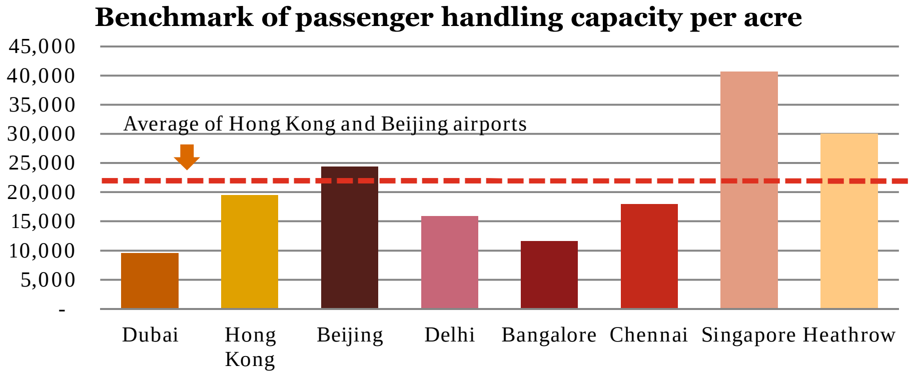
Criteria	Preferred locations
could justify development of an airport	
Filter 3: Locations serving the maximum number of nodes within a range of 150 km	• ***Mulbagal (ability to serve 4 locations) – preferred location*** o Kalikiri – 84 km o Hosur – 91 km o Bidadi – 129 km o Hindupur – 144 km • Tumkur (ability to serve 3 locations) o Hosur – 89 km o Bidadi – 86 km o Hindupur – 89 km
Source: JICA Study Team analysis	

As per the above analysis framework, Mulbagal emerges as the preferred location for development of an additional airport near Bangalore. It is recommended that a separate study be commissioned for development of the proposed airport and also determine its passenger and freight handling capacities.

A map showing the locations of the proposed airports in the CBIC region along with the locations of the existing airports and proposed nodes is captured as under:



A critical goal for the corridor region would be to create world class airport infrastructure and target the efficiency levels observed in international airports. A benchmark of passenger handling capacity per acre shows that the airports of Chennai & Bangalore have lower capacity utilization per acre when compared to international benchmarks. Chennai airport, built over an area of 1,283 acres handles 23 million passengers, implying ~ 18,000 passenger handling capacity per acre. While this compares higher than the equivalent benchmark for Bangalore and Delhi airport, it falls short significantly when compared to airports such as Beijing and Hong Kong, as captured in the following chart. The corresponding benchmark for Bangalore stands at ~11,600 implying a lower passenger handling capacity per acre.



Source: JICA Study Team analysis based on publicly available information

The additional airports to be developed in the region could ideally target capacities of 22,000 passengers per acre which is an average of Hong Kong and Beijing airports. Further, an economic cost benefit assessment of the proposed airports is recommended to be undertaken in evaluation of the financial feasibility of the airport development projects. Features such as standardized designs for airports could be adopted in order to ensure that the cost of development of the proposed airports is optimally arrived at.

6.6.6 *Development Plan and Suggested Projects*

In order to cater to the projected increase in traffic flow in the BIS scenario in the corridor region, additional airport infrastructure shall be required to be developed. This additional infrastructure requirement is likely to be a mix of capacity expansion of the existing airport infrastructure facilities in the cities of Chennai and Bangalore as well as creation of Greenfield airports at various locations.

The suggested development plan, linked to the strategy and development goals above, is presented below with the following set of suggested projects to be implemented in the CBIC region:

Sr.	Projects	Committed / Required project	Cost (USD million)	Term
1.	Development of airport at Sriperumbudur	Committed	2,459	Medium Term
2.	Intervention to evaluate possibilities of advancing capacity expansion plans of Bangalore airport as per the below schedule: • 6 million by 2019 • 10 million by 2022 • 8 million by 2025 • 6 million by 2027 • 5 million by 2029	Committed (revision of expansion plans to be evaluated by Bangalore Airport)	860	Short & Medium Term
3.	Development of airport at Krishnapatnam	New	490	Medium Term
4.	Interventions to evaluate options for modernization of passenger and cargo handling facilities at Chennai and Bengaluru airports	New	NA	Short to Medium Term
5.	Development of airport at Mulbagal	New	490	Long Term

6.6.7 *Phasing Plan*

The indicative phasing plan for the development plan above is captured as under:

Sr.	Projects	Short term	Medium term	Long term
1.	Development of airport at Sriperumbudur		◇	
2.	Intervention to evaluate possibilities of advancing capacity expansion plans of Bangalore airport as per the below schedule: • 6 million by 2019 • 10 million by 2022 • 8 million by 2025 • 6 million by 2027 • 5 million by 2029	◇	◇	
3.	Development of airport at Krishnapatnam		◇	
4.	Interventions to evaluate options for modernization of passenger and cargo handling facilities at Chennai and Bengaluru airports	◇	◇	
5.	Development of airport at Mulbagal			◇

6.7 Logistics

6.7.1 Sector Overview

Current status of the logistics sector in the CBIC region

Logistics infrastructure in the CBIC region includes Container Freight stations (CFSs), Inland Container Depots (ICDs), logistic parks, warehouses, etc. The placement and utilization of these facilities are framed based on the flow of cargo from the source to destination. Transportation and infrastructure are equally important for a successful logistics operation. When cargo reaches gateways such as ports, it undergoes various flow of activities and finally reaches the destination. As mentioned in the Interim report1 for this study, there are 26 CFSs in the region and they are linked to Chennai and Kattupalli port. An ICD in Whitefield near Bengaluru is also present. The location and connectivity to these facilities are shown in figure 5.6-2.

The modal split of containers moving for imports and exports from Chennai port is 95% and the rail is 5%. Other than import containers catering to CFSs, there are Green Channel Containers which are directly delivered to industrial centres. These take 29% of the total import containers traffic and remaining by CFSs. Export containers from CFSs share 36% of total export containers traffic and remaining 64% by factory stuffed containers traffic.

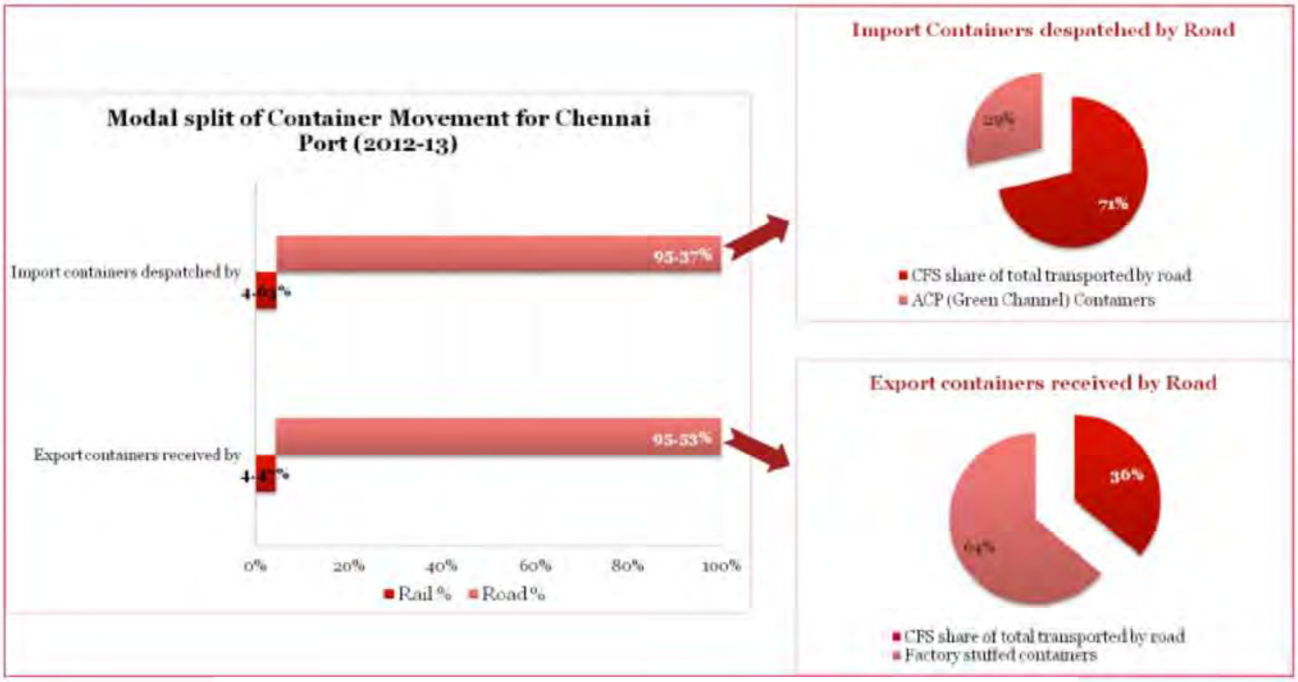


Figure 6.7.1: Modal Split of container traffic movement for Chennai Port

(Source: Chennai Port Administration Report 2012-13 and Primary Research)

Transportation via road is significant as compared to rail in the CBIC region. Rail transport is beneficial in carrying bulk cargo and containers over long distances. However issues of last mile connectivity exist at Chennai port. Though the cargo is taken by rail from ICDs, the last mile delivery of containers is done by road, which increases transportation cost and time. Security is another problem of concern as tracking of the goods in rail is difficult compared to roads. This leads to safety issues. Restriction in carriage of over dimensional cargo adds to the limited usage of rail.

The containers are stuffed / consolidated at CFSs near Chennai and Kattupalli ports. These are about 30%-35% of the total container traffic received at these ports. This is done after completing the customs procedure. Rest of the containers as mentioned earlier directly reach the factories. This distinction between various containers cause congestion at the port as the ACP trailers come at any time and they are preferred first to be filled as no additional procedure required which causes delay. The CFS trailers wait in along queue for the loading and unloading at the same area. This is a bottleneck at the last mile connecting to the port.

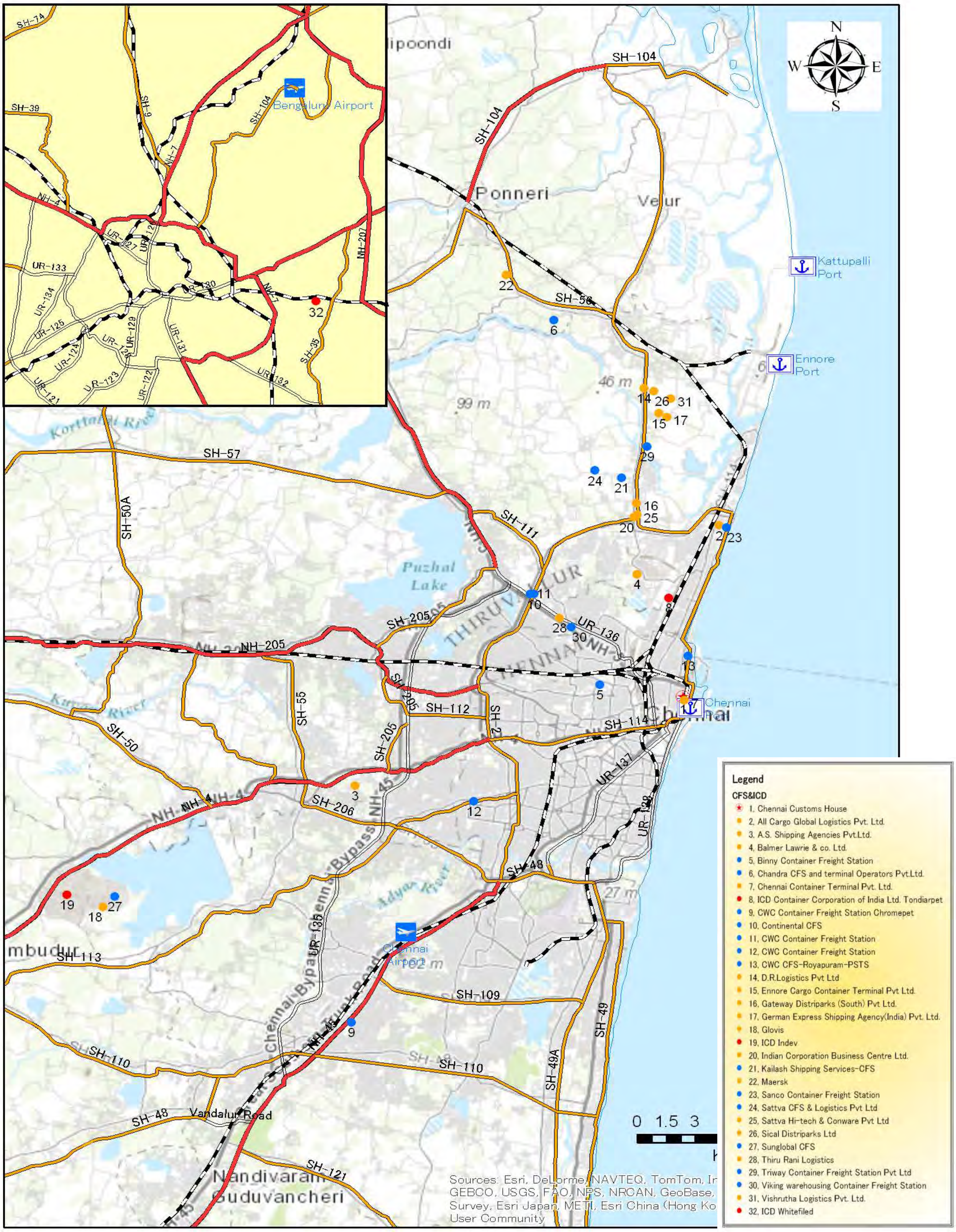


Figure 6.7.2: Location of CFS/ICD-Chennai

The CFSs and ICDs together in the region have a capacity of 2.4 Mn TEUs. The traffic handled by them per months is about 1.06 Mn TEUs per annum. So the capacity of these facilities utilized is around 45%. This leaves a good scope for enhancing in the utilization of these facilities.

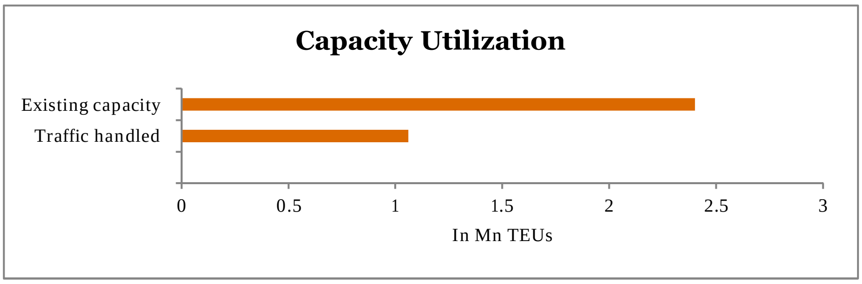


Figure 6.7.3: Capacity Utilization of CFSs and ICDs in CBIC region

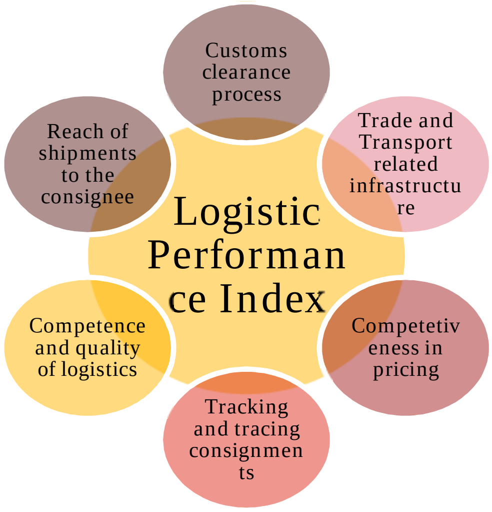
Ports are attached to the Customs house in Chennai. The fact that each CFS can be attached to only one port leads to the development of new CFSs for the terminal coming up at Ennore Port. This in turn increases the traffic of trailers creating a choke near customs house. As discussed above the utilization is only 45%, if these idle capacities are utilized i.e., if the attachment clause of CFSs with ports is amended, the choke can be reduced and the capacity can be optimally utilized. At the port entrance, the trailers are manually verified which adds up to the delay.

The time taken for export containers to reach from CFS to Chennai Port is 2-3 days and for import containers, time taken from Chennai Port to CFS is 4-6 hours which is on a higher end for a travelling a distance of approx. 10 Km. The delays are caused due to poor last mile connectivity. Also, softer issues like customs and documentation also add up to the delay further. The chain of activities taking place in import and export of containers are shown in the figure 5.6-4.

Figure 6.7.4: Chain of activities taking place in import and export of containers

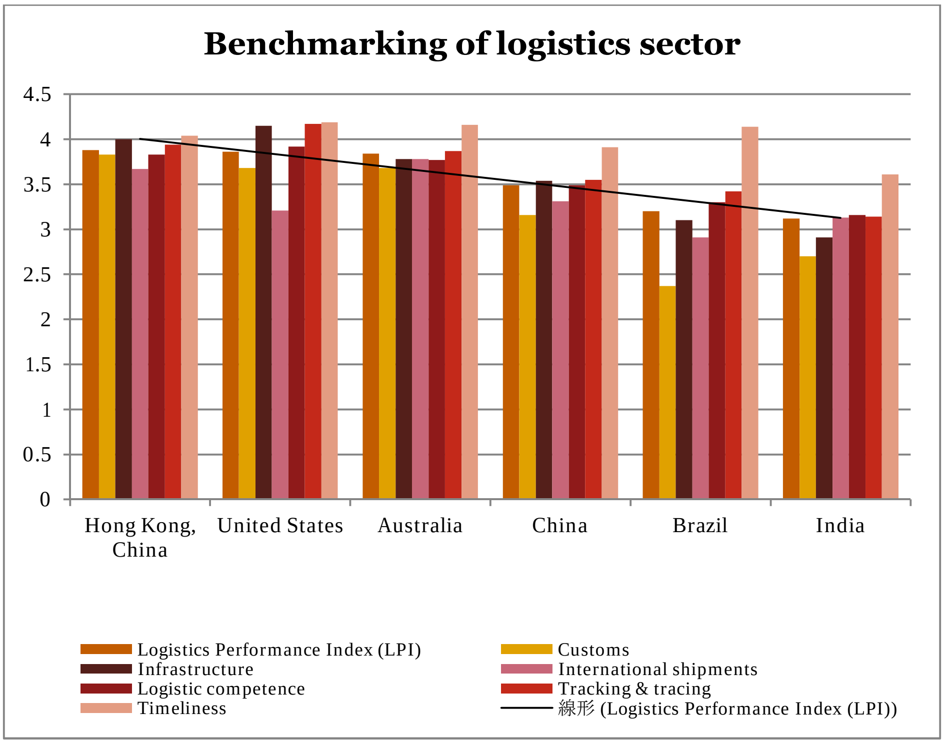
Logistical performance in India

The World Bank joint ventured with logistic providers and academic partners to arrive at benchmarking factors which can reflect the performance of the logistics in the country. The Logistic performance index (LPI) summarizes the performance of the countries by evaluating six factors.



According to this analysis, India stands at 47th position in the world. For the purposes of this report, a benchmark of India compared to countries such as Hong Kong, US, China, Australia and Brazil is analyzed. All of these countries (except Hong Kong) are similar in size compared to India. India's LPI stands at 3.12 and ranks lower compared to countries such as Hong Kong, Australia and China on almost all parameters, implying significant scope for improvement.

The performance of the Indian logistic sector can be further compared with the efficient countries in terms of time taken for inspection and clearance, lead time taken for export and import for port/airport, charge availed on the containers. The World Bank conducted a survey in about 130 countries to know the performance in these areas. In India, the time taken for customs clearance with inspection is 3.45 days and without physical inspection is 1.92 days. Lead time taken for export containers is 2.34 days and for import it is 5.31 days. Charge on a 40 ft export container is $660 and for an import container is $1,266. Basing on these factors only, LPI is calculated for the country.



Source: World Bank

On the backdrop of the above issues, the demand supply gaps and strategy for improvement of the logsitics infrastructure in the corridor is discussed in this section.

6.7.2 *Demand analysis*

The demand for the logistics services in the corridor is expected to be driven primarily by the projected container traffic at the ports in the CBIC region. The container traffic at ports has steadily increased over the years, in tune with the increasing use of containers in international trade. Container traffic is handled by Chennai, Kattupally and Krishnapatnam Ports in the CBIC region. Ennore is expected to join the contribution from 2015 with the start of new container terminal. As per the graph shown below, in the BAU case, the traffic attained at the end of 2034 is 10.38 million TEUs, with anticipated exports of 5.40 million TEUs and imports of 4.98 million TEUs. Under the BIS scenario, the container traffic attained is expected to be 19.74 million TEUs of which 10.27 million TEUs and 9.48 million TEUs constitute exports and imports respectively. In light of the anticipated growth in traffic, the need for efficient logistics facilities and supporting infrastructure is required to enable faster movement of cargo across the CBIC region.

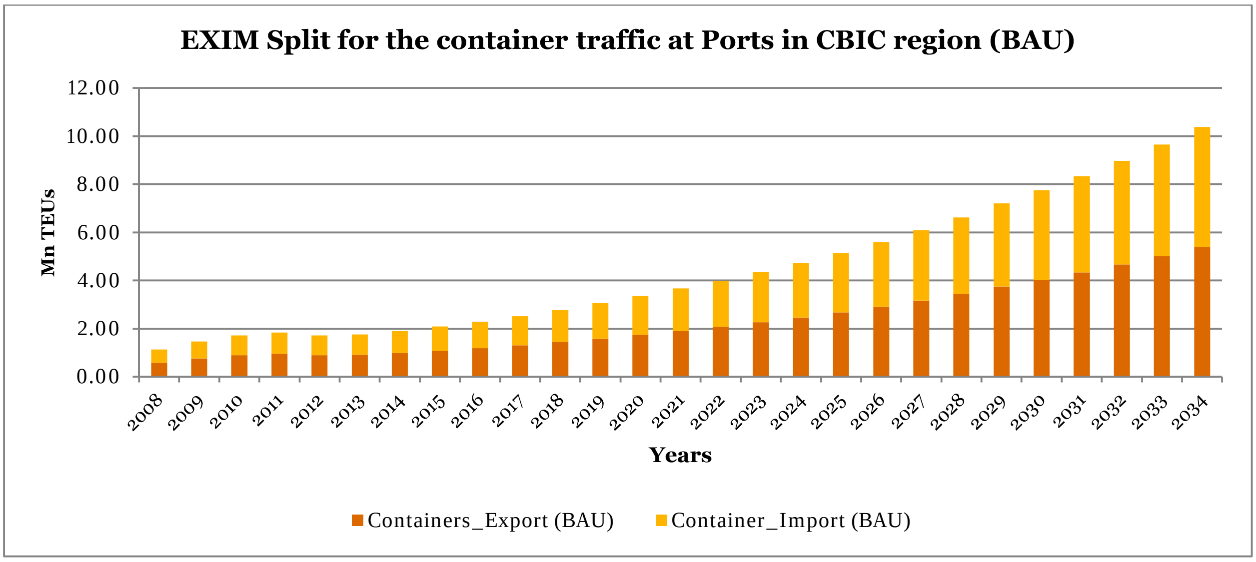


Figure 6.7.5: Container Traffic at Ports in CBIC Region (BAU)

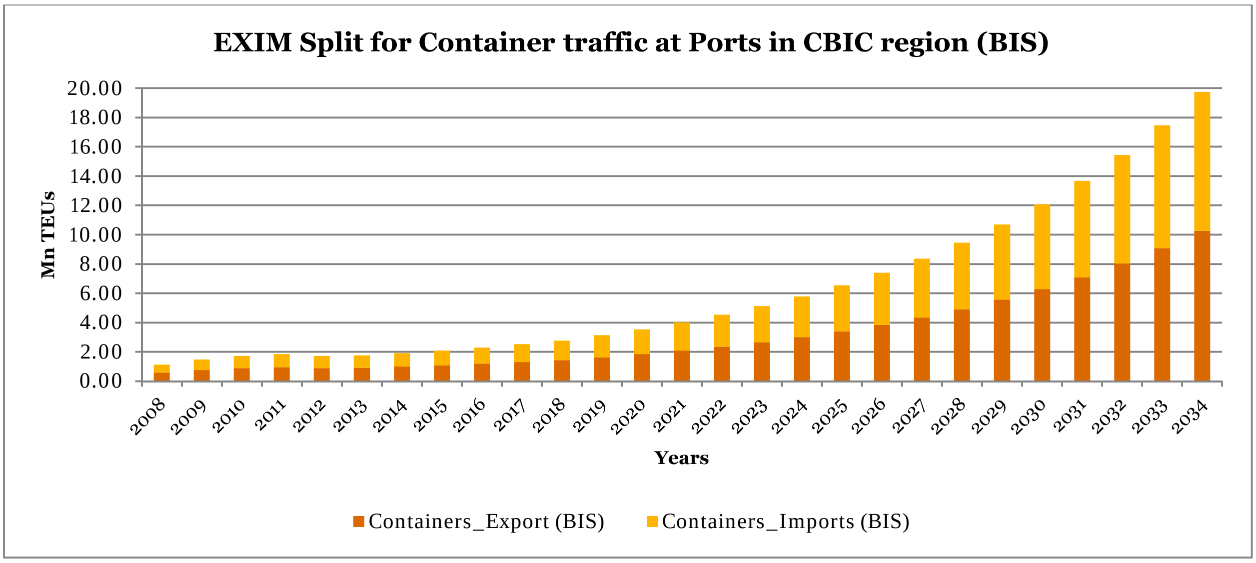
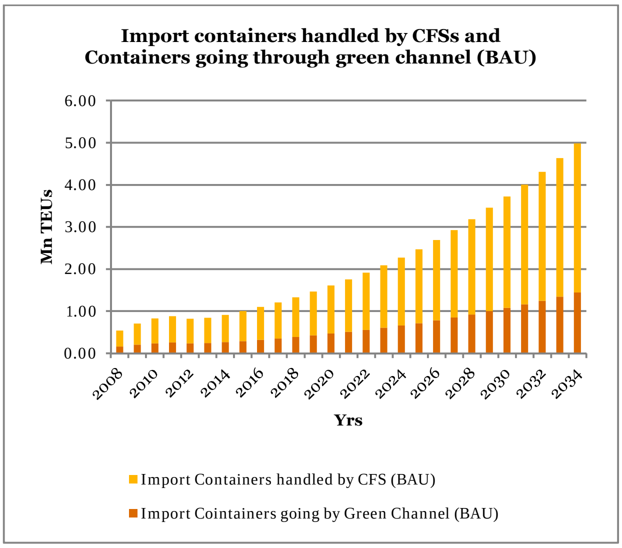
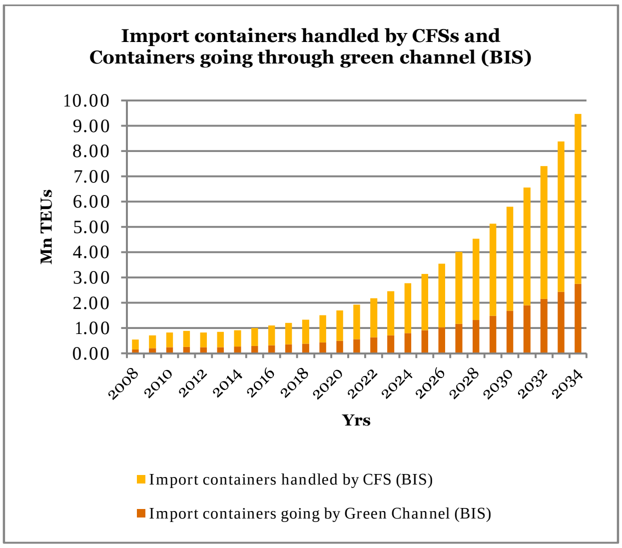


Figure 6.7.6: Container Traffic at Ports in CBIC Region (BIS)

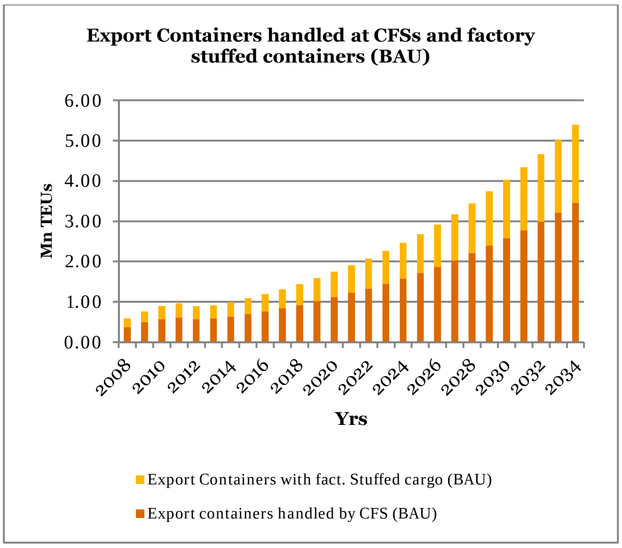
6.7.3 *Demand / Supply gaps*

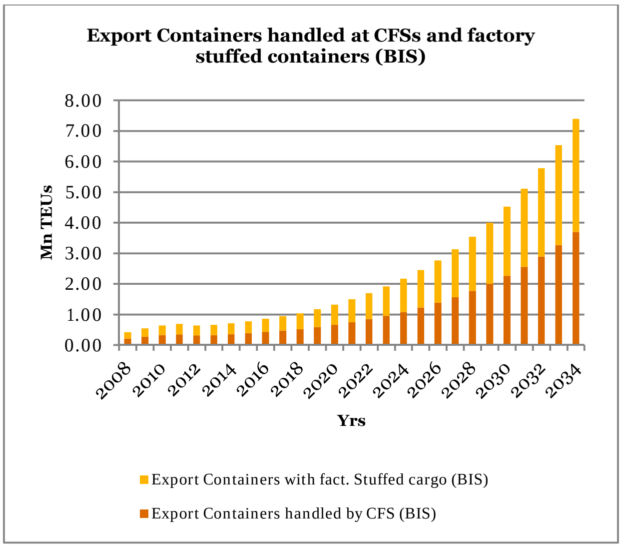
At present, CFSs handle 71% of the total import traffic at port while the remaining containers are directly sent to the delivery points through the Green Channel. Assuming that a similar trend continues, the import containers to be handled at CFSs in 2034 are expected to be 3.29 million TEUs in the BAU scenario and 5.95 million TEUs in the BIS scenario.





The proportion of export containers handled by CFSs is 36% while the rest 64% of the export containers are factory stuffed and directly driven to the ports. Assuming that a similar trend continues in future, the export containers demand at CFSs is estimated to be 1.94 million TEUs in the BAU scenario and 3.7 million TEUs in the BIS scenario.





Based on the above proportions, the total anticipated traffic to be handled at the CFSs is captured in the chart below, indicating the current capacities and gap thereof.

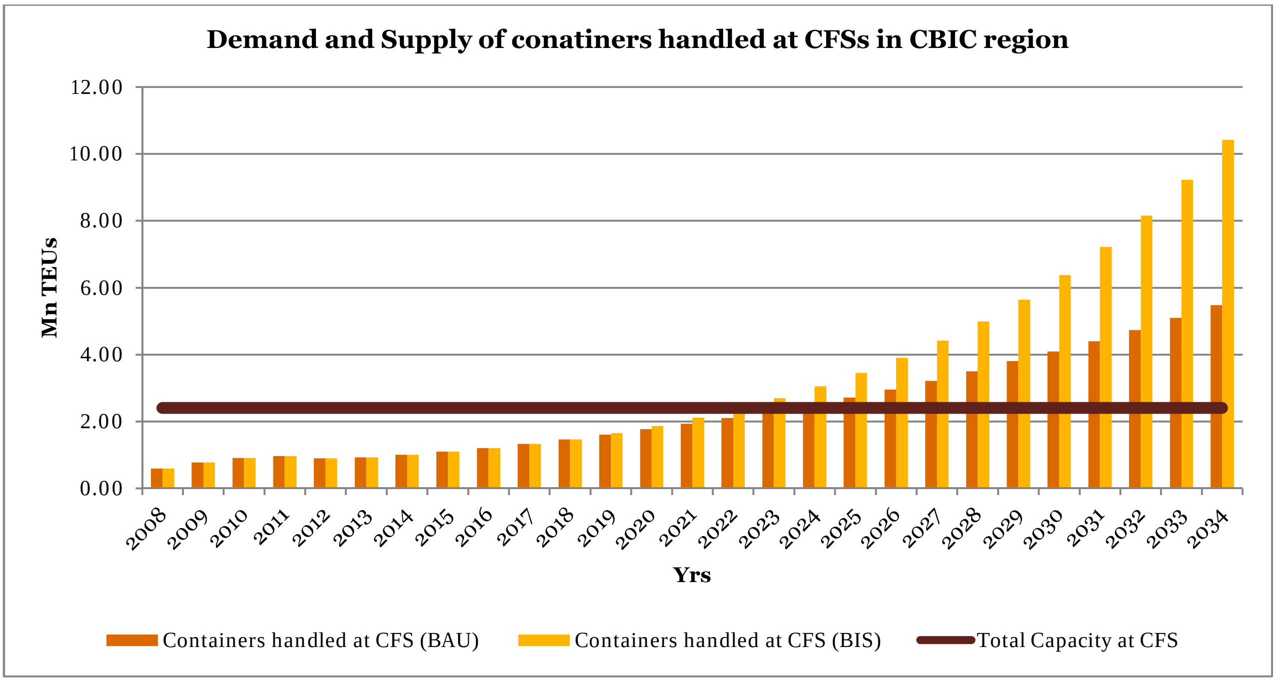
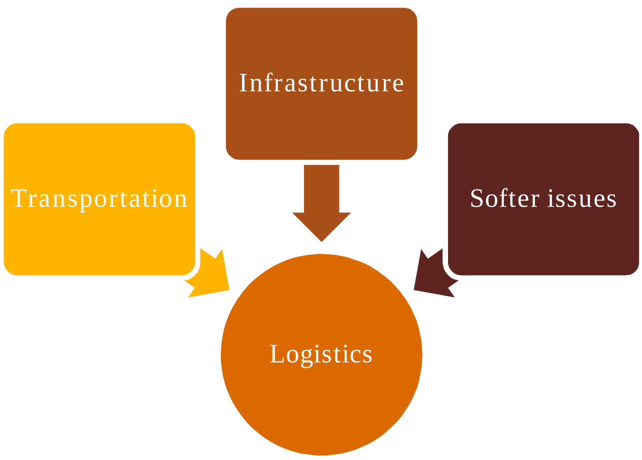


Figure 6.7.7: Demand and Supply of containers at CFSs

The total capacity of the infrastructure (CFSs & ICDs) in the region is 2.4 million TEUs. It is observed that, till 2022 the capacity is expected to be sufficient for the demand in both BAU and BIS cases. The constraint starts from 2023 in BIS scenario and from 2024 in BAU scenario. As per the projections, the capacity required at 2034 would be 5.48 million TEUs in BAU scenario and 10.42 million TEUs in BIS scenario. Capacity augmentation should be planned for the required additional logistics facilities.

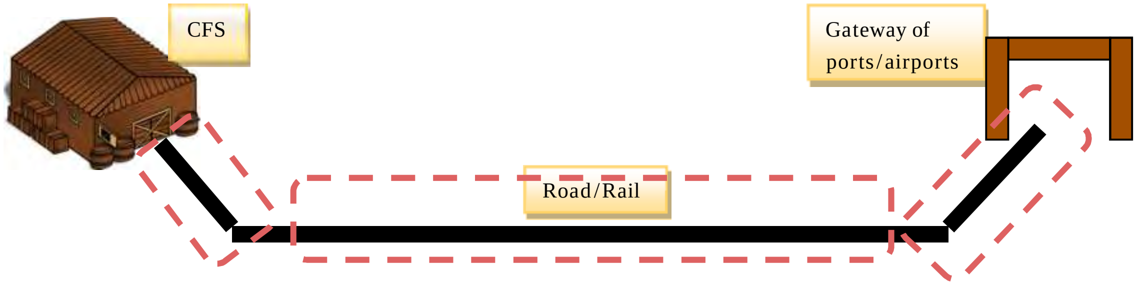
6.7.4 *Infrastructure development strategy*

Logistics infrastructure is a critical enabler for development of a country's economy. Logistics gives a strategic direction for optimum utilization of resources. Taking its criticality into consideration, the infrastructure development is given an utmost importance in the planning agenda of the country. It was estimated to invest one trillion dollars for the development of infrastructure in 12th five year plan, of which the maximum share is for transportation sector. Logistics is not an independent infrastructure. It is dependent on many factors which are stated below:



Transportation-Road and Rail

Road and rail are the basic transportation facilities to enable the movement of the cargo from gateways (ports and airports) to Logistic infrastructure (CFSs/ICDs/Warehouses/Logistic parks, etc). The factors contributing from this part are their linkage or the connectivity at various points of cargo movement and their capacity.



1. Last mile connectivity from/to Gateway

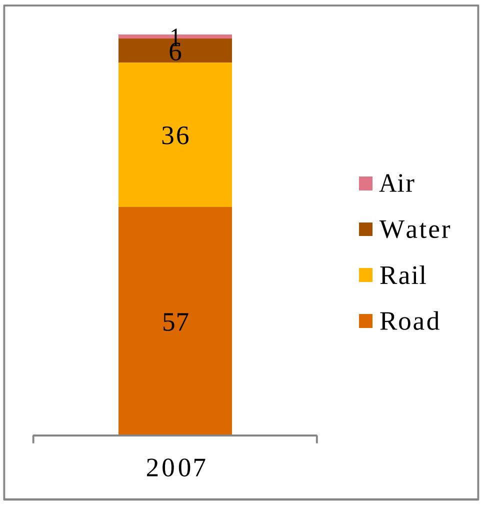
2. Last mile connectivity from/to CFS/ICD/Warehouse and to the production units

3. The rail / road trunk infrastructure

Logistics is impossible without proper connectivity. It enables the smooth flow of goods. As discussed in the interim report 1, poor last mile connectivity becomes a bottleneck causing congestion and time delays. Therefore, all the three areas of connectivity should be well planned and maintained for uninterrupted services.

In India, logistics is heavily dependent on roads. For long distances, more than 700 km better to go for railway or ways which can carry goods in bulk at a time and are eco-friendly compared to roads. It is seen that in 2007, the share or road was 57%, rail was 36% and water and air are 6% and less than 1% respectively.

This share of utilization has to be planned and sufficient transportation facilities can be developed for a balanced modal mix. Dedicated freight corridors can be built on all the major metro and golden quadrilateral connectivity. According to 12th plan, two DFCs are under progress one in east and other in west. Similarly, when done for rest of the places also, the share of the rail and road can be reached to nearly 46% and 47% respectively. Otherwise, by 2020 it is observed that the share of road increases to 69% from 57% in 2007. The analysis undertaken as part of the 12th Plan indicates that there is huge scope for achieving modal shifts. According to them, the shift from road to rail for miscellaneous commodities can go up to an extent of 78%. Also, the aim of railways in this plan is to improve its share by 2% by improvising its facilities. As discussed the first step is to go for DFCs, then encouraging containerized cargo which enables easy handling by wagons as well as ICDs. Also improve intermodal connectivity linked to inland water ways which adds to the modal s



Source: 12th five year plan

Infrastructure-CFSs/ICDs/Warehouses/Logistic Parks, etc and Gateways

Logistics infrastructure such as CFSs/ICDs/warehouses/logistic parks, etc. is helpful in enabling faster movement of cargo. It is found that that these capacities are also reaching saturation according to 12th five year plan. The capacity of these facilities is assessed based on their storage area and handling facilities. Handling facilities help in intermodal transfer of goods in these locations. These facilities are to be located in such a way that they are in proximity to gateways as well as delivery points.

Gateways which are ports and airports for international and domestic goods received and sent should are also very important. The capacity in managing number of vessels/planes at a time, their turnaround time, capacity of yards for storage, inland connectivity and accessibility in and out contribute to the time taken for cargo to reach the destination. Also, the efficient handling facilities at gateway contribute to the quick evacuation and less turnaround time enabling more carriers to be handled.

Customs Process Improvement

The last mile connectivity to Chennai, Ennore & Kattupalli ports are being improved through critical road projects (expected completion years in brackets) such as EMRIP (2015), Elevated Corridor from Maduravoyil (2018), Northern Port Access Road (2017) and NCTPS Road (2018). This, along with the expected completion of the ring roads in Chennai as noticed earlier, the last mile connectivity to Chennai, Ennore & Kattupally ports are expected to improve over the short to medium term. As per the study conducted by OCDI, the time taken for customs clearance is more than 12 hours for exports and over 38 hours for imports. Improving the efficiency of customs procedures at the ports are necessary for faster transit of cargo. It is proposed that a separate study be initiated for efficiency improvement in the customs procedures at the ports covering use of information technology solutions to enable faster movement of cargo.

The strategy for development of the logistics sector in the CBIC region takes into consideration the development improvements based on the key issues discussed above and in the earlier sections. Accordingly, the strategy for the logistics sector emphases on the following key aspects:

Short term	***Medium to long term***
1 Improving the efficiency of the existing logistics infrastructure & processes	***2*** Development of efficient logistic infrastructure for the corridor

6.7.5 *Development goals & target performance indicators*

Stakeholders, both in the manufacturing and logistics industry in the region have indicated that the corridor should target to deliver shipments from the production unit to the gateway and vice versa with a span of 1-1.5 days. Accordingly, the development goals for improvement of the logistics sector in the CBIC would be to:

"Achieve a transit time of 1.5-2 days for transportation of goods between the production units & gateways & vice versa"

Realization of the said goal is dependent on a variety of factors, as enumerated below:

- Efficiency improvements of the existing CFSs /ICDs including last mile connectivity enhancements to enable faster customs checks, efficient packaging / containerization / storage and faster movement of cargo to the gateways / production centers.

- Development of logistics facilities within the nodes for efficient packaging, containerization, customs check and other procedures and development of large logistics nodes to facilitate quicker modal shift of cargo from road to rail and vice versa; this, however, is contingent on the development of the Dedicated Freight Corridor (DFC) and the Expressway between Bangalore and Chennai.

6.7.6 *Development plan & suggested projects*

In order to cater to the projected increase in container traffic flow in the BIS scenario in the corridor region, additional logistics infrastructure shall be required to be developed. This additional infrastructure requirement is likely to be a mix of improvement of capacity utilization of the existing logistics infrastructure facilities in the cities of Chennai and Bangalore as well as creation of Greenfield logistics infrastructure at various locations.

The development plan is discussed as under:

Study on improvement of existing logistics infrastructure and customs procedures

The efficiency of CFSs depends upon its storage facility as well as its handling facility. The efficiency and operations of the CFSs are determined by not only the infrastructure within the CFS facility, but also the connectivity within the facility and the connectivity to gateways and industrial centres. Rapid urbanization is being witnessed in most of the locations of CFSs and ICDs in the region thereby causing access and evacuation issues. The last mile connectivity to Chennai, Ennore & Kattupalli ports are being improved through critical road projects (expected completion years in brackets) such as EMRIP (2015), Elevated Corridor from Maduravoyil (2018), Northern Port Access Road (2017) and NCTPS Road (2018). This, along with the expected completion of the ring roads in Chennai as noticed earlier, the last mile connectivity to Chennai, Ennore & Kattupally ports are expected to improve over the short to medium term.

In order to help improve the efficiency of the existing CFSs/ ICDs, it is recommended that a detailed analysis be undertaken to study the critical dependencies and facilities at these CFSs and chalk out a plan for modernization of these facilities. Further, as per the study conducted by OCDI, the time taken for customs clearance is more than 12 hours for exports and over 38 hours for imports. Improving the efficiency of customs procedures at the ports are necessary for faster transit of cargo. It is proposed that a separate study be initiated for efficiency improvement in the customs procedures at the ports covering use of information technology solutions to enable faster movement of cargo.

Creation of logistics infrastructure in the corridor

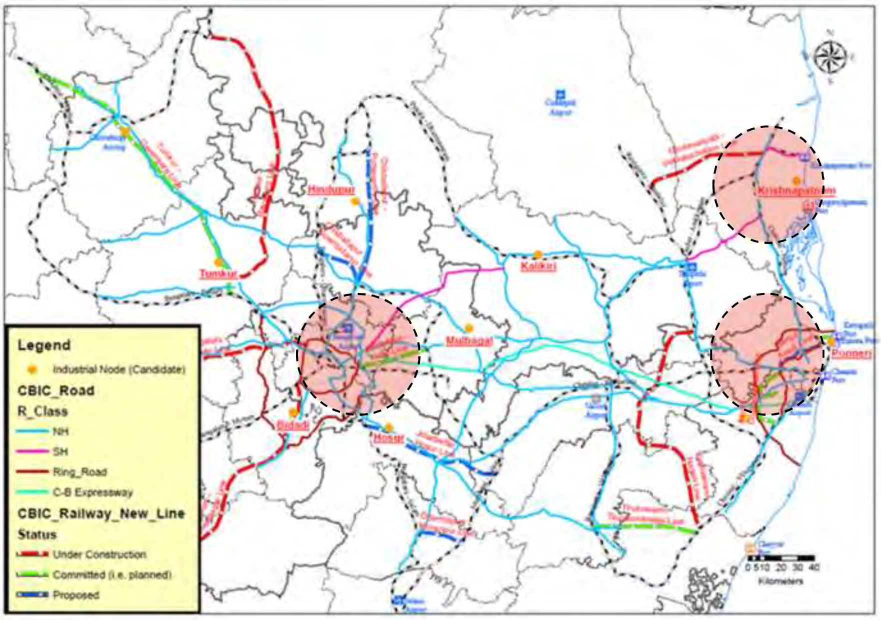
Additional logistics infrastructure such as node-level logistics parks and large multi-modal logistics are required to improve competitiveness of the region. However, these are dependent on a variety of factors.

Firstly, the existing CFSs in around the Chennai & Ennore region are operating below their capacities by over 50% owing to connectivity issues. The efficiency and operations of the CFSs are determined by not only the infrastructure within the CFS facility, but also the connectivity within the facility and the connectivity to gateways and industrial centres. Rapid urbanization is being witnessed in most of the locations of CFSs and ICDs in the region thereby causing access and evacuation issues. In order to help improve the efficiency of the existing CFSs/ ICDs, it is recommended that a detailed analysis be undertaken to study the critical dependences and facilities at these CFSs and chalk out a plan for modernization of these facilities and improvement of last mile connectivity.

Secondly, the lead time to set up logistics infrastructure is shorter and planning for such facilities could be taken up based on the need, changing traffic patterns and the pace of shift of traffic from the Chennai / Ennore belt to Krishnapatnam belt. Development of logistics parks attached to the port in Krishnapatnam would be critical to support for faster movement of cargo from the CBIC hinterland. It is anticipated that the private sector would be able to respond to market demand and set up the required logistical infrastructure based on changing traffic patterns and need for logistics infrastructure.

Thirdly, the nodes proposed for the CBIC region should house state of the art logistics facilities to improve their competitiveness. Timely requirement of raw materials and the delivery of the finished goods is utmost important. The inclusion of the below typical facilities could be further evaluated during preparation of the master plan for the nodes.

Facility	Description
Transport facilities	Availability of internal roads, connectivity roads and rail facilities, with inter-modal transit facilities
Information Centre	Essential for cost reduction and decision making as they provide timely and accurate information
Centres for storage, consolidation, and segregation of cargo	Availability of warehouses, cold chains & storage infrastructure and value added services like packaging, consolidation, labelling storing, etc.
Customs processing centre	Essential for processing and procuring customs clearance at the node level for direct shipment to ports / gateways
Support and Social infrastructure	Administration facility, communication facilities for the personnel, water and electricity provisions.



Lastly, large sized government planned logistics hubs may be needed, particularly with multi-modal facilities which are difficult to be developed by the private sector alone. However, a more specific Origin Destination (OD) study is necessary for development of such infrastructure which has not been undertaken at this stage. Also, such OD study should be undertaken after important projects such as the Dedicated Freight Corridor and the Bangalore Chennai Expressway are decided as these marquee projects could significantly change traffic patterns in the corridor. At this stage, three regions have broadly been identified for development of such logistics parks which include the Bengaluru outskirts, Chennai outskirts (near Sriperumbudur) and Krishnapatnam region. Development of such facilities should be undertaken outside the city limits to enable smooth last mile connectivity to the said facilities. As emphasized earlier, the planning for development of these facilities could be taken up after the alignments of the DFC and Expressway have been firmed up, backed by an Origin Destination (OD) study considering the effect of changing traffic flows in the corridor.

About large logistics nodes

Logistic node or a park is a recent phenomenon where several logistic operations are converged. The services and facilities available improve logistic efficiency and improve the flow of activities. It is a kind of distribution centre developed in the suburban area to meet various warehousing requirements. It is an integrated set-up which includes all logistic services such as warehousing, cold storage, multimodal transport facilities, customs clearance, and ICD/CFS. These centres also provide value added services like customization, stacking, cross-docking and labelling.

The availability of land, presence of multi-modal intersection points (primarily road & rail) and availability of human resources are some of the basic constituents of the logistic park. For logistic park to be successful and profitable, intermodal connectivity and their handling are very important. This results in timely & efficient handling of cargo by reducing number of lifts and also external factors like congestion, pollution, etc. A snapshot of a logistics park is captured in the picture below which shows rail mounted gantry cranes that are used for efficient movement of cargo from road to rail and vice versa.

(Courtesy: www.terex.com)

The projects critical for improvement of the logistics sector for the region include:

Sr.	Project / intervention	Status (new / existing)	Cost	Category
1.	Study to evaluate options for increasing the operational efficiency and last mile connectivity of CFSs in the Chennai / Ennore region	New	NA	Short term
2.	Study to evaluate options for increasing the operational efficiency and last mile connectivity of ICD in Whitefield, Bangalore	New	NA	Short term
3.	Study to evaluate options for improving & fast tracking customs procedures at ports, CFSs and ICDs	New	NA	Short term
4.	Development of logistics facilities within nodes (to be done undertaken at the time of preparation of the master plan for the nodes	New	Included in industrial infrastructure plan	As per development of nodes
5.	Study to evaluate options for creation of logistics nodes contingent on the alignment and development of the DFC and Expressway	New	Likely project to be approximately USD 150 million	Medium Term
6.	Development of logistics parks such as CFSs near Krishnapatnam port	New		Short to medium Term

6.7.7 *Phasing plan*

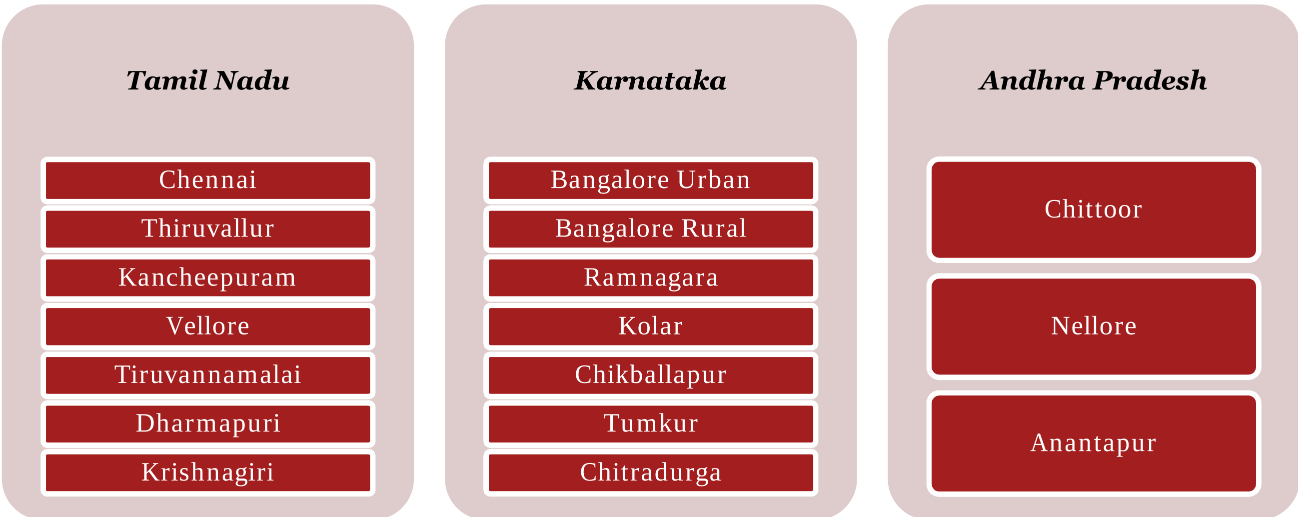
The phasing plan for the development plan and projects is as under:

Sr.	Project / intervention	Short term	Medium term	Long term
1.	Study to evaluate options for increasing the operational efficiency and last mile connectivity of CFSs in the Chennai / Ennore region	◇		
2.	Study to evaluate options for increasing the operational efficiency and last mile connectivity of ICD in Whitefield, Bangalore	◇		
3.	Study to evaluate options for improving & fast tracking customs procedures at ports, CFSs and ICDs	◇		
4.	Development of logistics facilities within nodes (to be done undertaken at the time of preparation of the master plan for the nodes)	◇	◇	◇
5.	Study to evaluate options for creation of logistics nodes– contingent on the alignment and development of the DFC & Expressway		◇	
6.	Development of logistics parks such as CFSs near Krishnapatnam port	◇	◇	

6.8 Power & Renewable Energy

6.8.1 Sector Overview

The Chennai-Bangalore Industrial Corridor Project is an upcoming mega infrastructure project of Government of India. Japan International Cooperation Agency (JICA) and The Department of Industrial and Promotion (DIPP) are the two nodal agencies supporting this project. The corridor will pass through the districts of Tamil Nadu, Karnataka, & Andhra Pradesh and will have 17 districts under its area of influence, captured in the following figure.



The power sector would play a crucial role in determining the overall success of the investments made in the industrial sector in the CBIC corridor. In the previous report, we saw the challenges being faced by the sector and the outlook of the sector in these three states. Although the power sector holds a huge potential for investments, especially from private sources, it is seeing its fair share of challenges such as the slow progress being made by the Kudankulam nuclear power plant and gas based plants in Andhra Pradesh due to inadequate fuel availability and limited connectivity with national grid.

The previous report showcased the current scenario of the sector in the three states and also highlighted the upcoming projects in the near future. This report on the other hand assesses the impact on the power sector of the three states due to the CBIC. The demand for power in light of the increased commercial activity in the corridor has been estimated in order to highlight the gaps in the envisaged demand-supply situation, as well as to present investment opportunities in them. The report's objective is to present an investment strategy for the sector in the three states, carefully identifying the opportunities and risks.

6.8.2 Demand forecast

6.8.2.1 Electricity demand growth

The three states in which the CBIC is planned namely Andhra Pradesh, Karnataka and Tamil Nadu, have seen a significant growth in power demand in the recent few years. A lot of this can be attributed to the increasing pace of industrialisation with a much more open electricity market which is increasingly allowing the consumer more choices. A review of the historical trend of the growth in energy requirement of these three states is given in the following figure.

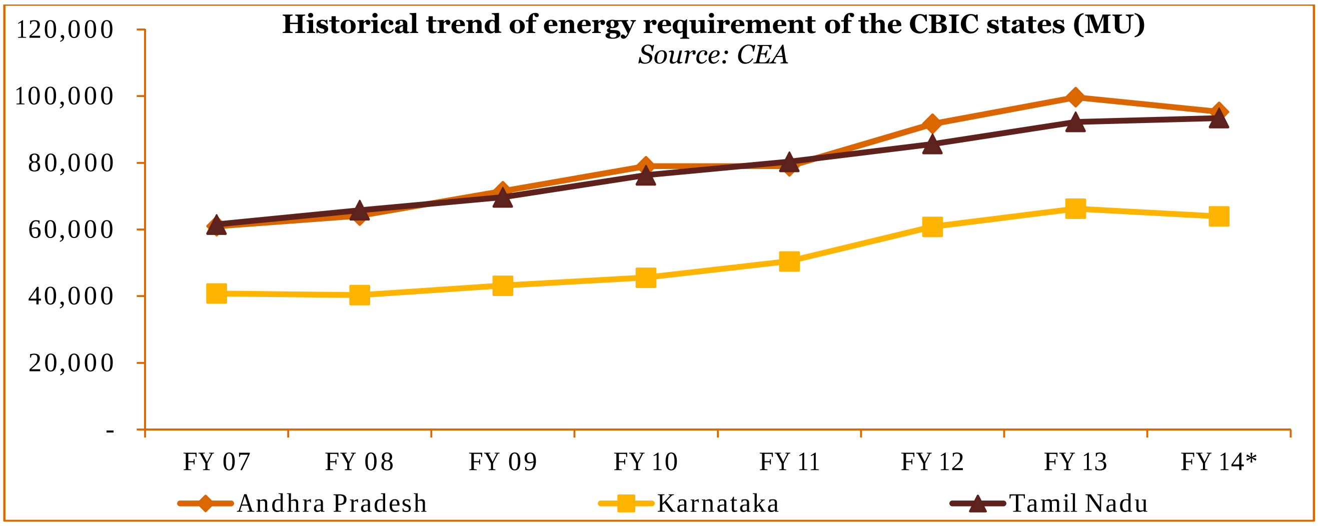


Figure 6.8.1: Historical trend of demand and supply in CBIC state; Source: CEA

**Data for FY 14 is available only till January 2014 and therefore the data for the entire FY 14 has been estimated based on the ratio of data till January 2013 (for FY 13) to the total FY 13 data*

6.8.2.2 Demand projections in BAU scenario

Electricity demand forecasts for the Business as Usual (BAU) scenario are published by the Central Electricity Authority (CEA) of India, and as per the latest 18th EPS, the following projections of demand growth have been made. However, since the projections made in the 18th EPS are based on the base year data of FY 2009-10, the projections captured here have been revised as per the deviations from the actual data observed for the years FY 2011 to FY 2013.

Table 6.8.1: Electricity demand projections for BAU (MU) based on 18th EPS (growth rates)

State	Growth rates considered	Short-term demand 2017	Mid-term demand 2022	Long-term demand 2032
Andhra Pradesh	12th Plan: 8.7% 13th Plan: 8.1% 14th Plan: 8.2% 15th Plan: 7.7%	121,865	180,204	387,712
% of India's requirement		*8.9%*	*9.4%*	*10.1%*
Karnataka	12th Plan: 7.7% 13th Plan: 6.4% 14th Plan: 6.4% 15th Plan: 6.4%	81,591	112,049	208,239
% of India's requirement		*6.0%*	*5.8%*	*5.4%*
Tamil Nadu	12th Plan: 6.8% 13th Plan: 7.5% 14th Plan: 7.3% 15th Plan: 6.6%	116,860	168,315	330,802
% of India's requirement		*8.5%*	*8.7%*	*8.6%*
Total for the 3 states		**320,316**	**460,567**	**926,753**
% of India's requirement		*23.4%*	*23.9%*	*24.2%*

The EPS is used in India by the States as well as the Centre for long term planning in the power sector at the beginning of the planning period. However since the EPS is based on the year FY 2009-10, it would be critical to assess the growth in electricity requirement on the basis of actual growth rates observed in the recent years. These projections have been given in the following table.

Table 6.8.2: Electricity demand projections for BAU (MU) based on historical trend

State	Growth rates considered	Short-term demand 2017	Mid-term demand 2022	Long-term demand 2032
Andhra Pradesh	4 year CAGR: 8.7%	122,272	185,219	425,015
% of India's requirement		*10.1%*	*11.2%*	*13.9%*
Karnataka	4 year CAGR: 11.3%	88,224	150,770	440,319
% of India's requirement		*7.3%*	*9.1%*	*14.4%*
Tamil Nadu	4 year CAGR: 7.3%	115,390	164,018	331,387
% of India's requirement		*9.5%*	*9.9%*	*10.8%*
Total for the 3 states	4 year CAGR: 6.4%	**325,886**	**500,006**	**1,196,721**
% of India's requirement		*26.9%*	*30.3%*	*39.1%*

Breakup of demand

The expected demand has been further divided in to 6 primary sources. These are domestic, commercial, industrial, agricultural, transportation and miscellaneous sources. The existing current ratios for demand have been used for predicting the future growth of the demand in each category.

(i) Karnataka

Category	Short-term demand 2017	Mid-term demand 2022	Long-term demand 2032
Domestic	13648	23324	68117
Commercial	4914	8397	24525
Industrial	15792	26987	78817
Agricultural	47993	82018	239533
Transportation	0	0	0
Miscellaneous	5875	10041	29325
Total	**88224**	**150770**	**440319**

(ii) Andhra Pradesh

Category	Short-term demand 2017	Mid-term demand 2022	Long-term demand 2032
Domestic	31546.18	47786.5	109653.9
Commercial	9243.763	14002.56	32131.13
Industrial	34969.79	52972.63	121554.3
Agricultural	38258.91	57955.03	132987.2
Transportation	3105.709	4704.563	10795.38
Miscellaneous	5147.651	7797.72	17893.13
Total	**122272**	**185219**	**425015**

(iii) Tamil Nadu

Category	Short-term demand 2017	Mid-term demand 2022	Long-term demand 2032
Domestic	37963.31	53961.92	109026.3
Commercial	13062.15	18566.84	37513.01

Category	Short-term demand 2017	Mid-term demand 2022	Long-term demand 2032
Industrial	31501.47	44776.91	90468.65
Agricultural	21497.16	30556.55	61737.4
Transportation	1500.07	2132.234	4308.031
Miscellaneous	9865.845	14023.54	28333.59
Total	**115390**	**164018**	**331387**

It can be seen that the projections based on historical trend show a higher growth in demand. Further the demand growth rate in Karnataka is exaggerated due to lumping of projects in recent past and projection over a smaller initial base. This may however not hold true in the long run.

It is our view that going forward, the likely growth in demand in the short term is going to follow a trend similar to that observed recently. However, in the medium to long term, the demand growth would fall in line to the rates projected by the 18th EPS. Therefore, in order to assess the future demand scenario, a hybrid approach has been adopted.

Table 6.8.3: Electricity demand projections for BAU (MU) based on hybrid approach

State	Growth rates considered	Short-term demand 2017	Mid-term demand 2022	Long-term demand 2032
Andhra Pradesh	12th Plan: 8.7% 13th Plan: 8.1% 14th Plan: 8.2% 15th Plan: 7.7%	122,272	180,805	389,005
Karnataka	12th Plan: 11.3% 13th Plan: 6.4% 14th Plan: 6.4% 15th Plan: 6.4%	88,224	120,471	223,890
Tamil Nadu	12th Plan: 7.3% 13th Plan: 7.5% 14th Plan: 7.3% 15th Plan: 6.6%	115,390	165,658	325,580
Total for the 3 states		**325,886**	**466,933**	**938,475**

Breakup of demand

The expected demand has been further divided in to 6 primary sources. These are domestic, commercial, industrial, agricultural, transportation and miscellaneous sources. The existing current ratios for demand have been used for predicting the future growth of the demand in each category.

(i) Karnataka

Category	Short-term demand 2017	Mid-term demand 2022	Long-term demand 2032
Domestic	13648	18636	34635
Commercial	4914	6710	12470
Industrial	15792	21564	40076
Agricultural	47993	65536	121796
Transportation	0	0	0
Miscellaneous	5875	8023	14911
Total	**88224**	**120471**	**223890**

(ii) Andhra Pradesh

Category	Short-term demand 2017	Mid-term demand 2022	Long-term demand 2032
Domestic	31546	46647	100363
Commercial	9243	13668	29408
Industrial	34969	51710	111255
Agricultural	38258	56573	121719
Transportation	3105	4592	9880
Miscellaneous	5147	7611	16377
Total	**122272**	**180805**	**389005**

(iii) Tamil Nadu

Category	Short-term demand 2017	Mid-term demand 2022	Long-term demand 2032
Domestic	37963	54501	107115
Commercial	13062	18752	36855
Industrial	31501.	45224	88883
Agricultural	21497	30862	60655
Transportation	1500	2153	4232
Miscellaneous	9865	14163	27837
Total	**115390**	**165658**	**325580**

6.8.3 *Demand projections in accelerated growth scenario*

6.8.3.1 GDP growth and electricity demand

Electricity in India, like other developing nations, is primarily utilised for massively expanding and attaining a sustained GDP target growth rate. Major economic activities in the country are mostly driven by electricity today. With a massive investment coming up in the Chennai Bangalore Industrial Corridor (CBIC), especially in the industrial and manufacturing sector which currently accounts for approximately 33% of the total power consumption in the country, the demand for power in the region is definitely going to rise at an accelerated pace.

Given the above background, the elasticity for electricity generation to the growth in GDP in the corridor has been taken into account for estimating the demand of the region. For India, the elasticity with respect to GDP which translates a percentage change in electricity generation/consumption requirement for one percent change in GDP has been constantly falling in the previous years. In lines with the approach adopted by the Planning Commission of India, the elasticity has taken to be 0.9 for the 12th Five Year Plan and 0.8 for the 13th Five Year Plan period. The elasticity in the subsequent plans has been retained at 0.8.

In order to estimate the electricity demand in the three states, we have assessed the additional electricity generation required to meet the increase in GDP from the BAU scenario. This quantum of electricity generation has been subsequently translated to additional capacity requirements taking into account standard benchmarks and conversion factors.

The BAU scenario for estimating the GSDP has been estimated by taking a long term GSDP growth rate of 8% for all three states, which has eventually been compared to the estimated GSDP post the CBIC. This additional GSDP consolidated for each state, has been taken for estimating the additional power demand. The following table captures the GDP growth of the districts surrounding the CBIC.

Table 6.8.4: Projections for district wise GDP (in Billion USD)

State	District	Scenario	Short-term for 2017	Mid-term for 2022	Long-term for 2032
Andhra Pradesh	**Chittoor Anantapur**	CBIC	8.2	12.2	26.8
		BAU	8.2	12.0	25.9
	Nellore	CBIC	3.3	5.6	16.0
		BAU	3.1	4.5	9.8
Karnataka	**Bangalore urban**	CBIC	25.6	45.1	140.0
		BAU	22.9	33.7	72.7
	Bangalore rural Ramnagara	CBIC	3.8	8.0	35.3
		BAU	3.1	4.5	9.8
	Kolar Chikkaballapura	CBIC	2.6	3.8	8.1
		BAU	2.6	3.8	8.1
	Tumkur	CBIC	2.8	5.1	17.4
		BAU	2.4	3.6	7.7
	Chitradurga	CBIC	1.4	2.3	5.9
		BAU	1.3	2.0	4.2
Tamil Nadu	**Chennai Tiruvallur Kancheepuram**	CBIC	24.2	41.4	120.6
		BAU	22.2	32.6	70.3
	Tiruvannamalai	CBIC	2.6	4.8	16.3
		BAU	2.3	3.4	7.2
	Vellore	CBIC	7.0	13.4	49.8
		BAU	5.9	8.7	18.8
	Dharmapuri Krishnagiri	CBIC	5.4	9.0	25.3
		BAU	5.0	7.3	15.8

*Note: Few districts have been combined together to reflect the combined GDP, owing to the fact that these districts lie in very close proximity to each other

For assessing the additional demand due to CBIC, the following approach has been adopted.

To begin with, a kWh to GSDP conversion factor based on historical data has been assumed. Further, in order to assess the additional power demand required to achieve the GSDP targets of each district, the GSDP difference between the State's GDP in the CBIC scenario and the BAU scenario have been taken. Elasticity of electricity during different Five Year Plan periods has then been considered for determining the incremental power requirement for achieving the said GSDP growth targets. This incremental power demand has subsequently been considered for each state separately, since the generation of power is not necessarily local to a particular district but can be safely consolidated at a state level.

Table 6.8.5: Additional electricity demand projections in accelerated growth scenario (Million Units)

State	Elasticity considered	Short-term demand 2017	Mid-term demand 2022	Long-term demand 2032
Andhra Pradesh	12th Plan: 0.90 13th Plan: 0.80 14th Plan: 0.75 15th Plan: 0.70	381	1,497	7,965
Karnataka	12th Plan: 0.90 13th Plan: 0.80	4,795	19,677	115,973

State	Elasticity considered	Short-term demand 2017	Mid-term demand 2022	Long-term demand 2032
	14th Plan: 0.75 15th Plan: 0.70			
Tamil Nadu	12th Plan: 0.90 13th Plan: 0.80 14th Plan: 0.75 15th Plan: 0.70	4,388	17,795	101,673
Total for the 3 states		**9,565**	**38,969**	**225,610**

6.8.3.2 Total power demand at state level in accelerated scenario

The three states comprising of the CBIC would therefore see a power demand in the future as follows.

Table 6.8.6: Summary of total state demand projections in CBIC scenario (Million Units)

State	Short-term demand 2017	Mid-term demand 2022	Long-term demand 2032
Andhra Pradesh	122,653	182,302	396,970
Karnataka	93,020	140,836	341,142
Tamil Nadu	119,778	183,992	428,314
Total for the 3 states	**335,451**	**507,130**	**1,166,425**

Expected Breakup of Demand

The expected demand has been further divided in to 6 primary sources. These are domestic, commercial, industrial, agricultural, transportation and miscellaneous sources. The existing current ratios for demand have been used for predicting the future growth of the demand in each category.

(i) Karnataka

Category	Short-term demand 2017	Mid-term demand 2022	Long-term demand 2032
Domestic	14390.19	21787.33	52774.67
Commercial	5181.214	7844.565	19001.61
Industrial	16650.58	25209.64	61064.42
Agricultural	50602.88	76614.78	185581.2
Transportation	0	0	0
Miscellaneous	6195.132	9379.678	22720.06
Total	**93,020**	**140,836**	**341,142**

(ii) Andhra Pradesh

Category	Short-term demand 2017	Mid-term demand 2022	Long-term demand 2032
Domestic	31644.47	47033.92	102418.3
Commercial	9272.567	13782.03	30010.93
Industrial	35078.76	52138.37	113533.4
Agricultural	38378.12	57042.3	124211.9
Transportation	3115.386	4630.471	10083.04
Miscellaneous	5163.691	7674.914	16712.44
Total	**122653**	**182302**	**396970**

(iii) Tamil Nadu

Category	Short-term demand 2017	Mid-term demand 2022	Long-term demand 2032
Domestic	30603.58	46335.04	112235.7
Commercial	10529.86	15942.64	38617.27
Industrial	25394.46	38448.23	93131.77
Agricultural	17329.63	26237.75	63554.75
Transportation	1209.26	1830.868	4434.846
Miscellaneous	7953.21	12041.48	29167.64
Total	**93020**	**140836**	**341142**

It can be observed that the incremental power requirement when compared to the BAU scenario shoots off in the mid-term after a rather slow growth in the short-term. This is due to the accelerated growth in economic activities after the CBIC is developed.

This demand growth would also lead to a growth in demand of fuels for power generation, and since at present coal based plants comprise of almost 61.5% of the installed generation capacity in the three states, assessing the demand for coal in the future also becomes critical. Further, since one of the objectives to be fulfilled by the power sector is to provide an affordable and reliable source of electricity, it appears that coal may continue to be the dominating fuel.

Further each type of power project has different capacity utilization factor (solar / wind are in the range of 20%). It would be meaningful to understand the demand in terms of conventional coal based capacity required. Therefore considering that the above power demand is met completely through coal based plants, the total coal based capacity to be added in the region would be as follows.

Table 6.8.7: Coal equivalent demand for the three states (MW)

State	Short-term demand 2017	Mid-term demand 2022	Long-term demand 2032
Andhra Pradesh	15,526	22,992	49,696
Karnataka	11,793	17,864	43,276
Tamil Nadu	15,198	23,341	54,331

6.8.4 *Demand/supply gaps*

6.8.4.1 Power supply projections for short term

To keep pace with the high electricity demand, the Central Government along with the State Governments has set some ambitious targets for generation capacity addition in the future. These have been planned considering after accounting for any volatility associated with imported fuel prices and potential of renewable sources in these states.

6.8.4.1.1 Andhra Pradesh

Andhra Pradesh had a total installed capacity of 17,174 MW at the end of September 2013 (which now stands at 17,285, January 2014). The majority of the generation is owned by the State with coal contributing the highest to the fuel mix in terms of installed capacity.

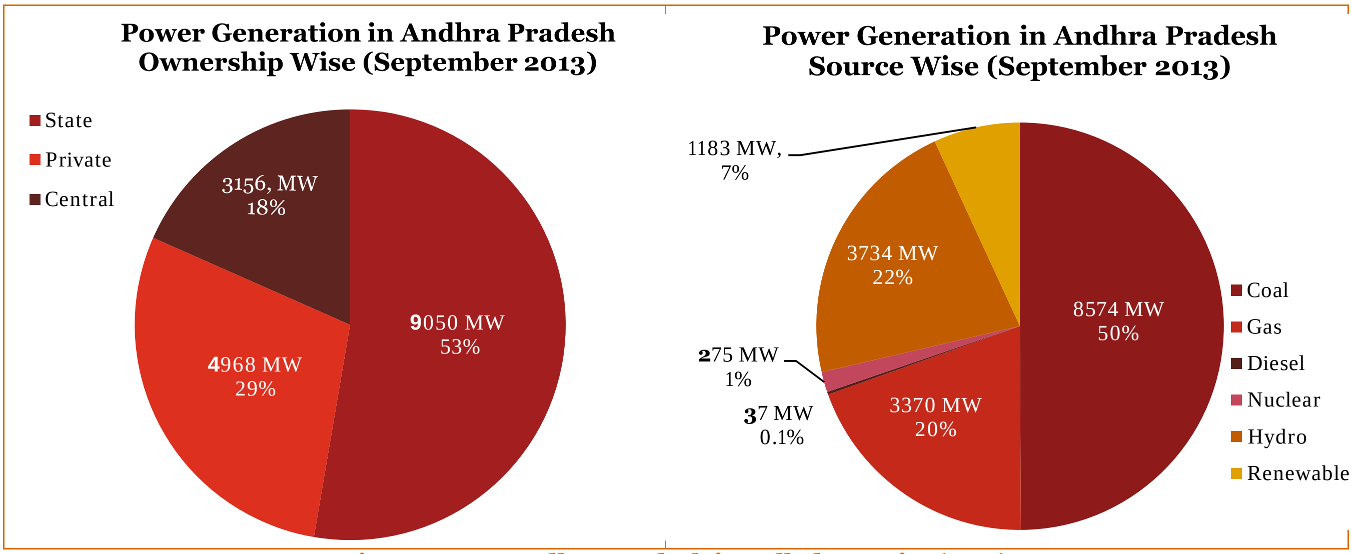


Figure 6.8.2: Andhra Pradesh installed capacity (CEA)

As seen from the graph below, Andhra Pradesh has been struggling with its electricity deficits for the past several years. The brisk industrial growth in the state, especially in Hyderabad and surrounding areas, coupled with low PLF of gas based units, has resulted in a soaring energy deficit in the state. The gap between peak demand and supply in FY13 was 20% resulting in one of the highest energy gaps in the country.

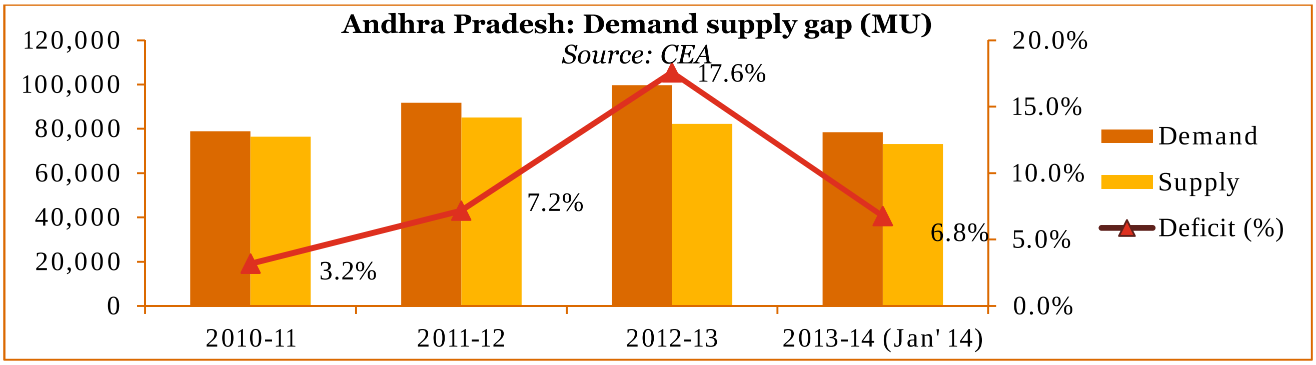
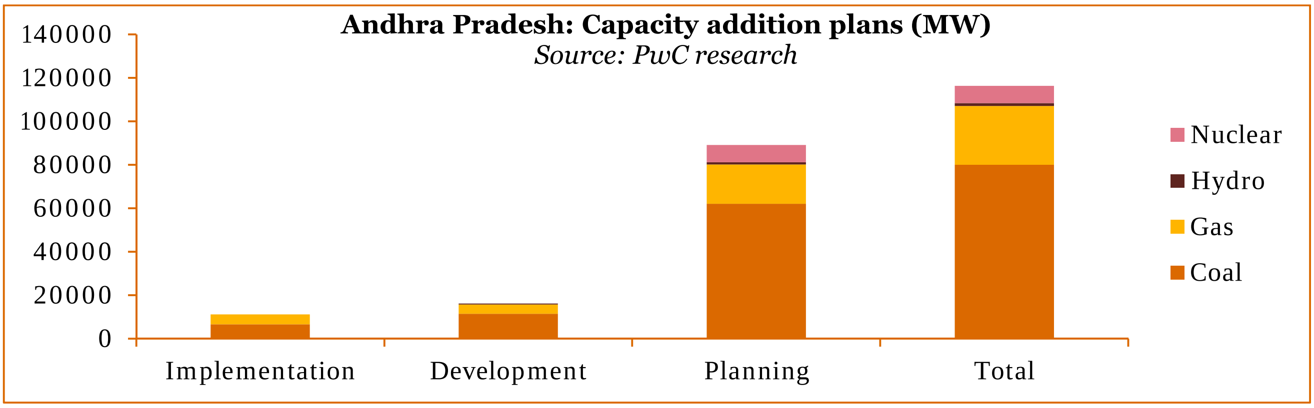


Figure 6.8.3: Andhra Pradesh demand supply gap (CEA)

Although the demand supply gap has been varying over the years, the State plans to add power projects of almost 116,350 MW capacities to enhance the power generation capacity of the state and reduce the demand supply gap in the future years. The projects that are under construction are expected by FY 2015 whereas most projects under implementation are expected between FY 2018 and FY 2020.



Source: PwC research

Figure 6.8.4: Andhra Pradesh: Capacity addition plans (MW)

The State plans to add approximately 10,000 MW of capacity by FY 2017, out of which 8,000 MW is expected to be coal based. A snapshot of the capacity enhancement plan has been given below, after considering suitable additions in line with the projections made by the CEA, the State Govt. as well as the Planning Commission in terms of conventional and renewable power additions.

Table 6.8.8: Andhra Pradesh – Expected installed capacity as per plans (MW)

Fuel	Present Capacity	Short-term Target at 2017
Coal	8,573	16,053
Gas	3,370	3,370
Diesel	37	37
Hydro	3,735	4,145
Nuclear	276	276
Total conventional	***15,991***	***23,881***
RES	1,294	3,403
Total	17,285	27,284
Thermal Capacity Equivalent (MW)	**12,027**	**20,113**

Table 6.8.9: Andhra Pradesh – Expected generation as per plans (Million Units)

Fuel	Present Generation	Short-term Target at 2017
Coal	67,590	126,566
Gas	13,285	13,286
Diesel	226	226
Hydro	9,816	14,522
Nuclear	1,644	1,643
Total conventional	*92,560*	*156,243*
RES	2,267	5,963
Total (MU)	**94,827**	**162,206**

6.8.4.1.2 Karnataka

Karnataka had a total installed capacity of 13,819 MW at the end of September 2013 (which now stands at 13,941, January 2014). 53% of this generation is owned by the State, with coal based power contributing to 44% of the installed capacity.

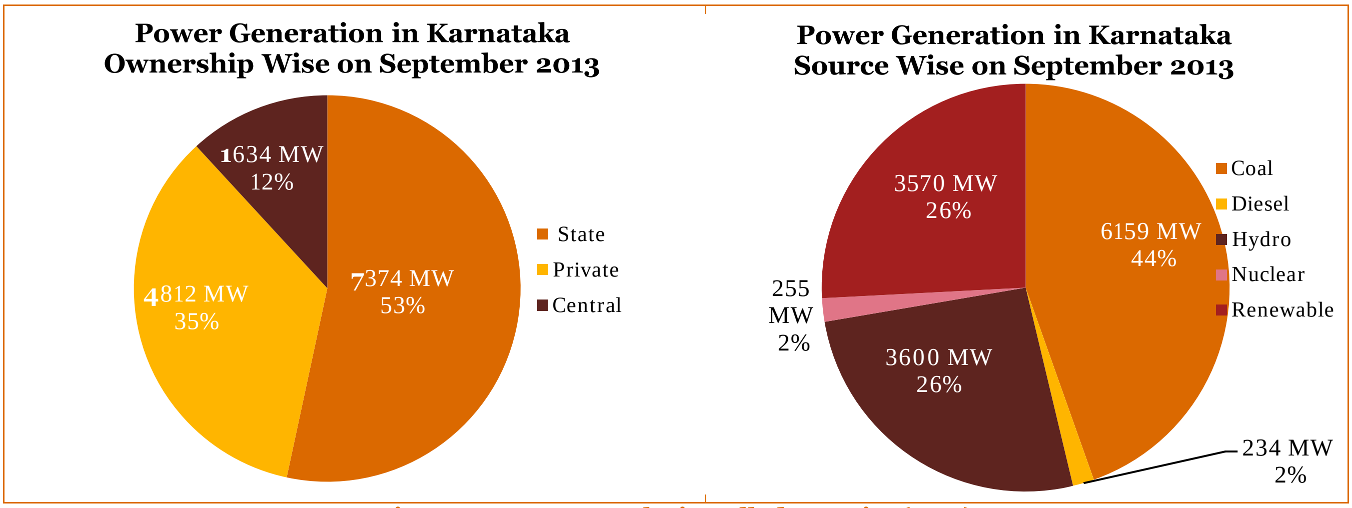


Figure 6.8.5: Karnataka installed capacity (CEA)

The present demand and supply deficit in India is around 9% whereas in the state of Karnataka the same is around 13%. For the peak demand and supply position presently the state has a deficit of around 10% which is more than double in comparison to the overall demand and supply scenario in India.

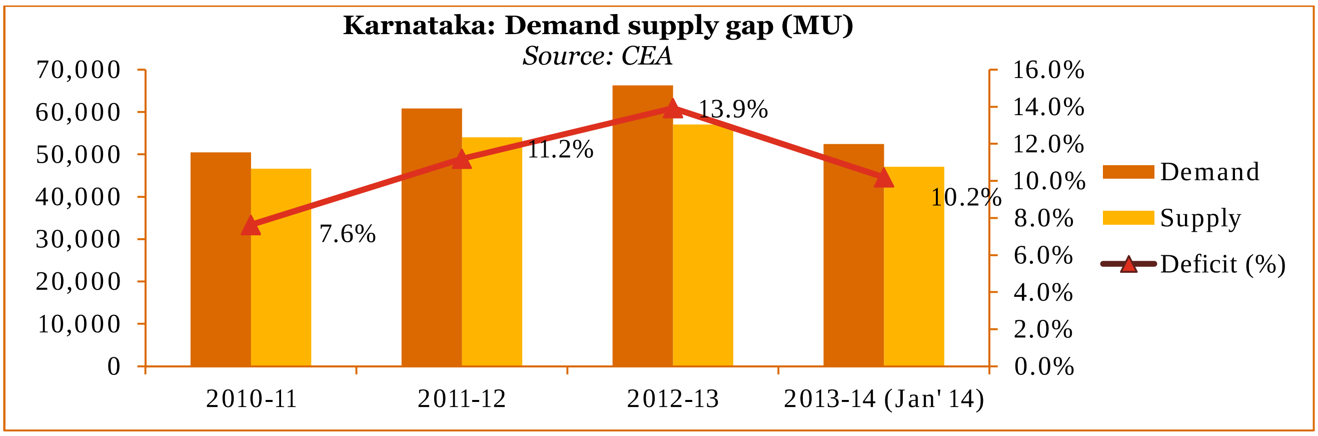


Figure 6.8.6: Karnataka demand supply gap (CEA)

A primary reason for this huge supply deficit has been insufficient capacity additions. In contrast to Andhra Pradesh and Tamil Nadu, projects of only 38,555 MW capacities are in the pipeline and at various phases of development. These would still help in reduction in the demand supply gap in the state that has been on the rise in the state, to an extent. The table below depicts the status on upcoming capacities in Karnataka. The projects under construction are expected by FY 2015 whereas those still under implementation are expected by FY 2019.

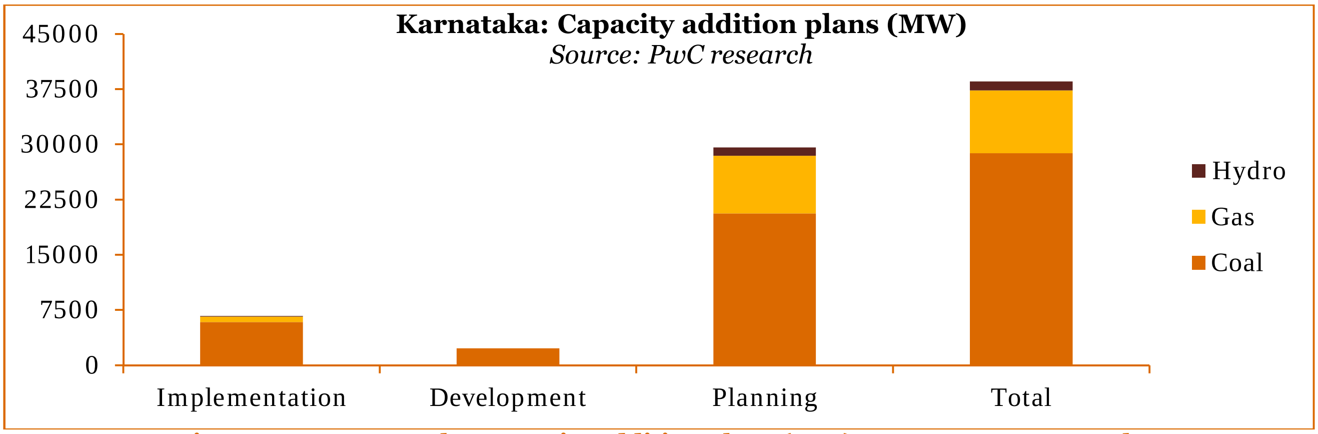


Figure 6.8.7: Karnataka: Capacity addition plans (MW); Source: PwC research

The supply position for Karnataka is given below:

Table 6.8.10: Karnataka – Expected installed capacity as per plans (MW)

Fuel	Current Capacity	Short-term Target at 2017
Coal	6,158	8,458
Gas	-	-
Diesel	234	234
Hydro	3,600	3,600
Nuclear	255	255
Total conventional	*10,247*	*12,547*
RES	3,693	5,696
Total	**13,941**	**18,244**
Thermal Capacity Equivalent (MW)	**8,553**	**11,298**

Table 6.8.11: Karnataka – Expected generation as per plans (Million Units)

Fuel	Current Generation	Short-term Target at 2017
Coal	48,550	66,683
Gas	0	0
Diesel	1,437	1,437
Hydro	9,461	9,461
Nuclear	1,519	1,519
Total conventional	*60,966*	*79,100*
RES	6,470	9,979
Total (MU)	**67,437**	**89,079**

The capacity projections have been done taking into account the fact that some of the existing plants would retire in the near future, after expiry of their economic life.

6.8.4.1.3 Tamil Nadu

Tamil Nadu had a total installed capacity of 20,111 MW at the end of September 2013 (which now has increased to 20,717, January 2014). Unlike the other two states, only 38% of the Tamil Nadu's generation is State owned.

Additionally, renewable based power plants also account for a significant share of 38% in the State's installed capacity. Conducive policy and investment environment are primarily the reason behind the State's significant success in renewable based power.

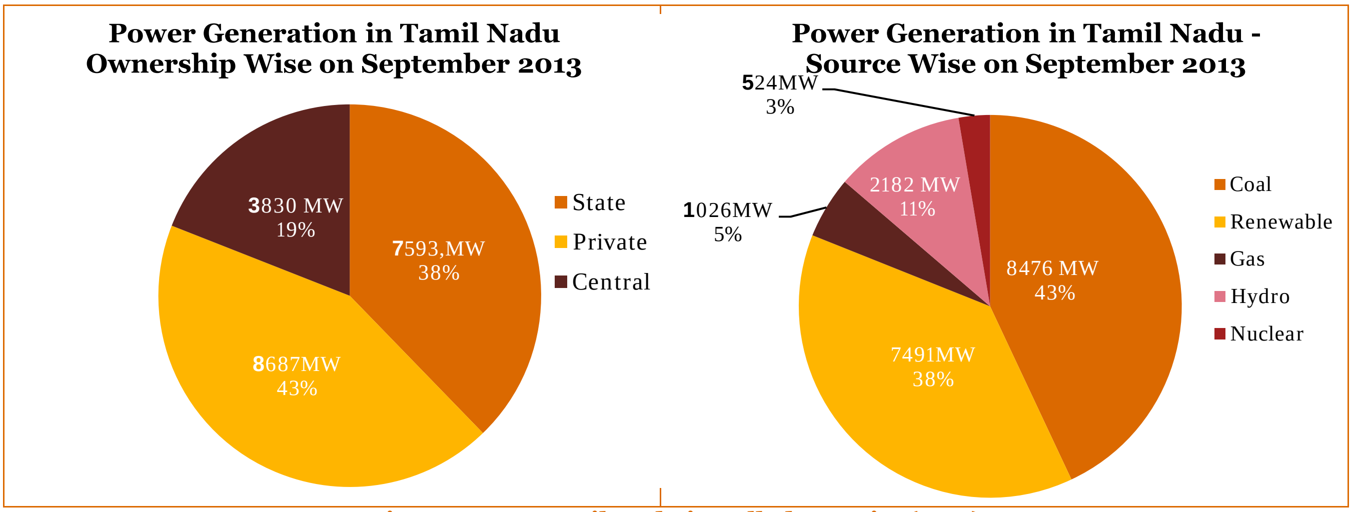


Figure 6.8.8: Tamil Nadu installed capacity (CEA)

Tamil Nadu, as compared to the other two states, has been able to take control of its supply deficit situation. From a glaring 17.5% in FY 2012-13, the State has been able to bring down the demand supply gap to a reasonable 6.1% in by the end of January 2014, as compared to a national average of 4.3%.

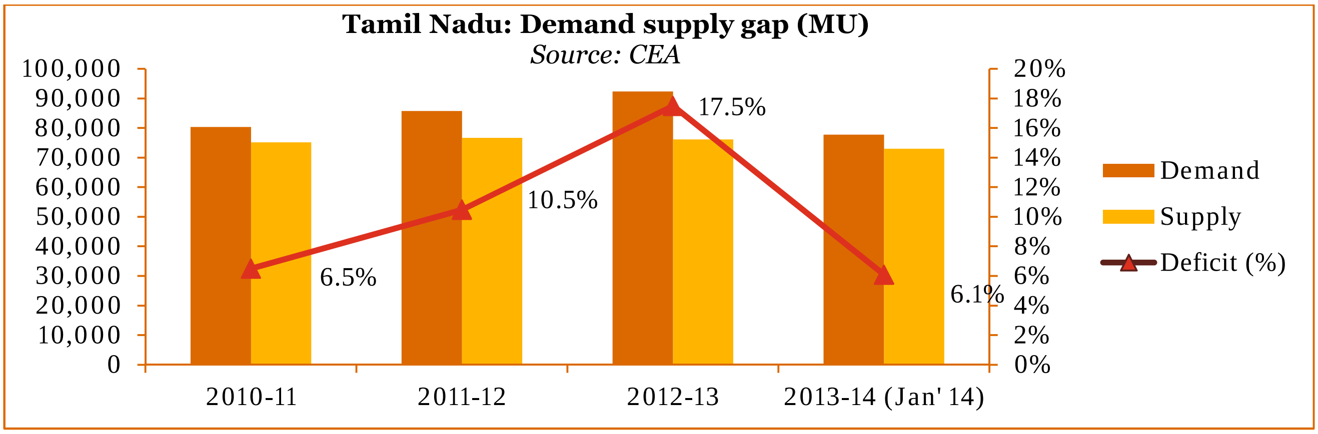


Figure 6.8.9: Tamil Nadu demand supply gap (CEA)

To ensure that the high levels of demand are adequately met, and that the State's dependence on Central power allocation is reduced, Tamil Nadu has a plan of developing close to 89,000 MW of power based on conventional sources. These are currently at various stages of development, a summary of which is given below.

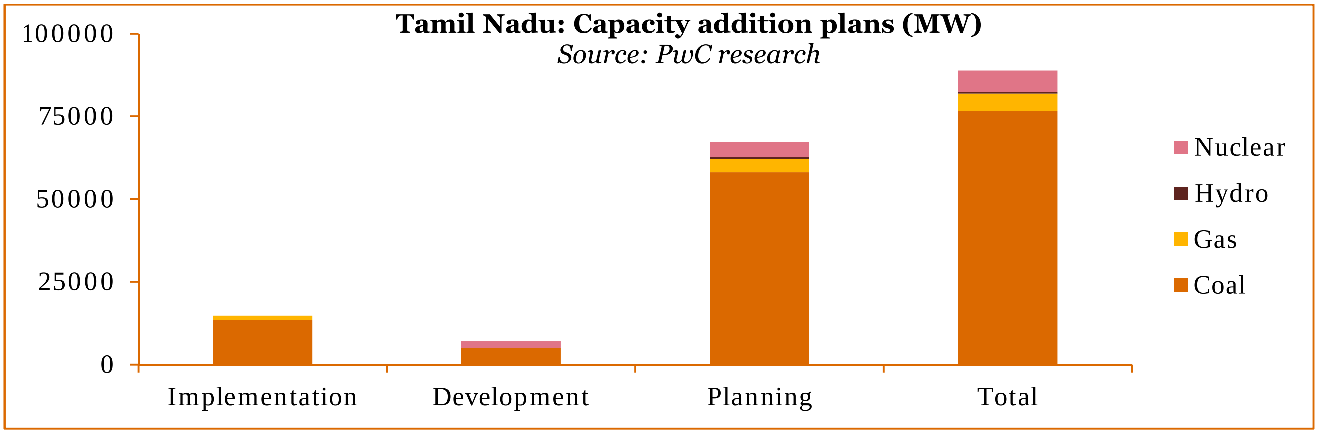


Figure 6.8.10: Tamil Nadu: Capacity addition plans (MW); Source: PwC research

By the end of FY 2021, Tamil Nadu has a capacity addition plan of close to 25,000 MW out of which 18,500 MW is expected to be coal based. To assess the supply position post FY 2021, for which plans are not available, a historical capacity growth rate of 4% per annum has been considered. The supply position for Karnataka is given below. The generation capacity and the expected generation for Karnataka are given below.

Table 6.8.12: Tamil Nadu – Expected installed capacity as per plans (MW)

Fuel	Current	Short-term Target at 2017
Coal	8,626	13,506
Gas	1,026	1,026
Diesel	412	412
Hydro	2,182	2,182
Nuclear	524	2,524
Total conventional	*12,770*	*19,650*
RES	7,946	10,946
Total	**20,717**	**30,597**
Thermal Capacity Equivalent (MW)	12,210	19,268

Table 6.8.13: Tamil Nadu – Expected generation as per plans (Million Units)

Fuel		Short-term Target at 2017
Coal	68,007	106,481
Gas	4,044	4,044
Diesel	1,437	1,437
Hydro	5,734	5,734
Nuclear	3,121	15,035
Total conventional	*82,345*	*132,732*
RES	13,921	19,177
Total (MU)	**96,266**	**151,909**

The capacity projections have been done taking into account the fact that some of the existing plants would retire in the near future, after expiry of their economic life.

For all the three states it is important to note that additional supply is possible at any time through purchase of power through case 1 or case 2 route of competitive bidding. Power procured through this route can be tied up for long durations across 10 or more years. Further short term power purchase / barter from other states and at electricity exchange is also a possibility which can boost supply.

6.8.4.2 Estimation of additional capacity requirement (coal equivalent) for medium/long term

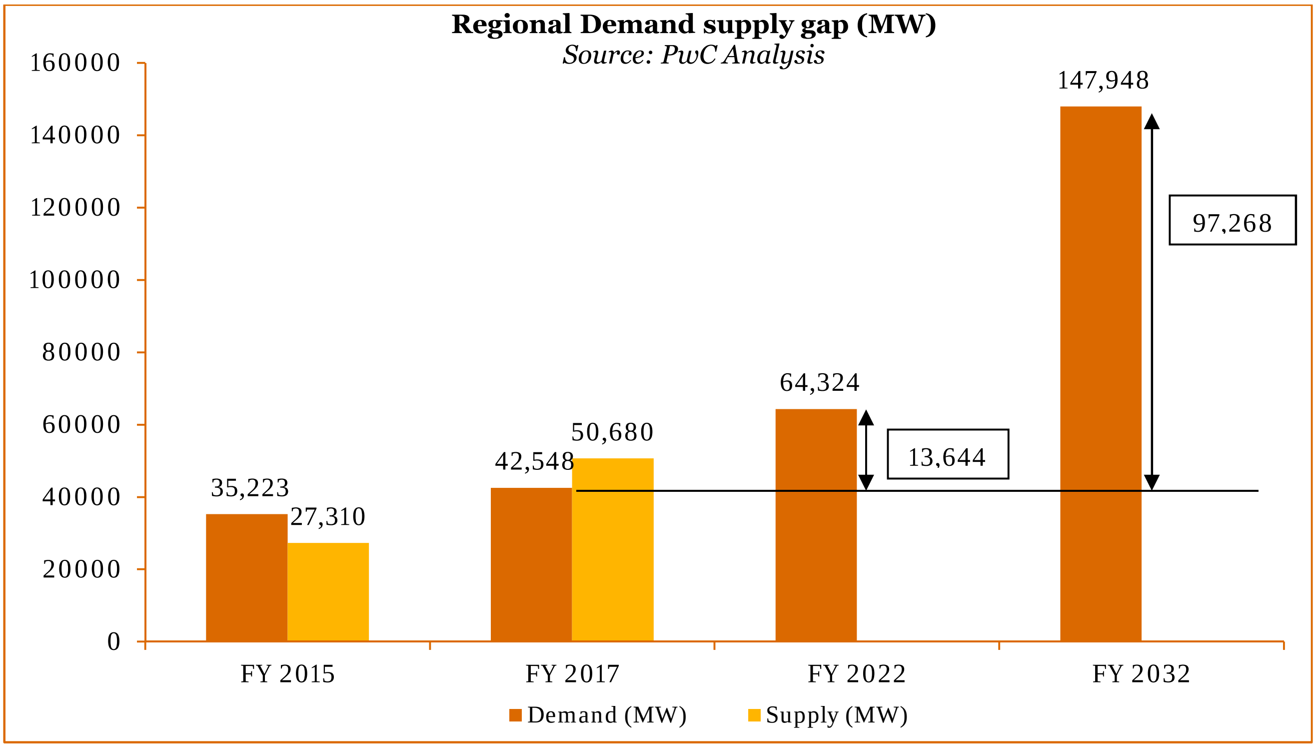


Figure 6.8.11: CBIC Region Demand Supply Gap (MW); Source: PwC research

*Since, supply from FY 2017 onwards is not possible to predict with accuracy therefore the total gap on forecasted demand and present supply numbers has been estimated. The gap will be filled up with a cumulative of coal, renewable, gas, hydro and nuclear supplies which will come up in the CBIC region. As a matter of approach, priority has been provided to cleaner fuels in planning of generation for the region. Next priority has been provided to base load capacities like Hydro and nuclear. The remaining is expected to be filled in by thermal capacity.

Table 6.8.14: Year wise demand supply gap forecast, Source: PwC analysis

Year	Demand (MW)	Supply (MW)	Gap (MW)
FY2013-14	35,223	27,310	7,913
FY2017-18	42,548	50,680	(8,132)
FY2022-23*	64,324	-	13,644
FY2032-33*	**147,948**	**-**	**97,268**

In FY 2017-18, according to estimates, supply will lead demand by 8,132 MW. However, this is expected to be largely nullified by the latent demand in the southern region. According to the CEA (LGBR Report, 2013-14), the unrestricted demand in the southern region of the country will exceed 25% of the total requirement by FY 2018-19. By PwC estimates, although energy gap is shown as negative with spare capacity of 8 GW by FY 2013-14, more than 75% of this spare capacity will meet the unmet latent demand in the southern region.

It is imperative that the generation growth required for the plant be matched with corresponding growth in distribution and transmission sectors. This will ensure removal of any bottlenecks in making generated power available to end consumer.

6.8.4.3 Source wise generation in medium/long term

A review of the planned projects in pipeline and the historical growth trends of power supply in the region (consolidated for the three states) clearly brings out that significant capacity addition would be needed to demand growth in the CBIC scenario till FY 2031-32.

Table 6.8.15: Coal equivalent requirement for filling the gap in the CBIC region

Coal requirement	FY 2017	FY 2022	FY 2032
Supply gap (MW)* - Coal equivalent capacity	(8,132)	13,644	83,624
Coal requirement to fill gap (MT)/annum	-	56.2	344.3

The above table shows the capacity requirement equivalent of an imported coal based power plant, operating at 90% PLF. To meet the entire deficit in each of the year, the above capacities must be added. In order to meet the supply deficit of the three states, it is essential to develop the new generation capacities which are in line with objectives of the infrastructure development plan. All new capacities should focus on providing reliability with respect to availability of fuel, reducing carbon emissions, enhancing efficiency and optimising costs.

Prioritization of capacity addition: In terms of generation, first preference is provided to Renewable energy. Next preference to Base load Nuclear and Hydro capacities. The diesel capacity going forward is being proposed to be converted to cleaner and cheaper coal based capacity.

(a) Renewable Sources: Key sources for meeting unmet demand in southern states is largely based on solar, wind, biomass and small hydro. In recent times, Waste to heat energy has also been added to the mix. Renewable energy sources have a distinct advantage in low carbon emissions. This provides an incentive to fully utilize the clean potential in new planning. The below table clearly demonstrates the net expected renewable capacity addition in CBIC states by FY 2022 and FY 2032. It is important to note that in Tamil Nadu a large percentage of renewable energy is already added. Further large addition may not be absorbable at the state level due limitations of renewable integration but regional potential to absorb this may exists subject to transmission availability, commercial and regulatory constraints.

Table 6.8.16: Renewable capacity addition proposed for CBIC states

Renewable	Potential	FY 2017	FY 2022	FY 2032
Wind (MW)	26,029	9,880	16,387	20,484
Solar (MW)	118,000	108	3,300	5,000
Biomass (MW)	3,124	1,417	1,771	2,214
Small Hydro (MW)	2,926	1,356	1,695	2,119
Waste to Heat (MW)	425	50	250	350
Total (MW)	**150,504**	**12,811**	**23,404**	**30,167**
Percentage of total potential		*9%*	*16%*	*20%*
Units Generated(MU)	263,683	22,444	41,002	52,852
Equivalent Coal Capacity (MW)		**2,846**	**5,200**	**6,703**
Additional capacity addition required with respect to previous period			**2,354**	**1,503**

(b) Hydro Sources: Hydro source for generation provides considerable scope for CBIC region. Out of the total potential of 30 GW, more than 32% would be tapped by FY 2015. Based on CEA (LGBR Report and Hydro Project monitoring report, MoP), the expectation for FY 2022 would be around 14 GW from hydro capacities in CBIC region. This would lead to 48% tapping of hydro capacity. In FY 2032, this number is expected to rise to 72% with better and cheaper plants coming up for taping hydro capacity. In terms of Coal equivalent 2,400 MW would be added from Hydro by FY 2022 and 3,700 would be added to the FY 2022 capacities by FY 2032.

Table 6.8.17: Hydro capacity addition for CBIC states

Hydro	Potential	FY 2017	FY 2022	FY 2032
Total	30,980	9,927.00	14,891	22,336
Percentage of total potential		*32%*	*48%*	*72%*
Units Generated(MU)	122,123	39,132	58,698	88,048
Equivalent Coal Capacity (MW)	15,490	4,964	7,445	11,168
Additional capacity (MW)			**2,482**	**3,723**

(c) Nuclear Sources: Nuclear plants have a higher lead time and capital cost for power generation. Also constraints on the location of the plant for nuclear implementation would continue to exist. Considering this no new capacity is expected by FY 2022 apart from 1,000 MW of Kundankulam. However by FY 2032, 3,500 MW of nuclear capacity is expected to come up in the southern region. In terms of coal equivalence, around 3,400 MW of capacity would be available from nuclear sources by FY 2032. However entire power may not be allocated regionally as it is distributed other nearby states as well.

Table 6.8.18: Nuclear capacity addition for CBIC states

Nuclear	Potential	FY 2017	FY 2022	FY 2032
Total	20,000	3,055	4,055	8,555
Percentage of total potential		*10%*	*13%*	*28%*
Units Generated(MU)	119,136	18,198	24,155	50960
Equivalent Coal Capacity (MW)	15,111	2,308	3,064	6464
Additional capacity (MW)			**756**	**3,400**

(d) Gas Sources: It is imperative that gas scenario in CBIC states is fully understood. Presently the region has a lot of stranded gas capacities due to lack of natural gas. But in the coming 2-3 years with Dhabol gas pipeline (3,000 MW of capacity gas per year) and resolution to KG-6 basin, natural gas would be available for gas capacities to develop in the region. On the other hand there are issues of gas pricing which make it a clean but expensive fuel. We therefore do not foresee significant capacity addition in gas based generation. It is estimated that total of around 7200 MW of gas based capacity would be available in FY 2022 up by 2500 MW from expected numbers of 4,300 MW in FY 2015. In FY 2032 this will continue with around 3000 MW capacity addition making the net gas based capacity to be around 10,000 MW. In terms of coal equivalent, 1400 MW would be needed by FY 2022 and additional 1400 MW would be needed by FY 2032.

Table 6.8.19: Gas capacity addition for CBIC states

Gas	Potential	FY 2017	FY 2022	FY 2032
Total	45,000	4,396	7,200	10,000
Percentage of total potential		*10%*	*16%*	*22%*
Units Generated (MU)	119,136	17,329	28,382	39,420
Equivalent Coal Capacity (MW)	15,111	2,198	3,600	5,000
Additional capacity (MW)			**1,402**	**1,400**

(e) Thermal Sources: In order to meet the regional energy gap, thermal capacity plays a major role. Subtracting from the total gap all the sources of energy described above, the net thermal capacity needed for fulfilling energy gap in region would be around 6,600 MW in FY 2022 and over 73,000 MW in FY 2032.

Table 6.8.20: Thermal capacity addition for CBIC states

Description – Additional Capacity requirement (Thermal Equivalent capacity)	FY 2022	FY 2032
Regional Energy Gap (MW)	***13,644***	***83,624***
Renewable (MW)	2,354	1,503
Hydro(MW)	2,482	3,723
Nuclear(MW)	756	3,400
Gas (MW)	1,402	1,400
Spinning Reserves (MW)	364	3,653
Net coal based capacity required (MW)	**6,650**	**73,598**

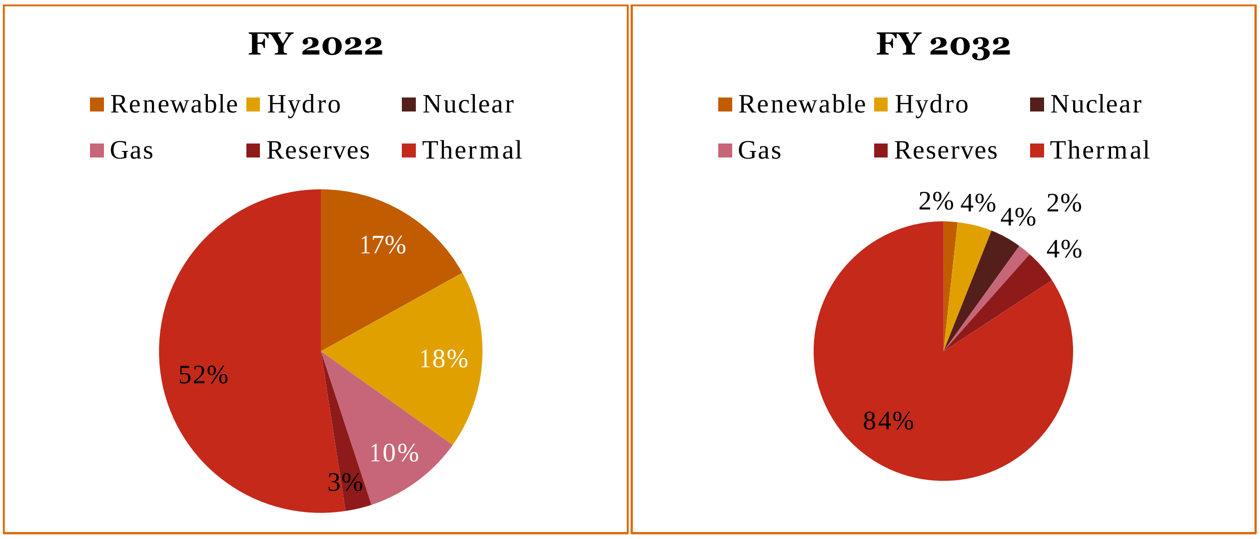


Figure 6.8.12: Source wise proposed capacity addition, Source: PwC research

Apart from the demand supply gap two additional factors have been considered in above analysis:

Potential of each fuel in the future in order to determine the fuel mix of the proposed additional capacity;

Strategy for meeting supply deficit: The states may take up a policy to add capacities only to meet any shortfalls above 5% deficit. Any shortfall below 5% may be met through short term trading, bilateral arrangements etc.

Our approach taken above translates in the following action plan:

Going into the future, it is imperative that cleaner fuel technology is adopted to minimise the carbon footprint, especially in generation of power. Therefore evaluating mainline capacity additions through benign technologies such as wind, solar, small hydro, waste to energy etc. becomes paramount. However, as subsequently elaborated in the chapter on Fuel, a significantly large supply gap needs to be filled in comparison to the potential of these resources in these states. Further there are grid integration and issues related commercial exploitation which may impact capacity addition. It may therefore not be possible and practical to add a considerable capacity through these technologies.

Given the above context and the fact that reliability and price competitiveness would be a major assessment criteria, coal based power plants might still continue to have a dominant presence in the additional capacity. In order to restrict the carbon emissions however, super-critical and ultra super-critical technologies should be used. Since availability of domestic coal may prove to be a challenge in the long term, it is suggested that most of the coal plants be based on imported coal, near the coast line. In the event indigenous coal plants are proposed, they may be located close to the pit head to avoid transportation costs and losses.

The capacity mix of various fuels in FY 2032, as per projections is given below. The mix is fairly consistent with today's scenario barring the increase in coal's proportion. Renewable energy capacity on the other hand, would still have a moderate share, however its capacity would have grown by 4 to 5 times today's capacity, pointing to the fact that their potential might be reached in the long term. Their reliability may therefore be a concern.

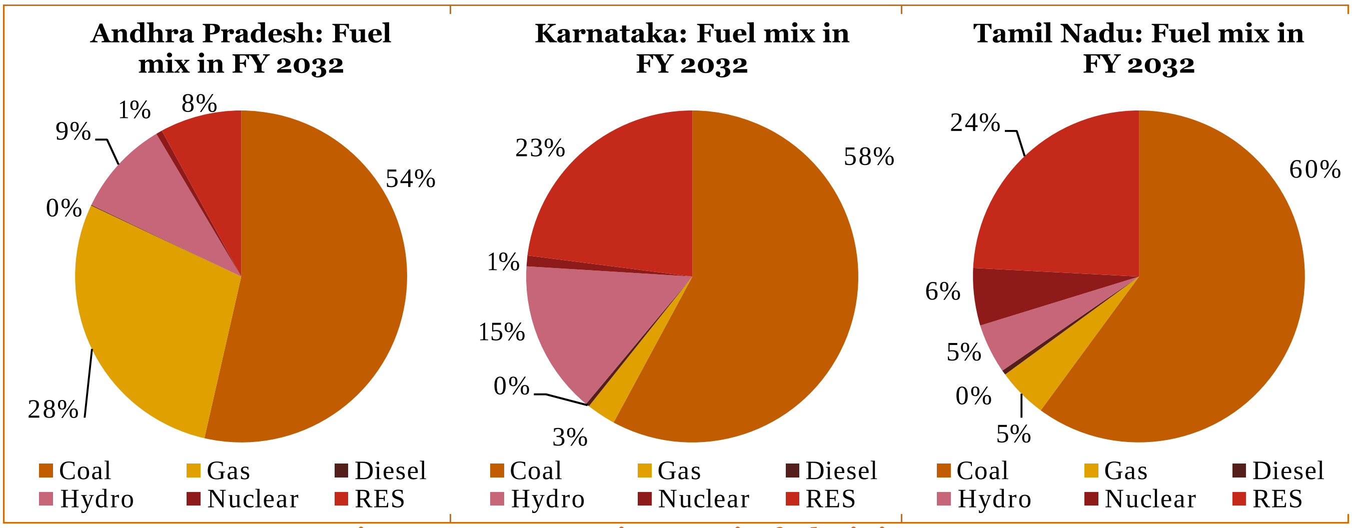


Figure 6.8.13: Generation capacity fuel mix in FY 2032

The future of other fuels, such as gas is also not certain as per the current scenario. Unavailability of gas supply in the Indian market and high prices in the international market might lead to most of the gas capacity operating at sub-optimal PLF levels (as is the scenario with most gas plants in Andhra Pradesh).

It is however expected that nuclear fuel based power would take off in the future, with higher levels of social acceptability. Besides this, their comparatively lesser emission levels as compared to thermal coal plants would also fall in line with the infrastructure development objectives. The only concern that however remains is that of high initial capital investments required for nuclear power plants.

6.8.5 *Development plan and suggested projects*

6.8.5.1 Planned projects

The Central and State planning agencies have drawn up significant capacity addition plans across the power sector value chain in the three states. Some of these projects that are currently either under development or construction, have been considered to estimate the supply position of the States and the region. Apart from the planned projects, in order to meet the accelerated demand growth due to the CBIC, it would become paramount to plan new capacity additions in the future. This section therefore covers an overview of upcoming planned projects in the three states, as well as suggests capacity addition plans to meet the additional demand owing to CBIC.

6.8.5.1.1 Generation

The three states have a massive amount of generation capacity planned to meet the rapid power demand of the country. An overview of the capacity addition plans of the three states has been given below.

In Andhra Pradesh, projects of 11,171 MW are presently under implementation, and projects of 16,095 MW are presently under construction. The table below shows the details of these projects.

Table 6.8.21: Andhra Pradesh – Generation projects planned

No	Project Title	Status	Project Cost (Million USD)	District	Priority [108]
1.	Simhapuri TPS II	Imported coal for the project will be sourced from the coalmine of PT Madhucon Indonesia which has a reserve of 900 MT. Dawas, South Sumatra and Marudhwa are the coal mines owned by PT Madhucon Indonesia	300	Nellore	A
2.	Lower Jurala	Hydro power project	320	Mahbubnagar	A
3.	Rajahmundry	GMR has sought clarity from the government on natural gas supplies to the plant from Reliance Industries' D-6 block in Krishna-Godavari basin	768	East Godavari	A
4.	Kondapalli III	Fuel supply pending	742	Krishna	A
5.	Panduranga I	o.4 mmscmd of natural Gas required for the 100 mw at 70/75% PLF. The Natural Gas required for the 470 mw plant (1.90 MMSCMD) is to be tapped from the existing GAIL/RGTIL pipe line	110	West Godavari	A
6.	Vishakhapattnam	Application for fuel linkage has been made	1,040	Vishakhapattnam	A
7.	Biccavolu I	2.5 MMSCMD natural gas required for both phases which will be sourced from Gail India Ltd. and Reliance Industries Ltd.	225	East Godavari	A
8.	Thermal Powertech I	Project will run on Domestic and Imported coal in ratio of 70:30 respectively, Company signed up contract with Indonesia-based PT Bayan Resources Tbk (Bayan) for supply of 1 MTPA coal for over 10 years. Supply expected to begin from 2014.	1,320	Nellore	A
9.	Meenakshi Thamminapatnam II	FSA for 70 % with MCL is too signed shortly and balance 30% imported coal the arrangements are already in-place.LOA is Granted for 600 MW only.	700	Nellore	A
10.	Sri Damodaram	Project secured fuel linkage of 5 MTPA from the Talcher mines of MCL and rest could be met from imports from Indonesia.	1,600	Nellore	A
11.	Samalkot II	Government assured to the company that gas linkage will be available shortly.	2,400	East Godavari	A
12.	Kakatiya II	Project has been allocated Tadicherla-I Coal block of SCCL (Singareni Colleries Company) by Ministry of Coal.	600	Warangal	A
13.	Nagarjuna Sagar Tail	Hydro power project	67	Nalgonda	A
14.	Bhavnapadu I	Coal Linkage for 70% of the coal consumption has been allocated from MCL, Orissa. ECEPL has signed Fuel Supply Agreement (FSA) for supply of	1,320	Srikakulam	A

[108] "A" refers to projects for implementation before 2018, "B" refers to projects for implementation in 2018 – 2022, and, "C" refers to projects for implementation after 2023

No	Project Title	Status	Project Cost (Million USD)	District	Priority [108]
		imported coal with Global Fuels Pte. Ltd. for 30% of the fuel required. 10 MTPA is total fuel requirement for both			
15.	Rayalseema IV	Project had provided 2.31 MTPA long term coal linkages from MCL previously. Now LOA is cancelled due to late submission of forest clearance document. MoC has been addressed for additional quantity of 1.2 MTPA required, linkage is awaited for additional quantity	600	Cuddapah	A
16.	Pulichintala	Company signed PPA with AP DISCOM for the sale of power from the project.	160	Nalgonda	A
17.	Komarada	Pending - Imported Coal requirement will be 7.61 MTPA whereas about 13.6 MTPA will be sourced from Talcher coal fields of Mahanadi Coalfields Limited (MCL).	2,640	Vizianagaram	B
18.	Vijjeswaram III	Gas will be supplied through GAIL and sourced from KG D6 Basin	700	West Godavari	B
19.	Bhavnapadu II	Pending	1,320	Srikakulam	B
20.	Gautami Expansion	Pending	800	East Godavari	B
21.	Jegurupadu Expansion	Pending	800	East Godavari	B
22.	Konaseema II	Pending	820	East Godavari	B
23.	Biccavolu II	2.5 MMSCMD natural gas required for both phases which will be sourced from Gail India Ltd. and Reliance Industries Ltd.	225	East Godavari	B
24.	Thamminapatnam I	Imported coal for the project will be sourced from the coalmine of PT Madhucon Indonesia which has a reserve of 900MT. Dawas, South Sumatra and Marudhwa are the coal mines owned by PT Madhucon Indonesia.	1,320	Nellore	B
25.	Muthukur Mandal I	70% domestic coal and 30% imported coal will be used for the project. NCCPPL has a 12-year fuel supply agreement (FSA) with Singapore-based APOLLONIUS Coal and Energy Ltd., a NCC group company (a 50% equity stake), for the supply of 1.8 MTPA coal	1,320	Nellore	B
26.	Poweravara	Pending	440	East Godavari	B
27.	Kakinada I	Source of natural gas will be from K.G. Basin. Gas requirement will be 6.7 MMSCMD.	350	East Godavari	B
28.	Rajahmundry II	Pending	436	East Godavari	B

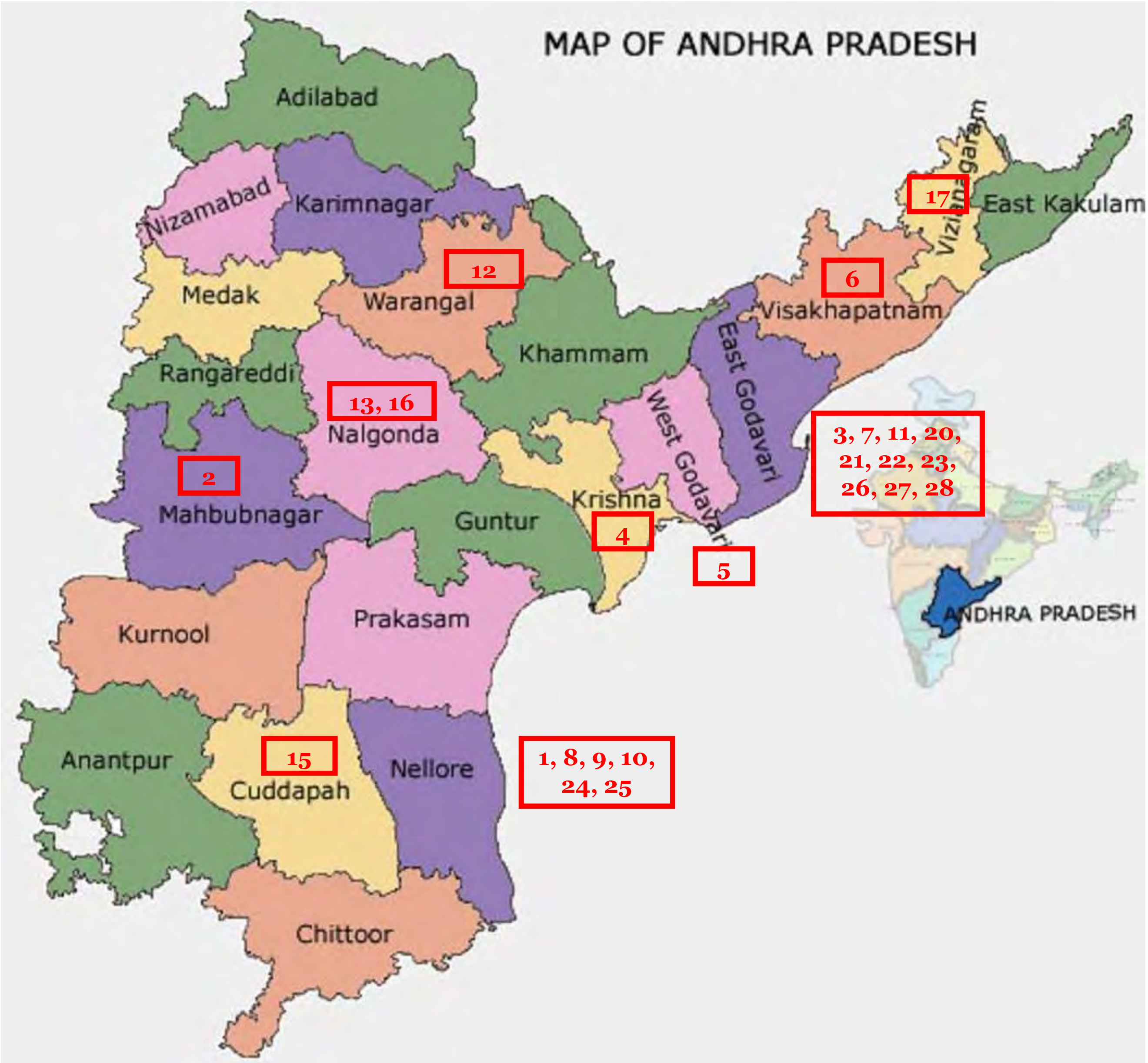


Figure 6.8.14:District wise status of planned power projects in Andhra Pradesh

All thermal projects in Andhra Pradesh have e

Apart from the above projects, the State also plans to add a capacity of 2,109 MW of renewable capacity in the short term. However, the project details for these are not available.

Karnataka, on the other hand has a plan of implementing and constructing a capacity of only 10,983 MW in the near future i.e. till the medium term. A summary of the 8,980 MW of conventional upcoming projects has been given in the following terms. The State also has a plan of adding another 29,575 MW of power post the end of the 12th Five Year Plan period. However, these projects have not been considered as no work has started at the ground level.

Table 6.8.22: Karnataka – Generation projects planned

No	Project Title	Status	Project Cost (Million USD)	District	Priority
1.	Bellary (Partly Commissioned)	About 4.8 MTPA coal will be required for the project.	700	Bellary	A
2.	Yermarus	Pending	1,600	Raichur	A
3.	Cauvery Basin	Pending	133	Cauvery	B
4.	Hassan	MoU signed with Khemco Indo Coal Resources Private Ltd, Singapore for imported coal for project.	660	Hassan	B
5.	Bidadi	The Karnataka government has approved the proposal of Karnataka Power Corporation Limited (KPCL), the state-owned power generator, to procure liquefied natural gas (LNG) for the first block of its proposed 700 Mw Bidadi Combined Cycle Power Plant (BCCP)	700	Ramnagara	B
6.	Edlapur	Pending	800	Raichur	B
7.	Kudgi I	Coal requirement will be 12.0 MTPA. Coal will be obtained from Parkri Barwadih Coal Block in Jharkhand	2,400	Bijapur	B
8.	Kudgi II	Coal requirement will be 12.0 MTPA. Coal will be obtained from Parkri Barwadih Coal Block in Jharkhand	1,600	Bijapur	B
9.	Vadlur	Coal requirement of about 1.43 MTPA will be sourced from Indonesia. Surana Power Limited acquired 51% stake in an Indonesian coal mine in Kalimanthan Island	420	Raichur	B

Figure 6.8.15: District wise status of planned power projects in Karnataka

Tamil Nadu has projects coming up to the tune of 21,724 MW capacity based on conventional sources and another 3,000 MW of renewable power in the medium term. A brief of the conventional power projects which are at various stages of implementation and development is given below.

Table 6.8.23: Tamil Nadu – Generation projects planned

No	Project Title	Status	Project Cost (Million USD)	District	Priority
1.	Mutiara	Company has entered into Fuel Supply Agreement (FSA) with M/s Coal & Oil, Dubai for Supply of Entire Coal requirement for the Project.	1,200	Tuticorin	A
2.	Ind Barath Thootukudi (Partly Commissioned)	Partial: Requirement will be about 2.476 MTPA. Coal will be sourced from Indonesia Coal Mines and Orissa. Agreement for sale and purchase of coal was executed between Ind-Barath Thermal Power Limited (formerly known as Ind-Barath Power (Karwar) Limited and PT Ind	150	Tuticorin	A
3.	Kudankulam I	FSA worth D400 million was signed between NPCIL and TVEL (Russian based fuel company) for fulfilment of fuel requirements.	3,333	Tirunelveli - Kattabomman	A
4.	Neyveli TPS II Ext (Partly Commissioned)	Project received lignite linkage for 4.5 MTPA from captive Mine-II Expansion.	250	Tuticorin	A
5.	Tuticorin NLC	Fuel to be procured from the existing lignite sources	1,000	Tuticorin	A
6.	Vallur II	Clearances received from ministry of coal for linkage	500	Thiruvallur	A
7.	Chennai IV	Plant will use blended coal i.e. domestic coal from MCL (1.3 MMTPA) and imported coal from Indonesia (about 0.86 MMTPA).According to a company official agreements had been signed with South Eastern Coal Fields and with an Indonesian company.	160	Chennai	A
8.	Ennore II	Coal allotted to the project from Mandakini B block. Total coal requirement is estimated as 2.46 million tpa and 1.96 million tpa coal will be sourced from Mandakini B coal block and 0.5 million tpa coal will be imported from Indonesia	660	Thiruvallur	A
9.	Ind Barath Madras I	clearance received	660	Tuticorin	A
10.	Nagai	Plant is using combination of coal from MCL and imported coal from Indonesia for a requirement of 1.91 mtpa.	300	Nagapattinam	A
11.	Gummidipoondi	Plant will use domestic coal from Talcher coal fields and imported coal from Dubai Multi Commodities Centre (DMCC), a Dubai based Coal and Oil Company for which Memorandum of Understanding was signed in May 2010.	126	Thiruvallur	A
12.	Sirupulalpettai	Project will use domestic coal for a requirement of 1.7885 MTPA to be sourced	300	Thiruvallur	B

No	Project Title	Status	Project Cost (Million USD)	District	Priority
		from various mines of Orissa and imported coal for a requirement of 1.33 MTPA to be sourced from Indonesia			
13.	Cuddalore Power	Coal for project will be sourced from Indonesia. Total coal requirement will be 4 MTPA	1,320	Cuddalore	B
14.	Ind Barath Thootukudi II	Coal will be sourced from Indonesia Coal Mines and Orissa.	150	Tuticorin	B
15.	ILandFS Cuddalore II	IL&FS has acquired a coal mine in Indonesia	2,400	Cuddalore	B
16.	ILandFS Cuddalore I	IL&FS has acquired a coal mine in Indonesia	1,200	Cuddalore	B
17.	Tirumalai	Pending	1,050	Nagapattinam	B
18.	Valuthur	Gas requirement would be about 900000 SCMD.	93	Ramanathapuram	B
19.	PPN Power	The naphtha will be supplied by Indian Oil Corporation Ltd and Natural gas will be supplied by GAIL/RIL from gas wells of PY 01 and KG Basin	1,080	Nagapttinam	B
20.	Spic Tuticorin	Imported coal requirement will be 1.55 MTPA from Rio Tinto of Australia for which an agreement was signed.	525	Tuticorin	B
21.	Cuddalore SRM	Signed an Agreement for 5.0 million tons per annum imported coal from Indonesia with an option to increase 6.0 million per annum for a period of 20 years on Cost plus basis. And applied for a coal linkage of 3.2 MTPA for Blending.	1,980	Cuddalore	B
22.	Ennore SEZ	MoU has been signed with M/s MMTC Ltd., New Delhi for supply of coal. About 8.10 MTPA coal will be required for the project. Imported Coal requirement will be 4.29 MTPA, which will be obtained from Indonesia.	1,320	Thiruvallur	B
23.	Udangudi	MMTC has given consent letter for the supply of 4.5 MTPA of imported coal from Indonesia. DPR and EIA study is being revised for 100% usage of imported coal.	1,320	Thoothukudi	B
24.	Sindya Nagapattinam	Imported Coal requirement will be 6.11 MTPA. Imported Coal will be obtained from Indonesia. FSA has been signed with M/s Sindya Resource Pte. Ltd.	1,980	Nagapattinam	B

In addition to the above projects, which are either under construction or are in the implementation phase, there are several other projects based on conventional sources which are planned and would likely be available in the long term to supply power. These projects are in line with those planned by the Central Electricity Authority of India (CEA). Additionally, the Ministry of New and Renewable Sources (MNRE), has also planned projects in the short term sourced by renewable power. Since the project wise break-up of these planned projects is not available, these have not been included in this section. However, in order to the demand/supply surplus/deficit, we have considered such capacities for estimating the scenario.

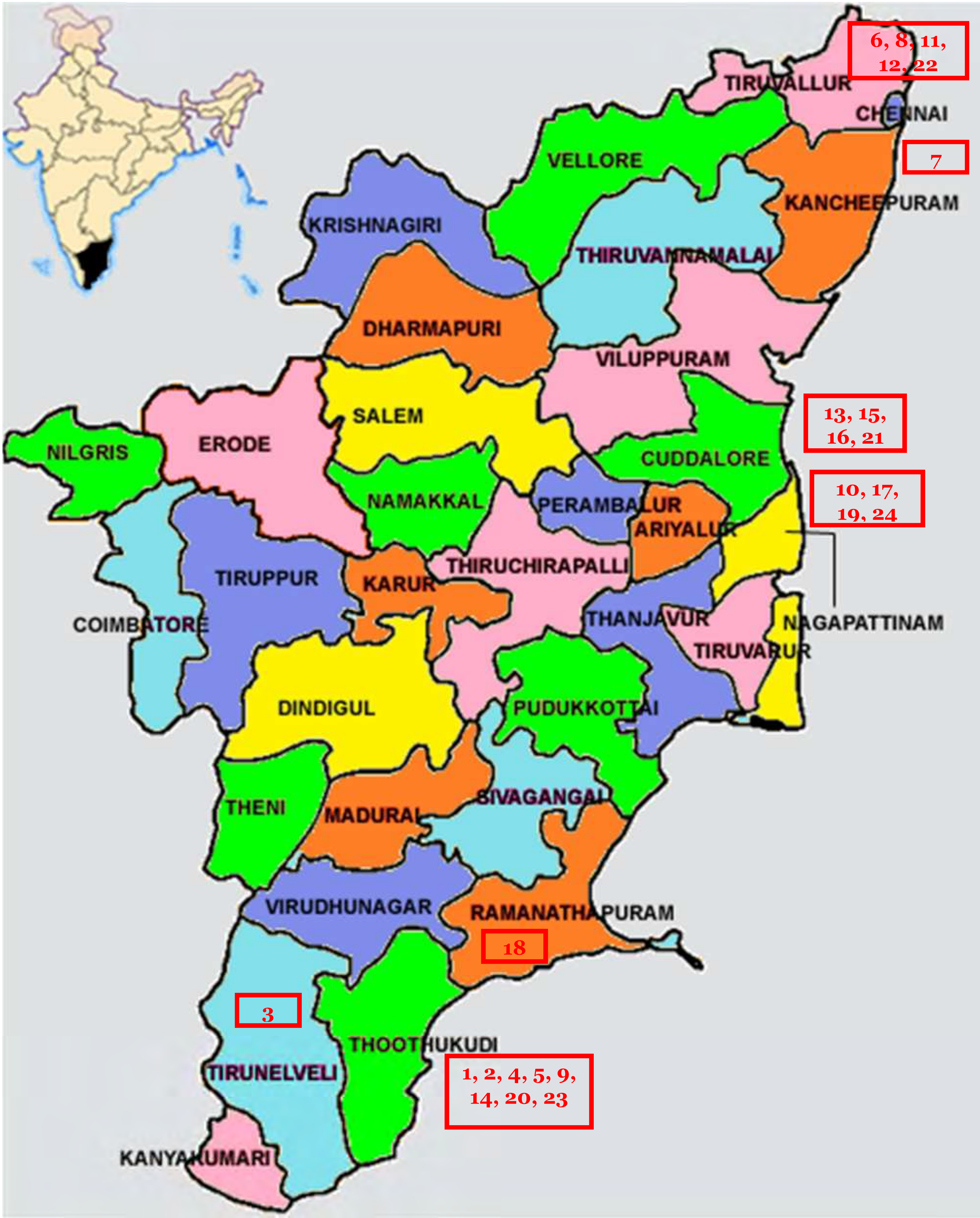


Figure 6.8.16: District wise status of planned power projects in Tamil Nadu

6.8.5.1.2 Transmission

Transmission planning in India is done at two levels, the Central level for inter-state power transmission and at the State level for intra-state transmission. As per the 12th Five Year Plan, the inter-regional transmission capacity between the Southern and Western region is expected to increase by 6,400 MW thereby enhancing the capacity to 7,920 MW by 2017.

The transmission system infrastructure development plans comprise of plans for meeting the generation capacity additions, system strengthening, reducing congestion, establishing point to point evacuation links from generating plants etc. System strengthening schemes are being planned in the Southern Region as per schemes SR-XII, XIII, XIV, XV, XVI, XVII. State wise plans for transmission system augmentation and new construction have been given in the following sub-sections.

Andhra Pradesh's state transmission utility, AP Transco, has undertaken various system strengthening and augmentation projects in the recent past, with a capital expenditure of more than USD 817 million over the past 4 years. This capital expenditure will enhance the capacity of the state for transmission and at the same time increase the transmission tariffs thereby increasing the cost for consumers.

Table 6.8.24: Investment in the past 4 years by APTRANSCO (INR Crs.), Source: Andhra Pradesh Transmission Corporation Tariff order FY 2009-14

Financial Year	Evacuation and System Improvement		GIS and UG Cable Project, HMDA Area	Renovation and Modernization	Telecom Infra.	Total
	440 kV	220 and 132kV				
2009-10	33	33	83	8	2	160
2010-11	50	33	83	8	2	177
2011-12	58	33	83	8	2	185
2012-13	58	33	83	8	2	185
2013-14	67	33	0	8	2	110
Total	**267**	**167**	**470**	**42**	**8**	**817**

Table 6.8.25: Andhra Pradesh transmission schemes; Source: National Electricity Plan

No	Project Title	Status	Project Cost (Million USD)	Priority
1.	Simhapuri Coastal-KPTNM: 570 MW	Generation IPP project; SR-AP-01 & SR-AP-02	Unavailable	A
2.	Meenakshi Energy ST-I + II: 900 MW	Generation IPP project; SR-AP-01 & SR-AP-02	Unavailable	A
3.	Thermal Powertech Corp: 1980 MW	Generation IPP project; SR-AP-01 & SR-AP-02	Unavailable	A
4.	Krishnapatnam Navyuga 1320 MW	Generation IPP project; SR-AP-01 & SR-AP-02	Unavailable	A
5.	Kineta Power 1980 MW	Generation IPP project; SR-AP-01 & SR-AP-02	Unavailable	A
6.	Ultra Mega Krishnapatnam 3960 MW	Generation IPP project; SR-AP-03 & SR-AP-04	Unavailable	A
7.	East Coast 1320 MW	Generation IPP project; SR-AP-05 & SR-AP-06	Unavailable	A
8.	GMR Rajmundry 768 MW	Generation IPP project; SR-AP-07 & SR-AP-08	Unavailable	A
9.	Spectrum-Vemagiri-Gas 1400 MW	Generation IPP project; SR-AP-07 & SR-AP-08	Unavailable	A
10.	Reliance-Vemagiri-Gas 2400 MW	Generation IPP project; SR-AP-07 & SR-AP-08	Unavailable	A
11.	GVK-Gautmi-Vemagiri-Gas 800 MW	Generation IPP project; SR-AP-07 & SR-AP-08	Unavailable	A
12.	GVK-Jegrupadu-Vemagiri-Gas 800 MW	Generation IPP project; SR-AP-07 & SR-AP-08	Unavailable	A
13.	Hinduja Vizag 1040 MW	Generation IPP project; SR-AP-09	Unavailable	A

No	Project Title	Status	Project Cost (Million USD)	Priority
14.	Lanco Kondapally St-III 740 MW	Generation IPP project; SR-AP-10	Unavailable	A
15.	Rayalseema St -III (U-6) 600 MW	Generation State project; SR-AP-11	Unavailable	A
16.	Pulichintala 120 MW	Generation State project; SR-AP-12	Unavailable	A
17.	Lower Jurala U1-6 240 MW	Generation State project; SR-AP-13	Unavailable	A
18.	Krishnapatnam (1600) 1600 MW	Generation State project; SR-AP-14	Unavailable	A
19.	Kakatiya TPP I +II 600 MW	Generation State project; SR-AP-15	Unavailable	A

Karnataka's state transmission utility, KPTCL added 31,539 kms of transmission lines in FY 13 and proposes to add a similar quantum in the short term. In addition, more than 19,000 terminal bays were present in the network till FY 13, and an action plan is already in place to enhance the same in the short term.

The details of the transmission lines & terminal bays to be added by KPTCL are as below:

Table 6.8.26: Transmission lines to be added by KPTCL (Ckt Kms.); Source: Karnataka Transco Tariff order FY 2013-14

Voltage Class	2013-14 (Projected)	2014-15 (Projected)	2015-16 (Projected)
400 kV	2,338	2,338	2,938
220 kV	9,919	10,019	10,219
110 kV	9,444	9,644	9,844
66 kV	10,388	10,688	10,888
Total	**32,089**	**32,689**	**33,889**

Table 6.8.27: Terminal Bays to be added by KPTCL (Nos.), Source: Karnataka Transco Tariff order FY 2013-14

Year	Line Bay	Transformer Bay	PT Bay	Capacitor Bank Bay	11 kV Bay	Total
2012-13	5,052	2,229	1,451	794	350	**19,624**
2014-15	5,152	2,304	1,491	844	350	**20,239**
2015-16	5,252	2,379	1,531	894	350	**20,854**

The investment plan of the state regarding the above projects is given in the following table.

Table 6.8.28: Capital investments; Source: Karnataka Transco Tariff order FY 2013-14

No	Project Title	Status	Project Cost (Million USD)	Priority
1.	Meeting additional load requirements	Ongoing project for the period 2013 to 2016	312	A
2.	Improvement of Voltage Profile	Ongoing project for the period 2013 to 2016	25	A
3.	Evacuation of power from new Generating Stations	Ongoing project for the period 2013 to 2016	211	A
4.	Strengthening of Existing Systems	Ongoing project for the period 2013 to 2016	152	A

Apart from the above projects for system strengthening, the following projects have also been planned which would be developed to meet the additional transmission capacity required for the new planned generation.

[109] "A" refers to projects for implementation before 2018, "B" refers to projects for implementation in 2018 – 2022, and, "C" refers to projects for implementation after 2023

Table 6.8.29: Karnataka transmission schemes; Source: National Electricity Plan

No	Project Title	Status	Project Cost (Million USD)	Priority
1.	Torangallu U 3 300 MW	Generation IPP project; SR-KA-01	Unavailable	A
2.	Gundia HEP 400 MW	Generation State project; SR-KA-02	Unavailable	A
3.	Bellary DGPP +TPP U1,U2, U3 600 MW	Generation State project; SR-KA-03	Unavailable	A
4.	Yermarus TPP 1600 MW	Generation State project; SR-KA-04	Unavailable	A
5.	Edlapur 800 MW	Generation State project; SR-KA-05	Unavailable	A

The State Transmission utility of Tamil Nadu, TANTRANSCO has planned for almost USD 1,667 million of transmission investment over the next 2 years. Given the additional power generation capacity of 6,000 Mw, which is expected to be commissioned within the next two years, investment in transmission is the need of the hour for TN.

Table 6.8.30: Planned capital investments by Tamil Nadu in transmission, Source: TNERC, Tariff order, FY 2013-14

No	Project Title	Status	Project Cost (Million USD)	Priority
1.	New projects – 400 kV Sub Stations	Ongoing project for the period 2013 to 2016	366	A
2.	New projects – 230 kV Sub Stations	Ongoing project for the period 2013 to 2016	218	A
3.	New projects – 110 kV Sub Stations	Ongoing project for the period 2013 to 2016	81	A
4.	Power evacuation link lines – 400 kV Sub Stations	Ongoing project for the period 2013 to 2016	538	A
5.	Power evacuation link lines – 230 kV Sub Stations	Ongoing project for the period 2013 to 2016	239	A
6.	Power evacuation link lines – 110 kV Sub Stations	Ongoing project for the period 2013 to 2016	91	A
7.	Improvement of sub-station lines – Substations	Ongoing project for the period 2013 to 2016	32	
8.	Improvement of sub-station lines – 400 kV lines	Ongoing project for the period 2013 to 2016	385	
9.	Improvement of sub-station lines – 230 kV lines	Ongoing project for the period 2013 to 2016	42	
10.	Improvement of sub-station lines – 110 kV lines	Ongoing project for the period 2013 to 2016	67	
11.	Improvement of sub-station lines – HTLS	Ongoing project for the period 2013 to 2016	31	
12.	Enhancements / Additional Power Transformers	Ongoing project for the period 2013 to 2016	50	

Some of the major capital investment schemes in Tamil Nadu for the transmission sector, funded by the JICA are:

Japan International Cooperation Agency (JICA):

- A Memorandum of Understanding (MoU) has been signed between the Government of India and Government of Japan for availing a loan assistance of USD 583 million from JICA for the improvement of Transmission system in Tamil Nadu.

- A Memorandum of Understanding (MoU) has been signed between the Government of India and Government of Japan for availing a loan assistance of USD 538 million from JICA for the improvement of Transmission system in Tamil Nadu.

- Around USD 513 million has been tied up with an interest rate of 0.55% and moratorium period of 10 years and 0.1% as a commitment charges on the difference in the amount balance to be disbursed.

Table 6.8.31: Details of upcoming Transmission network in Tamil Nadu, Source: TANTRASCO

Particulars	2013-14	2014-15	2015-16
400 KV Substations (nos.)	1	9	5
230 KV Substation (nos.)	9	14	6
110 KV Substation (nos.)	27	28	28
110 KV Substation (U/G. /intro)(Nos.)	12	12	12
EHT lines (Ckt. Kms.)	1958	100	100
230 KV Lines (Ckt. Kms.)	361	100	100
110 KV Lines (Ckt. Kms.)	500	1000	500
Power Transformer Enhancement (nos.)	120	120	120

The Transmission utility of Tamil Nadu had taken up the development of transmission network adequate to evacuate the power generated from the proposed new power plants. It is proposed to establish 400 KV substations with 2500 ckt km of 400 KV lines, 230 KV substations and 200 numbers of 110 KV substations during the 12th Five Year Plan. An additional backbone network of 400 KV double circuit line with Quad conductors would be constructed connecting Kayathar (New Sub Station (SS))- Karaikudi (existing PGCIL SS) – Pugalur (existing PGCIL SS) – Singarapet (New SS) – Ottiyambakkam (New SS).

An exclusive corridor for evacuation of wind power is also planned:

Thappagundu (New SS) - Anaikadavu (New SS) -Rasipalayam (New SS) - Salem(765 KV new SS by PGCIL)

Abhisekapatty (PGCIL SS) –Kanarpatty (Prop. New SS) – Kayathar (New SS) – Thennampatti (New SS) – Kovilpatty (New 765 KV PGCIL SS)

Vagarai (New SS) – Singarapet (New SS)

New 400 KV substations are proposed for the Greater Chennai city at Thervaykandiagai, Korattur, Manali and Guindy. Further, the transmission network strengthening plan is proposed under the Official Development Assistance (ODA) loan of Japan International Co-operative Agency (JICA) for establishing five 400 kV substations and 14 nos., of 230 kV substations with associated lines.

Table 6.8.32: Tamil Nadu transmission schemes; Source: National Electricity Plan – Transmission

No	Project Title	Status	Project Cost (Million USD)	Priority
1.	Vallur(Ennore)JV 500 MW	Generation Central project; SR-TN-01	Unavailable	A
2.	Tuticorin JV-NLC 1000 MW	Generation Central project; SR-TN-02	Unavailable	A
3.	WIND 650 MW	Generation Central project; SR-TN-03	Unavailable	A
4.	Coastal Energen-Tutikorin 1200 MW	Generation IPP project; SR-TN-04 & 05	Unavailable	A
5.	Ind Barath-Tutikorin 1320 MW	Generation IPP project; SR-TN-04 & 05	Unavailable	A
6.	NSL-Nagapatnam 1320 MW	Generation IPP project; SR-TN-06 & 07	Unavailable	A
7.	PPN Power Generating Company 1080 MW	Generation IPP project; SR-TN-06 & 07	Unavailable	A
8.	Mettur ext. U-1 + U2 600 MW	Generation State project; SR-TN-08	Unavailable	A

No	Project Title	Status	Project Cost (Million USD)	Priority
9.	Udanguddi JV 1600 MW	Generation State project; SR-TN-09	Unavailable	A
10.	Nayveli TPS III 500 MW	Generation State project; SR-TN-10	Unavailable	A
11.	TN UMPP 1320 MW	Generation IPP project; SR-TN-11	Unavailable	A
12.	Ennore EXT 500 MW	Generation State project; SR-TN-12	Unavailable	A

6.8.5.1.3 Distribution

The three states have rigorous plans to expand their distribution systems including increasing access to rural areas, catering to the demand growth, improving system efficiencies, increasing the levels of automations. The distribution sector in general is a major bottleneck in the Indian power sector, accounting for the majority of financial losses in the sector. This part of the value chain is plagued with issues of high losses, inadequate revenue recovery, high cross subsidy levels, inaccurate meter reading and billing and other operational inefficiencies. These three states, also faced with similar challenges have however taken aggressive steps to improve the condition of the segment. In fact, the three states have also applied for the central financial restructuring plan which aims at improving the financial positions of distribution companies by providing them with liquidity support based on aggressive loss reduction targets, in all helping them in turning around. The primary objective apart from improving the financial positions is also to provide high quality of service to consumers.

Andhra Pradesh has four distribution companies namely, Central, Northern, Western and Southern Power Distribution Company Ltd. The state is also in the process of implementing several IT related automation projects such as R-APDRP and SCADA, which aim at reducing errors, providing greater reliability and minimising manual intervention. Further other projects for system improvement and meeting the load growth are also underway.

Karnataka's distribution business is segregated into five areas, managed by five companies, namely Bangalore, Mangalore, Hubli, Gulbarga and Chamundeshwari Electricity Supply Company. BESCOM can be classified as one of the most forward looking distribution companies in the country, with a significant investment in system improvement and automation activities. An overview of the planned investments by the company is given in the following table.

Table 6.8.33: Capex plan BESCOM (Million USD); Source: BESCOM Tariff Order, FY 2013-14

No	Schemes	2013-14	2014-15	2015-16
1	**E&I**			
1A	11 KV Lines for New Stations	3.3	8.3	13.3
1B	11 KV Other Work+ DTCs including dedicated DTCs for DWS Schemes.	2.5	6.7	11.7
1C	Re- conductoring of ACSR /Rabbit to Coyote in Bangalore Urban	1.7	1.7	5.0
1D	Re-conductoring of LT line using Rabbit conductor	0.8	0.8	3.3
1E	Re- conductoring (Improvement works on 11 KV Rural Feeders)	1.7	3.3	3.3
1F	Strengthening of 11 KV UG cable network with RMUs	1.7	1.7	4.2
2	NJY	61.7	-	-
3	Providing infrastructure to Un authorized IP Sets	3.3	10.0	10.0
4	(A) DTC Metering Programme Non RAPDRP Area	1.7	4.2	5.0
	(B)Replacing Mechanical Meter By Electrostatic.	6.7	5.0	3.3
	(C) Smart Meter, HT- TOD Meter Replacing MNR etc.	3.3	6.7	5.0
5	RAPDRP & DAS	25.0	23.3	-
6	Service connections	4.2	4.2	4.2
7	Replacement of failure DTCs by new ones	2.5	2.5	2.5
8	A)Civil Engineering works, DSM & Others	4.2	4.2	4.2
	B)Consumer Education	0.2	0.2	0.2

No	Schemes	2013-14	2014-15	2015-16
9	HVDS	5.0	20.0	-
10	Providing fault locators	0.8	0.2	0.2
11	Electrification Hamlets /Villages	1.0	1.0	0.8
12	Energisation of IP Sets	1.0	3.3	3.3
13	T &P and Computers	0.8	1.7	1.7
14	Other works including Safety measures fund, Local Planning	3.3	3.3	3.3
15	Providing AB Cable	5.0	15.0	20.0
	Total	**141.3**	**127.2**	**104.5**

Tamil Nadu, unlike the other two states has a single company, namely TANGEDCO, for catering to the state's generation and distribution activities. As compared to the other two states, TANGEDCO has a much higher distribution loss level. To implement reforms in this area, the State has planned a detailed capital expenditure programme, targeting the smooth addition of new consumers into the system.

Table 6.8.34: Capex plan of TANGEDCO; Source: Tariff order 2013

Scheme	FY 2013-14	FY 2014-15	FY 2015-16
33 KV Lines	5.5	6.4	7.7
33 KV Substations	8.0	9.2	11.0
11 KV Lines and Other LT Lines	4.7	5.4	6.4
Other Construction Schemes	119.6	137.6	165.1
General Improvement Schemes	59.3	68.2	81.8
Distribution Transformers			
Failure/Replacement			
100 KVA	1.8	2.1	2.3
250 KVA	3.1	3.5	3.9
500 KVA	2.3	2.6	2.9
New/Additional with Structure			
100 KVA	1.9	2.2	2.4
250 KVA	3.2	3.7	4.1
500 KVA	2.4	2.8	3.1
Extension of Service connections			
HT Industry	4.4	5.1	5.6
LT Industries	2.5	2.8	3.1
LT Domestic	2.8	3.2	3.5
LT Commercial	2.0	2.3	2.5
Other categories	3.7	4.3	4.7
Deposit Contribution Works (DCW)	9.6	10.8	12.1
Rural Electrification Works	8.3	9.5	11.4
Agricultural Services	8.3	9.5	11.4
Segregation of Feeders	0.4	0.5	0.6
Hut Electrification	0.2	0.2	0.2
RAPDRP - PART B Schemes - Erection of new SS, RMU, Meters, Sectionalisation, etc	152.7	125.3	80.8
RGGVY	0.2	-	-
Survey, investigation, computerization	0.4	0.5	0.5
Others if any	1.1	1.2	1.3
Total	**408.3**	**418.7**	**428.3**

The above projects give an idea of the upcoming investment in the CBIC region in the near future in distribution. However, unlike generation and transmission projects, distribution projects are local to the location of the end consumer and hence have to be specifically planned for the areas that would undergo rapid industrialisation or urbanisation due to CBIC. Although distribution schemes have been approved for the BAU scenario in the districts that would lie in proximity to the CBIC, no specific distribution projects have been planned for the CBIC scenario as of now.

Apart from these projects, there are two smart grid pilot projects that are coming up in the state of Andhra Pradesh and Karnataka which are a part of the national plan of 14 smart grid pilots. A brief of these two projects is given here.

Table 6.8.35: Smart grid pilot projects in distribution

State	Utility	Area	Functionality proposed	Consumer base
Andhra Pradesh	APCPDCL	Jeedimetla industrial area	AMI R, AMI I, OM, PLM, PQM	11,904
Karnataka	CESC Mysore	Mysore additional city area division	AMI R, AMI I, OM, PLM, MG,DG	21,824

6.8.5.2 Proposed projects

6.8.5.2.1 Generation

Keeping in mind that the respective capacities should be commissioned from FY 2031 onwards, and considering the following investments and construction periods, various following projects have been suggested for meeting the expected supply gap.

Table 6.8.36: Assumptions for estimating investment in proposed projects (Million USD)

Fuel	Investment per MW (Million USD)	Construction period (Years)
Coal power plants	1.0	12.0
Gas power plants	0.8	12.0
Diesel power plants	0.7	10.0
Hydro power plants	1.3	12.0
Nuclear power plants	1.7	14.0
RES based power plants	1.2	11.0

Table 6.8.37: New generation projects proposed in the region

No	Project Title	Status	Project Cost (Million USD)
1.	Nuclear power plant commissioning in FY 2032 – Capacity: 3,400 MW	New project proposed in FY 2025	5780
2.	Coal power plant commissioning in FY 2022 – Capacity: 4,000 MW	New project proposed in FY 2016	4000
3.	RES power plant commissioning in FY 2022 – Capacity:2,500 MW - UMPP	New project proposed in FY 2018	3250
4.	RES power plant commissioning in FY 2032 – Capacity:1,500 MW - UMPP	New project proposed in FY 2028	1950
5.	Gas Based plant commissioning in FY 2022 – Capacity 2000 MW	New Project proposed in FY 2019	1600
6.	Gas Based plant commissioning in FY 2032 – Capacity 1400 MW	New Project proposed in FY 2029	1120
7.	Gas Based plant commissioning in FY 2032 – Capacity 3500 MW	New Project proposed in FY 2026	2800
8.	Hydro based plant capacity in FY 2022- Capacity 2400 MW	New Project proposed in FY 2016	3120
9.	Hydro based plant capacity in FY 2032 – Capacity 3500 MW	New Project proposed in FY 2023	4550
10.	Coal power plant commissioning in FY 2022 – Capacity: 4,000 MW	New project proposed in FY 2016	4000
11.	Coal power plant commissioning in FY 2032 – Capacity: 4,000 MW	New project proposed in FY 2029	4000
12.	Coal power plant commissioning in FY 2032 – Capacity: 4,000 MW	New project proposed in FY 2029	4000
13.	Coal power plant commissioning in FY 2032 – Capacity: 4,000 MW	New project proposed in FY 2029	4000

No	Project Title	Status	Project Cost (Million USD)
14.	Coal power plant commissioning in FY 2032 – Capacity: 4,000 MW	New project proposed in FY 2029	4000
15.	Coal power plant commissioning in FY 2032 – Capacity: 4,000 MW	New project proposed in FY 2029	4000
16.	Coal power plant commissioning in FY 2032 – Capacity: 4,000 MW	New project proposed in FY 2029	4000
17.	Coal power plant commissioning in FY 2032 – Capacity: 4,000 MW	New project proposed in FY 2029	4000

6.8.5.2.2 Transmission

The three States have envisaged ambitious generation capacity addition plans. However it has been seen that due to the unavailability of an adequate transmission system to evacuate this power, a significant proportion of new generation capacity is stranded for a reasonable amount of time before it can be dispatched. Therefore in order to ensure that the installed capacity is delivered to the end consumer, transmission system planning would be done well in advance.

The States have already published their transmission system capacity addition projects in the short term, priority 'A' projects, specifically for generation projects coming up in the next 4-5 years. Similarly, other power projects that are either being planned at the Central or State level, or by Private players and for which clearances have been availed, in the BAU scenario would also have their respective transmission evacuation systems lined up. We have therefore proposed new transmission projects only for those power plants that have been suggested for meeting the power demand in the CBIC scenario. It is seen that typically the stabilisation period for power plants, especially thermal plants, is approximately six months, implying that the transmission system should be commissioned at least six months prior. Further, considering that the construction period could be anywhere between 2 to 2.5 years, transmission projects must be initiated at least 3 years prior to the commissioning of the generation project.

As per the data available from the Planning Commission of India, and other planning related studies, the ratio of generation and transmission investments for a particular project can be taken to be 1.0:0.4. Considering the same ratio for estimating the investment requirement for transmission projects, a summary of the proposed has been given in the following table.

Table 6.8.38: New transmission projects proposed in the region

No	Project Title	Status	Project Cost (Million USD)
1.	Transmission project for nuclear power plant commissioning in FY 2032 – Capacity: 3,400 MW	New project proposed in FY 2027	2312
2.	Transmission project for Coal power plant commissioning in FY 2022 – Capacity: 4,000 MW	New project proposed in FY 2019	1600
3.	Transmission project for RES power plant commissioning in FY 2022 – Capacity:2,500 MW - UMPP	New project proposed in FY 2019	1300
4.	Transmission project for RES power plant commissioning in FY 2032 – Capacity:1,500 MW - UMPP	New project proposed in FY 2027	780
5.	Transmission project for Gas Based plant commissioning in FY 2022 – Capacity 2000 MW	New project proposed in FY 2019	640
6.	Transmission project for Gas Based plant commissioning in FY 2032 – Capacity 1400 MW	New project proposed in FY 2030	448

No	Project Title	Status	Project Cost (Million USD)
7.	Transmission project for Gas Based plant commissioning in FY 2032 – Capacity 3500 MW	New project proposed in FY 2030	1120
8.	Transmission project for Hydro based plant capacity in FY 2022- Capacity 2400 MW	New project proposed in FY 2019	1248
9.	Transmission project for Hydro based plant capacity in FY 2032 – Capacity 3500 MW	New project proposed in FY 2029	1820
10.	Transmission project for Coal power plant commissioning in FY 2022 – Capacity: 4,000 MW	New project proposed in FY 2019	1600
11.	Transmission project for Coal power plant commissioning in FY 2032 – Capacity: 4,000 MW	New project proposed in FY 2028	1600
12.	Transmission project for Coal power plant commissioning in FY 2032 – Capacity: 4,000 MW	New project proposed in FY 2028	1600
13.	Transmission project for Coal power plant commissioning in FY 2032 – Capacity: 4,000 MW	New project proposed in FY 2028	1600
14.	Transmission project for Coal power plant commissioning in FY 2032 – Capacity: 4,000 MW	New project proposed in FY 2028	1600
15.	Transmission project for Coal power plant commissioning in FY 2032 – Capacity: 4,000 MW	New project proposed in FY 2028	1600
16.	Transmission project for Coal power plant commissioning in FY 2032 – Capacity: 4,000 MW	New project proposed in FY 2028	1600
17.	Transmission project for Coal power plant commissioning in FY 2032 – Capacity: 4,000 MW	New project proposed in FY 2028	1600

6.8.5.2.3 Distribution

For estimating the investment requirements in the CBIC scenario for distribution projects, we have taken the ratio of per unit investment required for developing a distribution project for every unit of a generation project. As per the data available from the Planning Commission of India, this ratio is estimated at 0.2:1.0, taking into account the standard distribution systems. However since this project would be developed for new geographical areas, we propose that an advanced and technologically enabled system with the option of possible integration with smart grid and smart city be planned. For this reason, the ratio considered for investments has been taken to be 0.3:1.0. Additionally unlike the new generation and transmission projects which have been proposed only for meeting the State's overall demand supply gap, the distribution system planning would be done for the entire generation capacity required for the CBIC region.

The weighted average generation investment for the additional units due to CBIC has been calculated based on the assumptions used for estimating generation investments. Further, distribution investment requirements have been estimated as a percentage of the additional generation capacity required for sustaining CBIC's growth.

Table 6.8.39: Cumulative investment proposed in distribution projects in CBIC area (Million USD)

State	Mid-term investment 2022	Long-term investment 2032
CBIC States	**1,748**	**9,316**

The investment requirement further goes up in FY 2034, considering the demand growth. Therefore, in order to optimally and efficiently plan the development of the distribution network, the maximum generation demand for the projections period (i.e. from 2015 to 2034) has been taken. This has been subsequently translated into the investment requirement for the network which would need to be made upfront due to non-existence of any distribution network in the corridor area.

The new distribution projects can strive to achieve high levels of operational efficiency and consumer satisfaction through the use of technology such as automated billing systems, online billing and payment, load management at the consumer's end, offering options of choosing the power source for optimising electricity bills and reducing use of conventional sources etc. Therefore, a smart grid based distribution system is most suitable for the planned new infrastructure. This can also be integrated with other smart infrastructures to develop a smart city in the future.

Smart city

The CBIC would see in the future a significant part of the population relocate to areas that are currently inhabited and rural owing to the growth of industrialisation and development of huge manufacturing and commercial facilities' along the corridor. This therefore presents an enormous opportunity for developing 'smart cities' in the newer areas. Smart city is a fast growing concept which has been conceptualised to provide a sustainable growth, taking into consideration the increasing adverse impact of economic activities on the environment.

In the scenario of rapid industrialisation such as in the case of the CBIC, large extent of agricultural land and other natural resources would be utilised to ensure the success of such a reform. For developing nations such as India, resources including primary energy, electricity, water, transportation, communication etc., are extremely crucial to achieve the target level of industrialisation and urbanisation. Therefore to affect an efficient and optimal use of resources, reduce the impact on the environment, and to reduce the effort required for attaining target quality standards, smart cities have been increasingly gaining popularity. An ideal smart city utilises an ICT (Information and Communications Technology) based system which helps integrating the following infrastructure facets.

An important component of a smart city is the power infrastructure. An optimal smart system can help achieve electrical energy savings of upto 20% through demand response systems. A lot of the power requirement therefore arising in the CBIC can be internally met through the implementation of such systems. Another significant advantage that a smart power system would offer is the ease of integration with renewable systems and the option to the consumer of optimising his expenditure on electricity by encouraging demand side management.

6.8.6 *Fuel and energy sources*

6.8.6.1 Estimated generation

With the enormous growth in demand, and ultimately supply of power, the fuel requirement for generation would also significantly rise. An important decision point in today's scenario prior to setting up any power plant is the outlook on the fuel's availability and affordability in the future. On one hand where it is imperative to develop any infrastructure to meet reliability standards, it is also essential to offer this reliability at a reasonable price, to stay competitive in the market. This chapter estimates the fuel requirements in the future for power generation and gives an overview of the future outlook. The table given here displays the energy generation from the planned projects as well as the ones proposed for meeting the net supply gap of the CBIC region, through various fuel sources.

Table 6.8.40: CBIC region – Power supply and generation mix (MU)

Parameter	Short-term Target at 2017	Mid-term Target at 2022	Long-term Target at 2032
Coal	299,726	357,118	933,126
Gas	17,329	24,291	44,210
Diesel	3,100	3,100	3,100
Hydro	26,088	32,610	42,393
Nuclear	18,198	18,198	38,451
RES	35,119	39,243	41,876
Total	**399,560**	**474,559**	**1,103,156**

6.8.6.2 Fuel requirement

6.8.6.2.1 Coal

As per the planned capacity expected to come up in the future, coal would remain to be the dominant fuel used for power generation. The following figures project the total coal requirement for power generation.

Table 6.8.41: Coal requirement (Million Tonnes)

Parameter	Short-term Target at 2017	Mid-term Target at 2022	Long-term Target at 2032
Total coal requirement	156.52	186.49	487.30
Domestic coal Requirement	76.00	90.55	236.61
Domestic coal requirement – coastal route	47.00	56.00	146.32
Imported coal requirement	33.52	39.94	104.37

The average coal requirement at source (pit heads and the respective ports) has been calculated by taking a gross heat rate of 2,350 kCal/kWh and a GCV of 4,500 kCal/kg, considering a 2% handling loss.

Imported coal requirements for existing plants have been taken at a 15% blending ratio whereas for all new plants, this ratio has been taken as 60% in the short term, 75% in the medium term and 100% in the long term. The assumptions consider the fact that existing plants are developed on boiler designs that can allow efficient power generation only up to a specific blended GCV level, which is usually higher for imported coal. Therefore these would continue to be primarily dependent on domestic coal. New plants however are designed for much higher levels of operation and on international specifications and hence they would primarily be based on imported coal. Majority of the coal demand in India, approximately 72%, is for power generation as estimated by Ministry of Coal for FY 2011-12. The working group for the 12th Five Year Plan estimates the coal demand for power to be about 682 MT in FY 2016-17 and about 938 MT in FY 2021-22.

Table 6.8.42: Coal reserves in some major states of India (Billion Tonnes); Source: GSI

	Andhra Pradesh	Chhattisgarh	Jharkhand	Orissa	West Bengal	India
Proved reserves	9.6	13.9	40.1	25.5	12.4	**117.6**
Total resources	22.2	50.8	80.3	71.4	30.6	**292.0**

Although the above table shows huge proven and total resources in the country (a significant share lies within Andhra Pradesh), the Planning Commission estimates a supply gap of 185 MT for all sectors in FY 2016-17. Issues leading to controversies, availability of geological data, land acquisition and R&R, environmental issues, mining lease etc. are primary reasons behind the demand supply gap despite huge reserves.

Another challenge that remains for coal within India is its transportation and associated costs. Coal India Limited estimates that during the 11th Five Year Plan period, 53% was transported by rail, 22.5% by belts and other means, 19% by road and 5.5% by coastal shipping. Coastal shipping is taking off in India and is expected to significantly offer lower freights as compared inland coal transportation costs. Additional advantages of coastal shipping such as that they conserve energy being more fuel efficient than trucks, they are safer, help reduce air pollution as compared to trucks, reduce land congestion and are capable of carrying much larger cargo sizes. At present India transports only 7% of its domestic cargo by coastal shipping, or so-called short-sea shipping, while the European Union transports 42%, China 43% and the US 15%. Keeping the above considerations in mind, it has been assumed that 50% of the domestic fuel could potentially be moved through the coastal shipping route. The government has in fact approved an incentive package for a few manufacturing industries for shifting a part of their rail and road transportation to coastal-shipping.

Imported coal is expected to gain higher acceptability in the long term owing to its higher quality and reliability. An overview of production and coal reserves in 2011 in the following countries shows the huge available supply as well as the dominance of coal export from these countries. This is expected to rise in the future, and India which currently purchases coal mostly from Indonesia and some from South Africa, would have a significant share.

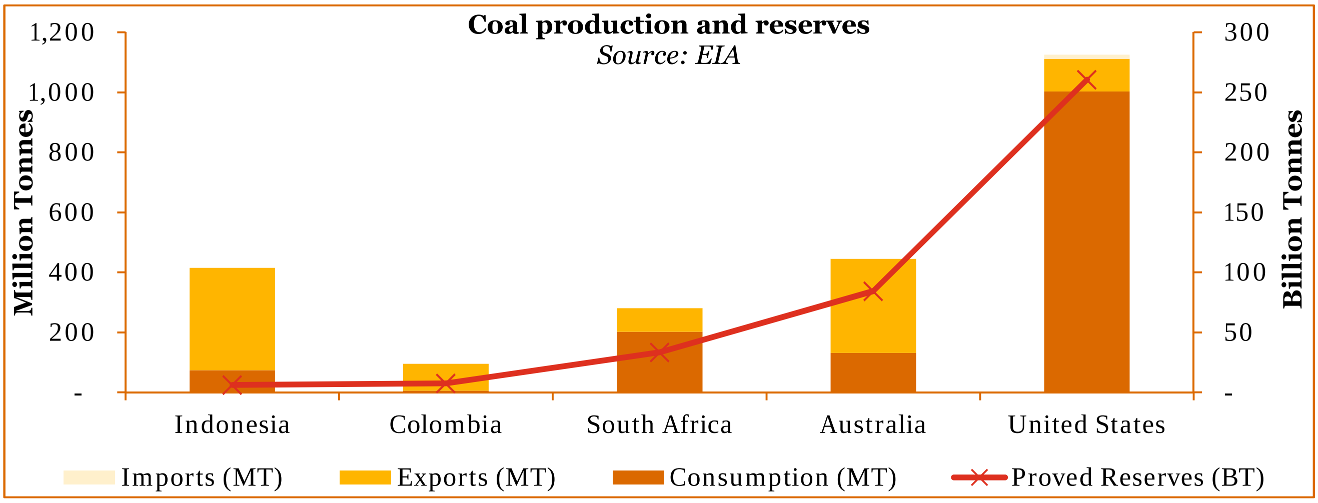


Figure 6.8.17: International coal production (2011, MT) and coal reserves (2008, BT); Source: EIA

It is critical to note that the share of Indian imports from South Africa declined to 15.91% in 2012, from 18.5% in 2011 and 23.55% in 2010. Indonesia accounted for 76% of the imported coal in India during 2010 and 2012. Given the large quantity of coal being imported from Indonesia, the Central Electricity Regulatory Commission (CERC) of India has modified its index for determining regulated tariff, which earlier comprised of Australian coal and South African coal only. The new methodology gives 50% weight age to Indonesian coal, 25% weight age to Australian coal and 25% weight age to South African coal. Therefore, the risks borne by power producers are passed through to consumers for regulated power sale.

The only issue that concern imported coal in India are the comparatively higher FOB prices and freight, especially from countries like South Africa, USA and Columbia which render the price of power uncompetitive. We believe that in the long term, the Indian power market would be price agnostic to domestic and imported coal, and therefore expect the imported coal demand to rise due to higher grade and supply reliability. However, trend analysis of historical prices show that the annual change in international coal indices have been fairly constant, except in 2009 when the prices had shot up but are now again coming down in the recent years.

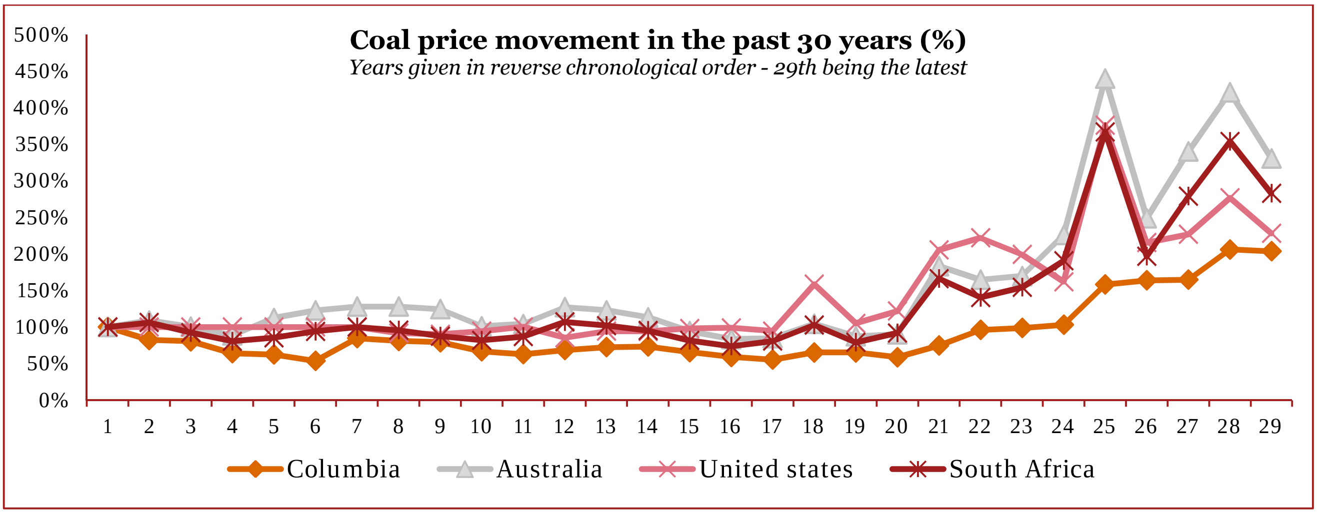


Figure 6.8.18 : Coal price movement of international indices; Source: PwC research

Overall the scenario for coal based plants, even on imported coal looks positive and therefore would continue to be the reliable source of power in the future.

6.8.6.2.2 Gas

It has been assumed that in the short term, 90% of the gas plants would operate on open cycle and this share would go down to 50% in the long run. To estimate the gas quantity, the gross heat rate has been taken as 2,900 kCal/kWh for open cycle and 2,000 for kCal/kWh for closed cycle. The calorific value of fuel has been assumed as 9,500 kCal/cm.

Table 6.8.43: Gas requirement (mm scmd)

Parameter	Short-term Target at 2017	Mid-term Target at 2022	Long-term Target at 2032
Total coal requirement			
Andhra Pradesh	10.4	41.5	61.9
Karnataka	2.1	2.1	4.1
Tamil Nadu	3.2	7.6	11.3
Unallocated proposed plants in the region	-	-	-
Total	**13.6**	**51.2**	**77.3**

A significant gas based power supply has been planned in the region, especially in Andhra Pradesh. However given the current gas supply crisis in the country, it is not likely that the entire capacity would be available for generation and therefore, it has been assumed that the PLF of gas plants would be 25% in the short term and gradually increase to 50% in the long term, to develop a conservative scenario.

In India, power sector has been the biggest consumer of natural gas and is expected to remain so going into the future. And within the power sector, gas contributes to approximately 10% of the power generation.

Table 6.8.44: Natural gas demand (mmscmd); Source: PNGRB Report on natural gas

Source of Usage	2012-13	2016-17	2021-22	2026-27	2029-30
Power	86.5	158.9	238.9	308.9	353.9
Fertilizer	59.9	96.8	107.8	110.0	110.0
City Gas	15.3	22.3	46.2	68.0	85.6
Industrial	20.0	27.0	37.0	52.1	63.9
Petrochemicals / Refineries / Internal Consumption	54.0	65.0	82.0	103.4	118.8

Source of Usage	2012-13	2016-17	2021-22	2026-27	2029-30
Sponge / Iron & Steel	7.0	8.0	10.0	12.2	13.7
Total Realistic Demand	242.7	378.1	517.0	654.5	746.0

Gas based power generation is however constrained by the higher cost of gas and its availability across regions. In recent years, the Plant Load Factor (PLF) of gas based power plants has dropped to around 50% due to lack of natural gas availability at affordable prices. Natural gas demand for power generation remains highly price sensitive and is expected to fall drastically at a price in excess of $8-$9/MMBTU. The shortage in natural gas supply has hampered the capacity addition and performance of the existing plants. Allocation of domestic gas to power sector will remain constrained due to competing demand pressures from the fertilizer sector. In the future, the ability of power sector to absorb higher priced RLNG is likely to increase with the help of power sector reforms linked to periodic tariff revisions, peaking power regulation, time-of-day tariff, robust open access norms etc.

The power generation capacity based on gas in India stands highly concentrated in the western region. The region accounts for 45% of the total gas based power capacity. Northern and Southern regions of the country contribute about 25% to the total power generation based on gas. Out of the 8,766 MCM of offshore natural gas produced in India in FY 2011-12, as per Ministry of Petroleum and Natural Gas, Andhra Pradesh constituted 16% and Tamil Nadu 15% of the offshore production.

Table 6.8.45: Natural gas supply (mmscmd); Source: PNGRB Report on natural gas

Source of Supply	2012-13	2016-17	2021-22	2026-27	2029-30
Domestic Sources	101.1	156.7	182.0	211.0	230.0
LNG Imports	44.6	143.0	188.0	214.0	214.0
Gas Imports (Cross Border Pipelines)	-	-	30.0	30.0	30.0
Total	145.7	299.7	400.0	454	474

The supply of natural gas is likely to increase in future with the help of increase in domestic gas production and imported LNG. However, the expected increase in domestic production at present is significantly lower than earlier projections due to a steady reduction in gas output from the KG D6 field. The capacity of RLNG terminals in India is expected to increase from 17.3 MMTPA in 2012-13 to 83 MMTPA in 2029-30 assuming all the existing and planned terminals in India would materialize. Natural gas availability through non-conventional sources like Shale Gas and Gas Hydrates has not been considered in gas supply projections in the absence of clarity on key variables like data as most of India remains unexplored/underexplored, regulatory policy and lack of domestic infrastructure.

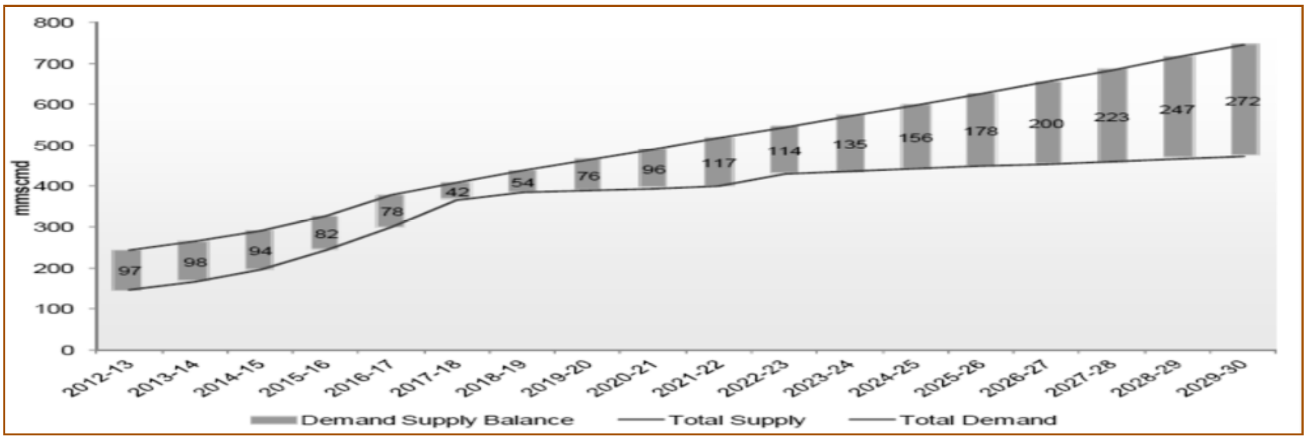


Figure 6.8.19: Projected demand-supply gap of gas in India (mmscmd); Source MoPNG

The availability of natural gas in India is expected to fall short of the total natural gas demand by around97 MMSCMD in 2012-13. However, this shortfall will reduce by 2017-18 due to substantial addition in regasification capacity and natural gas supply through cross border pipeline (TAPI). The demand-supply gap is likely to again increase post 2017-18 and reach about 272 MMSCMD by 2029-30 as increase in supply lag behind a steady increase in demand.

The production of natural gas from RIL KG D6 was commenced in the year 2008 and the production initially was 25mmscmd the production was further expanded to 40 mmscmd in the year 2009. However in the recent years and owing to geological surprises and settling down of silt and water in the basin the gas production has declined significantly and the gas expected to be supplied from the basin has not been up to the desired levels, owing to this there has been a scarcity of gas and the plants running on the gas from KG D6 have been operating on minimum PLF due to gas constraints.

The Dabhol – Bangalore gas pipeline was approved in the year 2009 and the work on the pipeline has been completed in the year 2013. This pipeline with a length of about 1,414 kms, has a capacity to carry 16 million cubic meters of gas, and has been developed at an investment of approximately 833 million USD. The pipeline shall span across the states of Maharashtra (covering Ratnagiri, Sindhudurg and Kolhapur districts), Goa (covering north and south Goa) and Karnataka (covering the districts of Belgaum, Dharwad, Gadag, Bellary, Davangere, Chitradurga, Tumkur, Ramnagara and Bangalore).

The Dabhol-Bangalore pipeline connects South India to the national gas grid for the first time. The total quantum of gas can be used to produce 3,000 MW of clean energy. GAIL also signed a gas transmission agreement with Karnataka Power Corporation Ltd. (KPCL) for the supply of 2.1 million metric standard cubic metres per day (mmscmd) of natural gas for its 700 MW power plant at Bidadi in 30 months. The project, for which KPCL invited tenders for engineering, procurement and construction (EPC) in October last, is to be ready by 2015.

The EGoM has decided the order of priority for the supply of gas which is as follows:

(i) Existing gas based urea plants getting gas below their full requirement, would be supplied gas for full capacity utilization

(ii) A maximum of 3 mmscmd would be supplied to existing gas based LPG plants

(iii) Upto 18 mmscmd gas (partial requirement of gas-based power plants lying idle/under-utilized and commissioned during 2008-09, and liquid fuel plants currently on liquid fuel and could switch over to natural gas) would be supplied to power plants

(iv) Maximum 5 mmscmd to be made available to City Gas Distribution projects for supply of Piped Natural Gas (PNG) to households and Compressed Natural Gas (CNG) in transport sector

(v) Any additional gas available, beyond categories i) to iv) above, would be supplied to existing gas-based power plants, as their requirement is more than 18 mmscmd

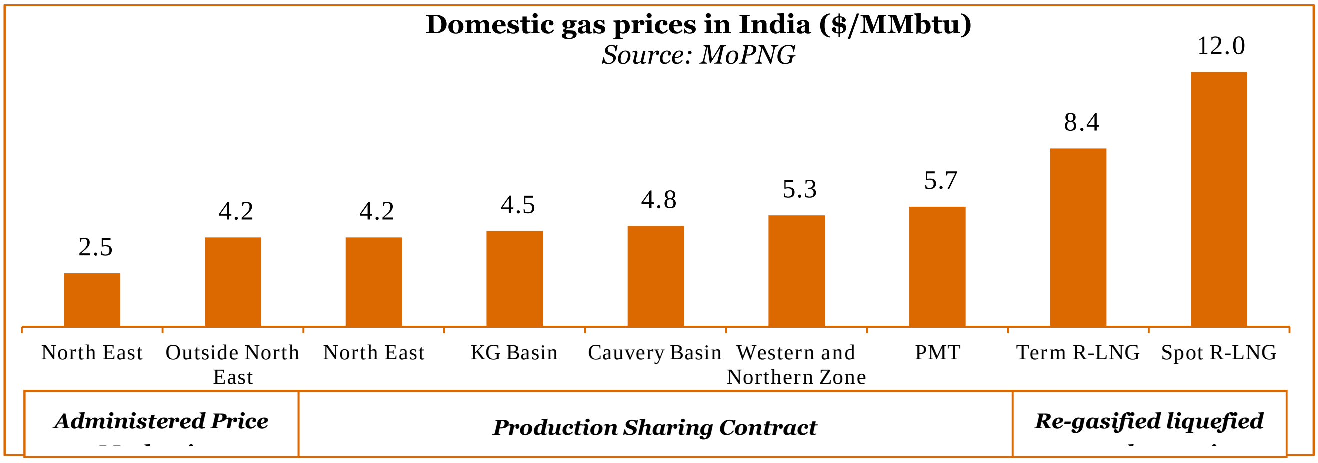


Figure 6.8.20: Domestic gas prices in India; Source: MoPNG

The Central Electricity Authority (CEA) has received applications for allocation of gas for about 1,30,000 MW capacity from various states, Central Public Sector Undertaking's(CPSU's) and Independent Power Producers (IPPS) for which about 600 MMSCMD gas is required. Out of these proposed projects, many projects can be commissioned within next 2-3 years provided gas is made available. However, considering ground reality of reduced gas availability in the country, it is difficult to presently plan for 25,000 MW gas based generation capacity addition during the 12th Plan. For instance, capacity of only 2,539 MW (comprising 1,452 MW slipped capacity from 11th Plan and 1,087 MW for which gas is proposed from local sources) has been considered. In addition to above, many gas based power projects in private sector are under advance stage of construction and awaiting gas supply for testing/commissioning and commercial operation. Some of these projects were initially expected to be commissioned during the 11th Five Year Plan period, if timely gas was made available. There are a few other projects for which orders have been placed and are under construction/ construction delayed due to uncertainty of gas availability.

Given the above context and outlook of gas supply, gas based plants may not be recommended in the short and medium term. Once a stable supply option is available and international gas prices fall below the hurdle mark, gas projects may be reinitiated.

6.8.6.2.3 Renewable energy

The three states have a significant share of renewable based power in their total installed capacity. Barring Andhra Pradesh, which at present has only 7.5% renewable capacity mix, Karnataka (26.5%) and Tamil Nadu (38.4%) have an impressive installed generation capacity mix. However owing to their relatively lower capacity utilisation factors as compared to conventional fuel sources, their share in generation is rather much lower. Other challenges such as higher technological costs, inadequacy of funds, lack of transmission facilities, absence of inter-state transmission, less robust and enforceable Renewable Purchase Obligations (RPOs), etc., also need to be appropriately addressed in order to meet the ambitious targets in the future.

6.8.6.2.3.1 Wind

Wind is the fastest growing technology in India, and now occupies approximately 70% of the grid-interactive renewable based power. The following overview of the potential and installed wind capacity in the CBIC states shows that on hand where Andhra Pradesh and Karnataka have a huge potential left to be explored, Tamil Nadu has already exceeded its estimated potential (probably indicating inaccurate wind potential assessment in the state).

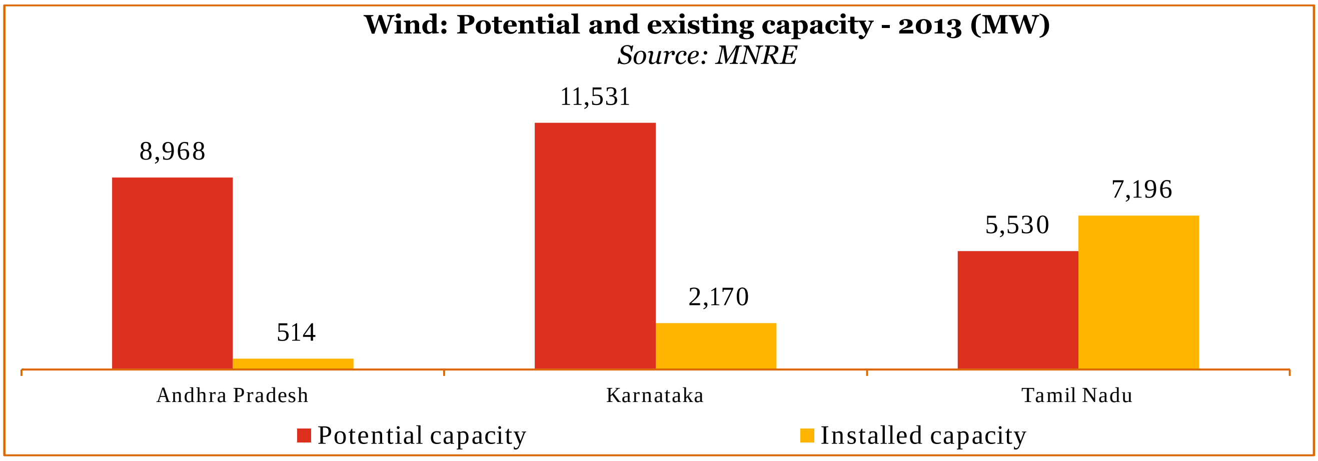


Figure 6.8.21: Wind capacity in India (MW); Source: MNRE

The FOR report on study of RPO in India estimates that despite having 7,000 MW of installed capacity, Tamil Nadu is expected to add another 7,000 to 8,000 MW of wind power by FY 2020. Andhra Pradesh might also see a similar achievement and Karnataka would probably add another 5,000 MW of wind based power.

Currently, two types of wind turbines have been installed in India namely, stall regulated with fixed blades and pitch regulated with adjustable blades. The MNRE has sponsored a programmed to validate wind potential for high mast designs at 100 m mast height, in seven states including the CBIC states. Acquisition of land, equipment and instrumentation for the programme is under progress. Mast designs that are 80-120 meters high have found acceptance across the globe, though in India they are still being tested.

MNRE has also released a draft of the National Offshore Wind Energy Policy 2013 in the current year. The policy identifies coastlines of Kerala, Goa, Gujarat and Tamil Nadu as high potential zones for developing offshore wind projects. A National Offshore Wind Authority is being envisaged as a nodal agency for promoting offshore wind energy projects. However, development of offshore wind will require investments in terms of resource assessment and environmental impact assessment studies in the initial phase. Subsequently, matters related to technology, grid connectivity and incentive framework will be formalised.

The Indian wind energy market witnessed a drop in investment and growth in installed capacity in FY 2011-12 due to discontinued benefits such as accelerated depreciation and generation based incentives. Other challenges such as uncertainty and divergence in approved feed-in tariffs, enforceability of RPO compliance, inadequate evacuation and transmission, inaccurate potential assessment, challenges pertaining to grid management and forecasting etc. are hampering the growth of the sector.

However, it is expected that the pace will again pick up as the GBI scheme was reintroduced to bring the sheen back to India's wind sector. Some of the other incentives provided for promoting wind based power, which may vary from state to state, include income tax exemption for a period of 10 years and waiver of import duty, soft loans from IREDA, feed-in tariffs, renewable purchase obligations and renewable energy certificate mechanism.

6.8.6.2.3.2 Solar

To promote and kick-start solar generation in the country, Government of India launched the Jawaharlal Nehru National Solar Mission (JNNSM) in January 2010. Among other objectives, the mission envisages reducing costs through local manufacturing and boosting R&D to accelerate the transition to cleaner energy. Another key driver is the solar RPO which mandates a percent of a distribution utility's power purchase through solar power. Tamil Nadu and Karnataka have announced capacity additions plan of more than 3,000 and 600 MW respectively. A review of the existing capacity and the solar power potential in the CBIC states is given in the following figure.

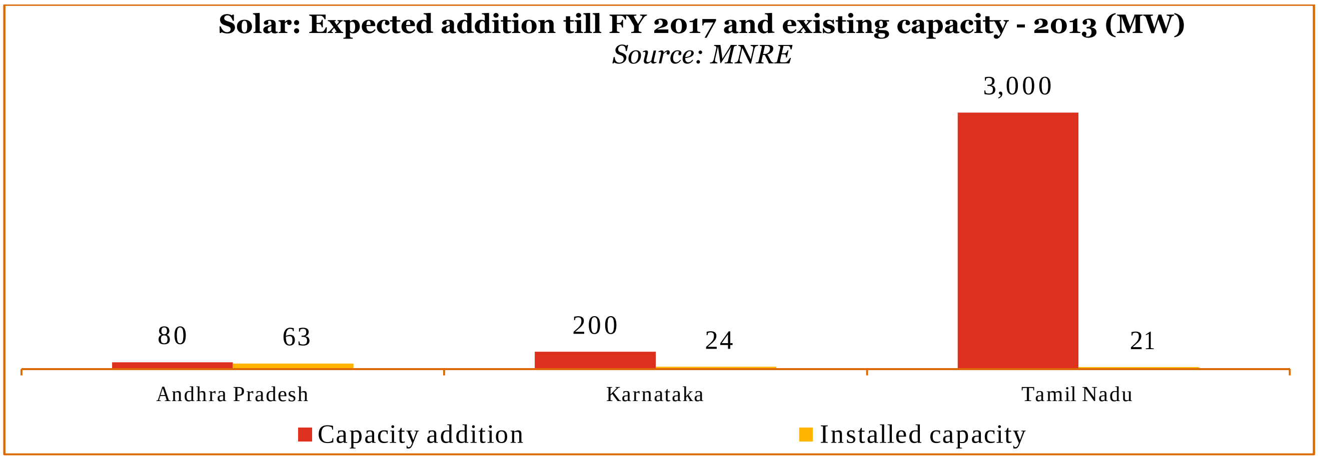


Figure 6.8.22: Wind capacity in India (MW); Source: MNRE

These states have a significant solar potential with Andhra Pradesh having an energy incident of 5.4-5.6 kWh/sq. km, Karnataka between 5.2 and 5.4 kWh/sq. km and Tamil Nadu having the highest potential of 5.8 to 6.0 kWh/sq.km. Several business models are available for solar power such as the development based model where the developer has the flexibility to select land, technology, project execution, O&M mode (turnkey, EPC, etc.). EPC installation of project components is generally within the scope of the OEM. Other models include the rooftop lease model wherein developers hire rooftops to install PV systems against power supply for the captive consumption of rooftop owners.

The JNNSM has three major revenue models namely, the bundling scheme under which power from solar plants is bundled with relatively cheaper power from the unallocated NTPC thermal power quota, generation based incentive and viability gap funding which is a PPP scheme that provides viability gap funding of up to 20% of the total project cost. Solar power can also be sold through the APPC and REC route under which energy is sold at an average power purchase cost (APPC) as notified by the SERC from time to time. Over and above this price, developers can claim RECs on the generated energy sold to the state which can be traded in power exchange. Developers can also explore options to sell power through bilateral agreements with voluntary green power purchasers such as corporates who wish to procure green power as a part of their corporate social responsibility initiatives or to conventional captive power producers for offsetting their RPO.

It has been identified that the following two initiatives would help foster India's solar power growth:

Introduction of solar radiation data collection stations which massively help determine the success of a project and;

Higher involvement by state agencies and developing a single-window clearance could cut down the lead time faced by developers.

Given the incentive of income tax exemptions, feed-in tariffs and solar RPOs, these three states are likely to pick-up their solar capacity addition targets.

6.8.6.2.3.3 Small hydro

Small hydropower in India is majorly driven by private investments, and since the previous projects have turned out to be viable, greater interest is being given to this segment. In a country like India with limited electricity supply and a vast and remote geographic expanse, small hydro fits in the bill perfectly. The CBIC states also have a substantial small hydro potential, and except Karnataka, still a lot is left to be tapped.

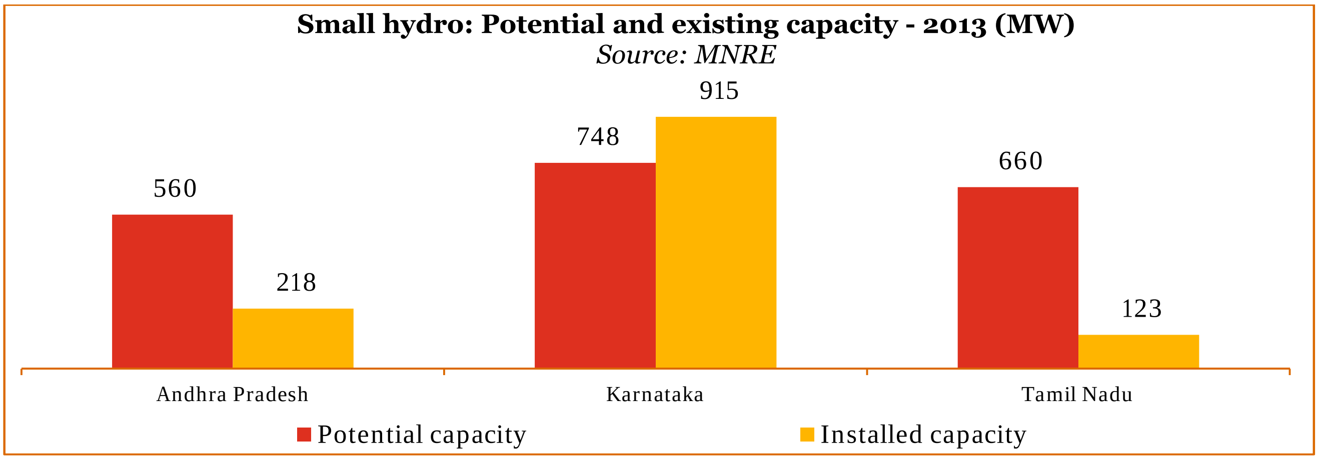


Figure 6.8.23: Small hydro capacity in India (MW); Source: MNRE

Despite the significant untapped potential, implementation of small hydro power projects has faced its own obstacles. Significant implementation time (small hydro power policies are still governed by States) and gestation period, limited access to sites due to difficult terrain and restricted season, uncertainties typically hydrological and inadequate evacuation systems are some of the challenges faced in the sector.

To overcome these, several incentives have been provided by the Central and State govt. A snapshot of such schemes for Tamil Nadu and Karnataka is captured in the following table.

Figure 6.8.24: Policy incentives for Small hydro; Source: FOR's study on RPO

Items	MNRE Guidelines	Karnataka	Tamil Nadu
Power Wheeling	2%	2% up to 1 MW 5% up to 3 MW 10% above 3 MW	15%
Power Banking	1 year	Negotiable	Allowed for captive
Third party sale	At mutually agreed rate	Allowed	Not allowed
Royalty on water	10% of electricity tariff	10% of prevailing electricity tariff	Included in power wheeling charges
Capital subsidy			10% of capital cost
Electricity duty exemption	Yes	Exemption for 5 years for captive	-

Going forward, investments in small hydro would still continue. However in the long run, they would continue to be only an attractive investment segment and not a high potential power source.

6.8.6.2.3.4 Biomass

An agrarian country like India has huge potential for biomass, and several states including Maharashtra and Karnataka have initiated action for setting up agro residue based projects. Biomass gasifier systems have also been installed in rice mills and other industries for captive power consumption.

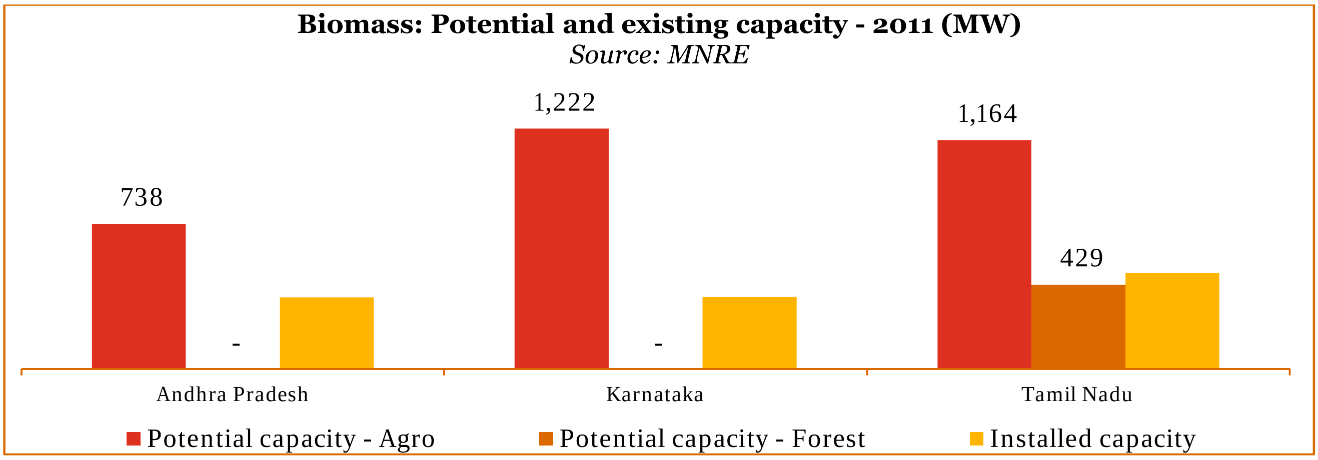


Figure 6.8.25: Biomass capacity in India (MW); Source: MNRE

**Potential capacity has been given in MWe; Installed capacity comprises of biomass and cogeneration capacity*

Efficient project specifications in new sugar mills and newer technologies can push the potential of additional at almost 5,000 MW. Central and state sector assistance has been provided for the sector, which although may vary from state to state, majorly include lower wheeling charges, banking of power up to 12 months, sale of biomass power to third party, amongst others.

6.8.6.2.3.5 Waste to energy

Waste to energy (W2E) in India is at a nascent stage with few projects being operational. Challenges obstructing evolution include poor waste management with inefficient separation of waste and no specific policies that promote W2E projects.

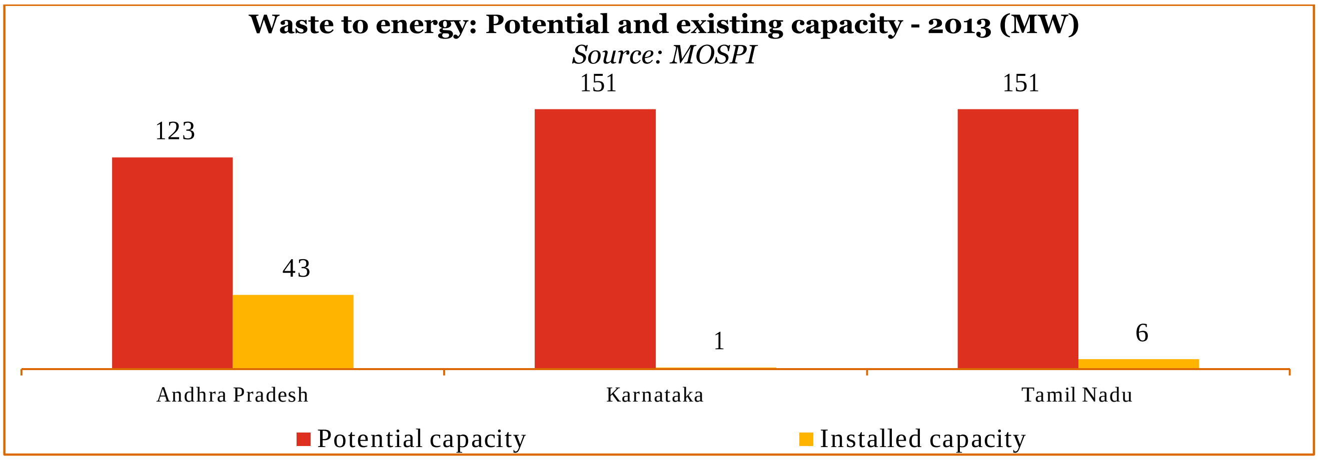


Figure 6.8.26: Biomass capacity in India (MW); Source: MNRE

In India, the Ministry of Urban Development developed a Solid Waste Management Manual in 2000. Subsequently, a National Master Plan for Development of Waste-to-Energy in India was developed to utilise urban and industrial waste for power projects in 2001. After more than a decade since the plan was launched, W2E implementation is still to scale up in India. National schemes such as the Jawaharlal Nehru Urban Renewal Mission (JNNURM) are expected to aid better solid waste management practices in urban centres. These in turn are expected to fuel growth of W2E projects.

Capital investment model: W2E project in India are primarily being awarded under the PPP route through competitive bidding based on the lowest tariff bid. BOT and BOOT are the most common PPP models. The developer is provided land on token lease basis and free garbage at the plant site the municipal authority. The Timarpur-Okhla 16 MW integrated W2E plant in New Delhi was awarded to JITF Urban Infrastructure Ltd on similar basis.

Revenue and sales model: The concessionaire usually enters into a PPA with the distribution companies operating in the area of the municipal authority to sell power at a tariff bid for during the bidding process.

There are three W2E projects ongoing in Tamil Nadu, a 440 kW project for the Municipality of Thanjavur, a Municipal solid waste processing plant at Ramayanpatti for Tirunelveli City Municipal Corporation under PPP on DFBOT basis, and a W2E project utilising 500 tonnes of municipal waste per day for the Coimbatore Corporation. Additionally, there is also a massive 40 MW project underway in Greater Hyderabad Municipal Corporation (GHMC) area under the PPP route in Andhra Pradesh.

Superior technology and adequate waste management can play a major role in shaping up the W2E story in India. Technology can help alleviate a lot of social challenges being faced due to harnessing of urban waste within city limits. However, W2E going forward is not expected to add a significant capacity out of the total renewable capacity mix.

6.8.7 *Development of goals and target performance indicators*

6.8.7.1 Principles for developing goals

The power sector infrastructure to be developed for the CBIC in order to cater to the increasing demand would be based on the guiding principles of reliability, sustainability, affordability and efficiency across the value chain. The crucial objectives of low carbon growth and access of uninterrupted power supply to everybody can be achieved if the following goals are met.

Table 6.8.46: Power sector goals and performance indicators

Goal	Indicator	Current Situation	Short-term Target at 2017	Mid-term Target at 2022	Long-term Target at 2032
Generation					
To bridge the demand supply gap	Energy deficit (%)	AP: 6.8% KN: 10.2% TN: 6.1%	AP: 5% KN: 7% TN: 5%	0% deficit across states	5%surplus across states
Transmission					
To ensure that transmission capacity is readily available for evacuating generated power	No stranded generation capacity	Transmission system is a constraint	Transmission system is a constraint	Transmission system is not a constraint	Transmission system is not a constraint
Distribution					
To ensure that the reliability indices benchmarks are met	SAIFI & SAIDI	SAIFI: 248 SAIDI: 4736 minutes	SAIFI: 50 SAIDI: 1000 minutes	SAIFI: 15 SAIDI: 200 minutes	SAIFI: 10 SAIDI: 100 minutes

Although the above goals are based on the primary performance indicators, a few other indicators can also be monitored for ensuring the delivery of the desired objectives from the infrastructure development plan. These are:

- Mix of renewable based power in total power generation;
- Availability/PLF/Utilisation Factor of power plants;

- Transformation capacity of the transmission system;
- Transmission losses which can be reduced through introduction of technology;
- Distribution losses [these should be benchmarked to in international standards since this would be a completely new and advanced infrastructure]
- Other reliability indices such as response time for customer complaints, outages, feeder breakdowns, consumer to employee ratio [this would ensure to track the levels of automation in the system]

6.8.8 *Investment outlook*

The development of CBIC would accelerate the economic growth of the region, which to sustain itself would require a matching investment across the power sector infrastructure value chain. However, in the existing scenario, the sector faces various challenges owing to market competitiveness, regulatory environment, consumer portfolio management and technology development. It is therefore critical to assess the various infrastructure bottlenecks and risks across the value chain in these states. This understanding would help in the future in shaping the risk mitigation strategies and the investment plan for the corridor.

6.8.8.1 Current bottlenecks in the sector

Responsibility for Bottleneck	Challenge	Current status
Generation		
Government of India	*Shortage of fuel supply*	**Andhra Pradesh:** MoUs to set up 119 projects for 7,481 MW were in place by early 2000s, which were mostly for gas based power projects and extremely dependent on private participation. Unfortunately, very few of these projects have been executed due to low gas availability from the KG-D6 basin and the ones operational, are running at very low PLF's (< 50%). **Karnataka:** Coal plants are facing fuel availability issues. BTPS units have operated at low plant load factor in the last 2 years due to inadequate coal supply even though the plant has captive mine blocks allocated to it as part of a JV between KPCL and EMTA.
Government of India	*Regulatory hurdles*	**Karnataka:** Greenfield projects in large hydro, especially untapped potential in Western Ghats continue to face stringent environment clearance norms and as such, its potential for contributing capacity in future is limited. Similarly, the growth of the solar power market is limited by the lack of clarity on incentives for developers. Stricter enforcement of RPO mandates with medium- to long-term clarity on policy is necessary for assured functioning of the REC market.
Government of India	*Seasonal sources of power*	**Tamil Nadu:** Dependence on wind power generation, which is highly seasonal in nature, is another reason for the massive power deficits in Tamil Nadu, which has the highest wind energy capacity in the country. However, the seasonal nature of wind energy has resulted in the supply being erratic and of poor quality.
Developer	*Sub optimal plant maintenance and*	**Andhra Pradesh:** Lack of proper maintenance and inefficient operation of the power plants has reduced

Responsibility for Bottleneck	Challenge	Current status
	operation	efficiencies, leading to a loss of generating capacity. Efforts to improve the capacity/performance of plants with life > 25 years have been stopped due to a lack of financing. **Karnataka**: a) *Poor coal quality*- The switch from raw coal to washed coal in a vast majority of the power plants in the country has resulted in a significant degradation in the coal quality and savings from lower coal costs have been offset by the reduction in PLF; b) *Lack of spares for old equipment* – A number of units, especially in Raichur and Kolar are over 25 years old. However, due to a lack of adequate resources to arrange for spares and renovation, there has been a decrease in efficiency of the plants.
Developer	*High cost of power from IPPs*	**Andhra Pradesh:** Reliance's decision to withdraw supply of natural gas from its K-G D6 basin to gas based IPPs has resulted in around 3407 MW of power being operated at 60-70 % below capacity. Gas shortage has also forced them to switch to imported gas, forcing the costs and the tariffs upwards.
Government of Karnataka, Government of Tamil Nadu	*Low installed capacity and over-dependence on outside sources*	**Karnataka:** KPCL has a thermal power capacity of only 2848 MW, relying mainly on quotas from Central Generating Stations and IPPs. Of the IPP-owned capacity, only 1,080 MW (UPCL) has long-term PPAs with utilities in the State. **Tamil Nadu:** Highly dependent on outside sources and has low capacities within the State. This leads to higher costs for short term power purchases and higher landed electricity costs.
Government of Tamil Nadu	*Lack of new projects*	**Tamil Nadu:** Lack of State Govt. owned investments have resulted in the lack of stable sources of electricity resulting in one of the highest energy deficits in the country. Capacity addition has been very limited in the past 7 years as compared to other states.
Karnataka Power Corporation Limited	*Weak financial status*	**Karnataka:** The pending dues to the State Genco were 1.45 Billion USD (FY 13). The financial situation of KPCL is a major concern and can weaken its ability for further investments in the sector.
	Transmission	
Government of India	*RoW issues and land availability issues*	Companies developing transmission networks are currently facing serious problems due to difficulties in getting environmental clearances including RoW, slowing down transmission capacity augmentation and leading to generation capacity being stranded. Land required for constructing sub-stations is also not available easily.
Government of India	*Congestion in the Southern Grid*	**Tamil Nadu:** The amount of power that can be transmitted to the Southern Region is quite low and is currently 5,350

Responsibility for Bottleneck	Challenge	Current status
		MW. Further, the southern grid is currently running at full capacity. This is a major problem for a state like Tamil Nadu which is at present dependent on outside sources of power.
Government of Karnataka	*Difficulties in management of demand and supply*	**Karnataka:** SLDC faces challenges due to shortage of generation capacity, particularly during the summer season when the load demand is high and hydro availability is low. The State Government must also take steps to ring-fence SLDC so that it can operate as a neutral and independent grid operator.
Government of Karnataka	*Non-conventional energy transmission*	**Karnataka:** Integration of a high quantity of renewable power with the grid also poses challenges and the State must prioritize planning for intermittency that is typical of renewable generation. Further, the gas-based generation planned at Bidadi is a combined cycle plant, designed for base load operation. In order to manage intermittency from renewable sources, the State needs to plan for a few open cycle gas plants that can be used as quick ramp-up sources of power. These open cycle plants can also serve as peaking stations in future. Further, proposals pending with the Government to harness current hydro stations to be developed into pumped storage projects should be taken up on priority.
Tamil Nadu Transmission Corporation (TATRANSCO)	*Lack of sufficient metering*	**Tamil Nadu:** The State's transmission utility needs to adopt steps for improving the metering status at the 11 kV lines and the distribution transformers.
	Distribution	
Government of India	*Shortage of skilled manpower and HR policies*	All discoms report a shortage of skilled manpower, mainly among the field staff. Training of staff becomes a critical avenue. Alternatively, certain non-critical activities can also be outsourced.
Government of Tamil Nadu	*Lack of financial support from the state government*	**Tamil Nadu:** Requisite financial support is not being provided by the Govt., by way of adequate subsidy to the discom.
Central, North, Eastern, Southern Power Distribution Utilities (Andhra Pradesh), Bangalore, Mangalore, Hubli, Gulbarga and Chamundeshwari Electricity Supply Company (Karnataka)	*Weak financial position of State utilities*	**Andhra Pradesh:** Policies like free and subsidized power to certain consumer categories has increased the financial burden to the discoms to the tune of over 83 Million USD. **Karnataka:** Unrecovered dues to the tune of 1.5 Billion USD from Government and local bodies has increased the State's financial burden and has significantly limited the ability to make further investments in the distribution network
Central, North, Eastern, Southern Power Distribution Utilities (Andhra	*Lack of quality of supply for rural areas*	**Andhra Pradesh:** Another impact of managing the financial situation for the discoms has been the utter neglect of rural power supply which has deteriorated. Maintenance and upgradation of the rural distribution network has taken

Responsibility for Bottleneck	Challenge	Current status
Pradesh),		a backseat.
Central, North, Eastern, Southern Power Distribution Utilities (Andhra Pradesh), Bangalore, Mangalore, Hubli, Gulbarga and Chamundeshwari Electricity Supply Company (Karnataka), Tamil Nadu Generation and Distribution Company (Tamil Nadu)	*Inaccurate estimates of demand and losses*	Since agricultural consumption is largely unmetered, the demand from these consumers is not accurately known, leading to inaccurate loss assessment, power purchase procurements etc. ultimately leading to a financial loss for the utility.
Bangalore, Mangalore, Hubli, Gulbarga and Chamundeshwari Electricity Supply Company (Karnataka)	*High distribution losses*	**Karnataka:** The State still suffers from high levels of distribution losses due to dilapidated network, theft and pilferage of energy etc. These can be tapped through the use of HVDS and by bring down the LT:HT line ratio.
Bangalore, Mangalore, Hubli, Gulbarga and Chamundeshwari Electricity Supply Company (Karnataka)	*Reliability of distribution system*	**Karnataka:** Consumers often experience periodic and prolonged loss of power. Number of interruptions duration of interruptions can be reduced through periodic inspection of lines, preventive maintenance and pre-monsoon works.
Tamil Nadu Generation and Distribution Company (Tamil Nadu)	*High levels of cross-subsidy*	**Tamil Nadu:** The agriculture category, for instance, is levied with only a fixed charge and no variable energy charge. This loss in revenue is thereby recovered from the commercial and industrial consumers, indicating a distorted cross-subsidy regime. The domestic and agriculture categories consume around 50% of the power whereas contribute only 20% of the revenues.

6.8.8.2 Infrastructure development strategy

The primary objectives for developing the infrastructure for the sector would be to achieve reliability, sustainability, affordability and efficiency across the value chain. An elaborate set of objectives and strategies to adopted for meeting these objectives for infrastructure, operation/management and institution have been given in this table.

Table 6.8.47: Power sector development strategy

Infrastructure	***Objectives***	• To ensure reliability across the value chain o Generation is able to minimize the demand supply gap o Transmission system is readily available for power evacuation o Distribution system meets consumer end reliability indices • To ensure sustainability across the value chain o Reduction in carbon emissions o Reduce impact on environment • To ensure affordability across the value chain o Power is available at competitive prices

		o Power is affordable by all consumers o Incremental project costs for augmentation/technology upgradation should be optimised
	Strategies	• In order to optimize costs and resources, infrastructure development in the short or medium term should be undertaken only if the energy deficit rises over 5%; Demand surplus of upto 5% should be optimally met through short term power contracts, power markets and bilateral trading • Promote the development of captive power plants to meet capacity requirements of at least large industries in the medium term • Technical design should be adopted from international best practices while planning infrastructure development • Opt for renewable sources for power generation • Optimisation of infrastructure development costs through use of technology • Explore technologies for generating power through fuels not used extensively in India such as geothermal energy, Shale gas, offshore wind etc. • Adopt high technology for use in transmission as well as distribution systems such as smart grid • Encourage the development of smart cities which may have higher upfront investments but would effect a lower lifecycle costs • Use high quality network components for the T&D network to reduce technical and heat loss • Accelerate process of clearances and other delays to avoid cost overruns, thereby affecting the project's affordability and sustainability • Bring in third party expertise for planning and project management to avoid project overruns • Focus on rehabilitation of old thermal plants • Ensure fuel and power purchase tie-ups prior to project commissioning and development of power plants based on gas and nuclear energy which are currently facing challenges may be relooked at • Provide greater services to the end consumer in terms of online and automatic billing, demand side management options, easier bill payment options etc.
Operations/Management	***Objectives***	• To ensure efficiency across the value chain o High levels of generation availability o Low losses in the transmission and distribution networks o Reduce operating costs of projects especially which have high capital investments o Enhance operational life of the infrastructure thereby enhancing the lifecycle benefits • To ensure operational reliability • To enhance operational efficiency in order to bring down running costs • To reduce dependency on backup or alternative power sources
	Strategies	• Develop technologies for improving the PLF of existing power plants • Utilise IT and other technologies for enhancing efficiency of O&M activities of the project such as using SCADA technologies for monitoring and control • Use of automatic and online billing systems would help improve efficiency • Ensure high levels of operation and management; such activities in critical plants may be outsourced to international experts • Enhanced performance through proper O&M practices can help in achieving a significant reduction in operating costs
Institution	***Objectives***	• To promote investment in the sector • To promote sale of power from captive generators • To enhance the renewable energy capacity addition • To promote sale/purchase of power between independent producers/buyers
	Strategies	• Conductive policy environment for mobilisation of large scale investment in the sector; an incentive mechanism can be devised to draw investments for projects

		that would support in reducing the carbon growth • Help expand generation capacities, transmission and distribution networks through private participation including the PPP mode • Special incentive for developing captive power plants based on low carbon power in the corridor • Provide a conducive framework for sharing of power from captive plants with other consumers (group captive) as well as other rural consumers in villages • Establish an institutional framework for operationalising open access even at lower voltage levels for optimizing power procurement and costs

6.8.8.3 Investment potential

CBIC's growth would require a massive investment in the power sector across the three states. Overviews of the investment in the sector, both which are already planned by the States and which are proposed to meet the additional demand growth, have been given below.

Table 6.8.48: Expected investments in power across G, T and D in the CBIC region (Million USD)

State	Category	Mid-term 2022	Long-term 2032	Total
Total region	Generation - Proposed	15,970	44,200	**60,170**
	Transmission - Proposed	6,388	17,680	24,068
	Distribution - Proposed	3,194	8,840	12,034
	Total	**25,552**	**70,720**	**96,272**

* The planned investment values are available only for generation and not for power transmission and distribution, and the investments shown here comprise of only the investment required to match the incremental growth from the BAU scenario. However it has been observed that investments in India in the generation, transmission and distribution sector are typically made in the ratio of 1.0 : 0.4 : 0.2, which means we will see an equivalent investment in the mid and downstream value chain as well.

The essence behind generation planning has been to maintain reliability through an assured fuel supply and hence a significant amount of capacity additions planned are based on coal, which would mostly be imported. Renewable energy based power has also been planned but nothing much beyond the short term. Since renewable energy has not completely taken off in the Indian context as well, we have considered a conservative scenario of most capacity being added by conventional sources only in the long term.

There are some other policy initiatives that have taken off in the region, which would prove to be conducive to investments in the region. Key initiatives considered at regional and national level are covered in annexure D

Next we define the key action areas.

6.8.8.4 Conclusion

Generation

- Coal would continue to be the dominant shoice of fuel in the forseeable future; Coal based plants should be located near adequate water supply, and the pit-head or the input port
- There is about 9 GW of stranded gas capacity and at this point the feasibility of gas based plants would be only for requirement of peaking power and consumer's ability to pay
- Renewable capacity addition will be driven by regulatory compliances, and specific measures like dedicated solar and wind farms would be required to keep them competitive

Transmission

- All the three states are part of the Green corridor and hence integration with renewable energy would be possible, enhancing RE capacity addition. However states like TN have already a high percentage of renewable capacity and additional renewable capacity needs to be absorbed regionally or in nearby states.
- For additional generation capacity, dedicated transmission linkages would be required .
- With increased integration in national grid , other non regional opportunties of power procurement like case 1 and Case 2 power procurement open up.

Distribution

- Undertake policy advocacy for ensuring deemed distribution licensee status for the entire corridor will allow attarcting private capital to distribution.
- Since most of the distribution network would be greenfield projects, a superior technology enabled system would help bring in efficiencies and improve consumer satisfaction

6.9 Town Development and Industrial Development

6.9.1 Sector Overview

6.9.1.1 Master Plan/development plans

The master plans/development plans have a vital role in sustainable socio-economic transformation and change. The objective of these plans are to provide further necessary details and intended actions in the form of strategies and physical proposals for various policies given in the perspective plan depending upon the economic and social needs and aspiration of the people, available resources and priorities.

The master plan is a land use plan prepared for towns with regulatory guidelines to ensure orderly development of the planning area. The plans while suggesting for broader land use restrictions, will also identify the problem areas in traffic and transport, location for education, recreation site etc., and propose for provision of infrastructure facilities based on the projected population for that area. Programmes are drawn and funding agencies are identified to take up such projects. It involves a continuous process like deriving, organizing and presenting a broad comprehensive programme for urban development and renewal.

The concept and methods of Master Planning in India owe their origin to the British town planning laws. The master plan, which was perceived to be a process rather than a conclusive statement, provides guidelines for the physical development of a city or town and guides people in locating their investments and residences in the city. In short, Master Plan is a design for the physical, social, economic and political framework for the city, which greatly improves the quality of urban governance also. The functions of the Master Plan, increasingly being called Development Plan, are presented in Figure 6.9.1**.**

Figure 6.9.1: Functions of Master/Development Plan in India

Quality of Life	• To guide development of a city is an orderly manner so as to improve the quality of life of the people
Land Use Control	• Organise and coordinate the complex relationships between urban land uses
Growth Review	• Chart a course for growth and change, be responsive to change and maintain its validity over time and space, and be subject to continual review
Physical Development	• Direct the physical development of the city in relation to its social and economic characteristics based on comprehensive surveys and studies on the present status and the future growth prospects
Resource Mobilisation	• Provide a resource mobilisation plan for the proposed development works

Detailed Development plans are prepared in conformity with master plan proposals, prepared for smaller areas within the urban area. These are the action plans where the development projects and programmes are envisaged. It is a micro-level plan with detailed road network in which master plan is translated for development of specific area in the town which exhibits faster growth. The development plans are also reviewed periodically based on the trend of development.

The plan formulation exercise must be completed within a specified time period and the time schedule for plan preparation, public notification/hearing and approval must be statutorily prescribed in the relevant Acts. Considering importance of the city, the approval of major changes in the development plan should be done at the higher level and within prescribed time period so as to evolve superior master plan. As per the draft Urban and Rural Development Planning Formulation and Implementation (URDPFI) guidelines, 2014 the urban development planning system has various emerging plans in addition to the existing planning system framework. The major heads of development planning system is presented in Figure 6.9.2**.**

Figure 6.9.2: *Urban Development Planning system as per UDPFI Guidelines*

Percpective Plan	Regional Plan	Development Plan	Annual Plan	Local Area Plan	Plans of Projects/Schemes
• Long term written document or Vision Plan • Statutory document • 20 years • Spatio-economic development policies, strategies and programmes of the local authority • Policy framework to prepare development plan	• The plan shall study the characteristics of the region. • Urban Nodes will be Identified in the next stage • 20 years • Connect the unconnected networks.	• Master plan in the form of statergies and physical proposals. • 20 years • Spatio-economic development of urban centre • Within the framework of perspective plan	• Short term action plan • Built-in system of continous annual review of the performance • Within the framework of Development Plan	• Provide improvements in the physical layout • Implementation details to comply with Govt. policies	• Working layouts of execution • Provide all required planning, engineering, architectural, financial and administrative details in drawing and written form for execution

According to the item 20 of the concurrent list in the seventh schedule of the Constitution of India, social and economic planning is a joint responsibility of the Central and State Governments. However, Land being State subject and the role of State governments becomes more pronounced in the implementation. At the State level, the system of economic planning is similar to the one at the national level. Spatial or physical planning is generally limited to a few selected urban settlements. The urban planning system includes the master plans, development plans further details annual plans. In some States provision of an interim general plan is also available. Generally the State Town and Country Planning Departments/Directorate is responsible for preparation of master/development plans for urban settlements under the respective State Regional and Town Planning Act. Private sector urban planning consultancy firms are also engaged by various organisations to prepare development plans of State capitals, new towns and other towns. In case of development Authorities, the Master Plan and other development plans are prepared by the Development Authorities themselves. The implementation of these plans is generally through development authorities and special function boards/undertakings. The general outline of development plan formulation produce is presented in Figure 6.9.3.

Figure 6.9.3: *Outline of Master/Development Plan formulation procedure*

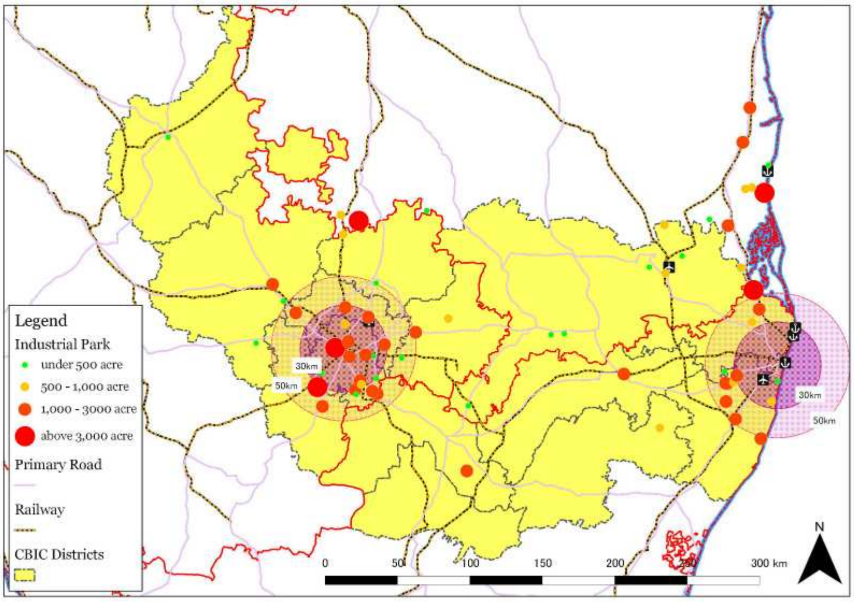
As mentioned in the above, preparation of development plan is a State subject since each State has its own Town and Country Planning Authority/Department to implement the development plans. Each State has a Town Planning Act, where the formulation procedure for development plans is detailed by taking into account the local regulations and laws.

6.9.1.2 Town Development and Industrial Development

Expansion of urbanized area is estimated based on the projected population increase. The result of this analysis shows 1,010 sq.km expansion of urbanized area (1% of whole CBIC area) over the next 20 years. This growth of urbanization will require parallel growth of urban infrastructure development.

At the same time, total population of CBIC is estimated to become to 1.5 times of current population. This will happen because it is estimated that 52 sub districts will be upgraded from village to “Town” as their total population increases. (Note: The criteria of town are either (1) More than 5,000 people, and (2) More than 400 people/sq.km). This annual population growth will create expansion of the urban area of each sub district. However, the majority of the sub districts currently don’t have urban master plans. Therefore the preparation of urban master plan for these areas is necessary as a tool to control urban development and to avoid urban sprawl.

Regarding industrial development, majority of the existing industrial parks in the CBIC area are located within a 50 km radius from the centres of Chennai and Bangalore. Some mid/small-sized industrial parks are scattered in other areas, but there is no concentrated industrial zone outside of the two metropolitan cities as shown in the following figure:



Source : Data from KIADB, TIDCO, SIPCOT and APIIC

Figure 6.9.4: *Location of Existing Industrial Parks*

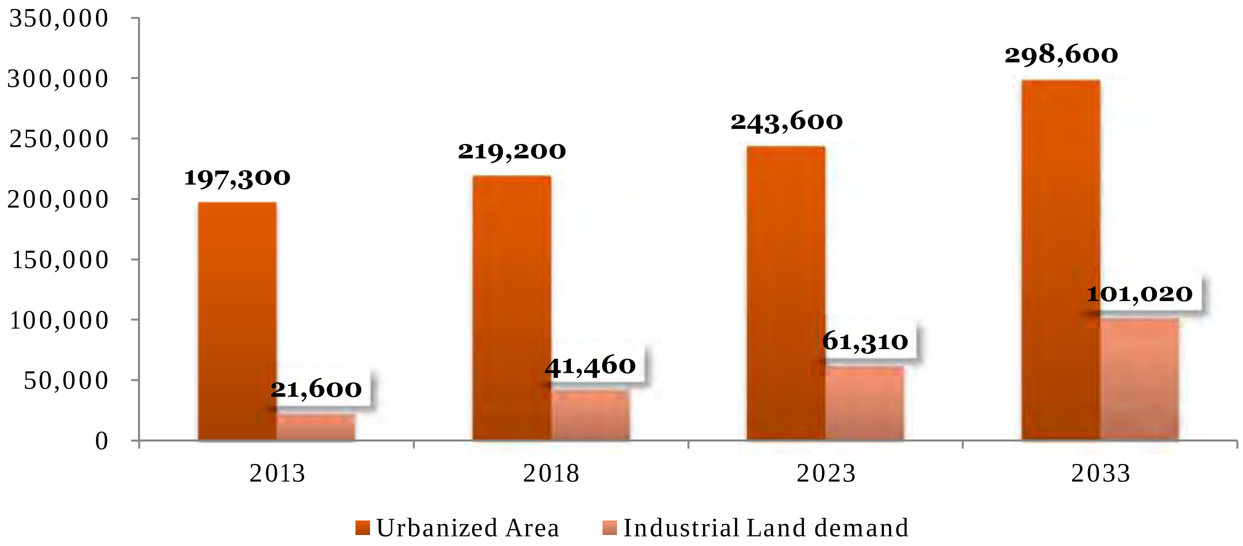
In addition to urban growth due to population, there will also be growth resulting from new industrial projects. In total, 11 on-going and planned projects are expected in Tamil Nadu, as well as 14 projects in Karnataka and 4 projects in Andhra Pradesh. The majority of them are expansions of existing industrial parks. New large projects have tended to be planned outside of urban areas, because of the unavailability of land and the difficulty of land acquisition in urbanized areas. They are planned or being developed at locations beyond 50 km from the major city centres.

In the case of major industrial parks in South East Asia which have foreign capital companies as tenants, it is common to guarantee the provision of stable power supply, water supply and waste water treatment system for 24 hours a day every day. Stable infrastructure systems such as these are essential conditions for international standard industrial parks. However, there are insufficient components at some existing industrial parks in CBIC area (e.g. water treatment plant, waste water treatment plant, power supply restriction). This situation creates a bottleneck for the industries. But conversely, the selling price of the factory plots is attractive compared to others.

In addition, to ensure the water availability, electricity availability, improvement of the access road and improvement of development regulations for the smooth government procedure are key issues for the promotion of industrial developments. Especially, basic infrastructure development (water supply, electricity supply infrastructure) which is agreed between the government and company should be implemented immediately.

Regarding industrial development surrounding area of Chennai city, securing soil for the land grading is also a big challenge. Chennai metropolitan Area has already been developed, and it is difficult to ensure the soil nearby urban centre. Developers have to transport the soil from farther areas which increases the cost of land development in this area.

In terms of land demand, 101,020 ha is estimated as total land demand for industrial land use of whole CBIC area for next 20 years, and the amount is more than 3 times of current demand. Currently approx. 35,000 ha is planned to be developed as node developments, and it covers 45% of estimated industrial land demand. Therefore, the gap between total projected industrial land demand (101,020 ha) and planned node development which is added current industrial area (35,000 ha + 21,600 ha = 56,600 ha) should be covered by the private sector's development with collaboration of government. (The gap is estimated as approx. 44,480 ha)



Source : JICA Study Team

Figure 6.9.5:*Sub district-wise Projected Population Density of 2033*

6.9.2 *Demand Forecast*

6.9.2.1 Projection of Urbanization

6.9.2.1.1 Current Number of Town and Urban Master Plan

According to Census 2011, 1 Corporation (Chennai), 42 Municipalities, 264 Towns and 3,346 Villages are located within the CBIC of Tamil Nadu State. In addition, 71 Towns and 8,801 Villages area belonging to Karnataka State, Andhra Pradesh State has 61 Towns and 3,469 Villages. Within these local government bodies, only 52 have the urban master plans. Some plans consider expansion of the urban area according to the future population, and there are some cases where they have not updated their own urban master plans for past 10 years. However, continual updating and new planning of existing urban master plans are necessary for comprehensive development for this area. Current number of each local government body is summarized as below:

Table 6.9.1: *Number of Local Government Bodies in CBIC Area by Census 2011*

State	District	Sub district/ Taluk	Town (Mcorp)	Town	Village
Tamil Nadu	Chennai	5	1	-	-
	Dharmapuri	5	-	13	251
	Kancheepuram	11	-	82	633
	Krishnagiri	5	-	14	333
	Thiruvallur	11	-	61	526
	Thiruvannamarai	8	-	22	860
	Vellore	11	-	72	743
Subtotal		**57**	**1**	**264**	**3346**
Karnataka	Bengaluru Urban	5	-	20	562
	Bengaluru Rural	4	-	8	957
	Ramanagara	6	-	8	1,324
	Kolar	6	-	9	948
	Chikballapur	5	-	8	1,608
	Tumkur	4	-	6	820
	Chitradurga	10	-	12	2,582
Subtotal		**40**	**-**	**71**	**8,801**
Andra Pradesh	Chittor	63	-	18	921
	Nellore	66	-	28	1,455
	Anatapur	46	-	15	1,093
Subtotal		**175**	**-**	**61**	**3,469**
Total		**272**	**1**	**396**	**16,666**

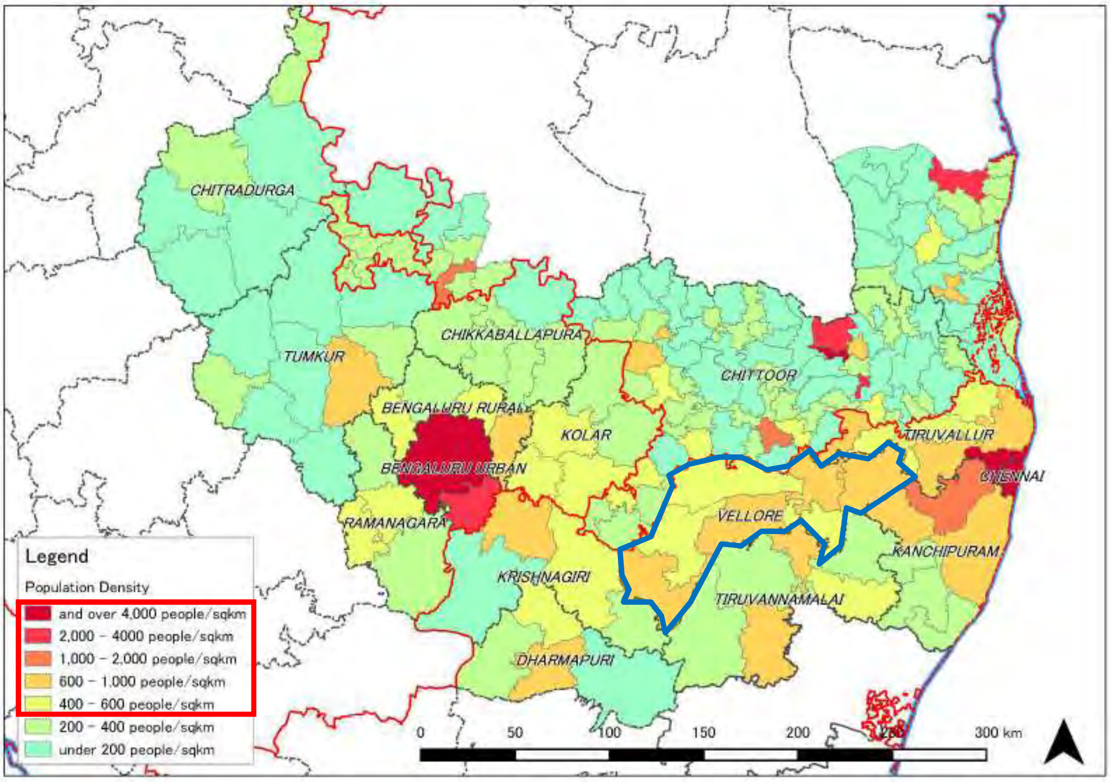
Source : Census 2011

6.9.2.1.2 Projection of the Future Number of Towns

According to the projected population in 2033, the total population of CBIC area is estimated at 1.5 times of current population. Because of this annual population increase, many "Villages" will be upgraded to "Towns". This expected phenomenon means annual expansion of the urban are, it shows necessity of urban master plans for newly urbanized areas. The criteria of "Town" are defined as below:

- Municipality, Corporation or Cantonment (Mcorp)
- All other places which satisfied the following criteria ; (i) A minimum population of 5,000. (ii) At least 75 % of the male working population was non-agricultural. (iii) A density of population of at least 400 sq.km.

The following figure illustrates the projected population density for 2033.



Source : JICA Study Team

Figure 6.9.6: *Sub district-wise Projected Population Density of 2033*

One case of interpreting this map follows. In all sub districts in Vellore district (blue outlined area in the above figure) which is located outside of Chennai Metropolitan is thought to become to be "Towns". And similar situation is identified surrounding areas of Chennai city and Bengaluru city. Preparation of urban master plans for these areas is quite important to control urban development and to avoid urban sprawl for CBIC development.

The following table describes the sub districts don't have urban master plans despite their population and population density are satisfied the definition of "Town" as of 2033. For these sub districts, some difficulties will appear against urban development control.

Table 6.9.2: List of Sub District to be defined as "Town"

State	District	Sub District
Tamil Nadu	Tiruvallur	(i) Ponneri(CMA), (ii) Uthukkottai, (iii) Pallipattu, (iv) Ambattur(CMA)
	Kanchipuram	(i) Poonamallee(CMA), (ii) Sriperumbudur(CMA), (iii) Sholinganallur(CMA)
	Tiruvannamalai	(i) Vandavasi
	Vellore	—
	Krishnagiri	(i) Pochampalli
	Dharmapuri	(i) Palakkodu
Karnataka	Kolar	(i) Malur, (ii) Bangarapet
Andhra Pradesh	Nellore	—
	Chittoor	(i) Nagari, (ii) Narayanavanam, (iii) Palamaner, (iv) Venkatagirikota, (v) Santhipuram
	Anantapur	—

*Note : Madhavaram, Ambattur, Poonamallee,*Alandur, Tambaram *and* Sholinganallur *towns are part of CMA (Chennai Metropolitan Area). The development strategies for these towns have already been included in the Second Master Plan 2026.*

Tamil Nadu State : Sub districts neighbouring Chennai district don't have individual urban master plan. These sub districts are included into Chennai Metropolitan Area, integrated urban master plan is planned by Chennai Metropolitan Development Authority for this area. However, surrounding areas of metropolitan are expected significant population increase, it needs to plan individual urban master plans separately from the integrated urban master plan.

Karnataka State : Regarding Bengaluru and the surrounding sub districts, majority of local government bodies have already planned urban master plans to facilitate further urban development. Only 2 sub districts (Malur Taluk and Bangarapet Taluk in Kolar district) need to plan urban master plan newly.

Andra Pradesh State : 5 sub districts which are located on the trunk road network from Bengaluru to Krishnapatnam and Krishnapatnam to Chennai.

6.9.2.2 Land Demand of Industrial Use

According to the industrial projection, approx. 79,000 ha will be estimated as industrial land demand (Accelerated Scenario case) for next 20years. Two metropolitans and their surrounding areas tend to be increased their industrial land demand based on significant GDDP increase of this areas. Especially, Chennai/Tiruvallur/Kancheepuram area shows remarkable industrial land demand increase. The following table shows the district-wise industrial land demand which is divided by distribution of projected population with accelerated scenario.

Table 6.9.3: District-wise Land Demand for Industrial Use (Unit : ha)

State	District	Short-term 2013-2018	Mid-term 2018-2023	Long-term 2023-2033	Total
Tamil Nadu	Chennai Tiruvallur Kancheepuram	2,474	5,535	39,892	47,901
	Tiruvannamalai	48	86	379	513
	Vellore	28	54	275	357
	Dharmapuri	171	331	1,730	2,231
	Krishnagiri	99	201	1,044	1,344
Karnataka	Bangalore Urban	483	994	5,641	7,118
	Bangalore Rural	460	974	6,978	8,413
	Ramnagara	18	38	207	262
	Kolar	36	77	570	683
	Chikballapur	5	12	83	99
	Tumkur	19	38	198	254
	Chitradurga	47	82	341	469
Andhra Pradesh	Chittoor	363	763	4,314	5,441
	Nellore	247	514	2,888	3,649
	Ananthapur	14	64	611	689
Total		**4,511**	**9,762**	**65,150**	**79,423**

Note : It is considered "Chennai, Tiruvallur and Kancheepuram" as one influential area, according to the industrial projection.
Source : JICA Study Team

6.9.3 *Demand/Supply Gaps*

6.9.3.1 Projection of Urban Area

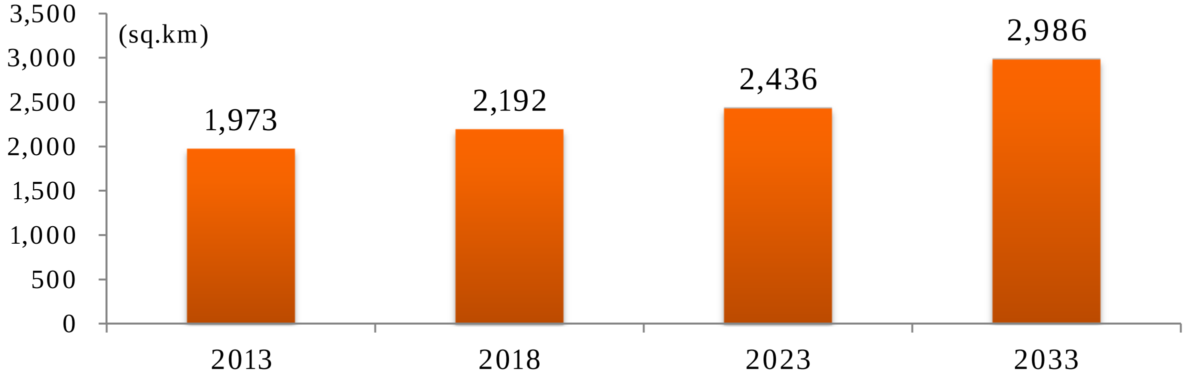
The analysis of urbanized area is made from satellite image analysis by using Landsat (2003 and 2013). As a result, 350 sq.km is estimated as increase of urbanized area during the period 2003 to 2013. On the other hand, according to projected population, 27million people are estimated to increase during the same term. The required unit area for increased residents is calculated as 37.2 sq.m/person on average. From this figure and projected population, the formula is shown as below:

$$\textbf{\textit{Increased Urban Area}}(2013-2033) = \textbf{\textit{Increased Popultion}}(2013-2033) \times \frac{\textbf{\textit{Increased Urban Area}}(2003-2013)}{\textbf{\textit{Increased Population}}(2003-2013)}$$

Note : The amount of increased urban area (2013 -2033) is calculated as district wise.

As a result, it is considered that required urban area in 2033 is "1,010 sq.km" (2018 : 220 sq.km, 2023 : 240 sq.km, 2033 : 550 sq.km). Therefore, approx 1% of whole CBIC area needs to be converted to urbanized area.

In addition, agricultural field of 307 sq.km has been converted to other land use including urban area during 2003 to 2013. This result shows the advance of urbanization for agricultural area. Based on these results, land areas to allocate to the increased population should be identified.



Source : JICA Study Team

Figure 6.9.7: Estimated Urbanized Land Volume

6.9.3.2 Projection of Number of Local Government Bodies defined as Town

Following table and figure show the numbers which have 5,000 and 10,000 of population in 2013 and 2033.

Table 6.9.4: Number of High-populated Towns

State	District	Town	Number of Towns			
			2011 (Census Data)		2033 (Projected)	
			More than 5,000	More than 10,000	More than 5,000	More than 10,000
Tamil Nadu	Tiruvallur	Uthukkottai	9	1	12	2
		Pallipattu	22	3	29	8
	Tiruvannamalai	Vandavasi	11	1	14	1
	Krishnagiri	Pochampalli	23	0	32	5
	Dharmapuri	Palakkodu	36	3	53	8
Karnataka	Kolar	Malur	2	1	3	2
		Bangarapet	4	3	6	3
Andhra Pradesh	Chittoor	Nagari	1	1	1	1
		Narayanavanam	1	1	1	1
		Palamaner	4	1	6	1
		Venkatagirikota	6	1	11	3
		Santhipuram	1	0	4	0
Total			**120**	**16**	**172**	**35**

Locations of local government bodies which are defined as “Town” by using projected population and population density are shown in the map below.

Source : JICA Study Team

Figure 6.9.8: Distribution of the Areas Need to Plan Urban Master Plans by 2033

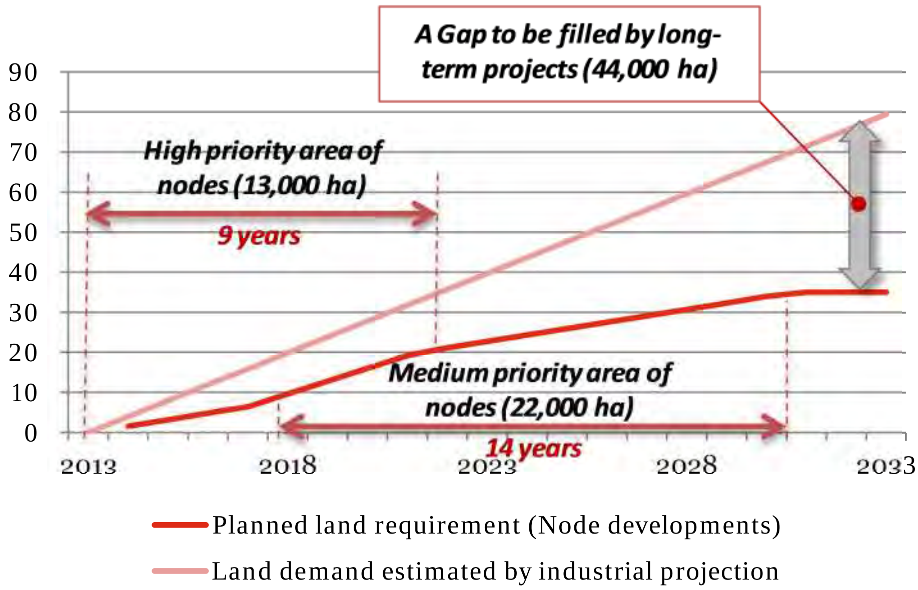
Characteristic features of town growth above figure are summarized below:

- **Location A :** Accumulation of newly upgraded Town is identified in north of Dharmapuri. It needs to prepare urban master plan with integration of few towns.
- **Location B :** This is an accumulation along State highway-95 to Bengaluru. Smooth accessibility to Bengaluru should be involved into the master plan for this area.
- **Location C :** Border area between Andra Pradesh state and Tamil Nadu State forms a cluster of newly upgraded towns. This area has a possibility to be a production or logistic hub for surrounding area, because of closeness to 3 major ports and Tirupati airport.
- **Candidates of Industrial Node :** Only Bidadi is identified as Bidadi Integrated Township with conceptual master plan, however other areas don’t have any urban master plans (Tumkur NIMZ and Krishnapatnam Industrial Area are designed industrial development master plan). For this reason, newly urban master planning including industrial node development and compatibility with existing industrial development master plans are challenges for this area. In terms of Krishnagiri, this district is the remarkable population growth area. If Hosur will be selected as a short list of industrial node, there is a possibility to be concentrated population which is expected as future population in surrounding area.

6.9.3.3 Land Demand of Industrial Use

As mentioned in ***section 6.9.2.2***, 79,000 ha are estimated as industrial land demand next 20 years. However, the land availability in the urbanized area (e.g. two metropolitan areas) is limited, because majority of the land is already built-up and difficult to find the green fields. On the other hand, the 8 candidates of industrial nodes have large parcels of industrial development area (as total, 35,000 ha). In case it is assumed that the development speed is 200 ha/year for 1 node, industrial development of 1,600 ha (= 200 ha * 8 nodes) can be implemented per year in high priority area of the nodes. And it takes about 9 years to complete high priority area of 13,000 ha. The development of medium priority area of the nodes is intended to start from 5th year, and it takes about 14 years to complete the developments of 22,000 ha. As total, 35,000 ha is covered by node developments, however, the projected demands wouldn't be satisfied by the implementation of node developments and the gap of the land demands is estimated as 44,000 ha in year 2033. For the GAP, 44,000 ha of industrial development (2,200 ha per year) will be required in addition to node development.

The comparison between projected land demand and proposed projects is shown as below:

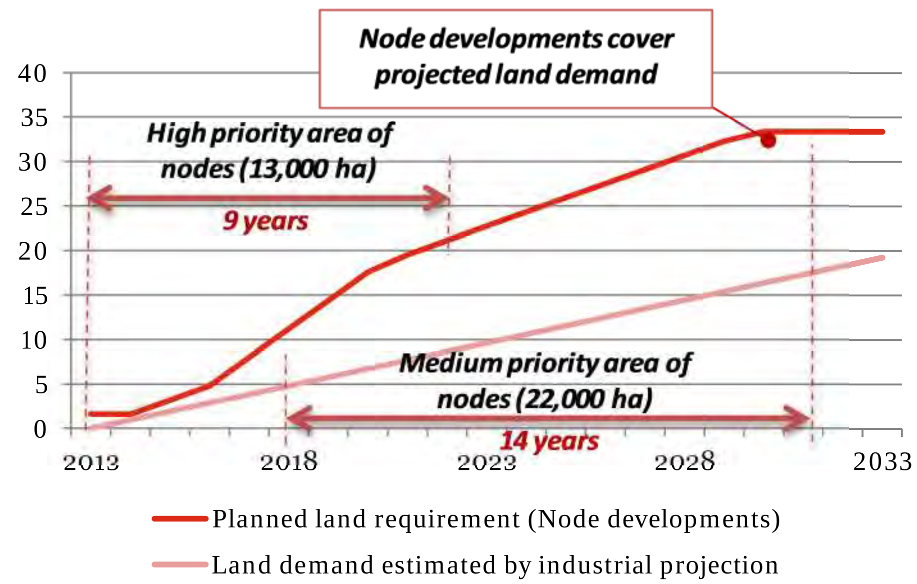


Note : 3/8 of total proposed project area is set up as high priority area of nodes, and 5/8 are medium priority area of nodes.

Source : TIDCO, SIPCOT, KIADB, APIIC and JICA Study Team

Figure 6.9.9: Projected Land Demand and Planned Land (Accelerated Scenario)

In case of Business As Usual Scenario, industrial land demand is projected as 20,000 ha additionally. Since the planned area of the industrial nodes is 35,000 ha, the projected land demand is covered by only the node developments.



Source : TIDCO, SIPCOT, KIADB, APIIC and JICA Study Team

Figure 6.9.10: Projected Land Demand and Planned land (Business As Usual Scenario)

6.9.4 *Urban Development Strategy*

Over the next 20 years, rapid population growth is projected in the whole CBIC area. This situation will accelerate upgrading from village to town and cause appearance of some high density areas. For this reason, new urban planning and updating of the existing urban master plans are urgent needed in order to control and regulate the developments. However the institutions managing the urban development are short staffed and need to be improving the management system to make it more effective. For this reason, capacity development of the concerned institutions and enhancement of institutional structure in parallel are necessary. For instance, digitization of land administration system linked by GIS database and improvement of building permission system are necesssary. Besides, also smooth government procedures and regulations regarding permissions and authorizations of the new developments should be included in the enhancement project for the concerned institutions.

Currently, existing companies which operate their factories in the CBIC area have some challenges against the operational environment. For instance, some industrial parks aren't connected to the public water supplying system. Because of this, they need to be develop the reservoir in their lands, buy the water from water tank cars of water supplier and develop the water recycling system. These investments are carried by the each company with their responsibility, it is identified the bottleneck for the investors. In addition this, unstable power supply and poor accessibility to the trunk roads are existing as the challenges to be solved immediately.

In response, Tamil Nadu State is implementing Tamil Nadu Investment Promotion Programs(TNIPP) to find the small scale projects to solve and improve the current situation. This is one of the ways to promote more investors to CBIC area. And second phase of this program for Tamil Nadu State and similar program for Karnataka State should be carried before completion of the node developments.

Table 6.9.5: Objectives and Strategies of Town and Industrial Development

Urban Development	**Objectives**	● Newly planning and updating of the urban master plan ● Development controls for urban area expansion ● Improvement of living environment and effectiveness of urban lives (e.g. improvement of infrastructure facilities to support the industrial growth etc.) ● Enhancement of development controls ability of concerned institutions
	Strategies	● Development of the exact criteria for the urban master plan (e.g. Definition of the criteria for the area which has to be planned urban master plan) ● Efficient development of public infrastructure centered on industrial node developments ● Enhancement of development control institution and capacity development of the related organization staff
Industrial Development	**Objectives**	● Solution of the challenges which existing industrial parks are holding ● Promotion of more industrial investments including foreign investors ● Securing of land for further industrial developments and development of the laws or regulations to carry out smooth implementation
	Strategies	● Provision of well-planned industrial area and improvement of current situation of the existing industrial parks (e.g. stable provision of water and electricity, improvement of the access road to the industrial area and improvement of the port accessibility etc.) ● Improvement of government procedures and related regulations to promote industrial investments and enhancement of management ability of the concerned government institutions. ● Implementation of land acquisition by government initiative for the priority developments

6.9.5 *Development Goals and Target Performance Indicators*

Population of CBIC area is projected to increase to 9 million in 2033. Accordingly, a total 172 areas will need planning for their areas. Urban planning for these 172 areas is a major target for their orderly development.

Regarding to industrial development, some parts of high priority area of node developments and other industrial developments without node developments are implemented as short-term projects (15,000 ha). The short list of industrial node developments should be continuously implemented up to mid-term to complete. In addition to remaining developments of high priority area of node developments and other industrial developments, medium priority area of node developments are implemented as mid-term projects(25,000 ha). After that, the 36,000 ha is planned to develop as long-term projects. It is necessary to cooperate with private developers for implementation to develop the projected industrial land demand. Thus, the government side has to facilitate its developments according to the development plans it prepares.

Table 6.9.6: Growth targets of Urban and Industrial Development

Item	*Unit*		*Short-term Target at 2018*	*Mid-term Target at 2023*	*Long-term Target at 2033*
Total Urbanized Area	Urban Area	New	+220 km^2	+240 km^2	+550 km^2
		Total	***2,190*** km^2	***2,430*** km^2	***2,9860*** km^2
Industrial Development	Development Area	New	+15,000 ha	+25,000 ha	+36,000 ha
		Total	**15,000 ha**	**40,000 ha**	**76,000 ha**
Town areas requiring Master Plans	Number of Towns	New	+43	+43	+86
		Total	**95**	**138**	**224**

Source : JICA Study Team

6.9.6 *Development Plan and Suggested Projects*

The preparation of urban master plans for newly urbanized areas is necessary to facilitate orderly development. In addition, some existing urban plans need to be updated because of rapid urbanization. However, concerned institutions suffer from chronic shortage of staff in the urban planning field. For this reason, capacity development of the urban planning sectors is needed to address this situation. And also, enhancement of the of the government structure, laws and regulations relating to the development controls should be carried out with the programs which is mentioned in ***section 6.9.4***

Regarding industrial developments, high priority area of the node developments are planned as short & medium-term projects and medium priority area of the node developments area planned as medium & long term projects. Short list of industrial node development is intended to be carried by collaboration of the government and private sector, but other projects are expected to implement with collaboration of the government and private sector or private sector only. Because of this, attraction of the private sector activities and promotion of investors are absolutely imperative.

It should be emphasized that currently operating foreign factories and developers for industrial park noted various issues in terms of accessibility from trunk road to industrial park, water availability, electricity availability, and accessibility to ports etc. Tamil Nadu Investment Promotion Program (TNIPP) is being carried out using JICA Yen Loan Scheme to improve such issues to promote investment. This program is mainly focusing on promotion of the infrastructure developments (e.g. road development, power supply, water supply etc.) to improve investment environment of Tamil Nadu State. Also, similar project for Karnataka state as well as TNIPP phase-2 should be realized and implemented to create good investment environment for foreign factorise and developers; such project proposals are mentioned in the project list below.

Table 6.9.7 : List of Town Development and Industrial Development Projects

No	Project Title	Status	Project Cost (Million US$)	Priority1/
U01	Urban Master Plan Planning and Capacity Development of Nodal Department (Upgrading/Newly Planning)	New	15 (52 towns)	A, B & C
U02	High Priority Area of Industrial Node Developments	New	5,200 (13,000 ha)	A& B
U03	Medium Priority Area of Node Developments	New	8,800 (22,000 ha)	B & C
U04	Other Industrial Developments without Node Developments	New	13,200 (44,000 ha)	A, B & C
U05	Industrial Development implemented by Local Development Companies	Ongoing	n.a. (12,800 ha)	A &B
U06	Tamil Nadu Investment Promotion Program	Ongoing	125	A &B
U07	Tamil Nadu Investment Promotion Program (Phase-2)	New	60	B&C
U08	Investment Promotion Project for Karnataka	New	125	A &B
U09	Industrial development management strengthening program for Tamil Nadu State Government	New	5	A &B
U10	Industrial development management strengthening program for Karnataka State Government	New	5	A &B
Total			***27,535***	

Note : 1/ "A" refers to projects for implementation before 2018, "B" refers to projects for implementation in 2018 – 2022, and, "C" refers to projects for implementation after 2023.
*2/ Unit price of node developments (U02 / U03) which includes development of sub station, water treatment plant, waste water treatment plant and other infrastructure developments are estimated as **40 USD/sq.m**, and other industrial developments(U04) with lower grade of infrastructures is estimated as **30 USD/sq.m** referred to industrial development of nearby and neighbouring countries.*
Source : JICA Study Team

6.9.7 *Phasing Plan*

Accordingly, projected population growth, town development and urban master plan preparation are planned as shown below for implementation in stages. However, because the expected town development area is large, the government needs to make a partnership with private sector investors.

High priority area of node developments are planned to be implemented as short-term projects and mid-term projects, and medium priority area of node developments are planned to be implemented as mid-term projects and long-term projects. Since a total of 27,705 million USD is forecasted to be needed to develop the projected industrial land demand and urban control framework. In addition to hard projects, capacity developments for the concerned institutions should be carried.

Table 6.9.8: Summary of Phasing Plan for Town Development and Industrial Development Sector Projects (Unit : Million USD)

Category	Short-term 2013-17	Mid-term 2018-22	Long-term 2023-33	Total
Urban Master Plan Planning (Upgrading/Newly Planning)	5	5	5	15
High Priority Area of Node Developments	2,600	2,600	-	5,200
Medium Priority Area of Node Developments without Node Developments	-	4,400	4,400	8,800
Other Industrial Developments	4,400	4,400	4,400	13,200
Tamil Nadu Investment Promotion Program (Phase-1)	60	65	-	125
Tamil Nadu Investment Promotion Program (Phase-2)		75	75	150
Investment Promotion Project for Karnataka	100	100	-	200
Skill development improvement project in Tamil Nadu	2.5	2.5	-	5
Industrial development management strengthening program for Tamil Nadu State Government	2.5	2.5	-	5
Industrial development management strengthening program for Karnataka State Government	2.5	2.5	-	5
Total	***7,172.5***	***11,652.5***	***8,880***	***27,705***

Source : JICA Study Team

6.10 Water

6.10.1 Sector Overview

6.10.1.1 Water resources

(1) The current status of water resources

1) Surface water

Surface Water sources in CBIC comprise Rivers, Reservoirs, Tanks etc., and depend on local rainfall. Majority of these sources are now being utilized for irrigation in major portion and a minor portion to domestic & industrial purposes. As irrigation water to the agriculture purpose is on priority and it involves the sensitive social factors, it is envisaged not to consider these surface water resources for industrial purposes in CBIC, until, unless a reliable water resource allocation is made by the respective State Governments in the absence of other water resources. Therefore, there are few water resources which can be used for drinking purposes and industrial purposes sustainably. In addition, there are not development plans of additional water resources such as a large-scaled dam which can improve drastically the current condition of water shortage for drinking purposes and industrial purposes.

In order to tackle the big issue of shortage of surface water resources for drinking purposes, an agreement between State Governments of Andhra Pradesh, Maharashtra & Tamil Nadu for drinking water supply to Chennai city is entered in the year 1983. Considering the scarcity of drinking water supply to metropolitan city of madras, three states have agreed to spare 5 TMC of water from Krishna River out of their respective shares to draw up to 15 TMC in a year. The cost incurred for necessary arrangements to bring water from Srisailam reservoir to Poondi reservoir and necessary O&M charges also to be borne by the state of Tamil Nadu. (*Source*: Website of Water Resources Information System of India)

2) Sea water

Sea Water is one of the potential water resource in the coastal areas of CBIC, especially Andhra Pradesh and Tamil Nadu States. At present, only Chennai Metropolitan Water Supply & Sewerage Board (CMWSSB) is operating 100 MLD desalinization plant at Minjur and 100 MLD plant at Nemmeli and has a proposal to construct a desalinization plant of 400 MLD capacity at Perur and an expansion of 150 MLD at Nemmeli.

Considering the current Seawater contribution to the domestic & industrial water supply of Chennai Metropolitan Area, it is envisaged that Seawater will be a potential water resource in CBIC, especially in the potential areas covered on coast line in Andhra Pradesh & Tamil Nadu.

3) Ground water

A) Tamil Nadu State

As per the Block wise categorization and state of ground water development as on march 2009, Tamil Nadu State has been classified into 139 Nos. as Over Exploited, 33 Blocks as Critical, 67 Blocks as Semi-critical Blocks and 136 Blocks as Safe out of 386 assessed blocks. Also, ground water depths in the districts of the state covered in CBIC are continuously depleting from year 2012 to the year 2013. The fall for average ground water depths (GWD) for the years 2012 & 2013 for the districts Chennai, Kancheepuram, Tiruvallur, Vellore, Thiruvannamalai, Dharmapuri & Krishnagiri are compared and presented in the figure below. The average ground water fall ranges from 0.04m (minimum) in Tiruvallur district to 2.02m (maximum) in Dhramapuri district for the years 2012 & 2013.

B) Karnataka State

As per the categorization of blocks by Central Ground Board (CGWB) (As on March 2009), total of 270 Nos. of blocks have been assessed, out of which 154 are Safe, 34 are Semi-Critical, 11 are Critical and 71 blocks are classified as Over Exploited.

C) Andhra Pradesh State

As per the categorization of blocks by Central Ground Board (CGWB) (As on March 2009), total of 1108 Nos. of blocks have been assessed, out of which 867 are Safe, 93 are Semi-Critical, 26 are Critical and 84 blocks are classified as Over Exploited. Latest average ground water rise from October-2012 to October-13 in Ananthapur & Chittoor districts are 0.84m and 2.18m respectively. The average ground water fall is recorded in Nellore District about 0.31m from October-12 to October-13.

CGWB has analysed the ground water resources availability, utilization and stage of development as on March 2009 for each district in a State. The net ground water availability is assessed for future irrigation use considering the net water availability (from ground water recharge) and groundwater draft including the projected demand for domestic & industrial uses up to 2025. However, the latest status of net water availability for domestic & industrial purposes is to be confirmed as on 2013. Such ground water availability can be treated as a potential water resource for domestic or industrial purposes in future depending on the potential ground water recharge and the subsequent ground water quality in the area under consideration.

The detailed data related to the current status of ground water is shown in Annex.

The current status and issues related to water resources are summarized as below.

i) In the three states located in CBIC , more than 80% of all water resources are used for irrigational purpose. In Karnataka State and in Andhra Pradesh State, one of the major water rice-growing area, more than 90% is used for irrigation.

ii) Surface Water sources in CBIC comprise Rivers, Reservoirs, Tanks etc., and depend on local rainfall. Majority of these sources are now being utilized for irrigation in major portion and a minor portion to domestic & industrial purposes. As irrigation water to the agriculture purpose is on priority and it involves the sensitive social factors, it is envisaged not to consider these surface water resources for industrial purposes in CBIC, until, unless a reliable water resource allocation is made by the respective State Governments in the absence of other water resources.

iii) Sea Water is one of the potential water resource in the coastal areas of CBIC, especially Andhra Pradesh and Tamil Nadu States. At present, only Chennai Metropolitan Water Supply & Sewerage Board (CMWSSB) is operating 100 MLD desalinization plant at Minjur and 100 MLD plant at Nemmeli and has a proposal to construct a desalinization plant of 400 MLD capacity at Perur and an expansion of 150 MLD at Nemmeli.

iv) Currently the ground water resources is utilized for the large portion of domestic and industrial purposes, the ground water accounts considerable part of total supplied amount of domestic water and industrial water in CBIC as of 2009 and 73% of industrial water is from the ground water resources at present. Although, there is an urgent need for the existing ground water resources to be developped on priority, approximately 55% of total ground water blocks in CBIC are estimated as “Over Exploited” as on March 2009. Therefore, although remaining 45% of ground water blocks has the potential to be developed additionally, the ground water resources can not be expected as a sustainable water resource, which can meet the future water demand. In addition, typically the ground water quality in CBIC is reducing year by year with respect to the decreased ground water levels. Also, Seawater intrusion in the coastal areas is an additional threat for poor ground water quality. It is recommended in CBIC area to develop the ground water resources and simultaneously to improve ground water quality with enforcement and continuous monitoring.

v) Selection of water resource for domestic or industrial water between surface water and sea water primarily depends on necessary costs for construction and O&M. According to the “DesalData” established by Global Water Intelligence (GWI), sea water desalination cost by reverse osmosis (RO) method, which is the most common method for desalination, has been reduced to as low as 0.8USD/m^3 including depreciation and O&M costs as the worldwide average. On the other hand, water production cost from surface water in India, which varies by raw water quality, is in a range of 0.1 to 0.3USD/m^3 in general.

vi) However, if surface water is not available within several-hundred-kilometer distance from a demand center, water production cost from surface water can be more expensive than desalination cost. If the demand center is located in coastal area, breakpoint of surface water treatment in terms of the distance of the water resource will be between 200 km to 400 km, which highly depends on geographical conditions along the water transmission line. In addition, it should also be noted that a long-distance transmission of surface water raises risk of system failure caused by unexpected accidents.

vii) Another important factor in selection of water resource between surface water and sea water is water resource allocation. Because it is free from the existing allocation system of water resources such as surface water and ground water, sea water desalination is advantageous in necessary procedures to realize the project and in possible capacity to develop or expand.

viii) As discussed above, finally, selection of water resource between surface water and sea water should be carried out based on overall costs, reliability of the system and hurdles to secure sufficient amount of surface water.

6.10.1.2 Domestic Water Supply

The current status and issues related to domestic water supply schemes are listed below. The numerical values which are described in following bullet points are sourced from the results of Demand/Supply Gaps in the later part.

i) All corporations and municipalities in CBIC have piped water services and the coverage is more than 90% in population, which is illustrated in Annex.

ii) The domestic water demand of CBIC is projected to increase with the future population growth, the demand in 2018 is estimated 119% of that in 2013, the demand in 2023 is estimated 133% of that in 2013 and the demand in 2033 is estimated 156% of that in 2013.

iii) Accordingly, the total demand/supply gap of domestic water in CBIC is estimated to continue to increase, the gap in 2013 is about 770MLD, that in 2018 will be about 1,060MLD, that in 2023 will be about 1,330MLD and that in 2033 will be about 2,210MLD.

iv) In the target states in CBIC, there are many ongoing and planned projects to expand the present water supply service. Contribution of ongoing water supply projects in CBIC is 502.5 MLD with a distribution of 42% in Tamil Nadu State, 23% in Karnataka State and 35% in Andhra Pradesh. Pre-Planned projects in CBIC contribute to the domestic water demand by 754 MLD, out of which 550 MLD is by Chennai, 10 MLD by Bengaluru Rural, 10 MLD by Tumkur and 184 MLD by Chittoor. Ongoing & planned water supply projects are listed in the Annex.

v) The supplied amount of domestic water of CBIC is projected to increase because of on-going and planned development projects of water supply schemes. However, the supplementary supply of domestic water which need to be met from the saving of fresh water being utilized by Industries by suitable adoption of the recycle water systems and by utilizing the recycled doemstic sewage as a potential water resource in the long term. Besides, the above savings, additional or expanded water supply schemes are proposed to meet the demand-supply gaps in short term, medium term & Long term.

vi) The water loss in distribution network of domestic water will have to be reduced in many corporations, municipalities and towns in CBIC area. As shown in Figure 6.10.23, for example, water loss ratio in Bangalore is more than 40% (There is a report that it is currently less than 40% but it is still at a high rate.). Worldwide, well-developed water supply schemes have achieved water loss ratios lower than 20%. In addition, in some areas where available water resource is limited such as Manila in the Philippines and Sao Paulo in Brazil, less-than-20% water loss ratios are pursued.

6.10.1.3 Industrial Water Supply

The current status and issues related to industrial water supply schemes are listed below.

i) The industrial water demand for the new indutrial development of CBIC is projected to increase with the future industrial development plan.

ii) According to the demand/supply gap of domestic water in CBIC, the gap is about 1,900MLD as of 2013.

iii) With refrence to the industrial water productivity, the productivity of industrial water in India is significantly at a low level compared to other countries, although the productivity is highly dependent on category of industry. Industrial water demand is forecast to increase at a high rate in the future, but it will be possible to lower the rate of demand increase by pursuing efficient water use in the industrial sector.

6.10.1.4 Sewerage

The current status and issues related to sewerage schemes are listed below.

i) Sanitary conditions in the CBIC area are almost at the same level as the national average.

ii) In the target area of CBIC, only two metro cities (Chennai and Bangalore) and 13 urban municipalities have sewage treatment plants (hereinafter called STPs), the ratio of connected population to the existing STPs is only 27%, which is illustrated in Annex.

iii) The other municipalities and most of the towns do not have STPs and they discharge untreated wastewater directly in to public water bodies or storm water drains. Hence, development of covered sewerage system with proper treatment facilities will be on priority, besides improvement of service levels in drinking water to these urban & semi-urban areas.

iv) Ongoing projects of Sewerage in CBIC contribute to a treatment capacity of 413.5 MLD, major being the capacity created in Bengaluru Urban area, which is of 345 MLD capacity. Pre-planned projects sewage treatment capacity is about 1018 MLD. Ongoing & planned Sewerage projects are listed in the Annex.

v) The Indian effluent standard which is applied to STPs is described in Table 6.10.1, additionally the effluent standard of Tokyo Metro. Japan is also described in the same Table 6.10.1.

Table 6.10.1 Effluent Standard of India and Japan (Tokyo)

No.	Parameter	Indian	Japanese (Tokyo Metro.)
		Discharge to Inland surface water	Discharge to General Inland water bodies from STPs
1	Suspended solids (SS)	100 mg/L	New developed STP: 10 mg/L Existing STP: 60 mg/L
2	Biochemical Oxygen demand (BOD)	30 mg/L	New developed STP: 15 mg/L Existing STP: 25 mg/L
3	Chemical Oxygen Demand (COD)	250 mg/L	New developed STP: 15 mg/L Existing STP: 35 mg/L
4	Total Nitrogen (T-N)	--	New developed STP: 20 mg/L Existing STP: 30 mg/L
5	Ammonical nitrogen (as N)	50 mg/L	--
6	Total Kjeldahl Nitrogen (as NH_3)	100 mg/L	--
7	Free ammonia (as NH_3)	5 mg/L	--
8	Nitrate Nitrogen	10 mg/L	--
9	Dissolved Phosphates (as P)	5 mg/L	New developed STP: 1 mg/L Existing STP: 3 mg/L
10	pH Value	5.5 to 9.0	5.8 to 8.6
11	Temperature	shall not exceed 5°C above the receiving water temperature	shall not exceed 40°C
12	Oil and grease	10 mg/L	5 mg/L
13	Total residual chlorin	1 mg/L	--
14	Arsenic (as As)	0.2 mg/L	0.1 mg/L
15	Mercury (as Hg)	0.01 mg/L	0.005 mg/L
16	Lead (as Pb)	0.1 mg/L	0.1 mg/L
17	Cadmium (as Cd)	2 mg/L	0.1 mg/L
18	Hexavalent Chromium (as Cr^{+6})	0.1 mg/L	0.5 mg/L
19	Total chromium (as Cr)	2 mg/L	2 mg/L
20	Copper (as Cu)	3 mg/L	3 mg/L
21	Zinc (As Zn.)	5 mg/L	2 mg/L
22	Selenium (as Se)	0.05 mg/L	0.1 mg/L
23	Nickel (as Ni)	3 mg/L	--
24	Cyanide (as CN)	0.2 mg/L	1 mg/L
25	Fluoride (as F)	2 mg/L	8 mg/L
26	Sulphide (as S)	2 mg/L	--
27	Phenoile compounds (as	1 mg/L	5 mg/L
28	Radioactive materials :		
	(a)Alpha emitter micro curie/ml.	10^{-7}	--
	(b)Beta emitter micro curie/ml.	10^{-6}	--
29	Bio-assay test	90% survival of fish after 96 hours in 100% effluent	--
30	Manganese (as Mn)	2 mg/L	10 mg/L
31	Iron (as Fe)	3 mg/L	10 mg/L
32	Vanadium (as V)	0.2 mg/L	--

Source: Central Pollution Control Board, Website of Tokyo Metropolitan Government

Basically, the Indian effluent regulations of general parameter such as SS and BOD in India are not stricter than Japan.

6.10.1.5 Drainage

According to NDMD, although the country is facing serious damages by floods, the CBIC area is not generally liable to flood as illustrated in Figure 6.10.1. This low possibility of flood in the area will be firstly because of the less precipitation and secondly geographically advantageous conditions. However, it should be noted that there have reportedly been several flood events in local areas in Chennai City which have flat and low-elevation areas close to the coast.

Overall, the CBIC area is not flood liable area but there are some local areas where floods can occur especially in the coastal areas in the Tamil Nadu State. In view point of industrial development, in order to avoid or mitigate flood risk, nodal points of the industry should be selected through a careful review of geographic conditions and past flood record.

Source: January 2008, National Disaster Management Authority, National Disaster Management Guidelines – Management of Flood –

Figure 6.10.1 Flood Liable Areas in India

Especially in Chennai City it should be noted that there have reportedly been several flood events because of flat terrain and low-elevation areas close to the coast. In order to mitigate flood damages, Corporation of Chennai City has developed and maintains a storm water drain network of approx. 1660km and 31 canals crossing across the city. Rain water runoff is drained thorough the storm water drain network & canals and reaches the Bay of Bengal via five waterways running across the Chennai City. In addition, the Chennai city is expanding the storm water drainage facilities, 130km length of storm water drain and 29km length of canal, which is in progress. Moreover, the Corporation of Chennai also has a plan to develop a storm water drain network and improve canals in the extended areas of Chennai City.

6.10.1.6 Constrains for industrial development

i) At present, Government has the higher priority for domestic water supply due to the social causes & Irrigation water for agriculture purpose for food security. Hence, it will be difficult for the respective state governments to allocate the surface water resources for industrial usage.

ii) Also, Due to the limited ground water availability with successive depletion of ground water levels year by year and reduced water quality, most of the ground water blocks are changed to “Over Exploited” and hence there is a limitation of the supply of ground water to the industries by the respective authorities.

iii) Non-availability of Water Sector Master Plan at District level with specific allocations for Agricultural, Domestic & Industrial purposes is one of the important reasons for Government's limited action to the industrial water supply.

iv) Institutionally, many authorities operate, control, monitor & regulate the water resources with their own targets & goals in CBIC. Hence, specific coordination between the authorities cannot be achieved without a centralized water agency to coordinate for the industrial water needs in CBIC.

6.10.2 *Demand Forecast*

6.10.2.1 Water demand forecast

(1) Domestic water

The domestic water demand is computed through the following steps.

i) The domestic water demand = (the forecasted population) x (the target per capita water supply amount)

ii) The target per capita water supply amount is used the LPCD (litre per capita per day) value shown in Table 6.10.2 which is based on the CPHEEO (The Central Public Health and Environmental Engineering Organization) Guideline nationwide.

Table 6.10.2 Target per capita water supply amount in the gap analysis

Level	Per capita water supply amount
Corporation	150
Municipality	135
Town	70
Village	40

Source: CPHEEO Guideline

iii) The existing villages may become urban either towns or municipalities in accordance with the population increase in the future, also the existing towns may become municipalities in the future. However, the JICA Study Team assumes that the "status of ULB" for corporation, municipality, town and village will not change in this gap analysis.

(2) Industrial water

The industrial water demand is computed through the following steps.

i) The current industrial water demand as of 2013 is based on the information provided by the authorities concerned, the district-wise current industrial water demand is assumed to be current amount of industrial water as described in Table 6.10.3.

Table 6.10.3 Existing Industrial Water demand details of in each District of CBIC

State	District	Supplied Amount of Industrial Water			
		Surface Water (MLD)	Ground Water (MLD)	Sea Water (MLD)	District Total (MLD)
Tamil Nadu	Chennai	47.2 (96.9%)	1.3 (2.7%)	0.2 (0.4%)	48.7 (100%)
	Thiruvallur	120.9 (46.5%)	138.3 (53.2%)	0.9 (0.3%)	260.1 (100%)
	Vellore	13.7 (21.3%)	50.3 (78.4%)	0.2 (0.3%)	64.2 (100%)
	Tiruvannamalai	4.1 (24.7%)	12.5 (75.3%)	0 (0.0%)	16.6 (100%)
	Kancheepruam	236.1 (66.0%)	121.8 (34.0%)	0.1 (0.0%)	358.0 (100%)
	Krishnagiri	9.9 (40.7%)	14.4 (59.3%)	0 (0.0%)	24.3 (100%)
	Dharmapuri	0.6 (7.4%)	7.5 (92.6%)	0 (0.0%)	8.1 (100%)
Karnataka	Bangalore Urban	906.7 (%)	2553.1 (%)	0 (0.0%)	3459.8 (100%)
	Bangalore Rural	44.1	153.1	0	197.2

State	District	Supplied Amount of Industrial Water			
		Surface Water (MLD)	**Ground Water (MLD)**	**Sea Water (MLD)**	**District Total (MLD)**
		(22.4%)	(77.6%)	(0.0%)	(100%)
	Chikkaballapura	0.1 (14.3%)	0.6 (85.7%)	0 (0.0%)	0.7 (100%)
	Chitradurga	7.5 (5.8%)	122.1 (94.2%)	0 (0.0%)	129.6 (100%)
	Kolar	2.0 (19.4%)	8.3 (80.6%)	0 (0.0%)	10.3 (100%)
	Ramanagara	10.2 (8.8%)	106.1 (91.2%)	0 (0.0%)	116.3 (100%)
	Tumkur	0.7 (0.1%)	480.2 (99.9%)	0 (0.0%)	480.9 (100%)
Andhra Pradesh	Anantapur	0 (0.0%)	17.0 (100.0%)	0 (0.0%)	17.0 (100%)
	Chittoor	0 (0.0%)	6.6 (100.0%)	0 (0.0%)	6.6 (100%)
	Nellore	3.6 (16.8%)	17.8 (83.2%)	0 (0.0%)	21.4 (100%)
CBIC-Total		1,407.4 (27.0%)	8,811.0 (73.0%)	1.4 (0.0%)	5,219.8 (100%)

Source: JICA Study Team

ii) The future industrial water demand is converted from the current industrial water demand as of 2013 with using the growth rate of industrial output forecast and the improvement of industrial water productivity, which is calculated from the following equation.

iii) The future industrial water demand = (the current industrial water demand as of 2013) x (the growth ratio of industrial output forecast) x (the reduction ratio of industrial water demand by the efficiency of productivity)

iv) In regard to water consumption for industry, Indian industries are expected to use supplied water more effectively in the future. Table 6.10.4 is the comparison of the unit consumption of industrial water of some industrial categories of India and Japan, which shows the unit water consumption of Indian industries are 3 – 7 times (5 times on average) larger than that of Japan.

Table 6.10.4 Comparison of unit water consumption of industrial water of India and Japan

Industrial Category	Unit Consumption of Industrial Water (m^3/ha/day)	
	India	Japan
Engineering Industry	12.5	2.0
Heavy Engineering Industry	22.5	4.0
Textiles	55.0	19.0

Source: Gujarat Industrial Development Corporation planning department, Census of Japanese Industry

v) For the future the unit consumption of industrial water of India can be expected to be reduced because of the promoting of efficiency of machineries and equipments, capacity building of workers. Therefore, the unit consumption of industrial water is assumed to be improved gradually to the Japanese level which is 1/5 of Indian level as described in Table 6.10.4 after 20 years, the reduction ratio of industrial water demand by the efficiency of productivity is estimated as follows;

In 2013 =1, in 2018 =1/2, in 2023 =1/3, in 2033 =1/5

(3) Sewage water

The demand of sewage treatment is the forecasted sewage generation amount which is at 80% of the domestic water demand as per the Indian Standard (CPHEEO) norms.

6.10.2.2 Water supply projection

(1) Domestic water

The domestic water supply projection is computed through the following steps.

i) The current supply amount at 2013 = (the population as of 2013) x (the current per capita water supply amount), which is obtained from the authorities concerned.
ii) The projected supply amount at 2018 = (the current supply amount at 2013) + (the capacity of WTP of the on-going projects). The on-going projects are assumed to be completed by 2018.
iii) The projected supply amount after 2023 = (the projected supply amount at 2018) + (the capacity of WTP of the planned project). *The JICA Study Team assumes the planned projects will be completed by 2023 and the domestic water supply projection will not increase after the completion of planned projects.*

(2) Industrial water

The industrial water supply is computed as follows.

i) The current supply amount at 2013 is based on the information provided by the authorities concerned, and the existing industrial water supply is assumed to at 70% of the level of supply of the domestic water as specified in the Table 6.10.1.
ii) As it stands now, most of industrial zones and factories acquire the freshwater from their own wells and reservoirs of rainwater or purchase the freshwater from the tankers. In addition, there are few planned projects of the public water supply services for industrial zones. Therefore, the JICA Study Team assumes that the domestic water supply services cannot be utilized for the industrial activities now and in the future.
iii) For the present situation and assumption, the future industrial water supply projection is estimated at the same amount of supply as the current supplied amount of industrial water as of 2013.

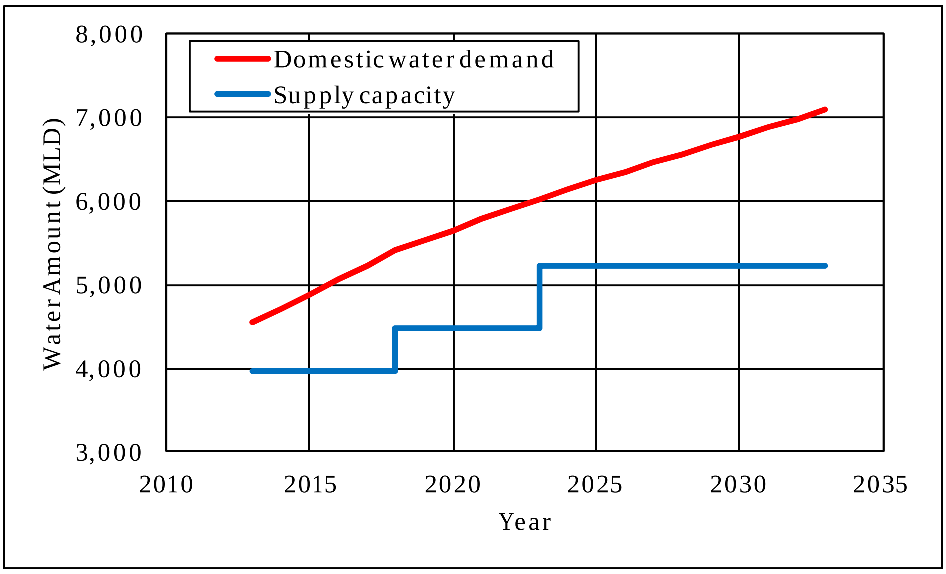
(3) Sewage water

The supply of sewage treatment means the capacities of sewage treatment plants (STPs). As well as the domestic water supply scheme, the future projected capacities of STPs is computed with consideration for the on-going projects and the planned projects, in which the on-going projects are assumed to be completed by 2018 and the planned projects are assumed to be completed by 2023.

6.10.3 *Demand/Supply Gaps*

6.10.3.1 Domestic water

As the results of analysis of domestic water, the demand/supply gap amounts and supply/demand percentages are given in the in Figures 6.10.2 – 6.10.4.



Source: JICA Study Team

Figure 6.10.2 Comparison of domestic water demand and water supply capacity in whole CBIC

Source: JICA Study Team

Figure 6.10.3 District-wise demand/supply gap of domestic water in CBIC in 2013

Source: JICA Study Team

Figure 6.10.4 District-wise demand/supply gap of domestic water in CBIC in 2033

Observations on the results of demand/supply gap analysis of demestic water are listed below.

i) Presently, the northeastern area of Bangalore Metro which includes Bangalore Rural District, Kolar District and Chikkaballapura District in Karnataka State are the most water-stressed area in CBIC, although the Urban Bangalore District has a better access to drinking water due to concentrated investment on the ongoing water supply project. Dharmapuri District and Krishnagiri District in Tamil Nadu State can fill the domestic water demand after the Hogenakal Project, although amount of excess water is not enough for development of industrial node. Limited allocation of the water from the Cauvery River to the state and reported high concentration of fluoride in groundwater in the area suggest that there will be little potential for more drinking water. However, if the groundwater with fluoride is usable for industrial purposes, groundwater may be utilized.

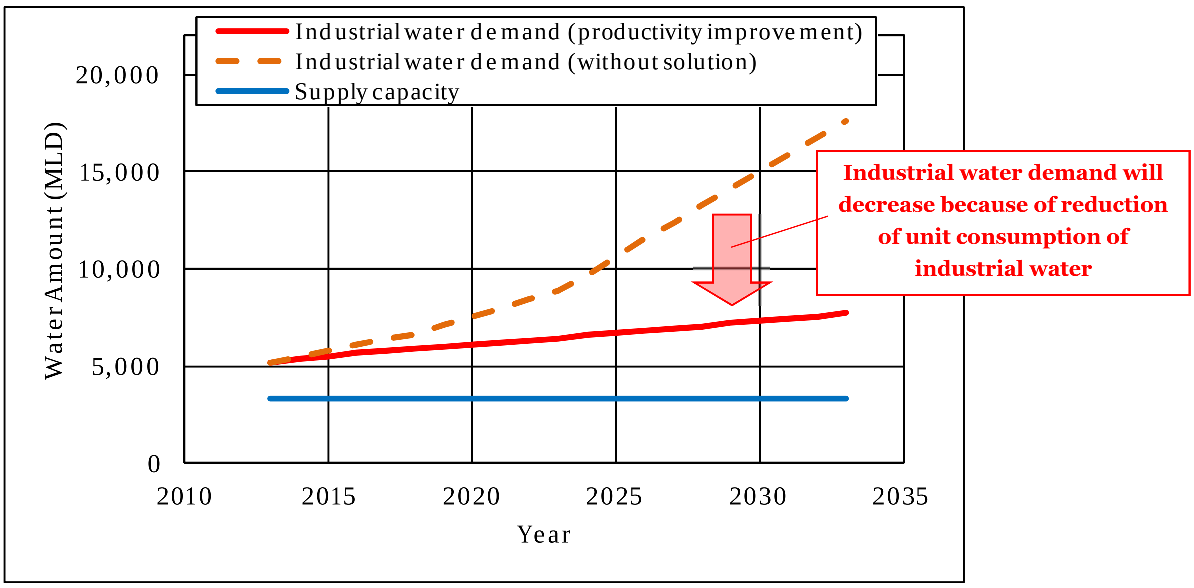
ii) Vellore District currently has only about 70% of water supply against the water demand and the supply gap is about 75MLD. The ongoing 181 MLD project will fill the gap but it should be noted that TWAD Board is to close the existing WTP treating water of the Palar River due to the polluted raw water. Improvement or utilization of water quality of the river may create excess water to be used for industrial purposes.

iii) The surrounding areas of Chennai Metro including Thiruvallur District and Kancheepuruam District in Tamil Nadu State have only 50 – 70% of water supply against the water demand for drinking purpose. Regardless of this situation, these two districts have large amount of industrial water supply as observed in Figure 6.10.2 and 6.10.3. This means that these two districts do not have enough drinking water because of large amount of industrial water use. Therefore, it is difficult to develop an additional industrial node in Thiruvallur District and Kancheepuruam District from the view point of water balance between drinking water and industrial water.

iv) Chennai, Vellore District and Chittoor District will be able to fill the demand/supply gap in 2023 and 2033 because of the planned large-scaled water supply projects. However, the demand/supply gaps of other districts will increase in the future because of the demand rise with population growth. Therefore, it is necessary to plan the water management strategically.

6.10.3.2 Industrial water

As the results of analysis of industrial water, the demand/supply gap amounts and supply/demand percentages are presented in the Figures 6.10.5 – 6.10.7.



Source: JICA Study Team

Figure 6.10.4 Comparison of industrial water demand and water supply capacity in whole CBIC

Source: JICA Study Team

Figure 6.10.6 District-wise demand/supply gap of industrial water in CBIC in 2013

Source: JICA Study Team

Figure 6.10.7 District-wise demand/supply gap of industrial water in CBIC in 2033

Observations on the results of demand/supply gap analysis of industrial water are listed below.

i) From the comparison of industrial water demand and supply which is presented in Figure 6.10.4, there is a clearly effect of the improvement of industrial water productivity. In case that no countermeasure will be implemented against the current situation of industrial water use, the industrial water demand forecast in 2033 will become more than 3.4 times higher than that in 2013. However, if the industrial water productivity will be improved, the industrial water demand in 2033 can be saved to 1.5 times of 2013. Therefore, it is crucially important to introduce Japanese investments and technologies for the industrial development with overcoming the water-stressed conditions in CBIC.

ii) The demand/supply gap of industrial water will increase in line with the industrial development projection. The present industrial gap is about 1899 MLD in CBIC, with higher industrial water demand in Bengaluru urban area about 66% of CBIC industrial water demand.

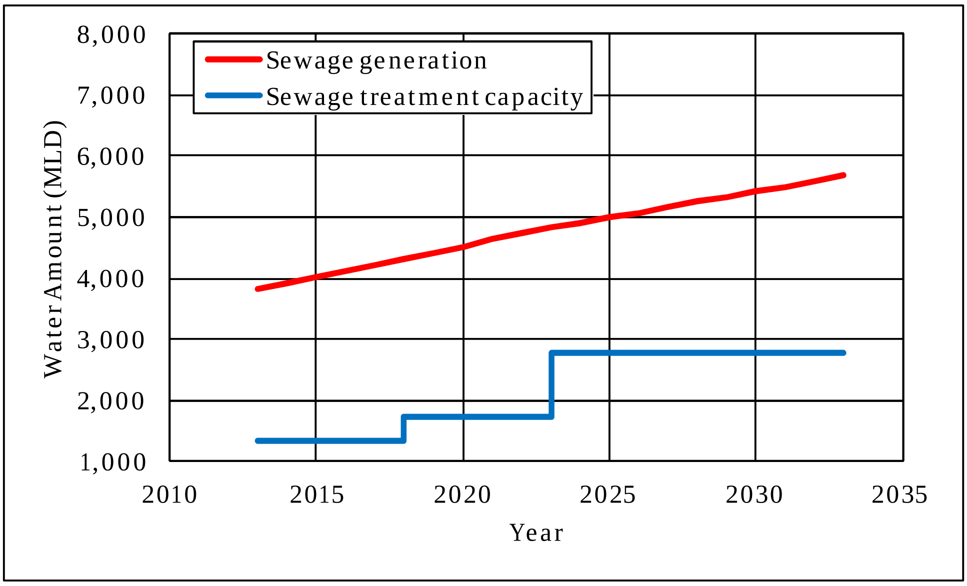
iii) Additionally, the existing industries / industrial parks in CBIC have to adopt the wastewater recycle system in oder to minimize the fresh water utilization, the existing industrial wastewater generation is about 1562 MLD, which can be re-cycled effectively and the existing industrial demand-supply gap can be met.

iv) Considering the district-wise trend, the demand/supply gap of industrial water will expand especially in the districts around Chennai Metro and Bangalore Metro, the gap of Chennai District, Kancheepuram District and Bangalore Rural District will increase more than 100MLD in 2033.

v) Some of the existing and planned industries / industrial parks surrounding to the Chennai Metropolitan Area are facing water severity. For exmaple, Chennai Metropolitan Water Supply & Sewerage Board (CMWSSB) has a plan to convey treated sewage using Teriary Treatment Reverse Osmosis (TTRO) plant of 45 MLD capacity at Koyambedu, and ultimately expand it to 90 MLD in future. Implementation of such scheme will help the industrial estates near Sriperambudur and ultimately reduce the stress on ground water, being one of the current major water source in this locality.

6.10.3.3 Sewage water

As the results of analysis the domestic sewage generation (demand), supply and their gap are presented in Figure 6.10.8-6.10.10.



Source: JICA Study Team

Figure 6.10.8 Comparison of sewage generation and sewage treatment capacity in whole CBIC

Source: *JICA Study Team*

Figure 6.10.9 District-wise demand/supply gap of sewage water in CBIC in 2013

Source: *JICA Study Team*

Figure 6.10.10 District-wise demand/supply gap of sewage water in CBIC in 2033

Observations on the results of demand/supply gap analysis of STP capacities is listed below.

- At present, only two metro cities (Chennai and Bangalore) and 13 urban municipalities have STPs in CBIC, accordingly in every district other than Chennnai and Bangalore Urban less than 20% of generated sewage can be treated before discharging to public water bodies because of the shortages of existing sewage treatment capacity at present.
- Kancheepuram, Tiruvannamalai, Vellore, Dharmapuri and Krishnagiri in Tamil Nadu State will improve the shortages of sewage treatment capacities because of on-going or planned projects, more than 30% of generated sewage will be able to be treated in 2033.
- Kolar and Chikkaballapura in Karnataka State will also improve the sewage treatment capacities because of on-going projects, more than 20% of generated sewage will be able to be treated in 2033.
- In contrast, Bangalore Rural and Chitradurga will not improve the sewage treatment capacities, less than 5% of generated sewage will be able to be treated even in 2033. Therefore, additional STPs are required to be developed.

6.10.4 *Infrastructure Development Strategy*

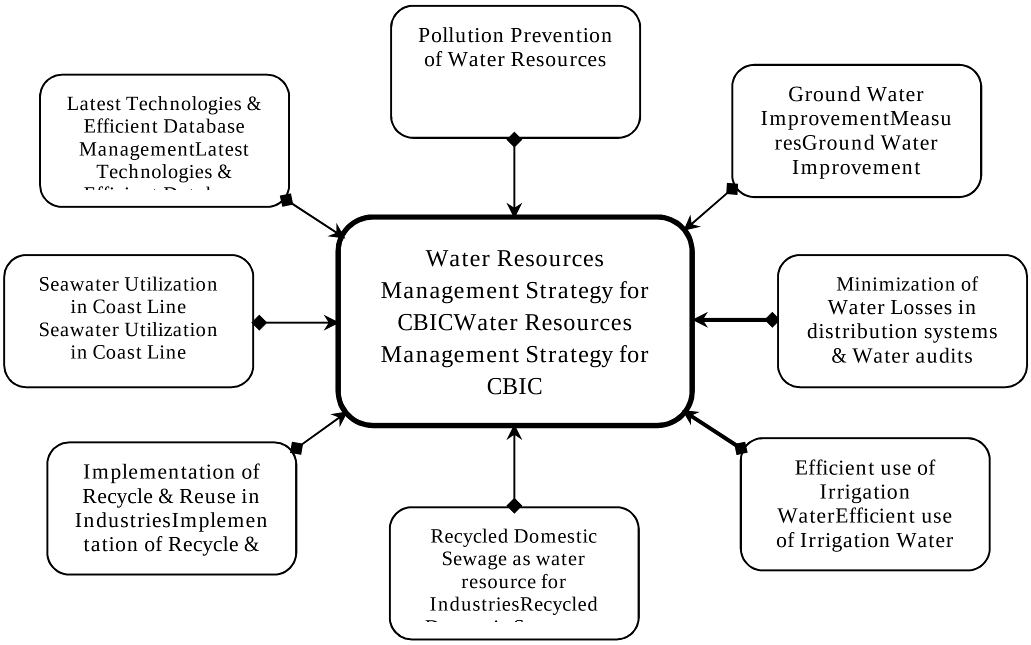
Through the studies above on the current conditions and issues related to water management in CBIC, the following objectives and strategies are proposed to improve the current status as described in Table 6.10.5.

Table 6.10.5 Summary of water subsector objectives and strategies

Infrastructure Development	Objectives	1) To fill the demand/supply gap of domestic water 2) To fill the demand/supply gap of industrial water 3) To utilize the limited local water resources effectively
	Strategies	1) Utilization of sea water as an alternative water resource for the coastal areas 2) Recycle of Sewage and Industrial Wastewater as alternative water resources 3) Saving water consumption 4) Other Supporting Measures shown in Figure 6.10.10
Operations / Management	Objectives	1) Minimization of Losses in the Distribution System 2) Telescoping Tariff Structure 3) Reduction of Operation & Maintenance Cost 4) Quality Assurance
	Strategies	1) Metering & Regular Water Auditing 2) Incentives for Water savers 3) Effective utilization of resources 4) Monitoring & Mitigation
Institutional	Objectives	1) Capacity Building for planned Infrastructure development 2) Skill Management
	Strategies	1) Strengthening of resources at National /State / Local levels. 2) Training on advanced technologies

Source: JICA Study Team

In order to fulfil the objectives set for water sector, overall water resources management strategy for CBIC area is shown in the Figure 6.10.11.



Source: JICA Study Team

Figure 6.10.11 Overall water resources management strategy for CBIC

Figure 6.10.10 shows the possible activities that will contribute to the water resources management in CBIC, and accordingly, some of these strategies are explained below.

1) Sea Water Utilization in Coast Line

Because of the limited water resources, additional water resources which are alternative to surface water resources and ground water resources are necessary for the additional industrial development. Sea water is a potential water resource in the coastal areas of CBIC. At present, only Chennai Metropolitan Water Supply & Sewerage Board (CMWSSB) is operating the desalination plants. Considering the current sea water contribution to the domestic & industrial water supply of Chennai Metropolitan Area, Sea water is expected to be an alternative water resource in CBIC, especially in the potential areas covered on coast line in Andhra Pradesh & Tamil Nadu.

The desalination technologies are necessary in order to utilize sea water for domestic purpose and industrial purpose. Total capacities of more than 40,000 MLD of desalination plants have been developed in the world, more than 50% of all desalination plants have been developed in water-stressed countries such as Gulf countries of Middle East, Mediterranean countries and North African countries.

The desalination technologies are classified into the Evaporation Process and the Membrane Process. The evaporation process is the desalination technology to produce fresh water by evaporating sea water. The evaporation process is suitable for the bulk production but consume energy more heavily than the membrane process, thus this process is generally utilized in the oil-producing countries in Middle East which can procure fossil fuel at a low price.

In contrast, the membrane process is the desalination technology to produce fresh water by filtration of sea water with the Reverse Osmosis (RO) membrane. Generally the construction cost of RO process is lower than the evaporation process. In addition, the RO process requires pre-treatment cost higher than the evaporation process in order to prevent the RO membrane clogging, but the energy consumption is lower than the evaporation process and total running cost is generally lower than the evaporation process. Therefore, this process is extensively-utilized in the countries other than Middle East countries.

Some of these desalination plants have been developed by Japanese manufacturers of wastewater treatment plants, and the current market share of Japanese manufacturers is about 20%. Moreover, the production of RO membrane is also Japanese specialty, the market share of Japanese manufacturers amounts more than 60%.

To support the industrial activities in the proposed industrial nodes located near the coastal area in Andhra Pradesh & Tamil Nadu from the aspect of sustainable water supply, the desalination system with RO process should be introduced and operated with use of Japanese advanced technologies.

2) Implementation of Recycle & Reuse in Industries

At present, most of the industries follow the “Zero Discharge Process” to comply the CPCB regulation, however the utilization of recycled water into the process is very minimal, most of industries utilize the treated wastewater for horticulture in their own sites. In order to support industrial activities in the proposed industrial nodes sustainably from the aspect of water supply, it is recommended to develop wastewater recycle systems by adopting advanced technologies.

The membrane processes are commonly-used as advanced technologies for recycle of industrial wastewater, and some Japanese manufacturers of wastewater treatment plants have developed these technologies in Japan and other countries, which can recycle more than 70% of wastewater. Generally these membrane processes are introduced as a tertiary treatment after the target wastewater is treated to the water quality which can be discharged to the public water bodies in primary and/or secondary processes. In addition, these membrane processes are classified into Micro-Filtration (MF) Process, Ultra Filtration (UF) Process, Membrane Bioreactor (MBR) Process and Reverse Osmosis (RO) Process, which are selected and can be combined on the basis of the required quality of recycled water.

In order to follow the “Zero Discharge” regulation and continue the industrial activities in the proposed industrial nodes in “water-stressed” CBIC, the wastewater recycle system should be introduced and operated with use of Japanese advanced technologies.

3) Recycle of domestic sewage as water resource for industries

Recycled Domestic sewage is also considered as one of the alternative water resources, especially for industrial usage. At present, only two metro cities (Chennai & Bangalore) in CBIC have schemes to recycle the domestic sewage. It is recommended development vision to develop additional STPs with recycle facilities of sewage around the proposed industrial nodes which are expected to increase the sewage generation with industrial development.

The membrane processes are commonly-used as advanced technologies for recycle of sewage as well as the recycle of industrial wastewater. Also, these membrane processes are introduced as a tertiary treatment after the target sewage is treated to the water quality which can be discharged to the public water bodies in primary and/or secondary processes.

In CBIC, 410 MLD capacities of additional STPs will be developed by 2018 and 1018 MLD by 2023 with considering ongoing & planned projects. Using the advanced recycling technologies, the un-utilized water resources can be recycled and used for Industrial purposes.

4) Efficient Use of Irrigation Water

In India, allocation to irrigational water is given the highest priority. Due to the limited water availability in CBIC, in order for acceleration of industrial development in CBIC, shift or dedicated allocation of irrigational water to domestic or industrial water will be necessary. In order to enable such a reallocation of water resources, involvement of higher authority is required, which have strong right and capacity of coordination between the stakeholders based on long-term and wide visions for the country’s development.

5) Minimization of water loss in the distribution systems

Considering the severity in the water availability in CBIC, corporations, municipalities and towns should make further efforts to minimize water losses in distribution network. Also, more emphasis has to be given in reduction of water loss in CBIC, as the water saved is water created. Regular water audits will help the water systems to function efficicently. Also, metering system need to be implemented for the real time quantification of water supplied.

6) Ground Water Improvement Measures

Simultaneous measures to be implemented to improve the ground water situation in CBIC such as Rain water harvesting in all urban & rural localities by CGWB regulations, which will enable water allocation for domestic purposes in future.

7) Pollution prevention of water resources

Re-cycling of domestic sewage & industrial wastewater generated will prevent the possible pollution of existing water resources such as rivers, water tanks. Additionally, effective solid waste management practices by ULBs & industries will avoid pollution of existing water resources.

8) Latest Technologies & Efficient Database Management

Adoption of latest advanced technologies in implementation of the proposed schemes in water sector will help in improving the services to both domestic & industrial sectors. Also, efficient database management in water sector, either domestic or industrial sectors will help in building a decision support system in future and has long term advantages.

9) Saving water consumption

In order to utilize the limited water resources, tariff structure will need to be reconsidered to give big water consumers incentives for water saving. It will also motivate the industries for water recycle.

For the selected nodes, methodology shown in the Figure 6.10.10 is adopted in general, besides critical evaluation of the specific local conditions such as sea water availability, specific allocations made to industries from surface water resources, ground water status & improvement plans by concerned authorities, exiting sewage treatment facilities & re-cycle infrastructure and existing industries re-cycling capability. Considering the above mentioned localized conditions, selected industrial nodes will be evaluated for the infrastructure gap, accordingly, the infrastructure gap will be fulfilled with supporting proposals in order to ensure the water requirement of the existing & new industrial development will be met at node level.

6.10.5 *Development Goals and Target Performance Indicators*

The development goals and target performance indicators of water subsector is presented in Table 6.10.6.

Table 6.10.6 Summary of water subsector goals and targets

Goal	Indicator	Current situation	Short-term target at 2018	Mid-term target at 2023	Long-term target at 2033
Expansion of domestic water supply system	Water supply capacity	3971 MLD	4500 MLD	5200 MLD	5700 MLD
	Supply / Demand	83%	80%	80%	80%
Development of industrial water supply system by sewage recycle system	Ratio of recycled treated sewage	0%	50%	67% (2/3)	100%
Development of recycle system of industrial wastewater	Ratio of covered industrial areas	0%	50%	67% (2/3)	100%
Development of sewage treatment system	Sewage treatment capacity	1334 MLD	1700 MLD	2700 MLD	3700 MLD
	Supply / Demand	35%	40%	50%	65%

Source: JICA Study Team

6.10.6 *Development Plan and Suggested Projects*

6.10.6.1 Domestic Water supply system

The development projects of additional water supply systems for domestic purposes are proposed as below in order to meet the goals and targets which are presented in Table 6.10.5

1) Project demand

i) The project demand to be supplied by the ongoing and provisionally-planned projects which are proposed by the local governments is as described in Annex.

ii) If the demand/supply gap in 2033 will not able to be meet the goal and target by the ongoing and provisionally-planned projects, the additional projects will be necessary. The project demand to be supplied by the additional new projects is calculated to meet the demand/supply gap of domestic water of each district in CBIC to 65%. Accordingly, the demand/supply gap of domestic water of whole CBIC is expected to increase to 80% as presented in Table 6.10.5.

2) Proposed Technologies

The Conventional water Treatment methods, which include preliminary, primary & secondary treatment units followed by disinfection, are proposed for the additional water supply schemes for domestic purpose.

3) Conditions of preliminary cost estimation of necessary projects

The preliminary project cost is calculated based on the unit cost (Rs./MLD) referring to the costs of the on-going and planned projects as described in Annex.

4) List of necessary projects

The district-wise project list is presented in Table 6.10.7.

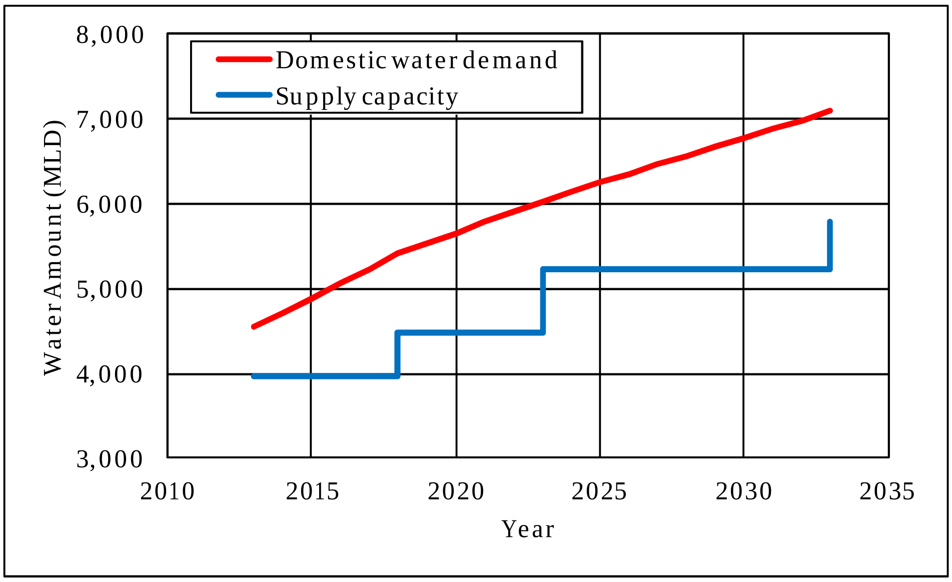
Table 6.10.7 List of domestic water supply projects

State	District	Status	Demand of Domestic Water (mld)	Preliminary Project Cost (million US$)	Priority[1/]
Tamil Nadu	Chennai	Preplanned	550.0	485	B
	Kancheepuram	On-going	2.9	178	A
		New	229.6	286	C
	Thiruvallur	New	266.9	322	C
	Tiruvannamalai	On-going	28.2	6	A
	Vellore	On-going	181.0	212	A
	Dharmapuri	New	1.9	3	C
	Krishnagiri	New	6.7	10	C
	State-Total		1267.2	1,502	
Karnataka	Bangalore Urban	New	49.7	72	C
	Bangalore Rural	Preplanned	10.0	8	B
	Ramanagara	On-going	13.0	4	A
	Kolar	On-going	43.4	26	A
	Chikkaballapura	On-going	14.9	2	A
	Tumukur	On-going	5.0	5	A
		Preplanned	10.0	11	B
	Chitradurga	On-going	38.8	28	A
	State-Total		184.8	156	
Andhra Pradesh	Anantapur	On-going	100.6	140	A
	Chittoor	On-going	26.0	21	A
		Preplanned	184.0	948	B
	Nellore	On-going	48.7	42	A
	State-Total		359.3	1,151	
CBIC-Total			1811.3	2,809	

1/ “A” refers to projects for implementation before 2018, “B” refers to projects for implementation in 2018 – 2022, and, “C” refers to projects for implementation after 2023.

Source: JICA Study Team

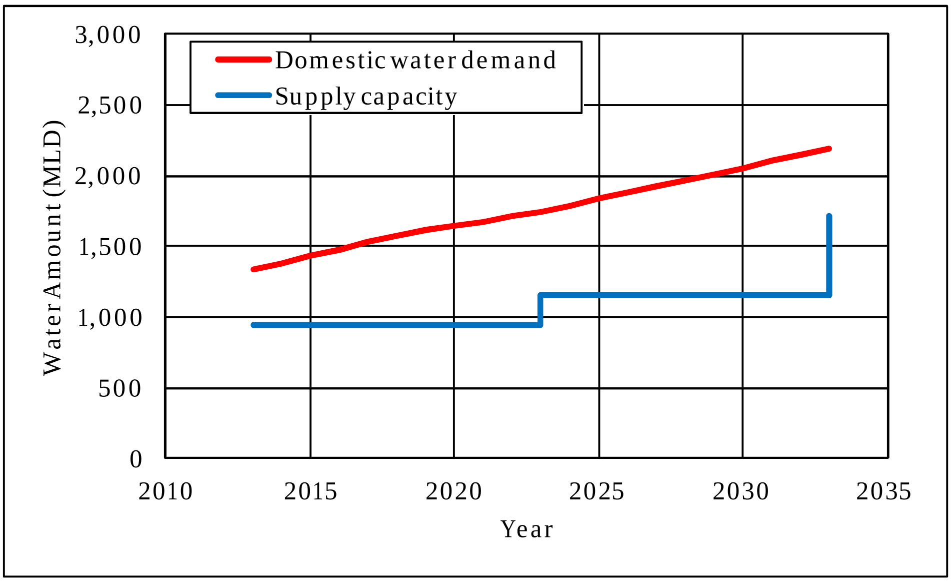
Figure 6.10.12 shows the expected improvement of demand/supply gap of domestic water. The water supply capacity will increase in line with completion of on-going, pre-planned and newly-proposed projects. However, the ratio of supply/demand will not meet 100% because the domestic water demand forecast will increase to 160% from 2013 to 2033 due to the rapid population growth. Therefore, as the development goal mentioned in Section 6.10.5 the ratio of supply demand will be approximately 80% in 2018, 2023 and 2033.



Source: JICA Study Team

Figure 6.10.12 Expected improvement of demand/supply gap of domestic water in whole CBIC

Figure 6.10.13 shows the expected improvement of demand/supply gap of domestic water which is focus on Chennai Metropolitan Area.

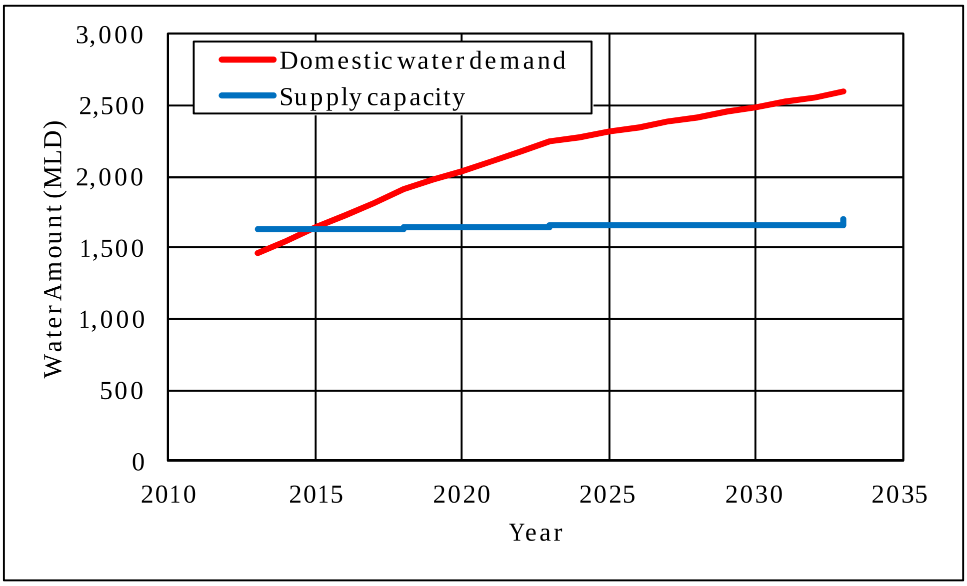


Source: JICA Study Team

Figure 6.10.13 Expected improvement of demand/supply gap of domestic water in Chennai Metropolitan Area

The supply capacity will be improved in 2023 by two seawater desalination projects of Chennai Metro Water Supply & Sewerage Board, however, the demand/supply gap will not meet 100% because of rapid increase of demand forecast. Therefore, additional water supply projects will be required especially for Kancheepuram District and Thiruvallur District whose demand/supply gap in 2033 is estimate to become less than 30% without newly-proposed projects.

Figure 6.10.14 shows the expected improvement of demand/supply gap of domestic water which is focus on Bangalore Metropolitan Area.



Source: JICA Study Team

Figure 6.10.14 Expected improvement of demand/supply gap of domestic water in Bangalore Metropolitan Area

The current supply capacity meets 100% of domestic water demand because of on-going Bangalore water supply & sewerage project which has been planned to be completed in 2013/2014. However, the demand/supply gap will expand year by year because of rapid increase of demand forecast although some on-going and pre-planned projects will be implemented. Therefore, the demand/supply gap in 2033 is estimated to decrease to 66%.

6.10.6.2 Industrial Water supply system

The development projects of additional water supply systems for industrial purposes are proposed as below in order to meet the goals and targets which are presented in Table 6.10.5

(1) Development of industrial water supply system by sewage recycle system

1) Project demand

i) The project demand to be supplied by the ongoing and provisionally-planned projects which are proposed by the local governments is as described in Annex.

ii) If the demand/supply gap in 2033 will not able to be meet the goal and target by the ongoing and provisionally-planned projects, the additional projects will be necessary. The project demand to be supplied by the additional new projects is calculated from sewage generation forecast and the target recycle ratio.

2) Proposed Technologies

The membrane processes which is including Micro-Filtration (MF) Process, Ultra Filtration (UF) Process, Membrane Bioreactor (MBR) Process and Reverse Osmosis (RO) Process are proposed for the sewage recycle systems based on the "Infrastructure Development Strategy" as mentioned in Section 6.10.4 above.

3) Conditions of preliminary cost estimation of necessary projects

The preliminary project costs are calculated based on the unit cost (INR/m^3) of RO process referring to the costs of Japanese manufacturers' past projects.

4) List of necessary projects

The district-wise project list is presented in Table 6.10.8.

Table 6.10.8 List of sewage recycle projects

State	District	Status	Target Volume of Sewage Recycle	Preliminary Project Cost	Priority[1/]
			(mld)	(million US$)	
Tamil Nadu	Chennai	Preplanned	45.0	22	A
		New	635.3	312	A
	Kancheepuram	New	293.7	144	A
	Thiruvallur	New	294.9	145	A
	Tiruvannamalai	New	78.3	38	C
	Vellore	New	166.1	81	C
	Dharmapuri	New	48.3	24	C
	Krishnagiri	New	66.7	33	C
	State-Total		1628.2	799	
Karnataka	Bangalore Urban[2/]	New	533.2	262	A
		New	533.2	262	B
	Bangalore Rural	New	35.9	18	A
	Ramanagara	On-going	30.0	15	A
		New	8.0	4	A
	Kolar	On-going	60.0	29	A
	Chikkaballapura	Preplanned	20.0	10	C
		New	22.2	11	C
	Tumukur	Preplanned	25.0	12	C
		New	53.5	26	C
	Chitradurga	New	52.4	26	C
	State-Total		1373.4	675	
Andhra Pradesh	Anantapur	New	153.1	75	C
	Chittoor	New	157.2	77	C
	Nellore	New	115.8	57	C
	State-Total		426.1	209	
CBIC-Total			3427.7	1,683	

1/ "A" refers to projects for implementation before 2018, "B" refers to projects for implementation in 2018 – 2022, and, "C" refers to projects for implementation after 2023.

2/ Target project demand of Bangalore Urban District is much larger than other districts. Therefore, the newly-proposed project of Bangalore Urban District is separated into two phases.

Source: JICA Study Team

(2) Development of recycle system of industrial wastewater

1) Project demand

The local governments have no on-going and provisionally-planned projects related to recycle of industrial wastewater, thus the additional projects will be necessary. The project demand to be supplied by the additional new projects is calculated from industrial water demand forecast and the target recycle ratio.

The target recycle ratio of industrial wastewater is calculated on the basis of the Japanese recycle ratio for each industrial sector activity as presented in the Table 6.10.9.

Table 6.10.9 Japanese Recycle Ratios

Sl.No	Sector Activity	Recycle Ratio (%)
1	Food Processing	29.8
2	Textiles & Apparels	48.3
3	Chemicals & Petrochemicals	86.0
4	Metallurgical industry	88.5

Sl.No	Sector Activity	Recycle Ratio (%)
5	Electronics	65.0
6	Electrical machinery	41.4
7	Auto and auto components	43.0
8	Machinery	89.5
9	Other manufacturing	57.0

Source: Japanese Industrial Census(2011)

2) Proposed Technologies

The membrane processes which is including Micro-Filtration (MF) Process, Ultra Filtration (UF) Process, Membrane Bioreactor (MBR) Process and Reverse Osmosis (RO) Process are proposed for the recycle systems of industrial wastewater based on the "Infrastructure Development Strategy" as mentioned in Section 6.10.4 above.

3) Conditions of preliminary cost estimation of necessary projects

The preliminary project costs are calculated based on the unit cost (INR/m^3) of RO process referring to the costs of Japanese manufacturers' past projects as well as sewage recycle projects.

4) List of necessary projects

The district-wise project list is presented in Table 6.10.10.

Table 6.10.10 List of industrial wastewater recycle projects

State	District	Status	Demand of Recyle Water for Industry (mld)	Preliminary Project Cost (million US$)	Priority[1/]
Tamil Nadu	Chennai	New	45.4	37	A
	Kancheepuram	New	333.8	273	A
	Thiruvallur	New	240.6	197	A
	Tiruvannamalai	New	8.7	7	C
	Vellore	New	55.5	45	C
	Dharmapuri	New	6.4	5	C
	Krishnagiri	New	15.1	12	C
	State-Total		705.4	576	
Karnataka	Bangalore Urban[2/]	New	1362.5	1,114	A
		New	1362.5	1,114	B
	Bangalore Rural	New	160.9	132	A
	Ramanagara	New	74.1	61	A
	Kolar	New	8.9	7	C
	Chikkaballapura	New	0.5	0.4	C
	Tumukur	New	306.8	251	C
	Chitradurga	New	78.7	64	C
	State-Total		3354.9	2,743	
Andhra Pradesh	Anantapur	New	18.9	15	C
	Chittoor	New	6.6	5	C
	Nellore	New	17.0	14	C
	State-Total		42.4	34	
CBIC-Total			4102.7	3,353	

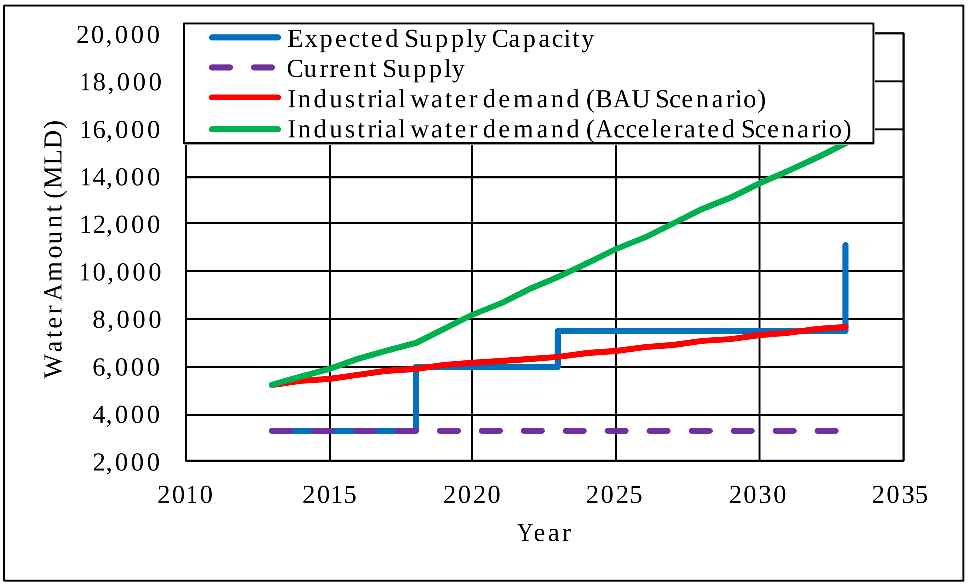
1/ "A" refers to projects for implementation before 2018, "B" refers to projects for implementation in 2018 – 2022, and, "C" refers to projects for implementation after 2023.

2/ Target project demand of Bangalore Urban District is much larger than other districts. Therefore, the newly-proposed project of Bangalore Urban District is separated into two phases.

Source: JICA Study Team

Figure 6.10.15 shows the expected improvement of demand/supply gap of industrial water in CBIC. The water supply capacity will increase in line with completion of suggested proposed projects related to recycle of sewage and industrial wastewater. Under the condition of the industrial development with the business-as-usual scenario, the ratio of supply/demand will achieve 100% in 2018. This result shows that the utilization of sewage and industrial wastewater as alternative water resources for industrial water is highly effective. In contrast, under the condition of the industrial development with the accelerated scenario, the ratio of supply/demand will remain approximately 80% in 2018, 75% in 2023.

Considering the development of industrial nodes, it is necessary to develop the recycle system of sewage and industrial wastewater to support the sustainable industrial activities. In addition, if the proposed industrial nodes will be developed at coastal areas such as Thiruvallur District, Kancheepuram District and Nellore District, the seawater desalination system can be proposed to be installed in order to support the stable water supply for industrial purpose.

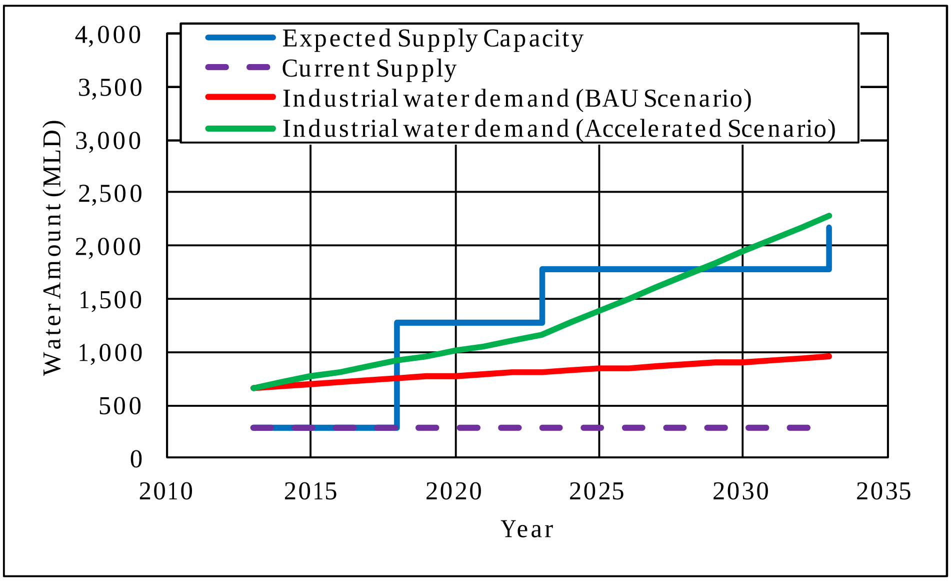


Source: JICA Study Team

Figure 6.10.15 Expected improvement of demand/supply gap of industrial water in whole CBIC

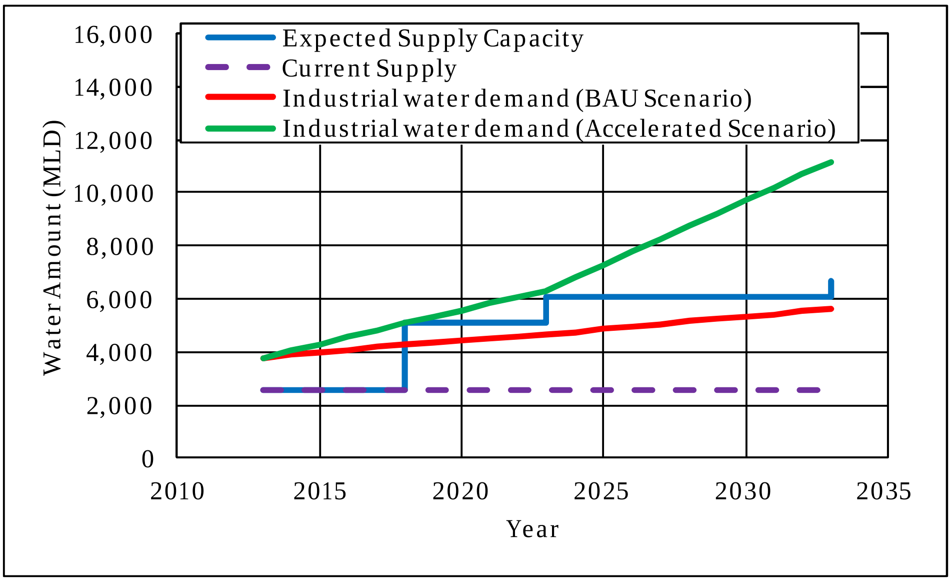
Figure 6.10.16 shows the expected improvement of demand/supply gap of industrial water which is focus on Chennai Metropolitan Area. In this area the supply capacity of industrial water will increase more rapidly than other areas and CBIC average because several prioritized projects related to sewage recycle and industrial wastewater recycle will be implemented. Therefore, the demand/supply gap will meet the demand of industrial water demand even under the accelerated scenario.

Also, figure 6.10.17 shows the expected improvement of demand/supply gap of industrial water which is focus on Bangalore Metropolitan Area. As well as Chennai Metropolitan Area, the supply capacity of industrial water will increase more rapidly than other areas and CBIC average because several prioritized projects related to sewage recycle and industrial wastewater recycle will be implemented. Therefore, the demand/supply gap will meet the industrial water demand even under the accelerated scenario in 2018 and 2023. However, the industrial water demand of this area will increase more rapidly than other area in CBIC, thus in 2033 the demand/supply gap will not meet the industrial water demand under the accelerated scenario.



Source: JICA Study Team

Figure 6.10.16 Expected improvement of demand/supply gap of industrial water in Chennai Metropolitan Area



Source: JICA Study Team

Figure 6.10.17 Expected improvement of demand/supply gap of industrial water in Bangalore Metropolitan Area

6.10.6.3 Sewerage system

The development projects of additional sewerage systems are proposed as below in order to meet the goals and targets which are presented in Table 6.10.6

1) Project demand

i) The project demand to be supplied by the Provisionally-Planned Projects which are proposed by the local governments is as described in Annex.

ii) If the demand/supply gap in 2033 will not able to be meet the goal and target by the ongoing and provisionally-planned projects, the additional projects will be necessary. The project demand to be supplied by the additional new projects is calculated to meet the demand/supply gap of domestic water of each district in CBIC to 55%. Accordingly, the demand/supply gap of domestic water is expected to increase to 65% as a whole CBIC.

2) Proposed Technologies

The Conventional Sewage Treatment processes including Preliminary, Primary & Secondary Treatment units are proposed for the additional sewerage system.

3) Conditions of preliminary cost estimation of necessary projects

The preliminary project cost is calculated based on the unit cost (Rs./MLD) referring to the costs of the on-going and planned projects as described in Annex.

4) List of necessary projects

The district-wise project list is presented in Table 6.10.11. Every necessary project is based on the development of STPs and sewer pipelines because most of municipalities and towns in CBIC other than only two metro cities and 13 urban municipalities have neither STPs nor sewage conveyance systems.

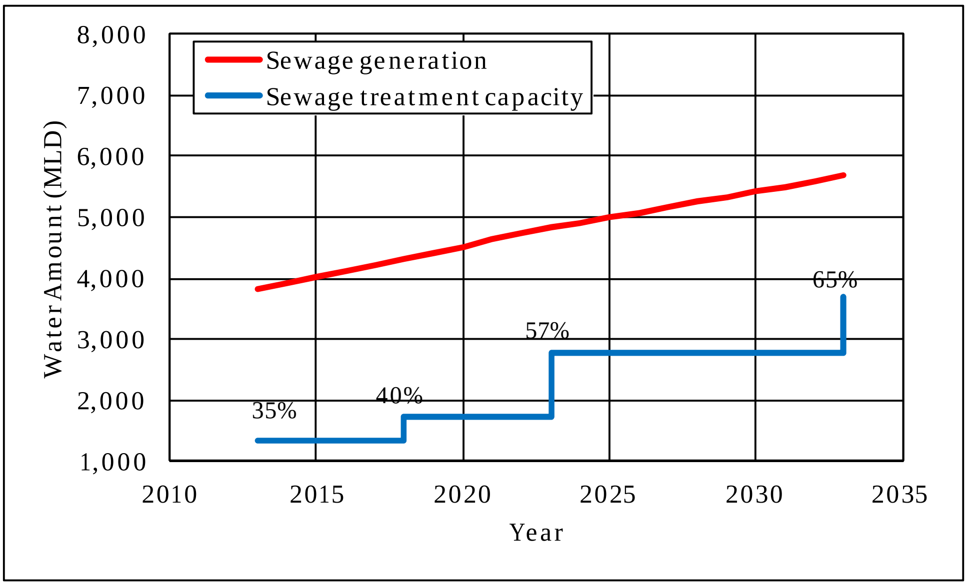
Table 6.10.11 List of sewerage development projects for whole CBIC

State	District	Status	Project Volume (Additional Volume of Sewage Treatment)	Preliminary Project Cost	Priority[1/]	Total Capacity of Sewage Treatment[2/]
			(mld)	(million US$)		(mld)
Tamil Nadu	Chennai	Preplanned	454.0	742	B	940.0
	Kancheepuram	On-going	2.9	5	A	293.7
		Preplanned	260.4	426	B	
		New	11.9	19	C	
	Thiruvallur	Preplanned	66.0	108	B	294.9
		New	222.7	364	C	
	Tiruvannamalai	Preplanned	45.7	74	B	78.3
		New	23.9	39	C	
	Vellore	Preplanned	121.0	199	B	166.1
		New	45.1	74	C	
	Dharmapuri	Preplanned	35.7	81	B	48.3
		New	7.7	13	C	
	Krishnagiri	Preplanned	35.5	100	B	66.7
		New	22.2	36	C	
	State-Total		1354.6	2,280		1887.9
Karnataka	Bangalore Urban	On-going	345.4	565	A	1066.4
	Bangalore Rural	New	35.9	59	C	35.9
	Ramanagara	New	30.4	50	C	38.0
	Kolar	On-going	8.0	5	A	59.6
		New	38.4	63	C	
	Chikkaballapura	On-going	14.3	3	A	42.2
		New	18.4	30	C	
	Tumukur	On-going	10.6	7	A	78.5
		New	43.4	71	C	
	Chitradurga	On-going	3.3	3	A	52.4
		New	49.1	80	C	
	State-Total		597.2	936		1373.0
Andhra Pradesh	Anantapur	New	153.1	250	C	153.1
	Chittoor	On-going	29.0	5	A	157.2
		New	103.2	169	C	
	Nellore	New	115.8	189	C	115.8
	State-Total		401.1	613		426.1
CBIC-Total			2352.9	3,829		3687.0

1/ "A" refers to projects for implementation before 2018, "B" refers to projects for implementation in 2018 – 2022, and, "C" refers to projects for implementation after 2023. 2/Including the capacities of existing sewage treatment plants

Source: JICA Study Team

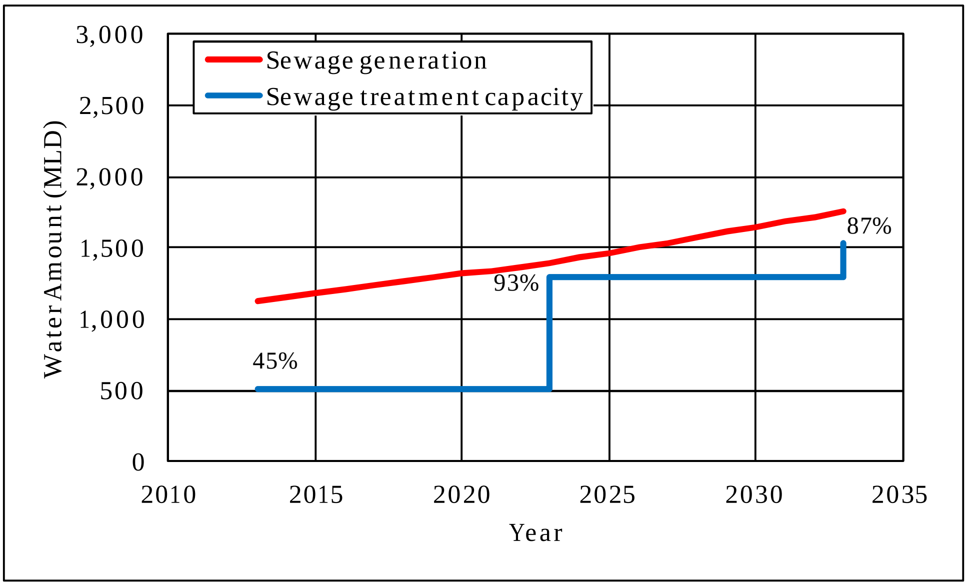
Figure 6.10.18 shows the expected improvement of demand/supply gap of sewage treatment. The sewage treatment capacity will increase in line with completion of on-going, pre-planned and newly-proposed projects. As the development goal mentioned in Section 6.10.5 the ratio of supply/demand will be 40% in 2018, 50% in 2023 and 65% in 2033.



Source: JICA Study Team

Figure 6.10.18 Expected improvement of demand/supply gap of sewage treatment in whole CBIC

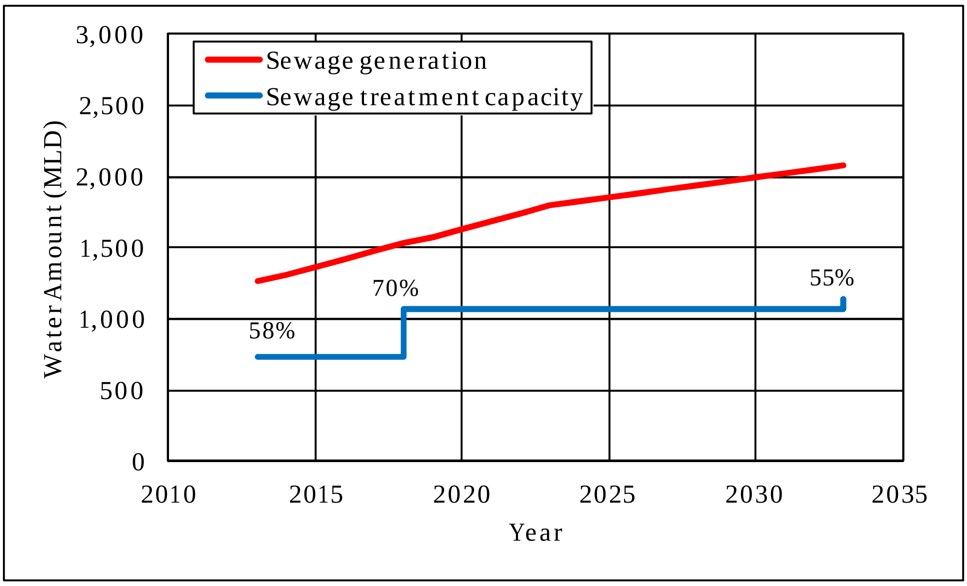
Figure 6.10.19 shows the expected improvement of demand/supply gap of sewage treatment which is focus on Chennai Metropolitan Area. The sewage treatment capacity will increase in line with completion of the pre-planned large-scaled projects of Chennai and Kancheepuram District, accordingly, the supply/demand will be approximately 80% in 2033.



Source: JICA Study Team

Figure 6.10.19 Expected improvement of demand/supply gap of sewage treatment in Chennai Metropolitan Area

Also, figure 6.10.20 shows the expected improvement of demand/supply gap of sewage treatment which is focus on Bangalore Metropolitan Area. The sewage treatment capacity will increase in line with completion of the on-going large-scaled projects of Bangalore Metro. However, the supply/demand will not reach the level of Chennai Metropolitan Area because the population of Bangalore Urban District is forecasted to reach 18,000,000, therefore, the additional sewage treatment plants will be required in the future.



Source: JICA Study Team

Figure 6.10.20 Expected improvement of demand/supply gap of sewage treatment in Bangalore Metropolitan Area

6.10.6.4Contribution of each solution

The expected contribution of each solution is presented as the improvement of demand/supply gap, which is summarized for entire CBIC, each state, Chennai Metropolitan Area and Bangalore Metropolitan Area as Table 6.10.12.

Table 6.10.12 Contribution of each solution related to water management

Solution	Contribution of each solution (Effect on demand/supply gap)					
	Entire CBIC	**TN State**	**KA State**	**AP State**	**Chennai Metro. Area**	**Bangalore Metro. Area**
1) Domestic Water Expansion of domestic water supply system	56%→83%	47%→69%	63%→94%	62%→92%	43%→79%	63%→66%
2) Industrial Water i) Installation and expansion of sewage recycle system	19%→40%	14%→78%	20%→30%	19%→401%	14%→68%	20%→30%
ii) Installation and expansion of industrial wastewater recycle system	40%→63%	78%→106%	30%→53%	401%→433%	68%→98%	30%→53%
iii) Improvement of the industrial water productivity	63%→144%	106%→234%	53%→121%	433%→916%	98%→215%	53%→123%
3) Sewage Development of sewage treatment system	24%→65%	22%→79%	31%→55%	3%→55%	29%→87%	35%→55%

Source: JICA Study Team

6.10.7 *Phasing Plan*

The phasing plan of suggested projects is summarized in Table 6.10.12 which is based on the development goal and the development plan above-discussed in Section 6.10.5 and 6.10.6.

Table 6.10.13 Phasing plan of development projects related to water management

(Unit: million US$)

Category	Short (2013/14 – 2017/18)	Mid (2018/19 – 2022/23)	Long (2023/24 – 2032/33)	Total
I: Domestic water supply				
Expansion of domestic water supply system	664	1,452	693	2,809
II: Industrial water supply				
Development of industrial water supply system by sewage recycle system	951	262	470	1,683
Development of recycle system of industrial wastewater	1,814	1,114	425	3,353
III: Sewage treatment				
Development of sewage treatment system	593	1,730	1,506	3,829
Total	4,022	4,558	3,094	11,674

Source: JICA Study Team

Additionally, the breakdown of state-wise phasing plan is presented in Table 6.10.14.

Table 6.10.14 Phasing plan of development projects related to water management

(Unit: million US$)

State	Category	Short (2013/14 – 2017/18)	Mid (2018/19 – 2022/23)	Long (2023/24 – 2032/33)	Total
Tamil Nadu	**I: Domestic water supply**				
	Expansion of domestic water supply system	396	485	621	1,502
	II: Industrial water supply				
	Development of industrial water supply system by sewage recycle system	623	0	176	799
	Development of recycle system of industrial wastewater	507	0	69	576
	III: Sewage treatment				
	Development of sewage treatment system	5	1,730	545	2,280
	State-Total	1,531	2,215	1,411	5,157
Karnataka	**I: Domestic water supply**				
	Expansion of domestic water supply system	65	19	72	156
	II: Industrial water supply				
	Development of industrial water supply system by sewage recycle system	328	262	85	675
	Development of recycle system of industrial wastewater	1,307	1,114	322	2,743
	III: Sewage treatment				
	Development of sewage treatment system	583	0	353	936
	State-Total	2,283	1,395	832	4,510
Andhra Pradesh	**I: Domestic water supply**				
	Expansion of domestic water supply system	203	948	0	1,151
	II: Industrial water supply				
	Development of industrial water supply system by sewage recycle system	0	0	209	209
	Development of recycle system of industrial wastewater	0	0	34	34
	III: Sewage treatment				
	Development of sewage treatment system	5	0	608	613
	State-Total	208	948	851	2,007

Source: JICA Study Team

6.11 Solid Waste Management

6.11.1 Sector Overview

Solid waste is classified in India as shown in the Table 6.11.1 below. Most of the industrial waste generated at industrial factories are classified as Hazardous waste.

Table 6.111.1 Classification of solid waste in India

Type of wastes		Outline of related regulations
Hazardous Wastes	• Hazardous waste means any waste or substances which by reason of any of its physical, chemical, reactive, toxic, flammable, explosive or corrosive characteristics causes danger or is likely to cause danger to health or environment, whether alone or when in contact with other wastes or substances (Rule 3). • 36 processes generating hazardous waste, and 114 types of hazardous wastes generated from each of those 36 processes are specified. • Limits for harmful substances which can be contained are also specified. • In addition, whether the hazardous waste requires prior consent upon export/import or otherwise is specified (Rule 14) • Any import of Hazardous Waste from a foreign country shall be permitted only for the recycling, recovery or reuse purposes (Rule 13). • 20 types of hazardous waste requiring registration for recycling / reprocessing are specified (Schedule IV).	Hazardous wastes (Management, Handling and Transboundary Movement) Rules, 2008 • A person who has, control over the affairs of the factory or the premises and includes in relation to any hazardous waste the person in possession of the hazardous waste(Occupier) shall be responsible for safe and environmentally sound handling of hazardous wastes generated in his establishment.(Rule 4 (1)) • The hazardous wastes generated in the establishment of an occupier shall be sent or sold to a recycler or re-processor or re-user registered or authorized under these rules or shall be disposed of in an authorized disposal facility(Rule4 (2)). • The State Government, occupier, operator of a facility or any association of occupiers shall individually or jointly or severally be responsible for, and identify sites for establishing the facility for treatment, storage and disposal of the hazardous wastes in the State (Rule 18 (1)). • Identification of site(s) for common Hazardous Waste Treatment Storage and Disposal Facility (TSDF) is the duty of the State Government / Union Territory Government / Administration.(ScheduleVII.3)
Municipal Solid Wastes	• "Municipal solid waste" includes commercial and residential wastes generated in municipal or notified areas in either solid or semi-solid form excluding industrial hazardous wastes but including treated bio-medical wastes (Rule3, xv).	Municipal Solid Wastes (Management and Handling) Rules, 2000 • Every municipal authority shall, within the territorial area of the municipality, be responsible for the implementation of the provisions of these rules, and for any infrastructure development for collection, storage, segregation, transportation, processing and disposal of municipal solid wastes (Rule4).
Plastic waste	• Any plastic product such as carry bags, pouches or multi-layered packaging, which have been discarded after use or after their intended life is over (Rule3 (m)).	Plastics waste (Management and handling) Rules, 2011 • The municipal authority shall be responsible for setting up, operationalization and coordination of the waste management system and to ensure safe collection, storage, segregation, transportation, processing and disposal of plastic waste (Rule6).
E-waste	• 'E-waste' means waste electrical and electronic equipment, whole or in part or rejects from their manufacturing and repair process, which are intended to be discarded (Rule3 (k)). Information Technology, Telecommunication Equipment, TV sets, Refrigerator, Washing Machine, Air-Conditioners are specified as E-wastes (Schedule I).	E-waste (Management and Handling) Rules, 2011 • The producer of electrical and electronic equipment shall be responsible for the collection of e-waste generated during the manufacturing process and the 'end of life' products, setting up the collection systems with registered dismantler or recycler, or the bear of administrative costs.(Rule4) • Consumers or Bulk consumers of electrical and electronic equipment listed in Schedule I shall

Type of wastes		Outline of related regulations
		ensure that e-waste generated by them is channelised to authorized collection centers or registered dismantlers or recyclers or is returned to the pick-up or take back services provided by the producers.(Rule6(1))
Bio-Medical waste	• Any waste, which is generated during the diagnosis, treatment or immunisation of human beings or animals or in research activities pertaining thereto or in the production or testing of biologicals (Rule3 (5)).	Bio-Medical Waste (Management and Handling) Rules, 2003 • It shall be the duty of every occupier of an institution generating bio-medical waste which includes a hospital, nursing home, clinic, etc, to ensure that such waste is handled without any adverse effect to human health and the environment. (Rule 4) • Every occupier, where required, shall set up requisite bio-medical waste treatment facilities like incinerator, autoclave, microwave system for the treatment of waste, or, ensure requisite treatment of waste at a common waste treatment facility or any other waste treatment facility.(Rule 5)
Battery Waste	•Used acid batteries or components	Batteries (Management and Handling) Rules, 2001 • It shall be the responsibility of a manufacturer, importer, assembler and re-conditioner to set up the collection centres.(Rule4) • It shall be the responsibility of the consumer and bulk consumer to ensure that used batteries are not disposed of in any manner other than by depositing with the dealer, manufacturer, importer, assembler, registered recycler, reconditioner or at the designated collection centres.(Rule 10)

Source: JICA Study team

As mentioned above, municipal solid waste management falls under the responsibility of Urban Local Body ULB), and each ULB conducts collection, storage, sorting, transportation, treatment and final disposal, including infrastructure development, depending on their own situation. There are 367 ULBs within the CBIC area (255 ULBs in Tamil Nadu, 64 ULBs in Karnataka, and 48 ULBs in Andra Pradesh).

For hazardous waste generated as result of industrial activities, waste generator is responsible for its management, either by its own or by contracting authorized operators of common Hazardous waste Treatment Storage and Disposal Facilities(TSDF). In principle, the treatment and disposal of hazardous waste should be done in the state where it is generated. Part A of this study focuses on hazardous waste management which has a significant impact due to regional industrial development. Municipal solid waste management will be considered, along with hazardous management, in Part B of the study by the time the specific node would be decided.

6.11.1.1 Status of management of Hazardous waste

For collection and transportation of hazardous waste, it is obligated to keep manifest of waste to ensure the flow of waste management. For the collection and transportation of landfillable and incinerable hazardous waste, TSDF operator who received a request from the waste generator conducts the collection and transportation. In addition, the collection and transportation costs are paid by the waste generator. Collection and transportation costs are set depending on the weight of waste and transport distance. (It was also reported that the price setting varies depending on who the waste generator is, according to the wide-area incineration company.) Also for collection and transportation of hazardous waste have to register for recycling / reprocessing, recyclers/re-processors conduct collection and transportation. In this case, transportation costs are borne by Recyclers/re-processors.

Regarding recyclable hazardous waste management, recycling is done by registered recyclers/re-processors for a fee. Types of recycling facilities are as shown in the table below. As recycling business is conducted by private companies based on market mechanism, it is expected that recycling business would expand along with the industrial development. Therefore this report only considers treatment and disposal of hazardous wastes, currently being an issue.

Table 6.11.2 Types of recycling facilities registered

Type of recycling facilities registered	
-Copper Re-processor -Copper etchant Re-processors -Spent Catalyst Re-processor -Molybdenum Acid Units -Grinding muck re-processor (ferrous sulphate) -Precious metal recovery from ETP sludge -Silver extract by X Ray solution -Aluminium Re-processor -Zinc Ash / Dross Recycling units	-Lead Re-processor -E-waste recycling -Used Oil Recycling units -Waste oil Re-processor -Spent Solvent Distillation units -Discarded Container Washing Units -waste PCB re-processor -PCB Sludge processors

Source: JICA Study team

The status of existing waste treatment and disposal facilities and planned infrastructure projects in the three states covered by the study are summarized below.

Table 6.11.3 Summary of existing and planned infrastructure

States	Existing Infrastructures	Planned Infrastructures
Tamil Nadu	• There is only one TSDF and one common incinerator at Gummidipoondi Tiruvallur District.	• For other two proposed sites, public hearings are being conducted
Karnataka	• There is also only one TSDF at Dabaspet and 5 common incinerators in Bengaluru, Tumkur and Ramanagara District.	• Another site was proposed for a TSDF, but it has not been realized yet.
Andhra Pradesh	• There are two TSDFs with common incinerators in Rangareddy and Visakhapatnam District.	• There are no future plans in Andhra Pradesh

Source: JICA Study Team

The landfill capacity is insufficient compared to the amount of waste generated, creating the first gap (referred to as “Gap 1”), in all three states. However, the actual amount of hazardous waste disposed at the landfill is less than the landfill capacity, creating the second gap (referred to as “Gap 2”). Gap 1 indicates the lack of Treatment Storage Disposal Facilities (TSDFs); more waste would be treated if additional TSDFs were established. Gap 2 indicates that waste is temporarily stored within each factory area, a practice which occurs due to the high cost of transportation and incineration.

TAMIL NADU

There is a processing capacity of 23,364 t/year against a generation of 17,334 t/year of incinerable waste.

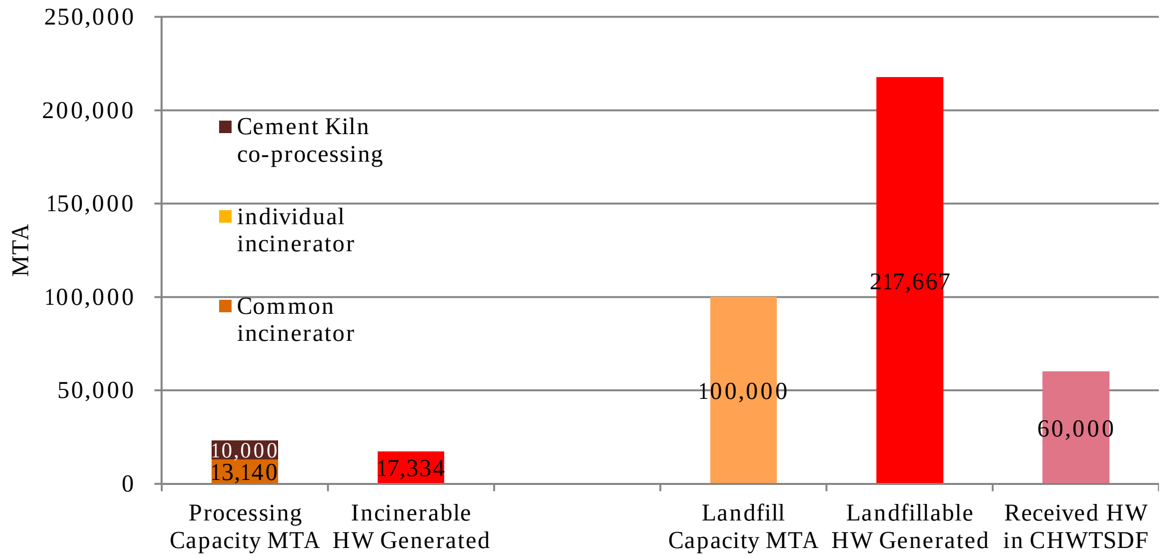
The total landfill capacity is 100,000 t/year against 217,667 tons of landfillable waste generated per year. However, the actual amount received at the landfill is only 60,000 t/year. It means the actual amount of hazardous waste disposed at the landfill is less than the landfill capacity.

Table 6.11.4 Supply-Demand Gap: Tamil Nadu

(Unit: t/year)

	Common Incinerator	Individual Incinerator	Cement Kiln	Total
Processing Capacity (MTA)	13,140	0	10,000	23,140
Incinerable HW Generated (MTA)				17,334
Landfill Capacity (MTA)				100,000
Landfillable HW Generated (MTA)				217,667
Actually Received HW at TSDF (MTA)				60,000

Note: The figures for the individual incinerators and the cement kilns indicate the actual performance for the year 2012, instead of the maximum capacity which is not available.
Source: JICA Study Team



Source: JICA Study Team

Figure 6.11.1 Supply-Demand Gap: Tamil Nadu

KARNATAKA

There is a processing capacity of 13,601 t/year in Karnataka against 43,609 t/year of incinerable waste generated (including the amount co-processed by cement kilns).

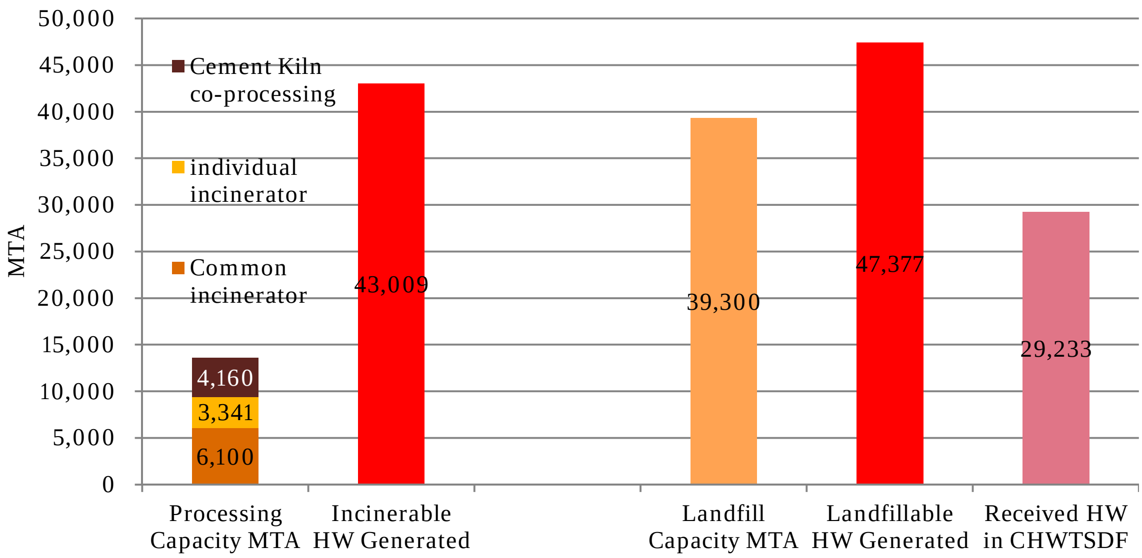
Although the total capacity of the two landfills is 39,300 t/year against landfillable waste generated of 47,377 t/year, the actual amount received at the landfill is only 29,233 t/year. This means the actual amount of hazardous waste disposed at the landfill is less than the landfill capacity.

Table 6.11.5 Supply-Demand Gap: Karnataka

(Unit: t/year)

	Common Incinerator	Individual Incinerator	Cement Kiln	Total
Processing Capacity (MTA)	6,100	3,341	4,160	13,601
Incinerable HW Generated (MTA)				43,609
Landfill Capacity (MTA)				39,300
Landfillable HW Generated (MTA)				47,377
Actually Received HW at TSDF (MTA)				29,233

Note: The figures for the individual incinerators and the cement kilns indicate the actual performance for the year 2012, instead of the maximum capacity which is not available. The data of waste generated are provided by Tamil Nadu PCB.
Source: JICA Study Team



Note: Received HW is based on the performance in 2013.
Source: JICA Study Team

Figure 6.11.2 Supply-Demand Gap: Karnataka

ANDHRA PRADESH

There is a processing capacity of 75,689 t/year in Andhra Pradesh against 42,826 t/year of incinerable waste generated (including the amount co-processed by cement kilns).

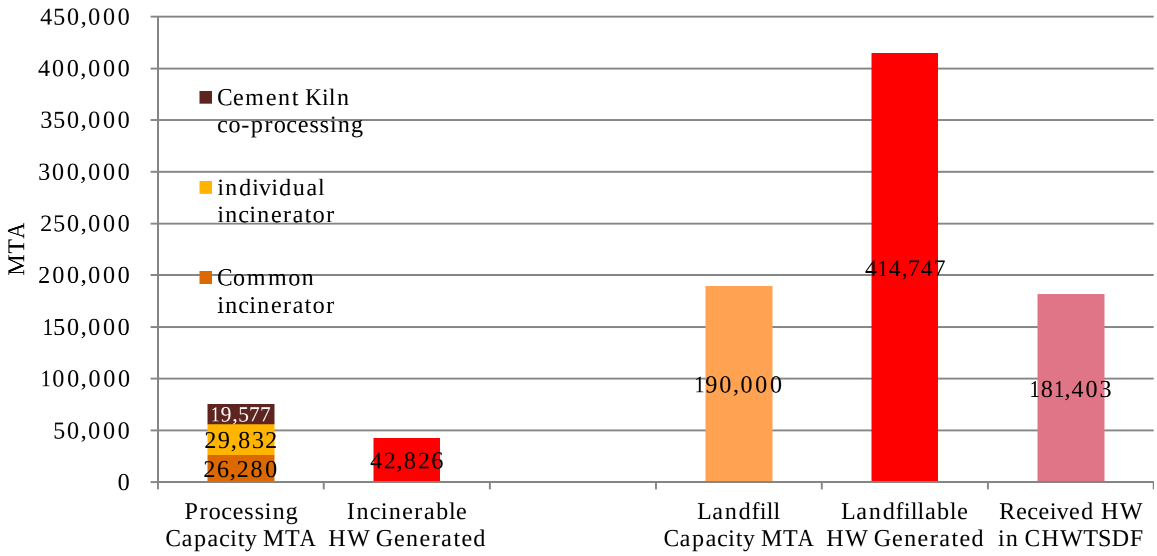
Although the total capacity of the two landfills is 190,000 t/year against landfillable waste generated of 414,747 t/year, the actual amount received at the landfill is only 181,403 t/year. It means the actual amount of hazardous waste disposed at the landfill is less than the landfill capacity.

Table 6.11.6 Supply-Demand Gap: Andhra Pradesh

(Unit: t/year)

	Common Incinerator	Individual l Incinerator	Cement Kiln	Total
Processing Capacity (MTA)	26,280	29,832	19,577	75,689
Incinerable HW Generated (MTA)				42,826
Landfill Capacity (MTA)				190,000
Landfillable HW Generated (MTA)				414,747
Actually Received HW at TSDF (MTA)				181,403

Note: The figures for the individual incinerators and the cement kilns indicate the actual performance for the year 2010-2011, instead of the maximum processing capacity which is not available.
Source: JICA Study Team



Source: JICA Study Team

Figure 6.11.3 Supply-Demand Gap: Andhra Pradesh

As seen in the above section, the landfill capacity is insufficient when compared to the amount of waste generated, making the first gap (i.e. "Gap 1"), in all three states covered by this study. However, the actual amount of hazardous waste disposed at the landfill is less than the landfill capacity, making the second gap (referred to as "Gap 2"). For the case of Tamil Nadu, for instance, only 60,000 tons of hazardous wastes were received in 2012 against the 100,000 tons annual capacity. Therefore, most of the landfillable wastes from factories are temporarily stored within their own sites.

Gap 1 shows the lack of TSDFs; more waste would be treated if additional TSDFs were established. In Tamil Nadu, there is only one CHWTSDF and Common incinerator. Three sites were proposed in the past, but none could be realized due to opposition by residents, and as a result, a different plan with sites proposed within industrial estates was formulated. Subsequently, TSDFs at four different sites have been proposed. Two of these sites have not progressed due to opposition by local residents. Public hearings are being conducted for the other two sites. In Karnataka, there is also only one CHWTSDF and 5 common incinerators. Another site for a TSDF was proposed, but has not been realized for the same reasons as in Tamil Nadu. In Andhra Pradesh, there are two CHWTSDFs and Common incinerators in Rangareddy and Visakhapatnam Districts. There are no plans for future facilities in Andhra Pradesh.

Gap 2 indicates that the practice of temporary storage within each factory area has been done due to the high costs of transportation and incineration. A limited of number of factories have Solid Waste Landfill Facilities (SLF) on their own premises; however, most factories do not have any such facilities and accordingly store their waste on-site temporarily. In India, temporary storage of waste is allowed up to 90 days, but often this rule is not complied. SPCB is hesitant to apply the rule of 90 days strictly under the current shortage of infrastructure needs

The cases seen in the CBIC area do not comply with this rule. Interviews have established that some foreign companies process hazardous waste at their own sites due to the absence of TSDC and/or a long transportation distance to TSDFs. On the other hand, it is also reported that hazardous waste generated from small and medium-sized factories are mixed with municipal solid waste or discarded illegally.

Governments have promoted the development of hazardous waste treatment facilities to improve the current environmental situation. However, governments have been unable to provide sufficient treatment facilities in their states yet due to “Not In My Back Yard (NIMBY)” problems. In view of the difficulties in the establishment of TSDFs, proposals to construct such facilities within industrial estates should be considered. In addition, recycling, and waste-to-energy generation should be considered in order to reduce the volume of landfill waste and decrease carbon dioxide emissions.

Promotion of minimization of waste generated has been considered in India as well. For example, the Indian government has promoted co-processing in cement kilns recently. All states under CBIC are currently testing the use of cement kilns for processing of incinerable and landfillable wastes, in accordance with the “Guidelines on Co-processing in Cement/Power/Steel Industry” devised in 2010. Use of cement kilns has a large potential for reducing the amount of the waste and has been widely adopted as "zero-emission technology" in a number of developed industrial countries, such as Japan and Germany. India is the second largest producer of cement in the world, and accordingly use of cement kilns will have a huge potential.

On the other hand, sufficient testing is required to secure the quality of the cement products. This is currently ongoing in each state. In addition, wastes with high calorific value are utilized for thermal recycling as a source of energy, whereas wastes with low calorific value still need to be landfilled. In the recent years, to solve these problems, the use of AFR(Alternative Fuels & Raw Materials) pre-processing facility that can be adjusted characteristics of wastes by mixing several types of waste are being promoted. Since this technology would significantly promote the further use of cement kilns, the technology should be promoted more in the future.

In addition, Technical standards of treatment and landfill facilities in India meet the world standards, whereas the promotion of the concepts of responsibilities of manufacturers and waste generators should be considered for more attention as these concepts would promote recycling further.

6.11.2 *Demand Forecast*

6.11.2.1 Methodology

Forecasting of the amount of hazardous waste generated was calculated based the forecasted industrial output by each industry in each district in 2013, 2023, 2028, and 2033. The calculated total amount of waste was multiplied by the estimated composition of waste in each forecasting year. The estimated amount of waste by type is then categorized into 3 types of waste categories used in India: namely landfillable waste, incinerable waste, and recycled waste.

6.11.2.2 Hazardous waste generated in the future

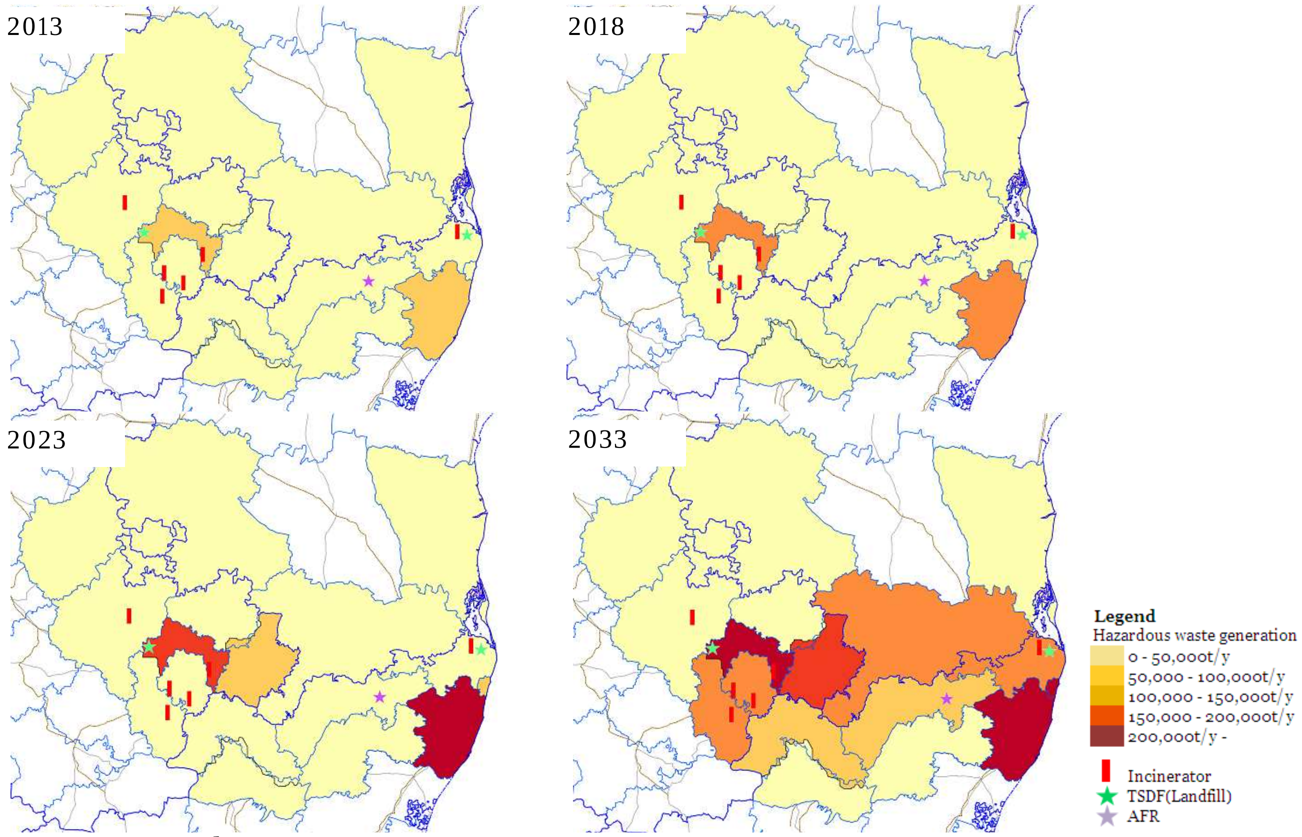
The amounts of hazardous wastes generated in the study area of CBIC in future are forecasted as shown in the Table 6.11.7.

Hazardous waste generated in the future

Table 6.11.7 Hazardous waste generated by district of target area in future

Unit: 1000 t/year	2,013	2,018	2,023	2,033
Tamil Nadu	**140**	**230**	**423**	**1,431**
1.Chennai	22	35	68	274
2.Tiruvallur	17	24	39	102
3.Kancheepuram	76	134	257	894
4.Tiruvannamalai	0	0	1	1
5.Vellore	17	23	35	90
6.Dharmapuri	0	0	0	0
7.Krishnagiri	8	14	24	69
Karnataka	**111**	**180**	**323**	**1,051**
1.Bangalore urban	13	20	34	112
2.Bangalore rural	69	111	197	631
3.Ramnagara	9	17	33	103
4.Kolar	17	27	51	182
5.Chickballapura	0	0	1	4
6.Tumkur	3	4	7	19
7.Chitradurga	0	0	0	1
Andhra Pradesh	**16**	**25**	**43**	**128**
1.Chittoor	13	21	36	108
2.Nellore	2	2	3	9
3.Anantapur	2	2	3	10

Source: JICA Study Team

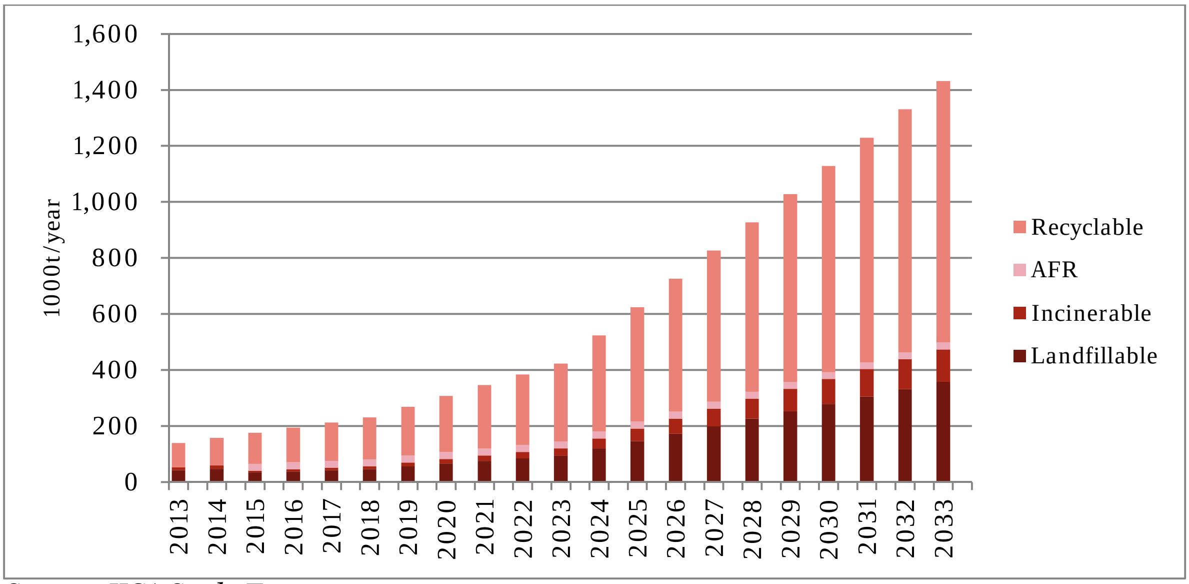


Source: JICA Study Team

Figure 6.11.4 Amount of waste generated by district

Hazardous waste generated by type (3 categories) in each State of the CBIC area

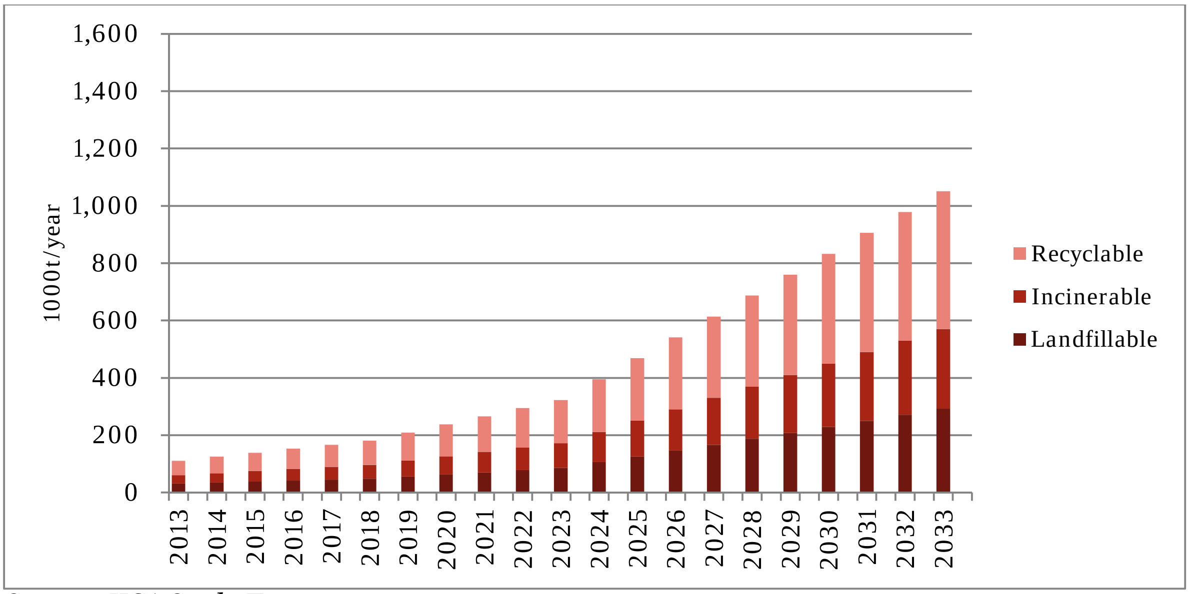
b. Tamil Nadu



Source: JICA Study Team

Figure 6.11.5 Hazardous waste generated in Tamil Nadu

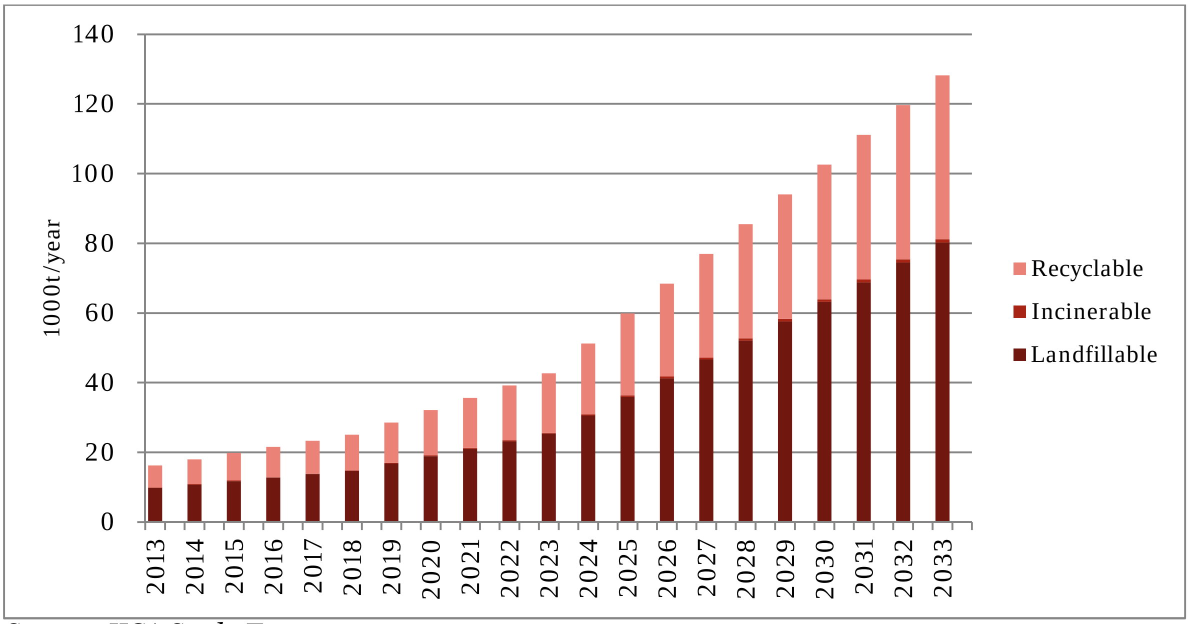
c. Karnataka



Source: JICA Study Team

Figure 6.11.6 Hazardous waste generated in Karnataka

d. AP



Source: JICA Study Team

Figure 6.11.7 Hazardous waste generated in AP

6.11.3 *Demand/Supply Gaps*

Demand/Supply Gap analysis was conducted on a state basis, since hazardous waste are processed and landfilled within the respected state where the waste was generated.

6.11.3.1 Tamil Nadu

There is one landfill and one incineration facility in Tiruvallur District, which falls within the CBIC area of the state, and those are the only operating waste treatment and disposal facilities in the whole of Tamil Nadu. There is a plan to set up an AFR pre-processing facility with the capacity of 25,000 t/year in Vellore District, also within the CBIC area. It is expected to come into operation in 2015. There are no other future plans for landfill or incineration facilities to be built within the CBIC area. Hazardous waste generated from the Chennai Metropolitan area is treated at the common landfill and the incinerator in the Tiruvallur District.

There are plans to build TSDFs for hazardous waste treatment in Virudhunagar District in the southern part of Tamil Nadu, and Erode District in the western and central part of Tamil Nadu respectively. It is assumed that hazardous waste generated in CBIC area can be treated at these facilities to be built in Virudhunagar and Erode districts. Based on this assumption, the supply and demand gap is examined for hazardous waste generated in the CBIC area only.

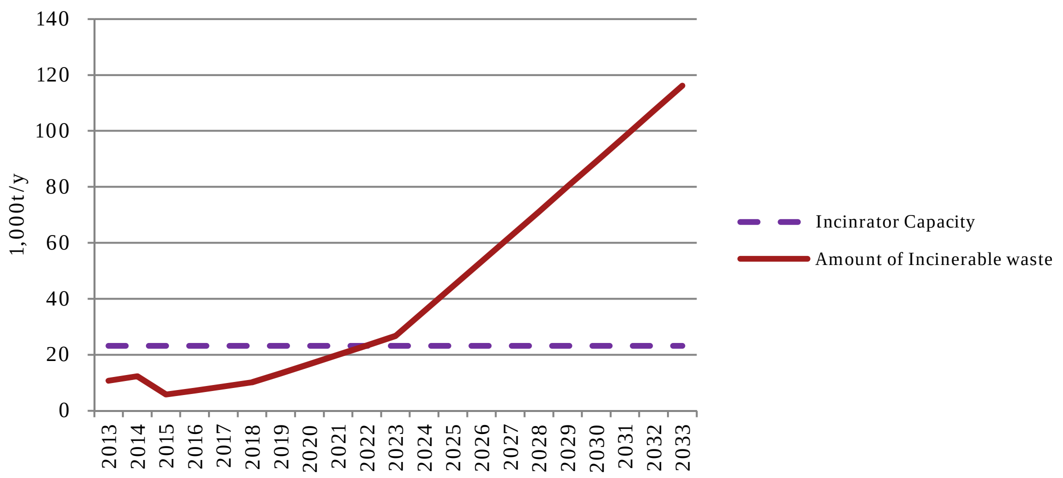
Table 6.11.8 Existing facilities and future plans in Tamil Nadu

	Within CBIC area		Outside CBIC area	
	Existing	Planned	Existing	Planned
AFR pre-processing facility	None	25,000 t/y (2015-)	None	Yes
Incinerator	1.5 t/h(24h/day)	None	None	Yes
Landfill	2,000,000 t (2008-)	None	None	Yes

Source: JICA Study Team

<u>Demand/Supply Gap for incineration facilities</u>

The amount of incinerable hazardous waste will exceed the incineration capacity in 2022 as shown in the following figure.

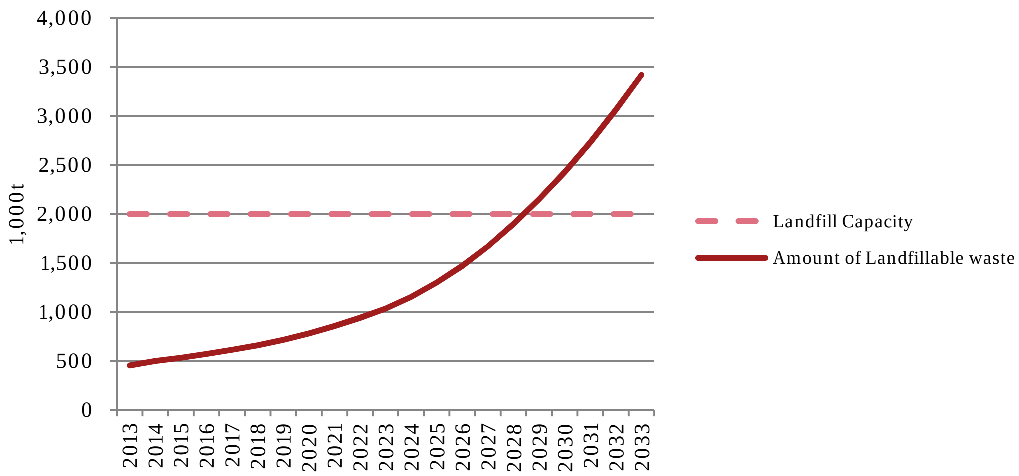


Source: JICA Study Team

Figure 6.11.8 Demand/Supply Gaps for incineration facility in Tamil Nadu

Demand/Supply Gap for landfills

The amount of landfillable hazardous waste will exceed the landfill capacity in 2029 as shown in the following figure.



Source: JICA Study Team

Figure 6.11.9 Demand/supply Gaps for landfilled waste in Tamil Nadu

6.11.3.2 Karnataka

There is one common landfill in Bengaluru Rural District and five common incineration facilities (two in Bengaluru Urban and one each in Bengaluru Rural, Ramanagara, and Tumkur, respectively) within the CBIC area and these are the only operating waste treatment and disposal facilities in the whole of Karnataka. Hazardous waste generated from Bangalore Metropolitan area is processed in the common facilities mentioned above.

There are no future plans to construct a new landfill or incineration facility either in or outside of the CBIC area. Therefore, the wastes are expected to be transported to the CBIC area from outside of CBIC area for treatment. The gap is analysed as the current waste amount brought in from outside of CBIC area will continue in the future.

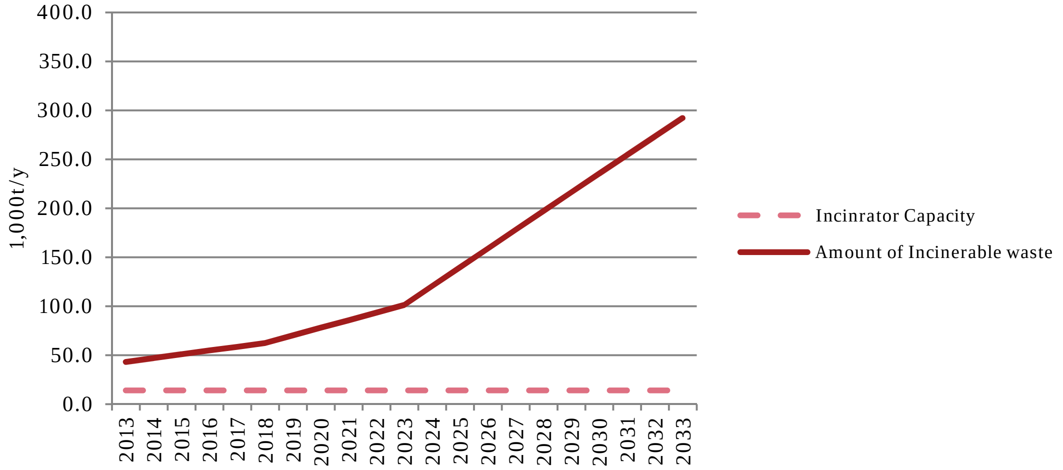
Table6.11.9 Existing facilities and future plans in Karnataka

	Within CBIC area		Outside CBIC area	
	Existing	Planned	Existing	Planned
AFR pre-processing facility	None	None	None	None
Incinerator	1.5 t/h(24 h/day)	None	None	None
Landfill	1,000,000 t (2008-)	None	None	None

Source: JICA Study Team

Demand/Supply Gap for incineration facility

The amount of incinerable hazardous waste does not meet the current and future demand as shown in the following figure.

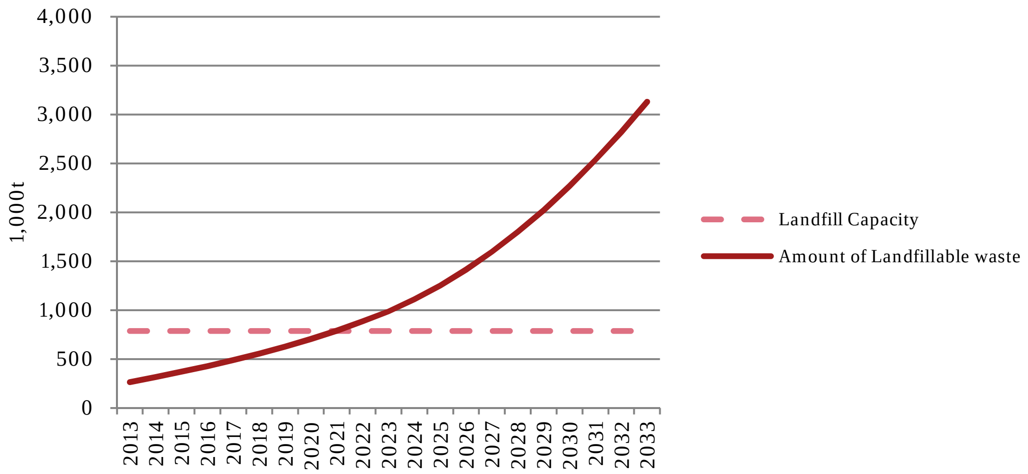


Source: JICA Study Team

Figure 6.11.10 Demand/Supply Gaps for incineration facility in Karnataka

<u>Demand/Supply Gap for the landfill facility</u>

The amount of landfillable hazardous waste will exceed the landfill capacity in 2021 as shown in the following figure.



Source: JICA Study Team

Figure 6.11.11 Demand/Supply Gaps for landfill facility in Karnataka

6.11.3.3 Andhra Pradesh

There are no landfill or incineration facilities in CBIC area in Andhra Pradesh state. Although there is a future plan to construct new ones in the CBIC area, it is not realistic physically and economically to transport wastes to the TSDF which is located more than 400 km away from the CBIC area and accordingly, new waste treatment facilities are required in this area.

6.11.4 *Infrastructure Development Strategy*

Appropriate waste management is an important element of achieving sustainable industrial development. Hazardous wastes discharged from industrial sector have caused serious water and soil pollution in the past. Therefore, appropriate management of hazardous waste discharged from industries in industrial development is absolutely necessary.

6.11.4.1 Strategy for hazardous waste management for CBIC

Table 6.11.10 below summarizes each component of the strategy.

Table 6.11.10 Summary of SWM Subsector Objectives and Strategies

Infrastructure	Objectives	• Reducing environmental burden by reduction of waste landfilled and incinerated • establishing appropriate management systems • providing waste management services to waste generators
	Strategies	• Promotion of recycling (by AFR and cement kilns) • Promotion of waste management facilities through development planning phase • Promotion of integrated waste management services in nodes
Operations/ Management	Objectives	• Promotion of appropriate waste management services
	Strategies	• Achieving the objectives through providing training for waste treatment and recycling business operators
Institutional Matters	Objectives	• Strengthening capacity of environmental administration at national and state levels • Promotion of Zero emission and cleaner production among waste generators
	Strategies	• Devising of a regional waste management plan for covering a greater area at the state level • Strengthening monitoring capacity at the state level • Providing training on Recycling Parks (industrial area for recycling businesses) • Promoting information exchange among waste generators on cleaner production and Zero emission etc.

Source: JICA Study Team

- Promotion of zero-emission towards the creation of a recycling-based society

For the environment, it is important to promote “zero-emissions”. That is to build a new recycling-based industrial system through reorganizing the production process in industrial activities and reducing generation of waste as close to zero as possible. The idea is based on the recognition that waste can be used as a raw material. For example, waste generated from A industry would be used as raw material for B industry by re-processing. Unused materials (waste) can be reduced as close to zero as possible by creating this circulation among different industries. In order to promote a zero-emission initiative, the activities must involve not only the industries but also the public institutions such as central and local governments as well as the general public.

- Promotion of recycling (by cement kilns and AFR pre-processing facility)

To minimize the waste to be landfilled and incinerated, it is desirable to expand the use of co-processing in cement kilns which has been taken up in India recently. In particular, utilization of AFR pre-processing facilities, as pre-treatment for co-processing in cement kiln, indicates high potentials to reduce incinerable and landfillable waste. In this regard, AFR pre-processing facility should be promoted more actively for the following reasons.

- It is possible to homogenize the quality of wastes and to adjust the calorific value of waste by blending. Therefore, the quality of waste can be changed from non-acceptable quality for the cement kiln to the acceptable quality.
- Although hazardous waste must be treated within the state where it is generated in principle, it can be transported to cement kilns even in other states (as recycled materials) once it is treated by AFR pre-processing facility.
- Technology of AFR pre-processing facility is simple with low environmental impact such as crushing machine and mixer, etc.

- Regional hazardous waste management by State

Although more generation of hazardous waste is expected, it is not easy to set up new waste treatment facilities due to NIMBY problem. From these situations, development of a regional hazardous waste management plan including reduction of waste should be formulated in each State as CBIC area.

- Promoting recycling/treatment of non-hazardous waste from industries

In developed industrial countries, even non-hazardous wastes generated by industries are treated under the responsibility of the waste emitter based on the "polluters pay principle." Although "polluters pay principle" is applied only to hazardous waste in India, it is desirable that application of this principle should be expanded to all waste including non-hazardous waste in the future.

- Promoting "soft-components" for institutional and individual capacity development

For promotion of "waste minimization" and "establishing appropriate waste management systems", capacity development is required not only for the administration but also for the business entities including generating waste , waste treatment, and recycling companies.

6.11.5 *Development Goals and Target Performance Indicators*

Development goals and target performance indicators for the target year are shown in the following table. The recycling rates of 2033 will be realized when recycling by proposed AFR pre-processing facility project is promoted.

Table 6.11.11 Summary of HWM Subsector Goals and Targets

Goal	Indicator	Current Situation	Short-term Target at 2017	Mid-term Target at 2022	Long-term Target at 2033
Increase in the rate recycling and decrease in the rate of landfill and incineration					
Tamil Nadu	Landfill & Incineration %	38%	35%	30%	20%
	Recycle %	62%	65%	70%	80%
Karnataka	Landfill & Incineration %	54%	50%	40%	25%
	Recycle %	46%	50%	60%	75%
Andhra Pradesh	Landfill & Incineration %	61%	55%	45%	25%
	Recycle %	39%	45%	55%	75%

Source: JICA Study Team

6.11.6 *Development Plan and Suggested Projects*

6.11.6.1 Infrastructure development plan

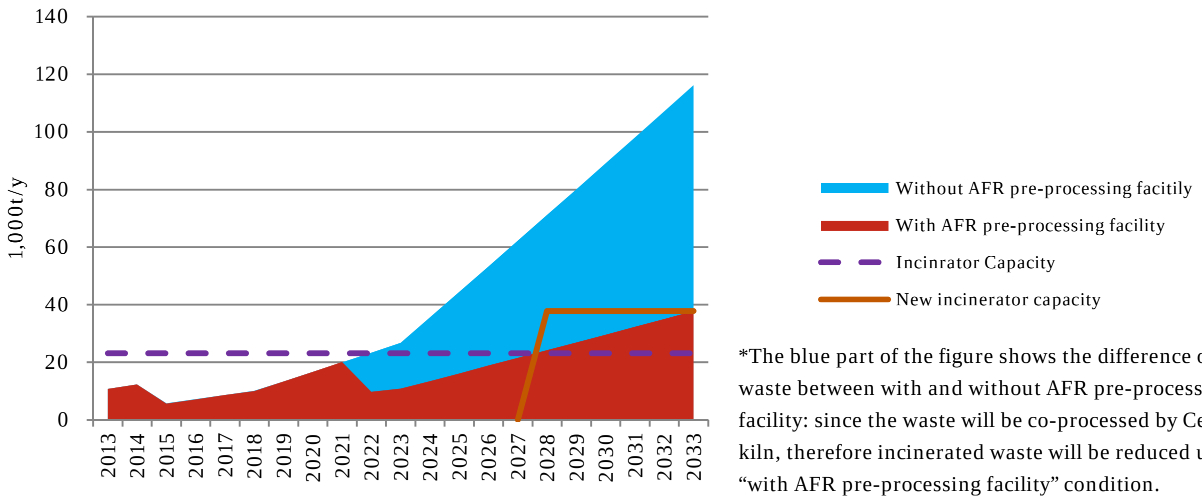
The waste management infrastructure development plan to promote recycling by the AFR pre-processing facility in the strategy was formulated. The capacities of each infrastructure are estimated with the following conditions.

i) The lifespan of the new landfill is set as 20[110] years.
ii) The Service provision of the incinerator and AFR pre-processing facility are set as 15 years.

6.11.6.2 Tamil Nadu

Demand/Supply for incineration facilities

The amount of incinerable hazardous waste will exceed the incineration capacity in 2022. Therefore AFR pre-processing facility should be installed before 2022. The capacity of the new incinerator can be utilized more efficiently through installation of new AFR, and accordingly, the new incinerator has to be installed before 2028 as shown below.



*The blue part of the figure shows the difference of waste between with and without AFR pre-processing facility: since the waste will be co-processed by Cement kiln, therefore incinerated waste will be reduced under "with AFR pre-processing facility" condition.

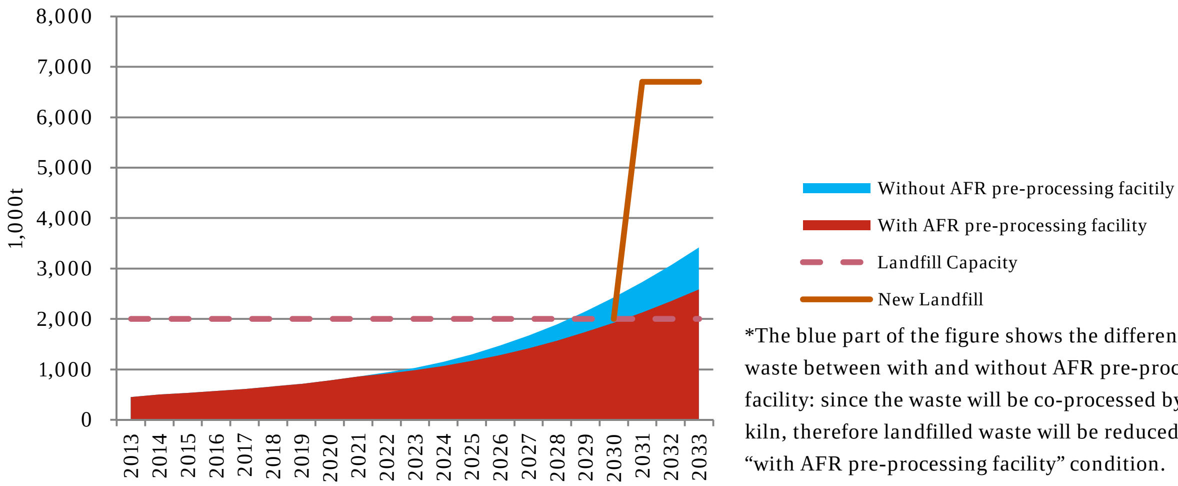
Source: JICA Study Team

Figure 6.11.12 Demand/Supply Gaps for incineration facility in Tamil Nadu

Demand/Supply for landfills

The amount of landfillable Hazardous waste will exceed the landfill capacity in 2029. However, it will be prolonging the life span until 2031 by new AFR pre-processing facility installation. In addition, the new disposal site capacity can be utilized more efficiently through installation of new AFR as shown below.

110 The lifespan of the new landfill was set for 20 years depending on the general lifespan (10-25 years) mentioned in the Criteria for Hazardous waste Landfills,HAZWAMS/17/2000-01 5.2 Design life and that of the existing landfill (20 years).



*The blue part of the figure shows the difference of waste between with and without AFR pre-processing facility: since the waste will be co-processed by Cement kiln, therefore landfilled waste will be reduced under "with AFR pre-processing facility" condition.

Source: JICA Study Team

Figure 6.11.13 Demand/supply Gaps for landfilled waste in Tamil Nadu

From the above estimation, the capacity of each facility should be as follows.

Table 6.11.12 Scale of infrastructure needed in each state

Tamil Nadu	
AFR pre-processing facility: 620 t/day	• AFR pre-processing facility should be constructed by year 2022. • The AFR pre-processing facility should meet the amount of waste required by ADR facility in 2036.
Incineration facility: 110 t/day	• A new incineration facility should be constructed by year 2028. • The new incineration facility should meet the amount of waste to be incinerated in 2042.
Landfill site: 4,701,000 t	• A new landfill should be constructed by year 2031. • The new landfill can provide the landfill capacity up to year 2050.

Source: JICA Study Team

For comparison, the capacity of each facility in business as usual scenario was estimated and the result is summarized as follows.

Table 6.11.13 Scale of Infrastructure Needed in Tamil Nadu State (in Business As Usual Scenario)

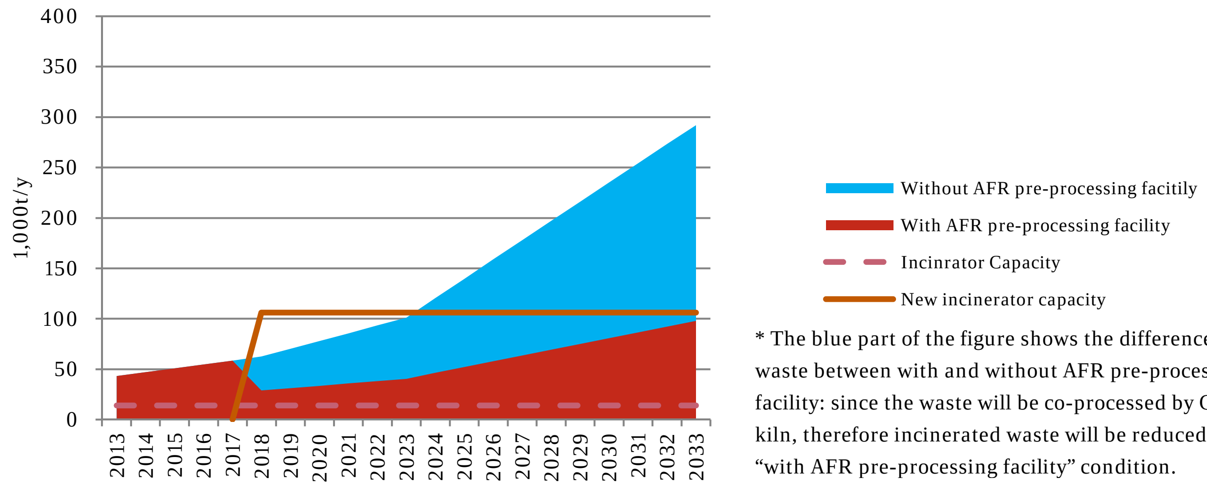
Tamil Nadu (in Business as usual scenario)	
AFR pre-processing facility: 180 t/day	• AFR pre-processing facility should be constructed by year 2031. • The AFR pre-processing facility should meet the amount of waste required by ADR facility in 2045.
Incineration facility: not required	• In the case of installation of the new AFR pre-processing facility above, incineration capacity will be sufficient until 2033.
Landfill site: not required	• Landfill capacity will be sufficient until 2033.

Source: JICA Study Team

6.11.6.3 Karnataka

<u>Demand/Supply for incineration facility</u>

The amount of incinerable hazardous waste does not meet the current and future demands. Therefore, it is necessary to install a new incinerator as soon as possible. In addition, installation of AFR pre-processing facility is also required in order to reduce the scale of the new incinerator. The period of the installation of new incinerator and AFR pre-processing facility will be until 2018.



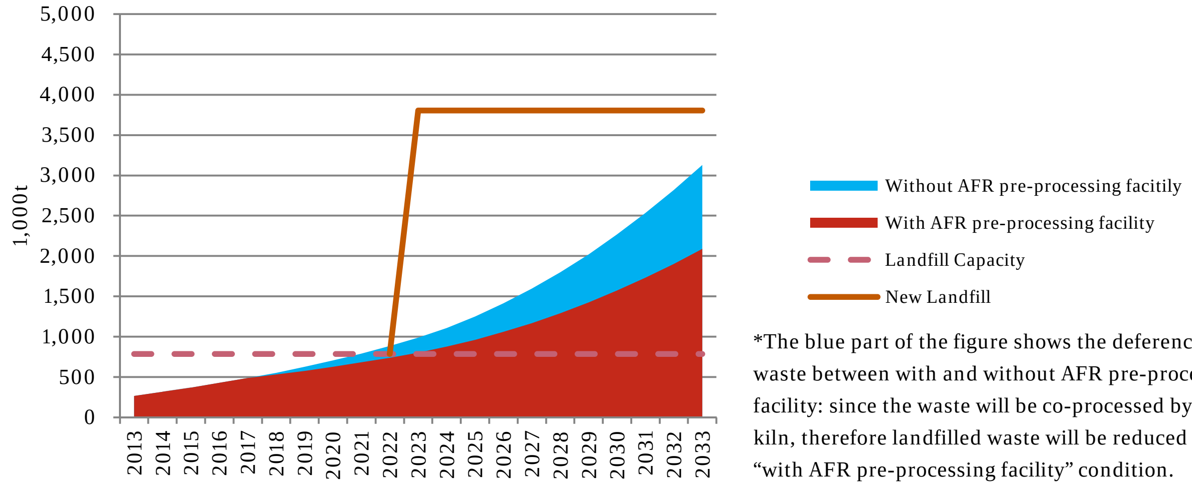
* The blue part of the figure shows the difference of waste between with and without AFR pre-processing facility: since the waste will be co-processed by Cement kiln, therefore incinerated waste will be reduced under “with AFR pre-processing facility” condition.

Source: JICA Study Team

Figure 6.11.14 Demand/Supply for incineration facility in Karnataka

<u>Demand/Supply for the landfill facility</u>

The amount of landfillable Hazardous waste will exceed the landfill capacity in 2022. However, it will be prolonging the life span until 2023 by the AFR pre-processing facility installation. In addition, the new disposal site capacity can be utilized more efficiently through installation of new AFR as shown below.



*The blue part of the figure shows the deference of waste between with and without AFR pre-processing facility: since the waste will be co-processed by Cement kiln, therefore landfilled waste will be reduced under “with AFR pre-processing facility” condition.

Source: JICA Study Team

Figure 6.11.15 Demand/Supply Gaps for landfill facility in Karnataka

From the above estimation, the capacity of each facility should be as follows.

Table 6.11.14 Scale of infrastructure needed in Karnataka state

Karnataka	
AFR pre-processing facility: 820 t/day	• AFR pre-processing facility should be constructed by year 2018. • The AFR pre-processing facility should meet the amount of waste required to be treated by ADR facility in 2032.
Incineration facility: 260 t/day	• A new incineration facility should be constructed by year 2018. • The new incineration facility should meet up to the amount of waste to be incinerated in 2032.
Landfill site: 3,018,000 t	• A new landfill should be constructed by year 2023. • The new landfill can provide the landfill capacity up to around 2042.

Source: JICA Study Team

For comparison, the capacity of each facility in business as usual scenario was estimated and the result is summarized as follows.

Table6.11.15 Scale of Infrastructure Needed in Karnataka State (in Business As Usual Scenario)

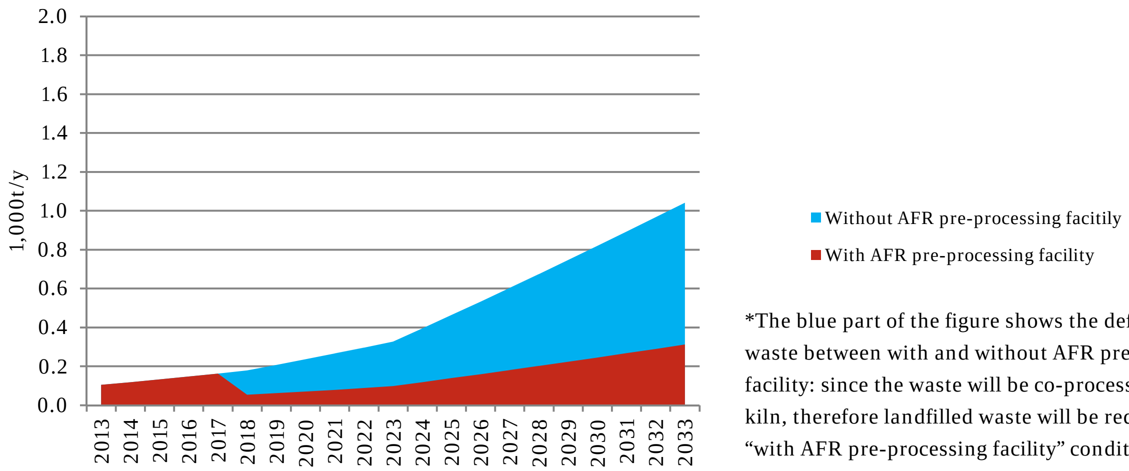
Karnataka (in Business as usual scenario)	
AFR pre-processing facility: 260 t/day	• AFR pre-processing facility should be constructed by year 2018. • The AFR pre-processing facility should meet the amount of waste required by ADR facility in 2032.
Incineration facility: 100 t/day	• A new incineration facility should be constructed by year 2018. • The new incineration facility should meet up to the amount of waste to be incinerated in 2032.
Landfill site: 1,266,000 t	• A new landfill should be constructed by year 2025. • The new landfill can provide the landfill capacity up to around 2044.

Source: JICA Study Team

6.11.6.4 Andhra Pradesh

Demand/Supply for facility

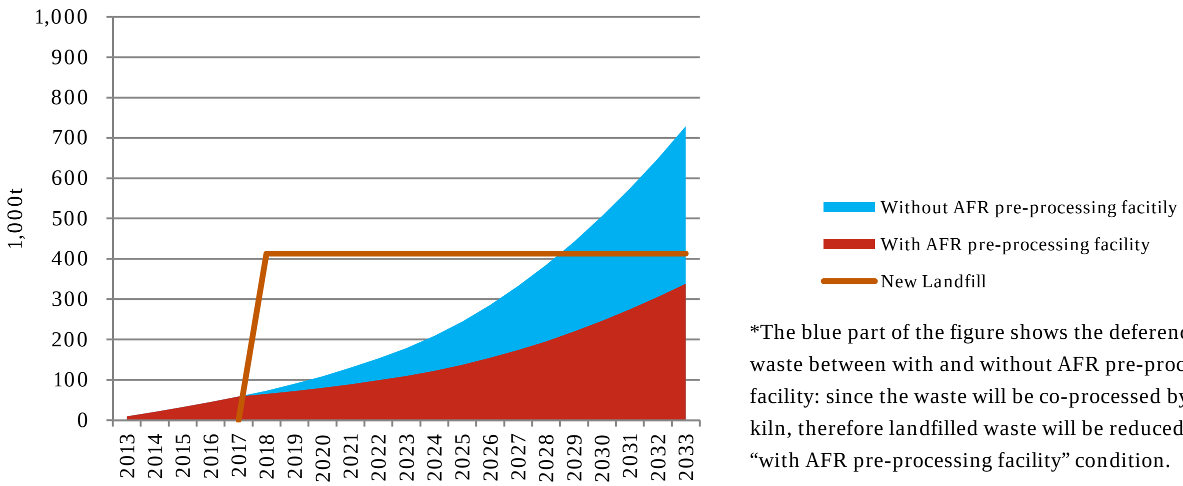
There are no landfill or incineration facilities in CBIC area in AP state. In addition, there is no future plan to construct new one in the CBIC area. Therefore new waste treatment facilities should be established in the area. The period of the installation of new Landfill facility and AFR pre-processing facility will be until 2018.



*The blue part of the figure shows the deference of waste between with and without AFR pre-processing facility: since the waste will be co-processed by Cement kiln, therefore landfilled waste will be reduced under "with AFR pre-processing facility" condition.

Source: JICA Study Team

Figure 6.11.16 Demand/Supply Gaps for landfill facility in Andhra Pradesh



*The blue part of the figure shows the deference of waste between with and without AFR pre-processing facility: since the waste will be co-processed by Cement kiln, therefore landfilled waste will be reduced under "with AFR pre-processing facility" condition.

Source: JICA Study Team

Figure 6.11.17 Demand/Supply Gaps for landfill facility in Andhra Pradesh

Table 6.11.16 Scale of infrastructure needed in Andhra Pradesh state

Andhra Pradesh	
AFR pre-processing facility: 130 t/day	• AFR pre-processing facility should be constructed by year 2018. • The new AFR pre-processing facility should meet the amount of waste required by AFR pre-processing facility in 2032.
Incineration facility: 1 t/day	• The new incineration facility is not economical way since the amount of incinerable waste is too small to install a incineration facilities. Therefore, the incinerable waste should be processed to TSDF facility in AP State.
Landfill site: 413,000 t	• A new landfill should be constructed by year 2018. • The new landfill can provide the landfill capacity up to year 2037.

Source: JICA Study Team

For comparison, the capacity of each facility in business as usual scenario was estimated and the result is summarized as follows.

Table 6.11.17 Scale of Infrastructure Needed in Andhra Pradesh State (in Business As Usual Scenario)

Andhra Pradesh (in Business as usual scenario)	
AFR pre-processing facility: 50 t/day	• AFR pre-processing facility should be constructed by year 2018. • The AFR pre-processing facility should meet the amount of waste required by ADR facility in 2032.
Incineration facility: 0.3 t/day	• The new incineration facility is not economical way since the amount of incinerable waste is too small to install a incineration facilities. Therefore, the incinerable waste should be processed to TSDF facility in AP State.
Landfill site: 191,000 t	• A new landfill should be constructed by year 2018. • The new landfill can provide the landfill capacity up to around 2037.

Source: JICA Study Team

The following table indicates the expected commencement year of the operation of each hazardous waste treatment facilities.

Table 6.11.18 Operation schedule of infrastructure for hazardous waste management by state

No	Project Title	Status	Short-term (-2017)	Mid-term (2018-2022)	Long-term (2023-2032)
Tamil Nadu	AFR facilities	New		2022-	-----------------------------
	Incinerator	New			2028---------
	Landfill	New			2031--
Karnataka	AFR facilities	New		2018----------------------	-----------------------------
	Incinerator	New		2018----------------------	-----------------------------
	Landfill	New			2023----------------------
Andhra Pradesh	AFR facilities	New		2018----------------------	-----------------------------
	Landfill	New		2018----------------------	-----------------------------

Source: JICA Study Team

Based on the requirement analysis, the following projects are proposed.

Table 6.11.19 List of SWM Subsector Projects

No	Project Title		Status	Project Cost (Million US$)	Priority1
01	Tamil Nadu	AFR construction Project	New	26.1	B
02		Incinerator construction Project	New	22.2	C
03		Landfill construction Project	New	37.9	C
04	Karnataka	AFR construction Project	New	34.5	A
05		Incinerator construction Project	New	52.4	A
06		Landfill construction Project	New	24.4	B
07	Andhra Pradesh	AFR construction Project	New	5.5	A
08		Landfill construction Project	New	3.3	A

Source: JICA Study Team

*1/ "A" refers to projects for implementation before 2018, "B" refers to projects for implementation in 2018 – 2022, and, "C" refers to projects for implementation after 2023.

*estimated at 1 INR=0.016137 USD

*The Preliminary project cost is calculated based on the unit cost (Rs/t) referring to the costs of the performance of existing facilities and manufacturer hearing.

The priority should be given to the areas with large amount of waste generation. It is noted that the most desirable locations to install treatment facilities are within the industrial estate.

6.11.6.5 Integrated waste management for the industrial nodes

6.11.6.5.1 Compatibility with node development

Hazardous waste management in each state should be done according to a regional hazardous waste management plan which considers the amount of hazardous waste to be generated, and the transportation distance. However, waste management in the eight nodes should be promoted within each node for the following reasons.

- Considering the forecasted increase in the amount of waste and the capacity of the existing facility, a new treatment facility, particularly AFR pre-processing facility, will be required for rapidly developed nodes.
- Waste treatment facilities located near the sources of waste has an economic merit such as lower transportation cost.
- Including an appropriate waste management system as part of the node development plan from the planning stage would be easier to obtain residents' consensus than to build a waste management facility after the node development.

From the above viewpoints, the waste management facilities in nodes are proposed as shown below.

Table 6.11.20 Waste management facilities in 8 nodes

State	Industrial Node	Landfill	Incinerator	AFR	
Tamil Nadu	Ponneri	-	-	○	There is an existing TSDF (landfill and incineration facility) in nearby Ponneri. Installation of an additional AFR pre-processing facility would be considered.
	Hosur	○	○	○	Hosur is more than 200km away from the existing TSDF. A new landfill, incineration facility and ADR facility will be installed.
Karnataka	Ramanagara	-	○	○	As all three industrial nodes are close to the existing TSDF, the landfill at TSDF should be used. One incineration and one AFR pre-processing facility are proposed to be installed within each node or one facility should be installed in one of the three nodes due to a relatively short distance.
	Kolar	-	○	○	
	Tumkur	-	○	○	
Andhra Pradesh	Chillakur	○	-	○	All three nodes are more than 400km away from the existing TSDF. It is proposed that waste management facilities are installed within each node, or one facility should be installed in one of the three nodes. The waste from Chittor district is expected to be the largest; therefore Kalikiri node (located within Chittor) could be the first option for installation.
	Kalikiri	○	-	○	
	Hindupur	○	-	○	

Source: JICA Study Team

6.11.6.5.2 Integrated waste management in node

For the node development in the future, an integrated waste management including recycling and treatment of non-hazardous waste generated within nodes is proposed as a model case for other industrial parks for the following reasons. Japan has some good examples of integrated waste management such as eco-town projects (see section on Japanese examples) to be considered in the node development.

– Within the node, it is expected that residents, public facilities and commercial buildings are also developed. This means that municipal solid waste would be generated, posing a significant burden to the local municipality where the node would be developed.
– Depending on the hazardous waste, more efficient waste management would be possible if treatment/disposal facilities are commonly used with municipal solid waste.

- Integrated Waste Management

In an integrated waste management, waste would become resources in a well-organized and controlled waste process flow as described in the section on zero emission. A modern integrated waste management policy is based on a combination of; i) waste prevention and avoidance, ii) maximized recycling, iii) maximized re-use, iv) sorting and, v) separate waste collection. This would result in minimized amount of landfillable waste. Waste management in the node should be implemented based on this concept.

- Exploiting technological synergies

The strength of an integrated waste management concept is the combination of several technologies. The combination will creates a synergy impact which would not be expected under application of individual technology. For example, the pre-processing techniques such as AFR pre-processing facility can expand the range of the waste for co-processing in cement kiln. This synergy will contribute to more energy and material recovery, and reduction of landfillable waste.

Possible waste management facilities by types of waste generated in the nodes are shown in the next table.

Table 6.11.21 Waste management facilities by type of waste

Types of waste		Treatment facility
Hazardous waste	• Recyclable waste • Incinerable waste • Landfillable waste	• AFR pre-processing facility • Incineration facility • Landfill facility
Municipal solid waste (including non-hazardous waste generated from industries)	• Landfillable waste • Recyclable waste • Organic waste • Food (organic) waste • Construction waste	• AFR pre-processing facility • Incineration facility • Landfill facility • Composting facility • Bio Methanization facility • Various recycling facility
Other waste designated by the law	• E-waste	• E-waste recycling facility
	• Batteries	• Batteries recycling facility
	• Medical waste	• Medical waste treatment facilities

Source: JICA Study Team
*it is assumed that these facilities are installed within industrial estates of nodes, which has merit of close distance between the waste generators and the treatment facilities.

- Japanese examples

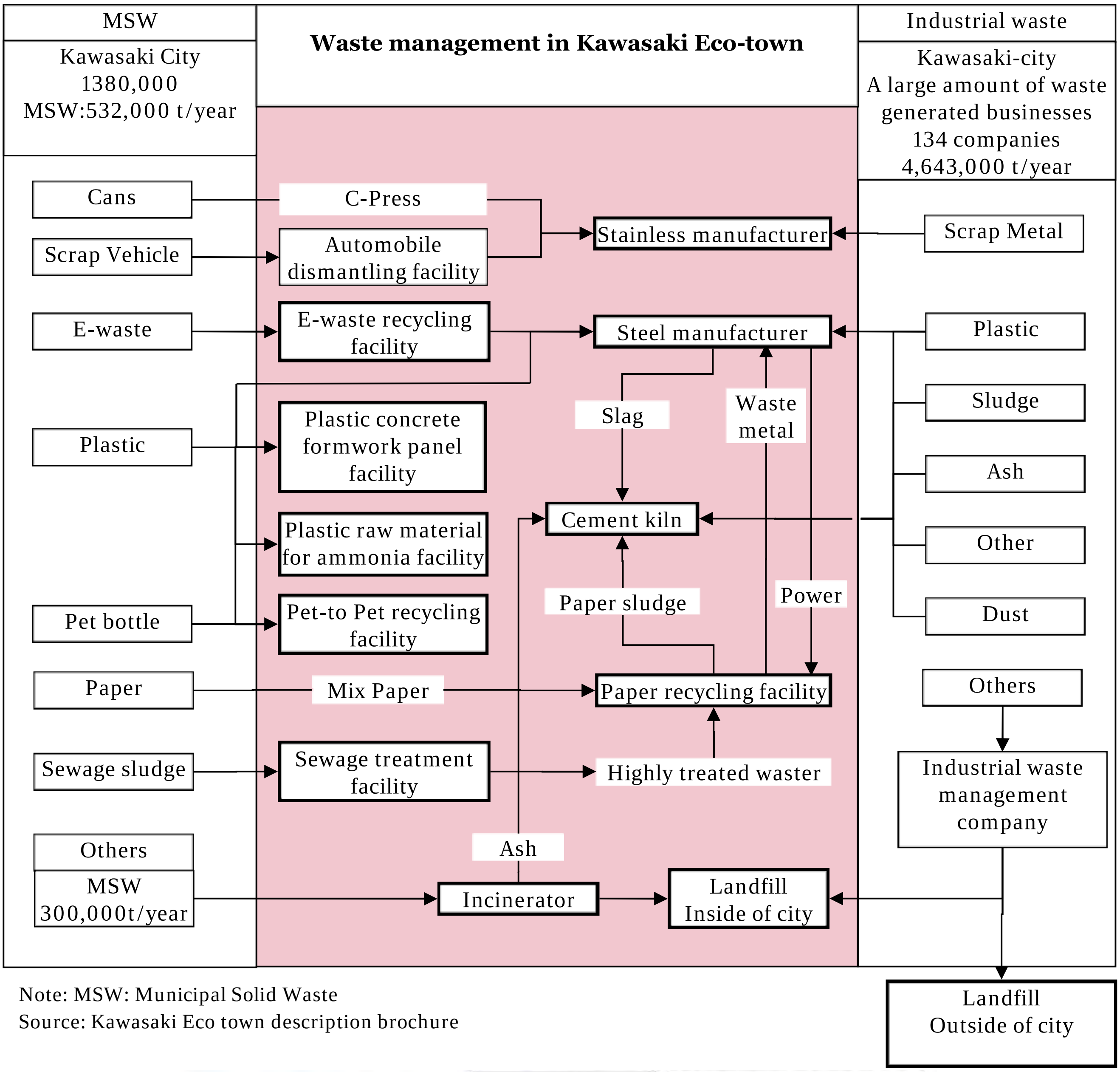
There are examples of integrated waste management in Japan as an eco-town project that is cooperating local governments and businesses. Cases in Japan are shown below.

- Case 1: Kawasaki Eco town, Recycling Parks(Formation of a regional network of resource recycling)

Kawasaki city designated the entire Kawasaki coastal area (2800 ha) located within the greater Tokyo Metropolitan area as an “Eco-Town” in 1997 through its "environment-friendly urban development (Eco-Town) promotion project," in aiming to achieve sustainable development and ensuring quality of life of the citizens into the future.

In the Eco-town, in addition to reducing the waste generated from business activities are as much as possible, zero emissions initiatives aiming to minimize the environmental impact through reuse/recycling of resources and energy are also being implemented.

This area has been an industrial area for a long time, where cement kilns and blast furnaces are present. This Eco-Town project is promoting a new recycling facility development while taking advantage of these facilities originally present.



Note: MSW: Municipal Solid Waste

Source: Kawasaki Eco town description brochure

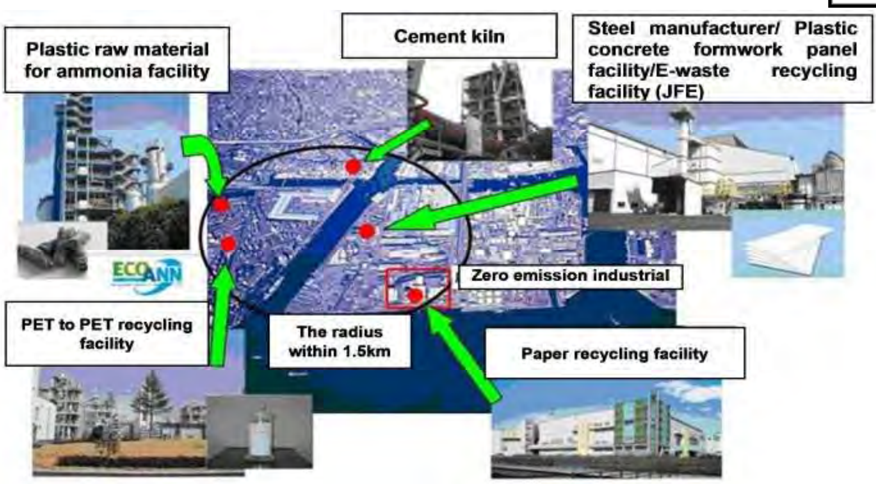


Figure 6.11.18 Waste stream in Kawasaki Eco town

Table 6.11.22 The Main Recycling Facilities in Kawasaki Eco Town

No	Type of waste	Main processing facility	Main product	Capacity
1	Plastic	Waste plastic blast furnace feed facility		25,000 t/year
2	Plastic	Waste plastic concrete formwork panel manufacturing facility	Concrete formwork board The used board used as a raw material for iron making.	20,000 t/year
3	Plastic	waste plastic raw material for ammonia facility	Ammonia raw material The production of chemical products from 195 t/year of waste plastics is 175 t/year.	65,000 t/year
4	Pet bottle	Pet to Pet recycling facility	PET resin nearly 100% Recycle	27,500 t/year
5	Paper	waste paper recycling facility	Toilet paper (Production of 54,000 t / year) The separate collection of mixed paper generated from households in the city. Products are sold in the city retailer	81,000 t/year
6	E-waste	E-waste recycling facility		40-50 million units/year
7	Industrial waste	Cement Kiln	Used as fuel and materials	
8	Scrap Metal	Non-ferrous metal products manufacturing facility	Raw materials of Blast Furnace	

Source: Kawasaki Eco town description brochure

- Example2: Saitama Prefectural Environmental Management Centre

Saitama Prefectural Environmental Management Centre is a comprehensive resource recycling model facilities by public involvement to propose the creation of a recycling-based society and sustainable development. The regional landfill facilities were constructed and managed for municipalities and small and medium-sized enterprises in Saitama which has difficulties in ensuring their own waste disposal sites. In addition, Resource recycling plant "Sai no Kuni" is run as a private business by Private Finance Initiative.

Table 6.11.23 Main Facilities of Saitama Prefectural Environmental Management Centre

No	Type of waste	Main processing facility	Main product	Capacity	Recycling rate	Site area
1	General waste	Thermal recycling facility (incineration)	Power generation, metal	450 t /day	100%	5.1 ha
2	General waste	Thermal recycling facility (incineration) RPF(Refuse Paper & Plastic Fuel) facility Composting facility	RPF Fertilizer	594 t/day	90%	3.0 ha
3	Plastic Food waste	RPF(Refuse Paper & Plastic Fuel) facility Composting facility	RPF Compost	57 t/day	100%	0.4 ha
4	Fluorescent tubes	Glass recovery facility Mercury recovery facility	Glass Metal	11 t/day	100%	1.1 ha
5	Food residue	Composting facility	Compost	108 t/day	100%	1.2 ha
6	Construction debris	Crushing, dewatering, sorting, compression packing facility	Recycled aggregate Wooden chip	588 t/day	87%	3.7 ha
7	Ash	Firing facility	Artificial	288 t/day	90%	1.6 ha

No	Type of waste	Main processing facility	Main product	Capacity	Recycling rate	Site area
			sand			
8	Sewage sludge	Composting facility	Organic fertilizer	200 t/day	100%	1.1 ha
9	Ash Incombustible Construction soil waste	Sanitary Landfill		Landfill weight 2.71 million tons		Total area 137.4 ha Reclamation area 28.3 ha

Project Operator 8 Private companies and Saitama Prefecture
Source: Facility information of Resource recycling plant "Aya no Kuni" and Saitama Prefectural Environmental Management Centre

6.11.7 *Phasing Plan*

Based on the project priority and situation of each state, the following phasing plan for the proposed projects is formulated.

Table 6.11.24 Summary of Phasing Plan for SWM Subsector Projects (Million US$)

No	State	Project Title	Status	Short-term (-2017)	Mid-term (2018-2022)	Long-term (2023-2032)
01	Tamil Nadu	AFR Construction Project	New		26.1	
02		Incineration facility construction project	New			22.2
03		Landfill facility construction project	New			37.9
04	Karnataka	AFR Construction Project	New	34.5		
05		Incineration facility construction project	New	52.4		
06		Landfill facility construction project	New		24.4	
07	AP	AFR Construction Project	New	5.5		
08		Landfill facility construction project	New	3.3		
				95.7	50.5	60.1

Source: JICA Study Team

7 Strategic Environmental Assessment

7.1 Overview of Environmental Conditions and Issues

7.1.1 Environmental Conditions in CBIC

The CBIC regions cover three states, i.e. Karnataka, Tamil Nadu and Andhra Pradesh. The environmental conditions for those states in terms of following factors are referred to Annexture.

- Topographic Conditions
- Climate Conditions
- Protected Areas
- Natural Disaster

7.1.2 Major Environmental Issues in India

Air pollution, water pollution and inadequate solid waste management are some of the major environmental issues India faces today. In addition to those environmental pollutions, involuntarily resettlement caused by land acquisition for development projects is also another serious social environmental issue for India.

(1) Air Pollution

In India, air pollution comes from many sources, stationary sources such as factories, power plants, and mobile sources such as cars, buses, planes, trucks, and trains. Air pollution has been aggravated by development that typically occurs as countries become industrialized: growing cities, increasing traffic, rapid economic development and industrialization, and higher levels of energy consumption.

Regarding air pollution generated from industrial activities, the Central Pollution Control Board (CPCB) of India has identified the list of categories of industries as significantly polluting and the list includes highly air polluting industries such as integrated iron and steel, thermal power plants, copper/zinc/aluminium smelters, cement, oil refineries, petrochemicals, pesticides and fertilizer units. Air borne emissions emitted from various industries are a cause of major concern. These emissions are of two forms viz., Suspended Particulate Matter (SPM) and gaseous emission of Sulphur dioxide (SO2), Nitrogen dioxide (NO2) and Carbon monoxide (CO).

Increase in vehicular growth is another pressure for air pollution in urban city. Vehicle population in India has been increasing over the years mainly on account of growing urbanization, rising real per capita income and increasing share of personalized mode of transport. For example, the number of motor vehicles has increased in the State of Tamil Nadu from 4,600,000 in 1999-2000 to 6,700,000 in 2003-04. Out of these, 48 per cent are concentrated in major cities like Chennai, Coimbatore, Salem, Madurai, Thiruchirapalli and Tirunelveli. Chennai itself accounts for about 24.5 per cent of the total registered vehicles. The registered vehicular population has increased more than two folds during the year 1996-2004.111

(2) Water Pollution

Most human activities whether domestic, industrial or agricultural have an impact on water and the ecosystems. World Health Organization statistics indicate that half of India's morbidity is water related. Water borne diseases can be, to a large extent, controlled by managing human consumption and production patterns.

Waste management systems have not been able to keep pace with the huge volumes of organic and non-biodegradable wastes generated daily. As a consequence, garbage in most parts of India is unscientifically disposed and ultimately leads to increase in the pollutant load of surface and groundwater courses. On the other hand, the large populations of the poor in India do not have much choice but to live off the natural resource base and pollute the environment in the process. They deforest for food, fuel, fodder and fibre and pollute the water sources on which they depend, since they cannot afford access to sanitation services.

In most parts of India, waste water from domestic sources is hardly treated due to inadequate sanitation facilities. This waste water, containing highly organic pollutant load, finds its way into surface and groundwater courses, very often close to dense pockets of human habitation from where further water is drawn for use.

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[111]State of Environment Report(Tamil Nadu-2005)

The industrial sector, contributing to about 20 per cent of the national income, accounts for about 8 per cent of the current water use. With rapid industrialization and urbanization, the water requirement for energy and industrial use is estimated torise to about 18 per cent of the total requirements in2025.112

Poor environmental management systems, especially in industries such as thermal power stations, chemicals, metals and minerals, leather processing and sugar mills, have led to discharge of highly toxic and organic wastewater. This has resulted in pollution of the surface and groundwater sources from which water is also drawn for irrigation and domestic use. The enforcement of regulations regarding discharge of industrial wastewater and limits to extraction of groundwater needs to be considerably strengthened, while more incentives are required for promoting waste water reuse and recycling.

(3) Solid Waste Management

Solid waste can be classified into mainly two types depending on their source: 1) municipal solid waste (MSW) and 2) Industrial waste as hazardous waste. At present most of the municipal solid waste (MSW) in India is disposed off unscientifically. The unsegregated municipal solid wastes generated are collected and are either disposed in low-lying areas or water bodies or disposed along the roadside and are set on fire causing air pollution. The leachate from the dumped solid wastes has caused water pollution, odour nuisance are mainly caused due to the putrefaction of the organic matter present in the unsegregated municipal solid wastes.

The plastic content of the municipal waste is picked up by the rag pickers for recycling at dumpsites. Plastic are recycled mostly in factories, which do not have adequate technologies to process them in a safe manner. This exposes the workers to toxic fumes and unhygienic conditions. Moreover, since the rag picking sector is not organized, not all the recyclables, particularly plastic bags, get picked up and are found littered everywhere, reaching the drains and water bodies ultimately and choking them.

The major hazardous waste-generating industries include textile, tannery, petrochemicals, pesticides, paint and dye, petroleum, fertilizers, asbestos, caustic soda, inorganic chemicals and general engineering industries. Hazardous wastes from the industrial sectors mentioned above contain heavy metals, cyanides, pesticides, complex aromatic compounds (such as PCBs), and other chemicals which are toxic, flammable, reactive, corrosive or have explosive properties affecting the environment.

(4) Involuntarily Resettlement and Land Acquisition

The conflicts caused by land acquisition for development projects are found frequently in India. The Land Acquisition Act (1894) applying to the land acquisition process is the one of oldest law in India. Since the law contains unclear stipulation especially for compensation cost, the affected households complain for less amount compensation cost. It often leads large scale protest movement consequently.

The considerable number of development projects suspend due to land acquisition issues recently. The summary of suspended projects due to land Issues is as shown in the Table 7.1.1.

Table 7.1.1: Summary of Suspended Projects Due to Land Issues

Project	Description
Construction project for vehicle of assembly factory by “Tata Group” at West Bengal State	West Bengal state acquired the land for the Factory. After completion of land acquisition, Tata had been forwarding the project. However, Tata Group met strong opposition from local people claiming additional compensation and the protest movement resulted in injury and death finally. Consequently Tata decided to move the factory to Gujarat state in 2008.
Construction of steel mill plant in Karnataka State by POSCO(Korean major steel company)	POSCO, one of the world’s top steel makers, signed a memorandum of understanding with the Karnataka government in 2010 to build a mill. However, POSCO decided to scrap the project because of opposition from residents on July 2013.
Construction of steel mill plant in Orissa State by Arcelor Mittal (the world’s	Arcelor Mittal decided to stop the construction of steel mill plant in Orissa State in Feb. 2014 due to delay of land acquisition as well as deterioration in

112State of Environment Report (India-2009)

Project	Description
top steel makers)	the market condition and uncertainty surrounding the steel demand
Road construction project in Goa and Kerala State by National Highways Authority of India (NHAI)	National Highways Authority of India (NHAI) decided to scrap six projects in Goa State and Kerala State due to land acquisition hurdles[113] in August 2013. Kerala and Goa have limited land availability and the state governments have been opposing the plans to acquire land for roads

Source: JICA Study Team

In order to solve the above situation, the new Land Acquisition Bill was submitted to parliament and enforced in January 2014(Land Acquisition, Rehabilitation and Resettlement Act).

The Table 7.1.2shows the results of the comparative analysis between "Old Law" and "New Law" of Land Acquisition

Table 7.1.2: Comparative Analysis between Old Law and New Law of Land Acquisition

Items	Old Law	New Law
Resettlement and Rehabilitation(R&R) for Affected Households(AHs)	Cash compensation for land only No stipulation for R&R	Stipulation on the R&R is added in addition to compensation cost for land. R&R includes provision of resettlement site with houses, basic infrastructure, job opportunity and related allowances.
Eligibility	Landowners only	AHs without land title such as agricultural labors and tenants are also eligible.
Compensation cost	In addition to the market value of land, 30% of the price will be added further.	The calculation method is same with old law; the compensation cost will be multiply by up to double in rural areas.
Prior consent from AHs for land acquisition for public purpose by private companies	No stipulation	In case of the project for public purpose by private companies, 80% of prior consent of AHs is necessary and at least 70% in case of Public Private Partnership Project. (Section 2(2)

Source: JICA Study Team

In addition to the increasing the compensation cost, the resettlement and rehabilitation package for AHs was introduced into New law. The cost for land acquisition will be increased largely for the future development project.

7.2 Objectives and Methodology of "SEA"

7.2.1 Objectives of "SEA"

In relation to the national development and environmental context, the "SEA" is said to have two important significances, as given in the following.

(i) To integrate appropriate environmental and social considerations into the process of decision making;

(ii) To supplement the limitation of conventional environmental impact assessment that will be carried out in the implementing stage

[113] "Business Standard" Feb. 27, 2014

7.2.2 *Methodologies*

At the moment, no single "best" SEA process has been established. Different techniques or methodologies have been applied in various stages and activities of SEA. The choice of techniques depends on a whole range of factors, including the purpose of the SEA, the availability of data, local environmental assessment capacity, decision-making structure and culture, and resource constraint114.

The examination on the proposed regional structure plan resulting from the process of "Node selection" was conducted using "the SEA approach" for CBIC.

The applied methodologies for the SEA approach are as followings.

(1) Review the Proposed Structure Plans

The contents of the proposed structure plan were reviewed carefully. In the review, the process of selection of nodes was also examined.

(2) Environmental Scoping

The sectoral development policies for the proposed structure plan were clarified first. Then the environmental scoping was conducted through consideration on the relationship between the environmental impact items and sectoral development policies for the structure plan using environmental impact check matrix. It is noteworthy that the thirty (30) general environmental impact items will be prepared referring the environmental check list of the "JICA Guidelines".

(3) Evaluation of the Environmental Impact Items

The anticipated environmental impacts caused by the structure plan were evaluated. The evaluation categories were social, natural environment and pollution. The environmental impacts were evaluated in positive and negative aspect respectively.

(4) Comparative Analysis on the Alternatives

The comparative analysis on the alternatives is a part of main component of SEA approach. The two alternatives of structure plans were prepared paying attention on implementation scheme. Anticipated environmental impacts to be caused by each of the alternatives were evaluated in the matrix manner.

(5) Establishment of Environmental Mitigation Plan

An environmental mitigation plan necessary in the implementation stage was prepared for the negative impacts identified in the process of the evaluation for the structure plan.

(6) Stakeholders Meeting(SHM)

The information disclosures and the transparency in the process of SEA is one of most essential factor. The SHM were held in state-wise for discussion of the results of "Node selection ".

The work flow of SEA for the structure plan for CBIC is shown in the Figure 7.2.1.

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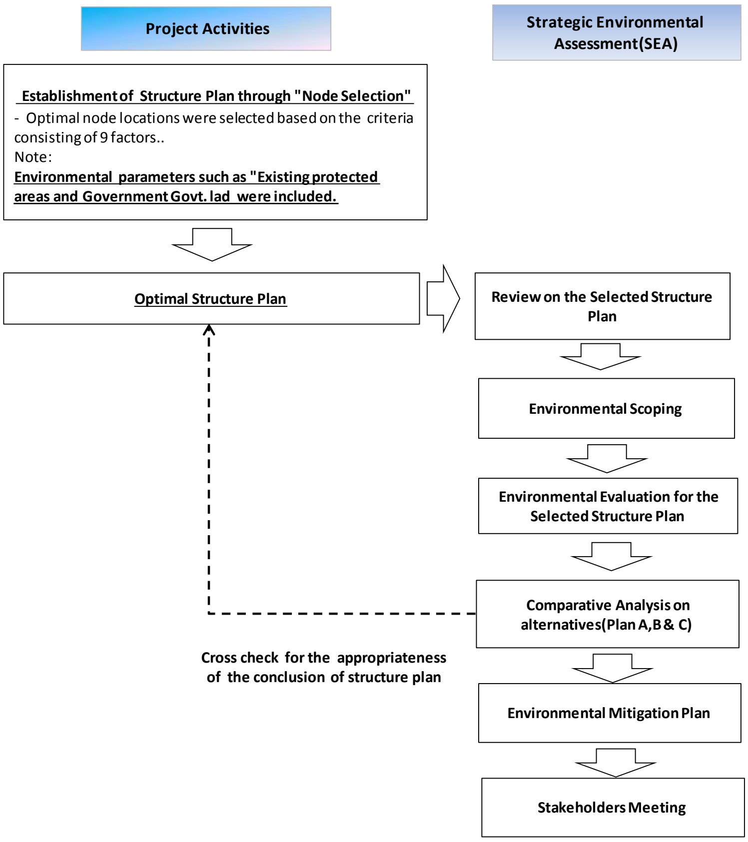
[114]Cited from "Strategic Environmental Assessment in World Bank Operations, May 2002".

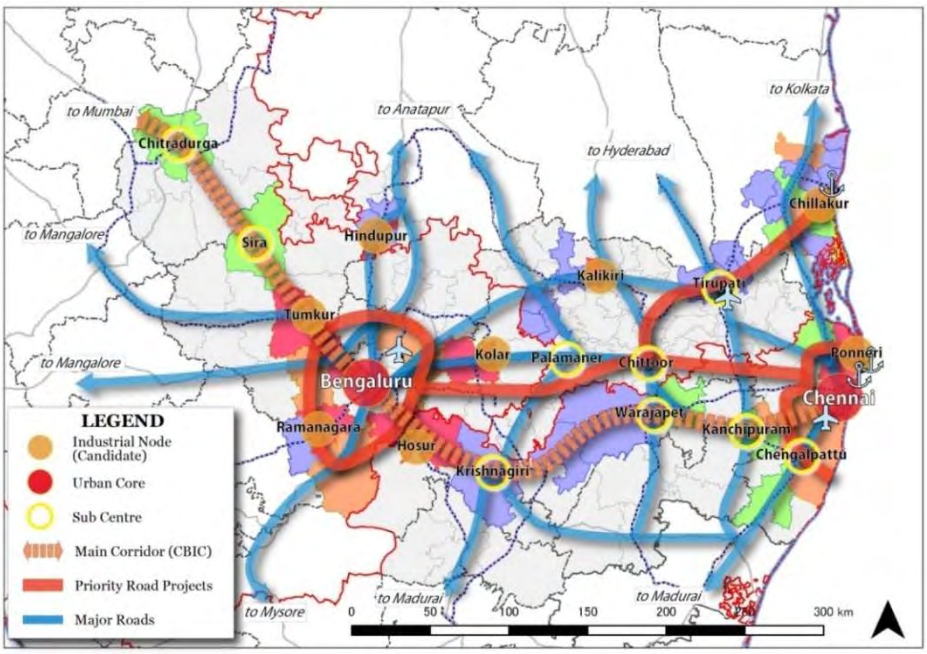


Source: JICA Study Team

Figure 7.2.1: Work Flow for SEA

7.3 Review of Process of Structure Plan Formulation

The structure plan for CBIC was proposed as shown in the Figure 6.3.1 resulting from the discussion for the node selection.



Source: JICA Study Team

Figure 7.3.1: Proposed Structure Plan

The overview of the proposed structure plan is as follows.

The corridor development will be conducted with construction of basic infrastructures such as road network (highway road between Bangalore and Chennai, ring roads at Bangalore and Chennai etc.). At the same time, the node development in the area which has high feasibility and development potential will be carried out simultaneously. The construction of basic infrastructures and node development will be undertaken systematically and comprehensively under initiatives of the government.

The development of nodes will be selected through consideration on the regional characteristics to ensure well-balanced sharing of the industrial functions for the sustainable development in the corridor. In the planning of development plan, the consideration for environmental conservation will be taken account through exclusion of the sensitive areas such as national parks, protected forest etc.

7.4 Environmental Scoping and Evaluation

The development policies for realizing the proposed regional structure plan were clarified first. Then, the environmental impact items which should be considered in the realization of the plan were selected using environmental checklist.

7.4.1 Development Policies for the Proposed Structure Plan

The development policies to realize the proposed structure plan are considered as shown in the Table 7.4.1.

Table 7.4.1: Development Policies for the Structure Plan

Sector	Infrastructure Sectors	Development Policies
Industrial Development	Establishment of industrial park including commercial zones and new housing areas	● "Node Development" on the areas which have high potential and are expected the introduction of basic infrastructures under initiatives of the Government
Transport Development	Construction of trunk roads and establishment of inter-city public transport	● Strengthening of logistic road network ● Enhancement of logistic road network capacity ● Establishment of effective intermodal system and logistic services ● Improvement of connectivity and accessibility to "Gateway" ● Improvement of urban transport of the industrial areas which is located in the vicinity of urban cities
	Railway development	● Expansion of railway route capacity in the CBIC Area ● Connection of the railway to the proposed nodes ● Improvement of railway connections to ports ● Construction of a Dedicated Freight Corridor (DFC) between Chennai and Bengaluru
	Development of Port/Logistic Facilities	● Improvement of the connectivity to Port of Chennai, Ennore and Kattupalli. ● Improvement of poor last mile connectivity to ports from Container Freight Stations(CFSs) ● Improvement of poor last mile connectivity to industrial centers from Inland Container Depots(ICDs)

Sector	Infrastructure Sectors	Development Policies
Utilities	Establishment of water supply /sewage treatment network	● Establishment of industrial water supply through development of ground water ● Encouragement of reuse of water in the areas of industrial nodes ● Encouragement of introduction of seawater desalinization plant in coastal areas ● Construction of sewage treatment with reprocessing facilities for water saving
	Provision of power supply	● Construction of new power plants ● Encouragement of the development of renewable energy production in both wind and solar
	Development of waste collection and recycling facilities	● Development of waste collection and recycling facilities for hazardous waste ● Encouragement of recycle of solid waste in the areas of industrial nodes ● Construction of pre-treatment facility and recycling facilities not only disposal site and incineration facility ● Construction of combined waste treatment facility including domestic waste treatment facility

Source: JICA Study Team

7.4.2 *Environmental Scoping*

The environmental scoping was conducted through consideration on the relationship between the environmental impact items and anticipated actions in the structure plan using environmental impact check matrix. It is noteworthy that the 30 general environmental impact items were prepared referring the environmental check list of the JICA Guidelines. As the results, 15 environmental impact items, namely 7 items in social environmental issues, 3 items in natural environmental issues and 5 items in pollution issues were selected respectively as shown in the Table 7.4.2

Table 7.4.2: Environmental Impact Matrix for the Structure Plan

		Development Activities		Industrial Development	Transpor Sectors			Utilities		
		Environmental Imapct Items	Identified Impact Items	Establishment of industrial park including commercial zones and new housing areas	Construction of trunk roads and establishment of inter-city public transport	Railway development	Development of Port/Logistic Facilities	Establishment of water supply/sewage Tetment network	Provision of power supply	Development of waste collection and recycling facilities
Social Environment(7)	1	Involuntary Resettlement	✔	✔	✔	✔	✔			
	2	Local economy such as employment and livelihood, etc	✔	✔	✔	✔	✔		✔	
	3	Land use and utilization of local resources	✔	✔	✔	✔	✔			
	4	Social institutions such as social infrastructureand local decision-making institutions								
	5	Existing social infrastructures and services	✔		✔	✔				
	6	The poor, indigenous and ethnic people								
	7	Misdistribution of benefit and damage	✔		✔	✔				
	8	Cultural heritage								
	9	Local conflict of interests								
	10	Water Usage or Water Rights and Rights ofCommon								
	11	Sanitation	✔	✔				✔		✔
	12	Hazards (Risk)Infectious diseases such as HIV/AIDS	✔		✔	✔				
Natural Environment(3)	13	Topography and Geographical features								
	14	Soil Erosion								
	15	Groundwater								
	16	Hydrological Situation								
	17	Coastal Zone								
	18	Flora, Fauna and Biodiversity	✔	✔						
	19	Meteorology								
	20	Landscape	✔		✔					
	21	Global Warming	✔			✔				
Pollution(5)	22	Air Pollution	✔		✔					
	23	Water Pollution	✔					✔		✔
	24	Soil Contamination								
	25	Waste	✔	✔						✔
	26	Noise and Vibration	✔		✔	✔				
	27	Ground Subsidence								
	28	Offensive Odor								
	29	Bottom sediment								
	30	Accidents	✔		✔					

Note:"✔" shows the relationship between environmental impact items and the development policies for the Structure Plan.

Source: JICA Study Team

7.4.3 *Evaluation of the Environmental Impact for the Structure Plan*

(1) Positive Impacts

The positive impacts were evaluated focusing on the following nine (9) environmental parameters consisting of 3 social environment aspects, 2 natural environment aspects and 4 pollution aspects respectively, out of fifteen (15) items which were selected in the environmental scoping.

- Social Environment (3) : (i) Local economy such as employment and livelihood, etc. (ii) Misdistribution of benefit and damage(iii)Sanitation
- Natural Environment (2) : (i) Flora, Fauna and Biodiversity(ii)Global Warming
- Pollution (4) : (i) Water pollution(ii) Waste(iii) Noise and vibration(iv)Accident

1) Social Environment

Regarding the structure plan, the following positive impacts of social environment are expected because the plan has the systematic development industrial nodes and construction of wide spread infrastructures. (i) The job opportunities will be increased with the development industrial nodes and construction of infrastructures and it will lead to activation of local economy consequently. (ii) The establishment of the railway-type public transportation will enable people to move to wide areas in shorter time than before. It will lead to an increase of the opportunity of entering schools and getting jobs. Consequently, an increase of the number of the "middle class" and distribution of benefit to wider areas will be expected. (iii)Appropriate social services such as securing the access to safe drinking water will be provided through the establishment of the effective infrastructure of water supply and sewage system.

2) Natural Environment

The well balanced environmental conservation will be ensured through environmental consideration for entire corridor. Also the plan could reduce the impact of global warming with the introducing of the railway-type public transportation system which emits less CO2 and is a high energy effective system.

3) Pollution

As for the Plan with systematic infrastructure development, the following positive impacts of pollution are expected. (i) The water pollution could be reduced with appropriate water supply, sewerage system and solid waste management. (ii) The appropriate solid waste management will be carried out widespread.(iii)The activation of the modal-shift to railway system with the establishment of the railway-type public transportation will alleviate the traffic jam and accident. And it is expected that there will be a reduction of air pollution by exhaust gas, noise and vibration due to the decreasing of the number of the vehicles. (iv) The conversion of private vehicle to public transportation will alleviate the traffic jam and accident.

(2) Evaluation for Negative Impacts

The evaluation for negative impacts were conducted focusing on the following nine (9) environmental parameters consisting of 4 social environment, 2 natural environment and 3 pollution respectively, out of sixteen(16) items which were selected in the environmental scoping.

- Social Environment (4) : (i) Involuntary Resettlement (ii) Land use and utilization of local resources (iii) Existing social infrastructures and services(iv) Hazards (Risk)Infectious diseases such as HIV/AIDS
- Natural Environment (2) : (i) Flora, Fauna and Biodiversity (ii) Landscape
- Pollution (3) : (i) Water pollution (ii) air pollution (iii) Noise and vibration

1) Social Environment

The Plan has negative impact that the construction of railway-type public transportation might cause the division of community in case of planning of the railway on the ground, not underground or viaduct. The plan also has the common potential to induce the spread of infectious diseases such as HIV/AIDS because large number of people will come to the construction areas from outside in the implementation stage.

As for the Plan, the following three negative impacts of social environment are anticipated. (i) There is a possibility to cause involuntary resettlement due to land acquisition for the construction of the new roads and railway. (ii) Some negative impact on existing land use might accrue due to construction of new infrastructures. (iii) The business of the private owner of the pick-up track and taxi will be affected by the introduction of the new public transportation. Therefore, it is a concern that the job opportunity of the drivers for those private entities might be decreased consequently.

2) *Natural Environment*

The plan has potential of having the negative impact to cause on urban landscape due to construction of viaduct of road and railway. To some extent, the decreasing of the green in the vicinity of existing big cities might be inevitable with the Plan.

3) *Pollution*

The plan has a potential of the air pollution, noise and vibration caused by the increasing of the number of vehicles.

The summary of evaluation matrix of the environmental impact for the plan is shown in the Table 7.4.3

Table 7.4.4: Summary of the Anticipated Environmental Impact

Items		Description
Positive Impact	**Social Environment** (Involuntary Resettlement/Local economy /Land use /Existing infrastructure/Misdistribution of benefit/ Sanitation/HIV)	● The job opportunities will be increased with the construction of infrastructures and it will lead to activation of local economy consequently. ● The establishment of the railway-type public transportation will enable people to move to wide areas in shorter time than before. It will lead to an increase of the opportunity of entering schools and getting jobs. Consequently, an increase of the number of the "middle class" and distribution of benefit to wider areas will be expected. ● Appropriate social services such as securing the access to safe drinking water will be provided through the establishment of the effective infrastructure of water supply and sewage system.
	Natural Environment (Flora, Fauna and Biodiversity/ Landscape/ Global Warming)	● The well balanced environmental conservation will be ensured through environmental consideration for entire corridor. ● The impact of global warming might be reduced through the introducing of the railway-type public transportation system which emits less CO2 and is a high energy effective system.
	Pollution (water pollution/air pollution/ waste/ noise and vibration/accident)	● The water pollution could be reduced with appropriate water supply, sewerage system and solid waste management. ● The appropriate solid waste management will be carried out widespread. ● The activation of the modal-shift to railway system with the establishment of the railway-type public transportation will alleviate the traffic jam and accident. And it is expected that there will be a reduction of air pollution by exhaust gas, noise and vibration due to the decreasing of the number of the vehicles. ● The modal-shift to public transportation from private vehicle alleviates the traffic jam and accident.
Negative Impact	**Social Environment** (Involuntary Resettlement/Local economy /Land use /Existing infrastructure/Misdistribution of benefit/ Sanitation/HIV)	● There is a possibility to cause involuntary resettlement due to land acquisition for the construction of the new roads and railway. ● Some negative impact on existing land use might accrue due to construction of new infrastructures. ● The business of the private owner of the pick-up track and taxi will be affected by the introduction of the new public transportation. Therefore, it is a concern that the job opportunity of the drivers for those private entities might be decreased consequently. ● The construction of railway-type public transportation might cause the division of community in case of planning of the railway on the ground, not underground or viaduct. ● In the implementation stage, a large number of labors will come to the construction areas from outside. This might induce the spread of infectious diseases such as HIV/AIDS.
	Natural Environment (Flora, Fauna and	● To some extent, the decreasing of the green in the vicinity of existing big cities might be inevitable. ● The negative impact might cause on urban landscape due to construction of viaduct of road and railway.

Items		Description
	Biodiversity/ Landscape/ Global Warming)	
	Pollution (water pollution/air pollution/ waste/ noise and vibration/accident)	● The increasing of the number of vehicles might cause air pollution, noise and vibration.

Source: JICA Study Team

7.5 Alternatives for the Structure Plan

The alternatives for the structure plan for CBIC region were considered to examine the appropriateness of the proposed structure plan. The alternatives were prepared through focusing on the implementation scheme for realization of the Master plan.

(1) Pattern of Implementation Scheme

There are two kinds of development activities which will be expected for the realization of the Master Plan, i.e. establishment of industrial nodes and construction of widespread infrastructures. The government and private sectors can be considered as implementation body for both development activities.

The proposed structure plan is based on the assumption of implementation under initiatives of Government for both establishment of industrial nodes and construction of widespread infrastructures. The two other patterns of implementation scheme were considered to conduct those development activities depending on the implementation body involved as shown in the Table 7.5.1

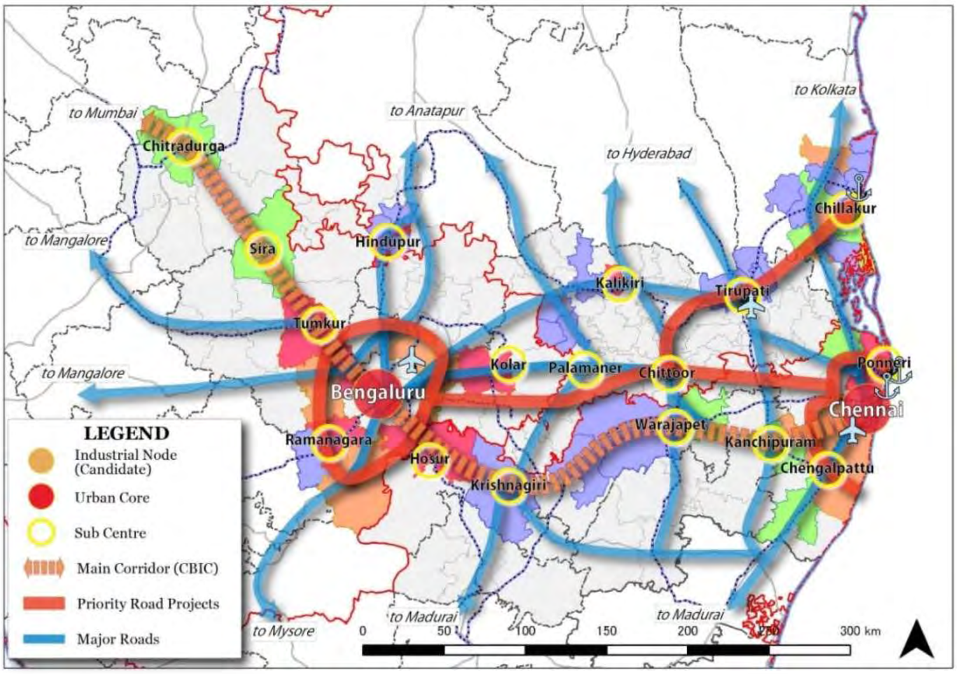
Table 7.5.1: Pattern of Implementation Scheme

Pattern of Implementation Scheme	Establishment of Industrial Nodes	Construction of Widespread Infrastructures
Alternative A	Implementation under Initiatives of Private Sectors	Implementation under Initiatives of Government
Alternative B	Implementation under Initiatives of Private Sectors	Implementation under Initiatives of Private Sectors

Source: JICA Study Team

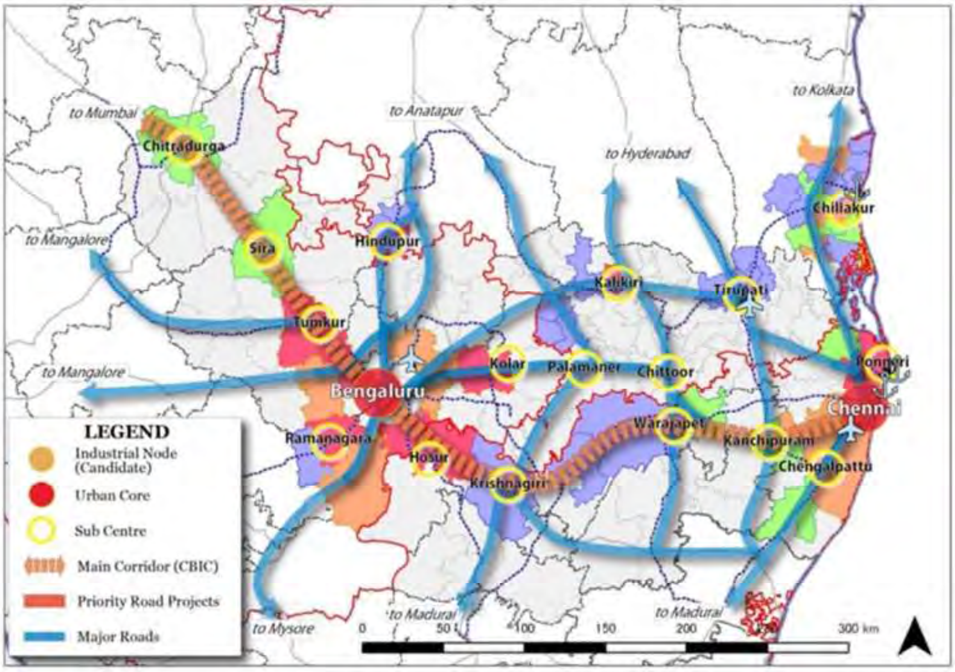
(2) Alternatives for Structure Plan

The two alternatives for structure plan are proposed, resulting from the consideration on the pattern of implementation schemes as shown in the Figures 7.5.1 and 7.5.2).



Source: JICA Study Team

Figure 7.5.1: Alternative A



Source: JICA Study Team

Figure 7.5.2: Alternative B

The characteristics of the proposed alternatives including the proposed plan are as shown in the Table.

Table 7.5.2: Characteristics of the Alternatives including Proposed Plan

Aspects	Proposed Plan	Alternative A	Alternative B
Implementation Scheme	implementation for both establishment of industrial nodes and construction of widespread infrastructures under initiatives of Government	The government will take responsibility for development of infrastructures only such as road and public transportation etc.	All industrial development activities will be conducted by private sectors
Economic connectivity in the industrial corridor	The industrial nodes will be allocated systematically to secure well-balanced economic development in the industrial corridor.	The development nodes will be allocated on the road network based but not in systematic manners. Therefore, it will be difficult to secure the economic connectivity.	The plan doesn't consider the economic connectivity in the industrial corridor.
Effective utilization of resources such as water and energy etc.	Utilities such as water supply, energy etc. will be provided for the industrial cities systematically, so the effective utilization of resources will be possible.	The systematic allocation of industrial cities will not be conducted and it will lead biased industrial development. As a result, the well-balanced supply of resources is difficult to achieve.	The utilization of resources will be not effective since every development activity including development of infrastructure will be conducted under initiative of private sectors.
Environmental conservation	The well-balanced environmental conservation will be possible due to consideration on the industrial activities and environmental aspect for the whole corridor.	The balance of open spaces in the whole corridor will be affected because the open spaces at vicinity of existing big city having high potential of industrial activities will be decreased.	The open spaces at vicinity of existing big city having high potential of industrial activities will be decreased.
Transport network	The effective traffic control will be possible through the systematic transport network based on consideration of total traffic demand.	The well-balanced road network can't be realized because the industrial development nodes will be selected only at place having high potential.	The fundamental traffic improvement can't be expected.
Cost	The cost for both construction of industrial nodes and widespread transport network will be necessary.	Although the construction of industrial nodes will be conducted by the private sectors, the cost for the construction of widespread transport network will be necessary.	The minimum cost for infrastructure development will be necessary based on the market principle.

Source: JICA Study Team

(3) Comparative Evaluation of Alternatives

The environmental comparative evaluation for the alternatives including proposed plan was conducted using matrix as shown in the Table 7.5.3

Table 7.5.3: Comparative Evaluation of Alternatives

Parameter	Proposed Plan	Alternative A	Alternative B
Social Environmental Impact	(*Positive Impact*) ● The job opportunities will be increased with the construction of infrastructures under initiative of Government and it will lead to activation of local economy consequently. ● Appropriate social services such as securing the access to safe drinking water will be provided through the establishment of the effective infrastructure of water supply and sewage system under initiative of Government. *(Negative Impact)* ● Involuntary resettlement due to land acquisition and negative impact on existing land use caused by the construction of the infrastructures ● Decreasing job opportunity of the drivers for private entities due to the introduction of the new public transportation ● The construction of railway-type public transportation might cause the division of community in case of planning of the railway on the ground, not underground or viaduct. ● In the implementation stage, a large number of labors will come to the construction areas from outside. This might induce the spread of infectious diseases such as HIV/AIDS.	(*Positive Impact*) ● The job opportunities will be increased with the construction of infrastructures under initiative of Government and it will lead to activation of local economy consequently. ● The establishment of infrastructure of water supply and sewage system will be ineffective due to implementation under private sector initiative. It will show the less positive impact on social services than those of the Proposed Plan. *(Negative Impact)* ● Involuntary resettlement due to land acquisition and negative impact on existing land use caused by the construction of the infrastructures ● Decreasing job opportunity of the drivers for private entities due to the introduction of the new public transportation ● The construction of railway-type public transportation might cause the division of community in case of planning of the railway on the ground, not underground or viaduct. ● In the implementation stage, a large number of labors will come to the construction areas from outside. This might induce the spread of infectious diseases such as HIV/AIDS.	(*Positive Impact*) ● The provision of job opportunities and activation of local economy will be unclear because the construction of infrastructures will be conducted under private sector initiative. ● The establishment of infrastructure of water supply and sewage system will be ineffective due to implementation under private sector initiative. It will show the less positive impact on social services than those of the Proposed Plan. *(Negative Impact)* ● Involuntary resettlement due to land acquisition and negative impact on existing land use caused by the construction of the infrastructures ● The impact on job opportunity of the drivers for private entities due to the introduction of the new public transportation will be unclear because the construction of infrastructures will be conducted under private sector initiative. ● The possibility of division of community in case of planning of the railway on the ground, not underground or viaduct will be unclear because the construction of infrastructures will be conducted under private sector initiative. ● In the implementation stage, a large number of labors will come to the construction areas from outside. This might induce the spread of infectious diseases such as HIV/AIDS.

Parameter	Proposed Plan	Alternative A	Alternative B
Natural Environmental Impact	(*Positive Impact*) ● The well balanced environmental conservation will be ensured through environmental consideration for entire corridor. ● The impact of global warming might be reduced through the introducing of the railway-type public transportation system which emits less CO2 and is a high energy effective system. *(Negative Impact)* ● To some extent, the decreasing of the green in the vicinity of existing big cities might be inevitable. ● The negative impact might cause on urban landscape due to construction of viaduct of road and railway.	(*Positive Impact*) ● The ensuring the well balanced environmental consideration for entire corridor will be conducted restrictive manner due to the construction of industrial city under private sector initiative ● The impact of global warming might be reduced through the introducing of the railway-type public transportation system which emits less CO2 and is a high energy effective system. *(Negative Impact)* ● To some extent, the decreasing of the green in the vicinity of existing big cities might be inevitable. ● The negative impact might cause on urban landscape due to construction of viaduct of road and railway.	(*Positive Impact*) ● The ensuring the well balanced environmental consideration for entire corridor will be conducted restrictive manner due to the construction of industrial city under private sector initiative ● The degree of reduction of the impact of global warming through introducing of the railway-type public transportation system will be unclear because the introduction of the system to be conducted under private sector initiative. *(Negative Impact)* ● To some extent, the decreasing of the green in the vicinity of existing big cities might be inevitable. ● The negative impact might cause on urban landscape due to construction of viaduct of road and railway will be unclear because the construction will be conducted under private sector initiative.

Parameter	Proposed Plan	Alternative A	Alternative B
Pollution	(*Positive Impact*) ● The water pollution could be reduced with appropriate water supply, sewerage system and solid waste management under initiative of Government. ● The appropriate solid waste management will be carried out widespread. ● The activation of the modal-shift to railway system with the establishment of the railway-type public transportation under initiative of Government will alleviate the traffic jam and accident. And it is expected that there will be a reduction of air pollution by exhaust gas, noise and vibration due to the decreasing of the number of the vehicles. ● The modal-shift to public transportation from private vehicle alleviates the traffic jam and accident. *(Negative Impact)* ● The increasing of the number of vehicles might cause air pollution, noise and vibration.	(*Positive Impact*) ● The reduction of water pollution with appropriate water supply, sewerage system and solid waste management will be limited because the construction of industrial city will be conducted under private sector initiative. ● The appropriate solid waste management will be carried out restrictively as well. ● The activation of the modal-shift to railway system with the establishment of the railway-type public transportation under initiative of Government will alleviate the traffic jam and accident. And it is expected that there will be a reduction of air pollution by exhaust gas, noise and vibration due to the decreasing of the number of the vehicles. ● The positive impact for alleviation of the traffic jam and accident will be less degree because modal-shift to public transportation from private vehicle will be conducted under private sector initiative. *(Negative Impact)* ● The increasing of the number of vehicles might cause air pollution, noise and vibration.	(*Positive Impact*) ● The reduction of water pollution with appropriate water supply, sewerage system and solid waste management will be limited because the construction of industrial city will be conducted under private sector initiative. ● The appropriate solid waste management will be carried out restrictively as well. ● The positive impact for alleviation of the traffic jam and accident will be less degree because modal-shift to public transportation from private vehicle will be conducted under private sector initiative. *(Negative Impact)* ● The increasing of the number of vehicles might cause air pollution, noise and vibration.

Source: JICA Study Team

(4) Conclusion

The CBIC has possibility of generating the unavoidable environmental negative impact such as involuntary resettlement due to land acquisition for large scale construction of infrastructures.

The Proposed Structure Plan is based on the assumption of implementation under initiatives of Government for both establishment of industrial nodes and construction of widespread infrastructures. The systematic implementing scheme will ensures to minimize the environmental negative impacts through the well balanced environmental and social considerations taking account for the entire CBIC corridor. The utilities such as water supply, energy etc. will be provided for the industrial cities systematically so that the effective utilization of resources could be possible.

While the comprehensive environmental management taking account for entire corridor will be limited under the alternative A. Because the plan is supposed to be implemented under initiatives of Government for construction of widespread infrastructures and the establishment of industrial nodes is expected to be conducted under private sector initiative.

Further the utilization of resource will be very ineffective under the alternative B. In addition, the control of “sprawl phenomena” will be difficult under the plan. As the results, the project implementation taking account of environmental social consideration under the alternative will be difficult comparing with other to plans.

7.6 Environmental Mitigation Plan

Mitigation measures for the identified negative impact for the optimal structure plan are proposed as follows.

＜Involuntary Resettlement＞

- To minimize the number of affected persons in the process of planning and designing
- To prepare the Resettlement Action Plan (RAP) in order to minimize the impact on the land acquisition, if a large number of the affected persons are identified

＜Land Use＞

- To minimize the impact on the existing land use through careful investigation in the planning process
- To investigate the status of land ownership for appropriate alteration of land use in the planning process
- To carefully design railway structure so as not cause division of community in case of planning on the ground, not underground or viaduct.

<HIV/AIDS etc.>

- All workers will have a regular medical screening to check for HIV/AIDS, sexually transmitted diseases, Malaria, etc.

＜Landscape＞

- To carefully design railway structure so as to minimize negative effects on landscape in strategically important areas

＜Air pollution, Noise and Vibration＞

- To avoid planning of the road alignment near the hospital, school etc. to reduce the impact of air pollution, noise and vibration

7.7 Environmental Monitoring Plan

The environmental parameters to be monitored are necessary to decide based on the characteristics of the individual development project. The proposed environmental monitoring plan consists of general environmental parameters focusing on mainly pollution control such as water quality, air quality and noise. In case of the project including a large scale involuntarily resettlement, additional social environmental parameters such as the appropriateness of paying system of compensation, livelihood restoration program and so on should be included as monitoring parameters.

The monitoring location and monitoring frequency are decided in the part of environmental management plan for individual project. The responsible agencies for implementation of the environmental monitoring activities should be decided for design stage (obtaining baseline data), construction stage and operation stage respectively. Table 7.7.1shows proposed general environmental monitoring plan.

Table 7.7.1: General Environmental Monitoring Plan

Items	Parameters
Water quality	pH, EC, DO, BOD,Nitrate, Phosphate, Chloride, Oil/Grease, Zinc, Lead, Total coli form, E. coli form etc.
Air quality/Dust	PM10, Sulphur dioxide(SO2), Nitrogen dioxide(NO2)etc.
Noise	Mean sound level (Leq (24))

7.8 Stakeholders Meeting (SHM)

7.8.1 General

The information disclosure and the transparency in the process of SEA is one of the most essential factors. Accordingly the results of the SEA were explained and discussed at the stakeholders meeting (SHM) for the purpose of information disclosure and transparency.

The SHM were held for the objectives as follows.

- To share the information related to the process of establishment of the structure plan
- To exchange opinions on the structure plans including alternatives
- To incorporate opinions coming from SHM into discussion of the perspective plan for CBIC

7.8.2 Stakeholders for CBIC

The stakeholders for CBIC in terms of central and local government are as follows.

- Ministry of External Affairs
- Department of Economic Affairs,
- Ministry of Finance
- Ministry of Shipping
- Ministry of Railways
- Ministry of Civil Aviation
- Ministry of Road Transport and Highways
- Government of Tamil Nadu
- Government of Karnataka
- Government of Andhra Pradesh
- DMICDC

The monitoring committee consisting of the above stakeholders chaired by Prime Minister Office (PMO) has been organized as organ decision-making for CBIC.

Given that the study areas is vast and include many administrative organizations, the direct involvement of local people in the process of decision making for the perspective plan(Part A of this study) was not supposed.

Note that the opportunities of absorption of local people will be ensured in the process of environmental impact assessment (EIA) for individual project through SHM to be conducted based on the requirement of environmental protection law of India.

In the Part B of this study, the development plans for selected industrial nodes will be prepared. EIA study for the development plans will be conducted including SHM.

7.8.3 *State-wise SHMs*

(1) SHM with the State of Tamil Nadu

Items	Contents
Date and time	28January 2014(11:00-12:00)
Location	Secretariat, Fort St George, Chennai, Tamil Nadu
Attendants	18persons
Agenda	Opening speech Presentation of the node selection and discussion of alternatives(JICA Study Team) Question and Answer

Summary of "Question and Answer"

Comments from Indian Side	Response from JST
The Secretary, Industries suggested for the private land to be considered, not only for government land.	We understand the importance of consideration on affected private land. We should pay attention on new land acquisition bill.
He raised a query regarding Bargur Taluk where SIPCOT acquired around 900 acres of land.	The size of our target is 50 sq. km area; therefore, Bargur would be out of consideration.
The Chief Planner, CMDA, suggested that JST have consultations with Directorate of Town Control Planning (DTCP), as a part of Ponneri Taluk falls under their planning zone.	-
We approve in principal for two industrial nodes – one in Ponneri Taluk and second in Hosur Taluk. We would undertake necessary efforts to acquire the land parcels as planned in the above prioritized node locations	-

(2) SHM with the State of Andhra Pradesh

Items	Contents
Date and time	14 February 2014(11:00-12:00)
Location	Office of the Principal Secretary, Industries and Commerce Department, Hyderabad, Andhra Pradesh
Attendants	21 persons
Agenda	Opening speech Presentation of the node selection and discussion of alternatives(JICA Study Team) Question and Answer

Summary of “Question and Answer”

Comments from Indian Side	Response from JST
We request the JST to consider Naidupeta-Ativaram and Sri City as a zone with high potential.	There were no urban development plans and government land availability witnessed for the Sri City area due to which it was not identified as a node.
The initiatives for preparation of the urban development plan for the Sri City area would be undertaken on priority by the Municipality Administration &Urban Development (MA&UD) within a week. Further, around 7,000 acres of land is under the possession of Andhra PradeshIndustrial Infrastructure Corporation (APIIC), adjacent to the existing industrial area in Sri City, and have a good access to national highway.	We request for details pertaining to the urban development situation and land availability in the Sri City area for further analysis(the officials of GoAP agreed to provide the necessary information)
Referring to the variables used to assess the potentiality of the zones, the officers highlighted that majority of the variables are supply driven and requested JST to include demand side variables of industries	for analyzing zones to which the JST responded that the possibility of inclusion of demand side variables will be examined
What are differences among those alternatives?	JST clarified the differences of characteristics among the alternatives upon the request of the officials

(3) SHM with the State of Karnataka

Items	Contents
Date and time	18 February 2014(12:30-14:00)
Location	Room 123, Vikasa Soudha, Government of Karnataka, Bengaluru
Attendants	30persons
Agenda	Opening speech(Mr. Kaushik Mukherjee, IAS, Chief Secretary, Government of Karnataka (GoK) Presentation of the node selection and discussion of alternatives(JICA Study Team) Question and Answer

Question and Answer

Comments from Indian Side	Response from JST
We accept the results of the selection of the potential development of nodes. However, we want to request that the study team also consider the land parcels identified at Gauribidanur and Srinivasapura as these land parcels could potentially constitute a cluster.	We will make further examination in finalization of the nodes selection based on the information provided from the GoK.
How did you evaluate the alternatives of structure plan?	The evaluation for the alternatives was conducted mainly focusing on the implementation scheme to realize the structure plan in qualitatively manner.

7.9 Conclusion and Recommendation

(1) Conclusion

- The examination on the proposed regional structure plan resulting from the process of "Node selection" was conducted using "the SEA approach" for CBIC. Although some environmental negative impacts were identified in the process of evaluation of the environmental impact for the Plan, those negative impacts were considered to alleviate with the proposed mitigation measures. As the results, no irreversible environmental negative impacts were found in the regional structure plan at this stage. Further environmental social consideration will be carried out through conducting environmental impact assessments (EIAs) for individual project which is expected come out next stage of this study (Part B), i.e. "preparation of development plans for prioritized industrial nodes".
- The state-wise SHMs for the structure plan were conducted with getting considerable number of participants. The comments came out from the meeting were respected and considered by JICA Study Team and some proposals were incorporated into the process of the finalization of nodes selection. Accordingly, the one of main objective of SHM, to integrate appropriate environmental and social considerations into the process of decision making, was achieved successfully. Note that the SHMs will be also conducted with affected local people in the EIAs for the development plans.

(2) Recommendation

- The government land availability was examined in the process of node selection. However, the private land will be affected for the infrastructure development which is necessary for enhancement of connectivity among proposed industrial cities and ports etc. Therefore, careful attention on the land issues should be paid through close consultation with related stakeholders as early stage as possible.
- "The Land Acquisition, Rehabilitation and Resettlement Act (2013)" has been enforced in this January. The land acquisition for the CBIC will be carried out under the responsibility of related state government. Given that the regulation for the Act has not been prepared yet, the responsible agencies in related states for the CBIC will be encouraged to commence the discussion with central government how to address land issues.

7.10 Necessary Actions for Part B

The prioritized nodes will be determined by Indian government referring the fact findings and assessment results of the JICA Study Team. The development plans for the prioritized nodes will be prepared by JICA Study Team in the next stage of this study (Part B).

As reported in the Interim Report 1 for CBIC, the JICA Study Team interviewed to Delhi Mumbai Industrial Corridor Development Cooperation Limited (DMICDC) to ask the necessity for conducting any environmental and social considerations on the development plan on 25th November 2013. As the results of the interview, the JICA Study Team understood that the EIA study have been conducting after the completion of the detailed project report (DPR) in DMIC as shown in the Figure 7.10.7.10.1

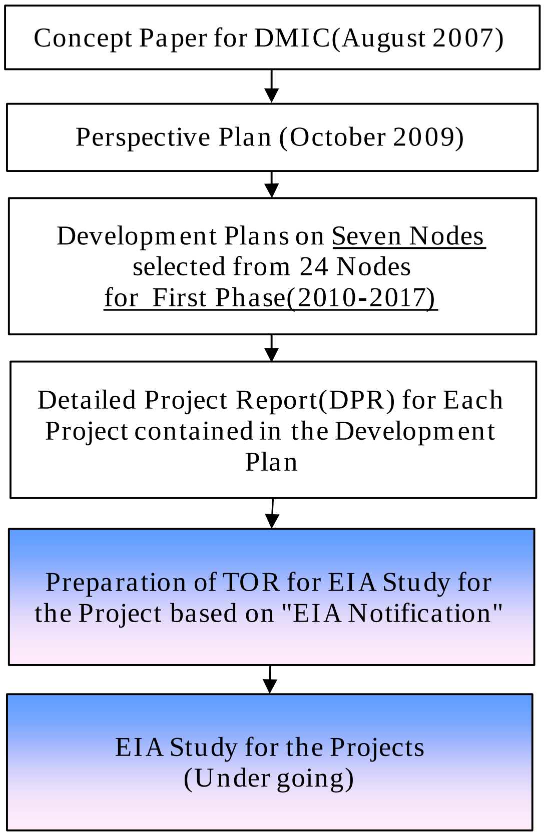
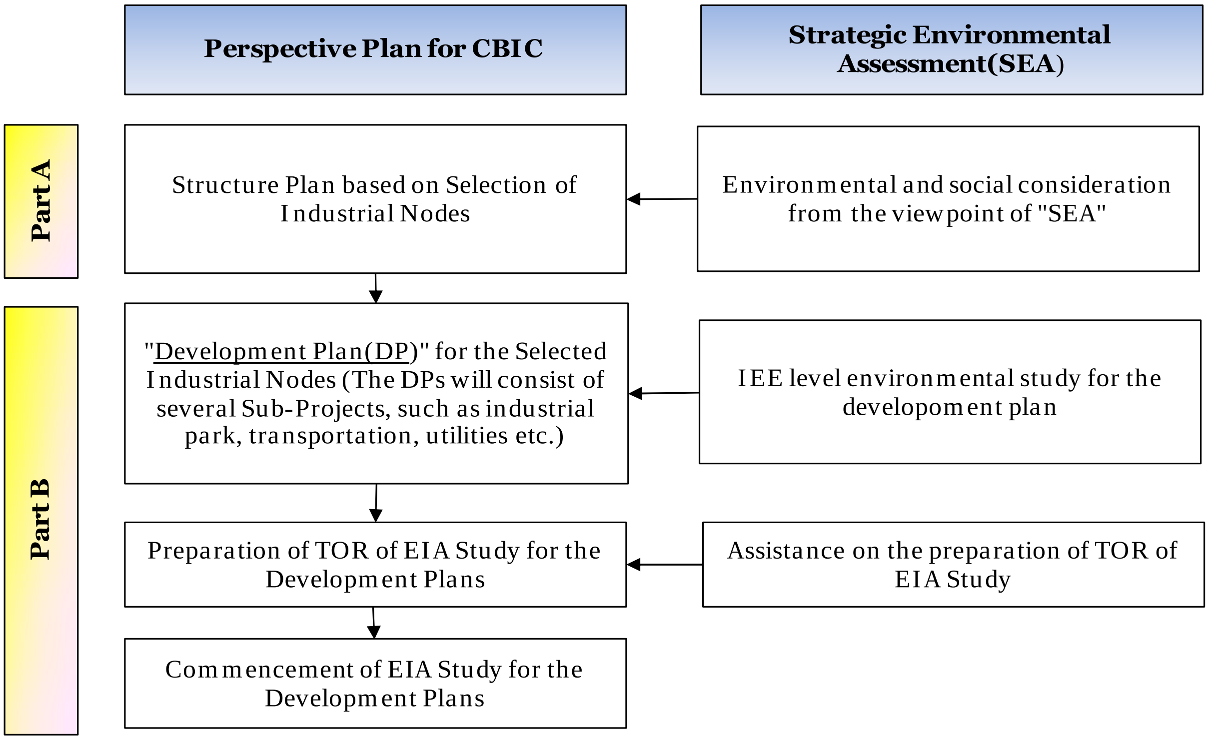


Figure 7.10.7.10.1: Process of EIA Study for the DMIC

However, it was revealed that the EIA studies have been conducting for development plans, not for detailed project Report (DPR) in DMIC through reconfirmation for the issue. As a result, the Environmental Clearance (EC) for the development plan will have to be obtained from Ministry of Environment and Forests (MoEF), Govt. of India.

The JICA Study Team will conduct the Initial Environmental Examination (IEE) level environmental study for the development plans for “Selected Nodes” to be prepared in the Part B of this study. The study will be conducted keeping consistency with the requirement of “JICA Guidelines for Environmental and Social Considerations (April 2010). The results of the IEE studies will be referential information for the preparation of the TOR for EIA study on the development plans.

The EIA studies for the development plans are under responsibility of Indian Govt. including securing the budget for hiring environmental consultants. According to the interviews by the JICA Study Team to DMIC and local consulting company, approximately 10 million Rs. will be necessary for conducting EIA study. The necessary action for Part B is shown in the Figure 7.10.2.



Source: JICA Study Team

Figure.7.10.2: Necessary Action for Part B

8 Comprehensive Regional Plan

8.1 CBIC's Regional Potentials and Challenges

India is the second most preferred country by Japanese investors based on the survey conducted by JBIC in 2013. The top five main advantages from investors'' perspectives are the potential of local market, low cost of labour, the existing local market, potential for supply hub and the hub for export to the third country. On the other hand, lack of infrastructure, competitive environment, unclear legal/regulatory framework, labour issues, complicated tax system are considered to be the main bottlenecks.

Similar to the above evaluation, based on the interviews with investors at the region, the following points are considered to be the potentials of CBIC:

- Strong existing industrial base with effective industrial clusters
- Connectivity to the domestic consumption market and regional gateways
- High population density, greater urbanization & increasing migration

Lack of infrastructure is the key bottleneck of the region and unclear legal/regulatory framework, labour and tax issues are also key concerns as in other cities in India.

Comprehensive Regional Perspective Plan for 20 years is aiming to transform the region into a globally competitive investment destination and suitable nodes to be taken up for industrial development within the project influence area are identified.

8.2 Vision and Target

8.2.1 The context

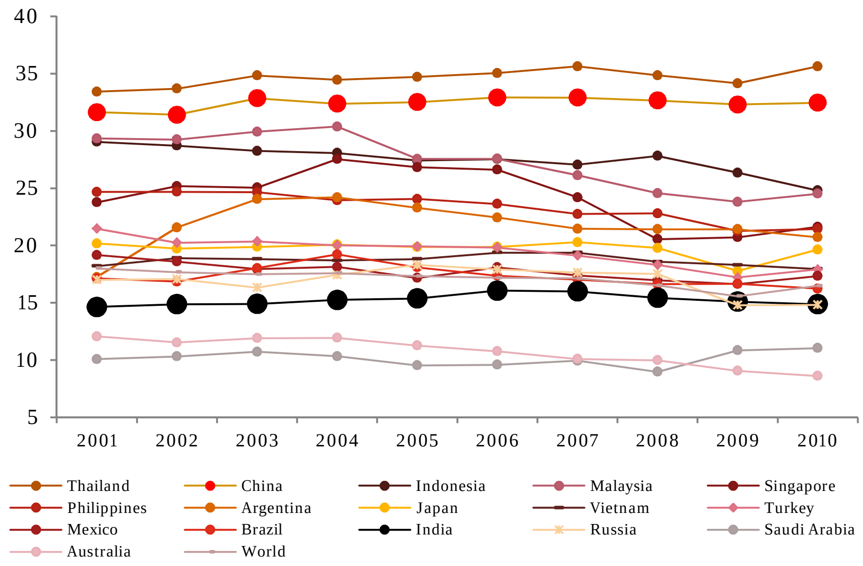


Figure 8.2.1:Trend in manufacturing GDP contribution in past 10 years

Post liberalisation, Indian manufacturing sector has been able to shift to a steeper trajectory from 5.37% CAGR to 6.73% CAGR[115]. In the past 10 years, Indian manufacturing has grown at a robust rate of 8.4%, putting itself on the map of some of the best performing manufacturing economies. However, when contribution of manufacturing sector to overall GDP is compared to fast developing economies in the region like Thailand, China, Indonesia and Malaysia, there appears to be further scope for improvement.

Recognising the opportunity, National Manufacturing Policy 2011 puts forward a vision for the manufacturing sector with following 6 objectives:

- Increase manufacturing growth to 12-14% and improve manufacturing contribution to 25% by 2022
- Creating 100 million additional jobs by 2022
- Creation of appropriate skill set among rural migrant and urban poor to enable inclusive growth

[115] *Planning Commission Data Tables*

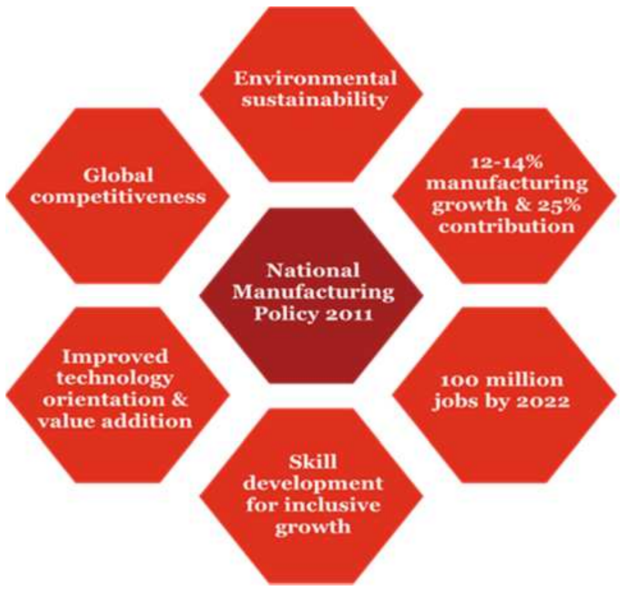


Figure 8.2.2: National Manufacturing Policy 2011

- Increase domestic value addition and technological depth in manufacturing
- Enhancing global competitiveness of global manufacturing through appropriate policy support
- Ensuring environmental sustainability

Chennai Bangalore Industrial Corridor (CBIC) constitutes a key step towards achieving the above objectives. CBIC's vision and strategies are aligned to national vision and shall aim at maximising contribution to achieving the national objectives.

8.2.2 *CBIC vision and strategy*

The long term vision of the corridor is to develop itself as ***"a globally competitive manufacturing hub that promotes sustainable development".*** The vision is articulated across five principle themes and strategies:

Table 8.2.1: Five Principle Themes

Theme	Strategy	Target outcome
Thrust to manufacturing in the region	While, tertiary sector has given substantial thrust to corridor economy in the past; going forward manufacturing will further add to this thrust.	• Manufacturing contribution in the corridor - Increase from 17% to 25% of corridor GDP by 2033-34. • Corridor's GDP growth in 20 years – Increase from 8-9% as seen during past decade to an average of 12-13%
Enabling global acceptance	The manufacturing industries in the corridor will be driven by high standards that gain preference in international markets.	• Drive export from the region by focus on sectors like Electronics, Automobile, Textiles, Food Processing
Activating higher value addition in key industries	The manufacturing industries will integrate further into hi-tech and down-stream products that will create higher value add per unit produced and shall drive up GDP. This will also include special intervention packages for boosting MSMEs.	• Promote higher value addition in sectors like Automobile, Electronics, Food Processing, and Textiles
Employment creation	The economic progression will focus on making a sustainable impact on local communities by creating and engaging an employable workforce with high skill levels.	• Create 22 million additional jobs in next 20 years • Drive growth of both large industries and SMEs within the corridor
Prioritising sustainable development	The corridor will take into account environmental responsibility with focus on green technologies for environment and promote development of green products	• Focus on environment sustainability - Textiles, Chemical & Petrochemicals, Metallurgy, Pharmaceuticals • Focus on green products - Automobile, Machinery and Electrical Machinery

Figure 8.2.3: Strategic framework for CBIC

8.2.3 *Creating the right levers - the balancing act*

It is important to recognise the fact that all industries are not equal in terms of contribution to the target outcomes. While the corridor has a large set of industries contributing to the manufacturing output a set of 10 short listed sectors that currently contribute to over 75% of the manufacturing output will drive the growth of the corridor.

Also, amongst the set of short listed sectors each one of them will have their own unique strengths. For example, while Food Processing may not be a substantial driver in terms of GDP growth (due to relatively lower potential of high value add even at higher levels of value chain), it may be a significant driver for employment. On the contrary, while pharmaceuticals can create the required value add it may not contribute to employment as much. Under such circumstances, a strategic mix of focus industries are required that can create a balance in terms of contribution to all 5 outcomes. Accordingly, as representative sample of 10 focus sectors have been identified based on individual characteristics and significance from the target outcome perspective.

Table 8.2.2 Focus sectors across corridor's objectives

Sectors	*Thrust to manufacturing in the region*	*Employment creation*	Thrust to MSME	*Activating higher value addition in key industries*	*Prioritising environment*	*Enabling global acceptance*
Food Processing		√	√		√	√
Textiles & Apparels		√	√	√		√
Machinery & Electrical Machinery	√	√	√	√		
Chemical & Petrochemical			√		√	
Pharmaceuticals	√		√	√	√	√
Automobiles	√	√	√	√		√
Computer, Electronics & Optical (CEO)	√	√				√
Others				√	√	

8.2.4 *Achieving the targets*

Thrust to manufacturing GDP

To ensure improved contribution of the manufacturing GDP of the corridor it would be essential to focus on sectors that are large in size. Machinery, Electrical Machinery, Pharmaceuticals, Automobiles and Computer, Electronics and Optical products would be key in driving GDP. These sectors together contribute to over 50% of the corridor's GVA. In addition to these sectors, amongst the services sector Information Technology and Financial Services sector would also play a key role in driving the industrial output from the corridor.

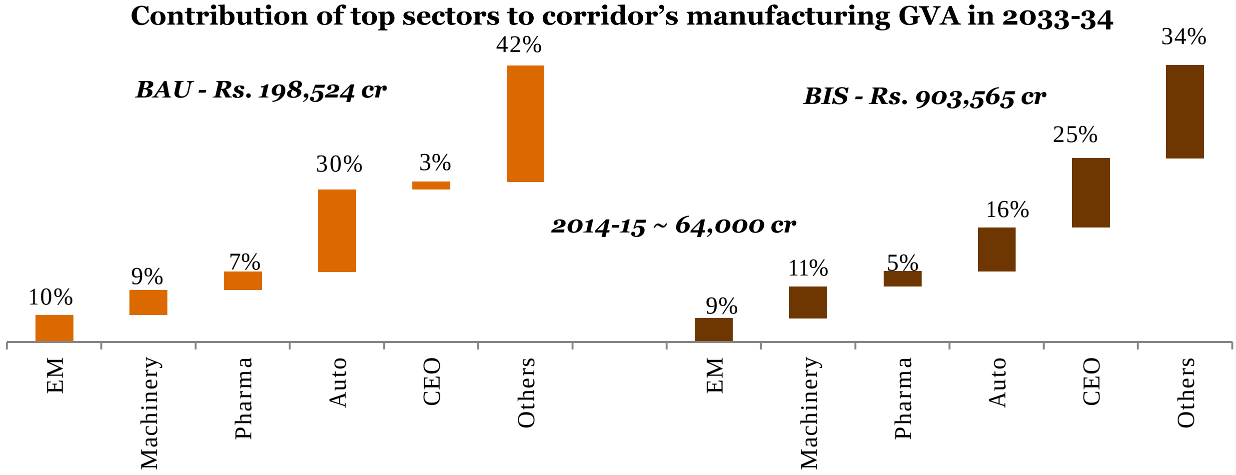
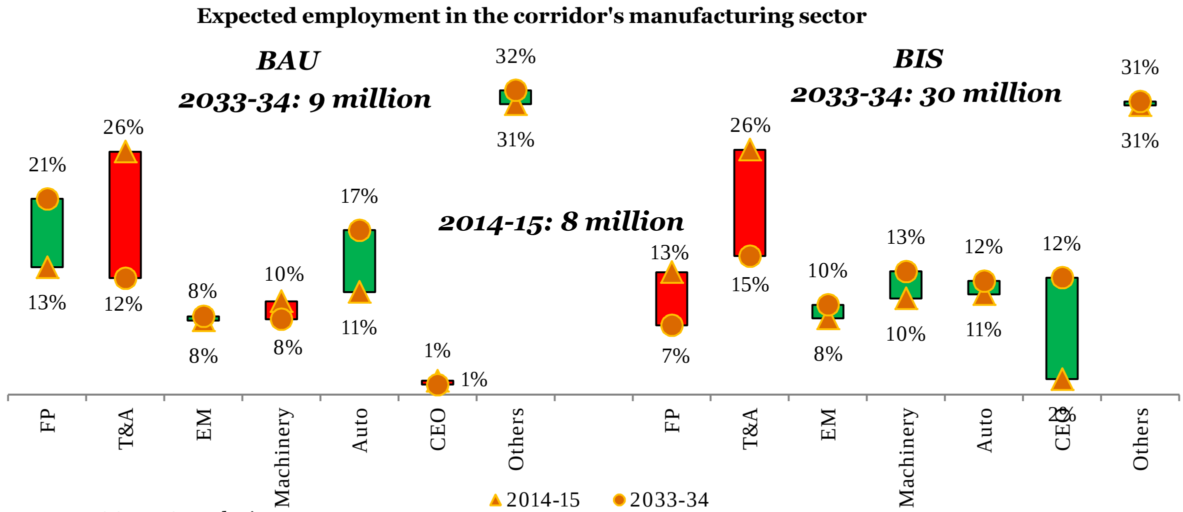


Figure 8.2.4: Contribution of top Sector's to corridor's Gross Value Added

Source: ASI, PwC analysis

Employment Creation

In terms of employment, Food processing, Textiles and Apparels, Electrical Machinery, Machinery, Automobiles and CEO sector are expected to generate around 70% of the employment. Proposed interventions in these sectors will help in increasing job creation by 1 million under business as usual to 22 million under the BIS scenario. In addition to this, IT sector is expected to generate an additional employment of around 10 million by 2033-34 in the corridor districts.



Source: NMCC, PwC analysis

Bars in green represent increase in % contribution to corridor's employment - 2013-14 vs. 2033-34

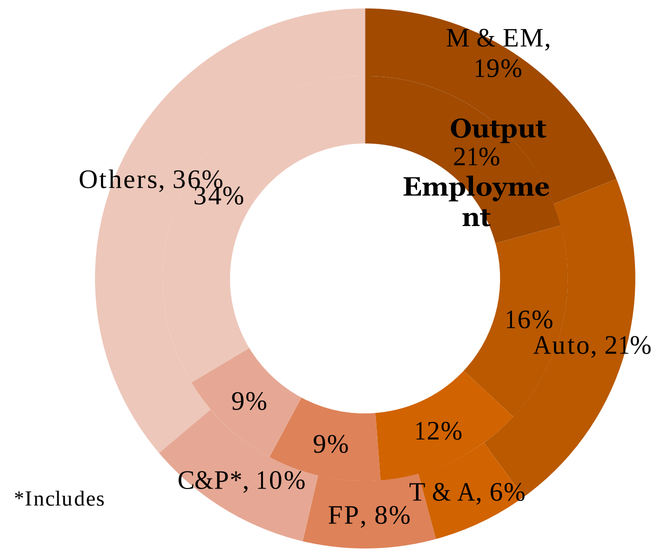
Bars in red represent decrease in % contribution to corridor's employment - 2013-14 vs. 2033-34

Figure 8.2.5: Expected employment in corridor's manufacturing sector in 2033-24

Thrust to MSME

Machinery, Electrical Machinery, Automobiles, Textiles and Apparels, Food Processing, Chemical & Petrochemical and Pharmaceuticals are likely to play a key role in developing the MSME output. These sectors together contribute to around 65% of the employment in the corridor in the MSME sector. For MSMEs to flourish in the corridor it would be essential to focus on these sectors and take steps to overcome the challenges faced by enterprises across all sectors.

Sector wise MSME statistics at corridor level



Source: Final Report, Fourth All Inida Census of Micro, Small and Medium Enterprises, Ministry of MSMEs, GoI, PwC analysis

Figure 8.2.6: Contribution of major sectors to employment in the MSME sector

Achieving higher value addition in key industries

Automobiles, Pharmaceuticals, Machinery, Electrical Machinery, Textiles and Apparels and Medical Equipment are among the highest value addition sectors. Amongst these, Pharmaceuticals and Electrical Machinery are expected to be the key drivers of value addition. Technical textiles and apparels segment are expected to have a higher value addition when compared to other segments in Textiles and Apparels sector. In addition to these sectors, Medical Equipment which is a sunrise sector in India is expected to be high on value addition and will be majorly driven by product innovation in India.

Sectors expected to drive value addition in corridor 2033-34

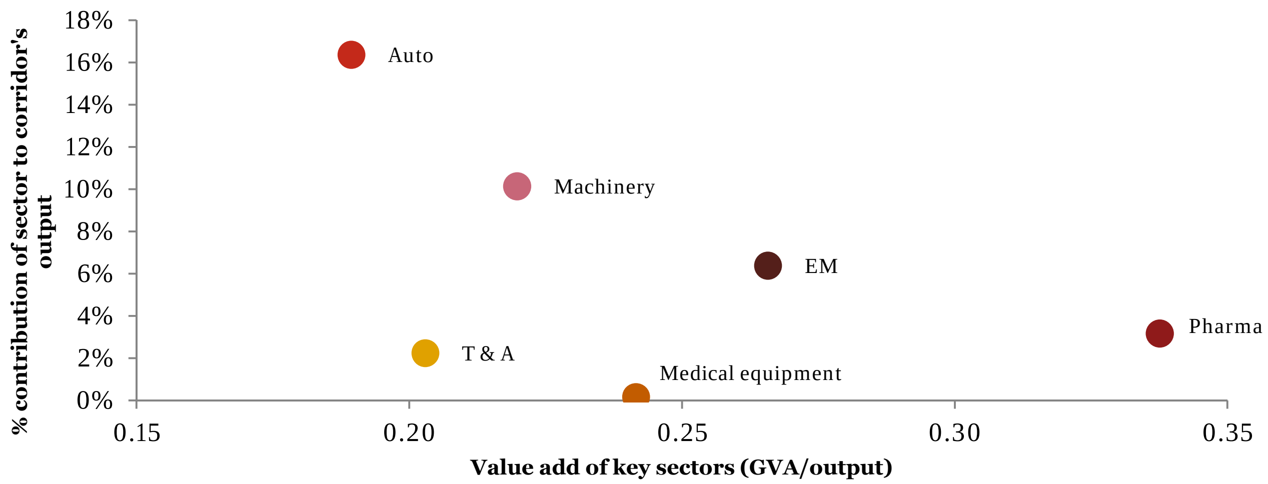


Figure 8.2.7: Focus sectors to increase corridor's value addition in the manufacturing sector

Prioritising sustainable development

The corridor will focus on promoting sustainable industrial development by focussing on efficient use of resources like Power, Water, and Land. Also, the corridor will promote green mobility through auto sector investments in electric vehicles and green energy through renewable energy sector investments. The food processing, pharmaceuticals, chemical & petrochemical, metallurgy are identified as highly polluting sectors. These sectors are also going to drive investmens within the corridor. Secondly, while MSMEs contribute to over 40% to industrial production, they account for substantial pollution i.e. 70% of the total industrial pollution load of India. Regulatory mechanisms to ensure compliance are ill-suited towards MSMEs, as they are tailored more towards larger industries, creating a scenario where MSMEs are unable to comply with regulations. Such approach will have to be avoided. The key strategies identified to ensure sustainability are:

- Incentivising scrap consolidation and recycling to reduce natural resource exploitation
- Incentivise products that are energy efficient and low on emissions
- Incentivise use of energy efficient machinery through subsidies
- Identify ways to prevent pollution at source through setting up of treatment plants. etc
- Improve efficient utilization of resources through productivity optimization projects, etc

Exports

Automobiles, Textiles & Apparels, Computer, electronic and Optical products (CEO), Pharmaceuticals and Food processing sectors are likely to drive exports in the corridor. Automobiles and CEO sector has the potential to drive over 50% of the exports from the corridor followed by Textiles & apparels, Pharmaceuticals and Food Processing.

8.2.5 *Growth Scenario of CBIC at a glance*

Two scenarios Business As Usual (BAU) which assumes Corridor's GDP to grow at the same rate based on past performance and Business Induced Scenario (BIS) which assumes GDP growth of around 12% with aggregation of vision and ambitions of different sectors were prepared for the analyses.

CBIC region can grow at 8-12% per annum, taking share of manufacturing to 17-25% and generate between 4-22 million employments in manufacturing, over the next 20 years.

By 2033-34, at an accelerated average growth rate of 12-13%, CBIC corridor GDP is expected to growth to more than twice the size it would have grown under business as usual case. Manufacturing contribution shall increase from around 17-18% currently to 24-25% in 2033-34. In addition CBIC will create 22 million new jobs instead of 4 million additional jobs that corridor would have created in business as usual scenario.

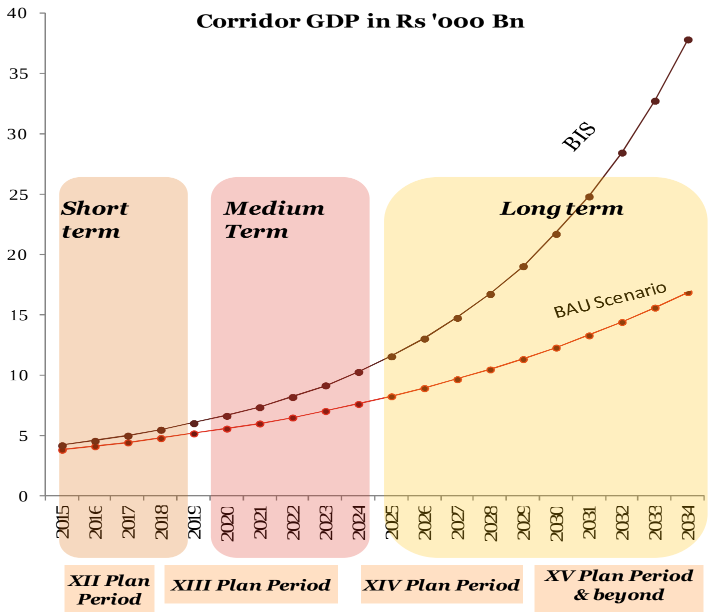


Figure 8.2.8: Corridor GDP

Overall, with efficient implementation of the proposed strategy and interventions, the corridor shall successfully deliver its vision of being a globally competitive manufacturing hub that can make sustainable economic and environmental impact locally.

Business As Usual (BAU)

- Corridor GDP grew at ~8.7% between 2006-13
- Corridor's GDP assumed to grow at the same rate based on past performance

Business Induced Scenario (BIS)

8.2.6 *Activating the levers*

Having identified the strategy to achieve the desired objectives of the vision, it is now important to understand what intervention shall be necessary to enable the sectors to move to a higher trajectory. In this context, a development framework comprising three elements – Economic enhancers, administrative enhancers and value enhancer has been created that attempts at improving the corridor competitiveness across individual sectors.

Economic enhancers refer to the interventions required in terms of industrial and support infrastructure to industries to operate efficiently.

Corridor competitiveness		
Economic enhancers	**Administrative enhancers**	**Value enhancers**
• Development of quality integrated industrial infrastructure • Promotion of local factor cost advantages • Easy of access to consumption markets and gateways to markets • Reliable availability of FoPs	• Institutional reforms • Regulatory & policy support (economic, trade, financial and tax systems) • Ease in doing business	• Productivity enhancement • Efficiency in resource use • Technological readiness and upgradation • Skill development • Effective supply chain • Research and development • Value addition

Administrative enhancers refer to the soft policy interventions that can enhance competitiveness and ease of operation of industries

Value enhancers refer to interventions that can directly or indirectly impact the operation of the industries to higher efficiency and improved value delivery.

Table 8.2.3: Enhancers by Industry

Sector	Economic enhancers	Administrative enhancers	Value enhancers
Auto	• Government needs to focus on developing the entire value chain by focusing on cost competitiveness, promote quality in the automobile sector and dissuade OEMs from bringing supplier network • Connectivity infrastructure for industrial parks with key ports within the corridor • Port capacity addition required • Ensure stable supply of water and power	• One of the key issues faced by foreign investors in India is the complicated and inconsistent tax system. There is a frequent change in the tax laws. Additionally, CST also acts as a hindrance for interstate transactions. • Currently, majority of the investments in the sector are in the OEM and Tier I sector. Majority of the foreign players are importing Tier I and Tier II parts from their base location. Hence, Specific plans need to be made to promote investment of Tier-2/Tier-3 industry members in India.	• 10-30% of the total production workers are employed on contract basis. Reducing the number of contract labours by giving flexibility in regulations to hire employees. • The Government needs to significantly strengthen non-proprietary R&D and design capacity that has strong connections with research institutes like IITs • Facilitate additional courses to cater to upcoming demand for skilled workforce in the corridor
CEO	• Availability of industrial land and improved availability of power • Improved logistics infrastructure and integration with global supply chain network	• Tax structure needs to be improved. India's current tax structure makes the final product less competitive and encourages low cost imports • Preferential market access for local companies needs to be improved. • Flexibility in labour laws is essential to cater to rapid seasonal variation in demand.	• Reliance on imports for raw materials needs to be reduced • China and Taiwan are key competitors that have invested heavily in research and development. Economies of scale create global competitiveness. The focus area should be adding more value to the existing products and creating new products through investment in R&D. • Availability of quality manpower
Pharmaceuticals	• High quality of utility infrastructure required – water availability and treatment, power availability and quality • Establishing clinical research facilities with private partnerships	• Incentivize R&D in product innovation and Good Laboratory Practices (GLP) • Improve regulatory mechanism for approval of clinical trials • Introduce reforms in health care insurance sector	• Facilitate assistance in technology transfer through collaborations with MNCs • Upgrade and design new courses in the institutes which cater to the industry requirements • Create dedicated R&D institute for promoting product innovation and facilitate creation of product promotion centers for SME players
Food Processing	• Development of support infrastructure in the form of warehousing/ cold storage infrastructure and customized transportation network required • Reduction in raw material costs and losses by bringing in efficient logistics network. Last mile connectivity should be improved in order to strengthen the linkage between raw material supplier and processing units	• Government should promote reliable and strong supply chain network between raw material suppliers and processing units on PPP basis • There is a need to introduce uniform tax rates in all states avoiding multiplicity of taxes at different stages. • Systems and procedures may be simplified. The need for documentation/ paperwork at multiple checks posts and in different states, customs formalities, needs to be reduced.	• Awareness on quality standards could be created through seminars, newsletters and training programmes • The linkage between government agencies, universities, industry and other stakeholders like cooperatives, farmer organisations etc needs to be strengthened • Government should provide support to clusters in form of credit, inputs, expertise and marketing links • Focus on improving the quality of products Specific incentives to be given to encourage

Sector	Economic enhancers	Administrative enhancers	Value enhancers
			product diversification and increase production of value added products
Machinery and Electrical Machinery	• Ensure availability of raw material (CGRO/CNGRO* electrical steel) – clear certification mechanism for importers in the short run and setting up indigenous facilities for electrical steel production in the long run • Strengthening rail network (specially Bengaluru rural, Krishnagiri, Thiruvallur) as necessary requirement to transport over dimensional consignments • Set up indigenous testing and calibrating facilities for equipment testing	• Promote technologies upgradation, new technology introduction and accordingly modify the existing procurement policies by PSUs/utilities to facilitate technology absorption by electrical machinery and machinery manufacturers. • Quality control mechanisms and certification systems in the sector to ensure product quality control (supplies from vendors and end-products) • Transition from import dependent to export oriented sectors: in the short run - support indigenous manufacturers, by putting restrictions on second hand equipment, mandating foreign partners to foster technology transfers along with setting up manufacturing facilities; in the long run – export promotion polities; preference to joint ventures, not 100% foreign owned companies	• Establishment of linkages between industry and academia – active involvement of public and private participation to bridge growing skill erosion • Support/incentives to the manufacturing units in setting of R&D facilities (especially MSMEs) • Enhancement of value addition – incentives to the foreign players to increase value addition in India under technology transfer, roadmap for setting up facilities for manufacturing of automation equipment indigenously
Metallurgy	• Rail connectivity from mines and industrial units of Bellary to Chitradurga, Anantapur and Chittoor districts to Krishnapatnam, Managlore and Chennai Ports • Railway connectivity from Nellore to West Godavari, East Godavari mines • Expanded power generation and transmission initiatives adding sufficient capacity and covering identified nodes	• Policies to provide power tariff subsidies for first 5-10 years of operation • Further allocation of mines to companies planning to set up smelter units in the corridor • Creation of state owned enterprises focused on scrap consolidation and recycling. This would address raw material bottlenecks as well as make the industry greener.	• Technological linkages with countries like Japan who have been top exporters in spite of scarcity of raw materials • Knowledge Transfer Partnerships to create larger institute-industry interface and focus on employable workforce • Improved R&D on mineral exploration and environmental friendly linkages
Medical instruments	• Infrastructure for uninterrupted power supply • Mixed cluster approach with electronics and electrical industry to enable synergies	• Quality standard norms to discourage low quality imports and give boost to domestic industry • State level healthcare initiatives in segments like telemedicine/portable clinics that can provide boost to portable device segment • Enhance branding of the industry in the corridor through initiatives like medical technology parks	• Incentives for R&D in hi-tech medical equipment segment e.g. pooled fund to support R&D within SMEs • Better grants in biomedical instrument or like subjects to attract brighter research talent • Focus on creating employable workforce
Textiles and Apparels	• Subsidizing unit rates of power or encourage usage of non conventional energy sources. Develop dedicated/captive power generating sources specifically for the major textile clusters.	• Regulations need to be focused on controlling raw material exports to ensure stable prices in the country and to make the sector more competitive and productive • Reimbursement schemes such as duty	• Technological upgradation, modernization of units and Automation needs to resolve the problems of shortage of labour, poor quality of product and will lead to higher productivity • Vocational training through ITIs, Textile

Sector	Economic enhancers	Administrative enhancers	Value enhancers
	• Concerned Ministries, Departments, State government need to be focus on reducing the transit time and cost at the international check points to make Indian textile products more competitive.	drawback, market development assistance etc to reduce the impact of exchange rate fluctuations • Labour laws need to be made more flexible to permit longer hours of overtime with due compensation, and to allow flexi-hiring of labour	Design & Management Institutions specially in the area of Apparel Manufacturing, Quality Control and Designing needs to be encouraged so that skilled work force is available • Amendment to Labour Laws is needed, to permit longer hours of overtime with due compensation, and to allow flexi-hiring of labour, especially to support apparels sector
Chemical and Petrochemica l	• Develop freight corridor between Bengaluru rural and Chennai seaport, to promote exports of chemicals and petrochemicals • Improve rail connectivity between Bengaluru rural and Chennai seaport • Ensure feedstock availability of natural gas and naphtha	• Consolidate acts into an Integrated Chemical Legislation, simplify regulatory structure and strengthen regulations and ensure stricter enforcement of regulations and promoting green manufacturing practices • Rationalize taxes and duties to promote domestic manufacturing • Incentivize the MSME players to increase the sectors' presence in the MSME segment along the corridor districts	• Set up a dedicated R&D centre and Centre of Excellence for Specialty Chemicals • Incentivize industry players to follow best practices of manufacturing like higher efficiency, latest technologies; promote "zero discharge" technologies • Establish a CBIC Chemical Innovation Fund to encourage commercialization efforts for innovations generating inclusive growth

Below the past growth trends and possible investment districts for key sectors are summarized.

Table 8.2.4: Summary of key sectors – historical growth rates and key districts for investment

Sector	Output growth India (CAGR)	Key districts for investment in the corridor
Computer, electronics and optical products	15% (2006-11)	Chennai, Kancheepuram, Bengaluru urban, Bengaluru rural
Metallurgy	14% (2004-12)	Chitradurga, Anantapur, Chittoor, Nellore, Tiruvallur, Thiruvannamala, Kancheepuram, Tumkur, Bengaluru rural
Textiles and Apparel	17% (2006-11)	Tiruvallur, Dharmapuri, Kancheepuram, Bengaluru Rural, Bengaluru Urban, Chitradurga
Food processing	20% (2009-11)	Nellore, Chittoor, Tiruvannamalai, Dharmapuri
Pharmaceuticals	14% (2008-12)	Bengaluru Urban, Bengaluru Rural, Chennai, Kancheepuram, Nellore
Chemical and petrochemicals	11% (2009-13)	Bengaluru Urban, Bengaluru Rural, Ramnagara, Chennai , Tiruvallur
Electrical machinery	23% (2009-11)	Kancheepuram, Chittoor, Chennai, Bengaluru urban, Bengaluru Rural, Krishnagiri, Tiruvallur
Machinery	14% (2009-11)	
IT and financial	8% (2008-12)	Bengaluru Urban, Bengaluru Rural, Chennai

Regional industrial agglomeration creates the advantages of districts including cost competitiveness, availability of skilled manpower and robust MSME base.

Cluster advantage

- Automobiles- clustered around **Chennai;** Corridor accounts for about 60% of India's automotive export
- IT/ITeS - about400 of the Fortune Global 500 companies outsource their IT/ITeS/other services to firms in **Bengaluru & Chennai**
- 30% of Japanese companies in the region

Factor cost advantage

- Textiles - **Kancheepuram** hub of silk weaving and handloom industries of India
- Food Processing – strong availability of raw materials in **Nellore**
- Leather – **Vellore** accounts for about 37% of the country's export of leather products

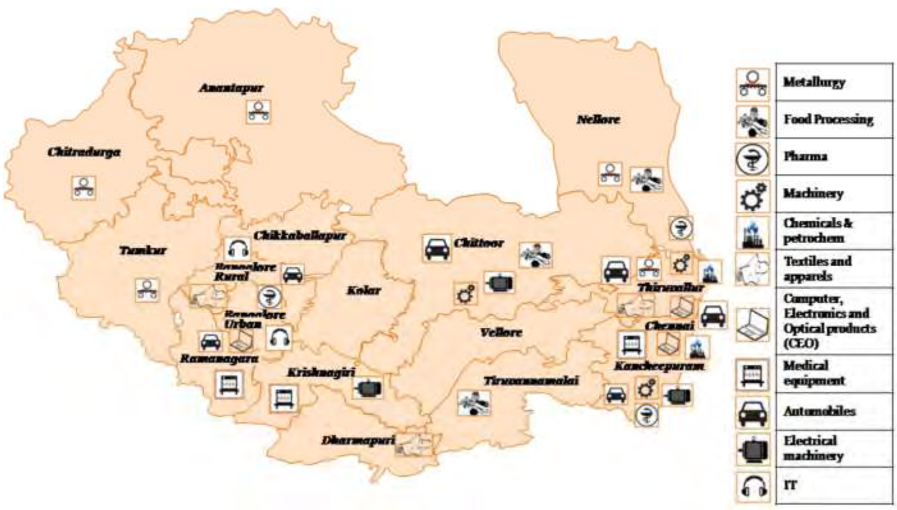


Figure 8.2.9: Key Potential Sectors

Skilled manpower availability

- **Bengaluru** is the 4th largest technological cluster in the world after Silicon Valley, Boston and London.
- About 50% of MNC R&D centres in India are based in Bengaluru

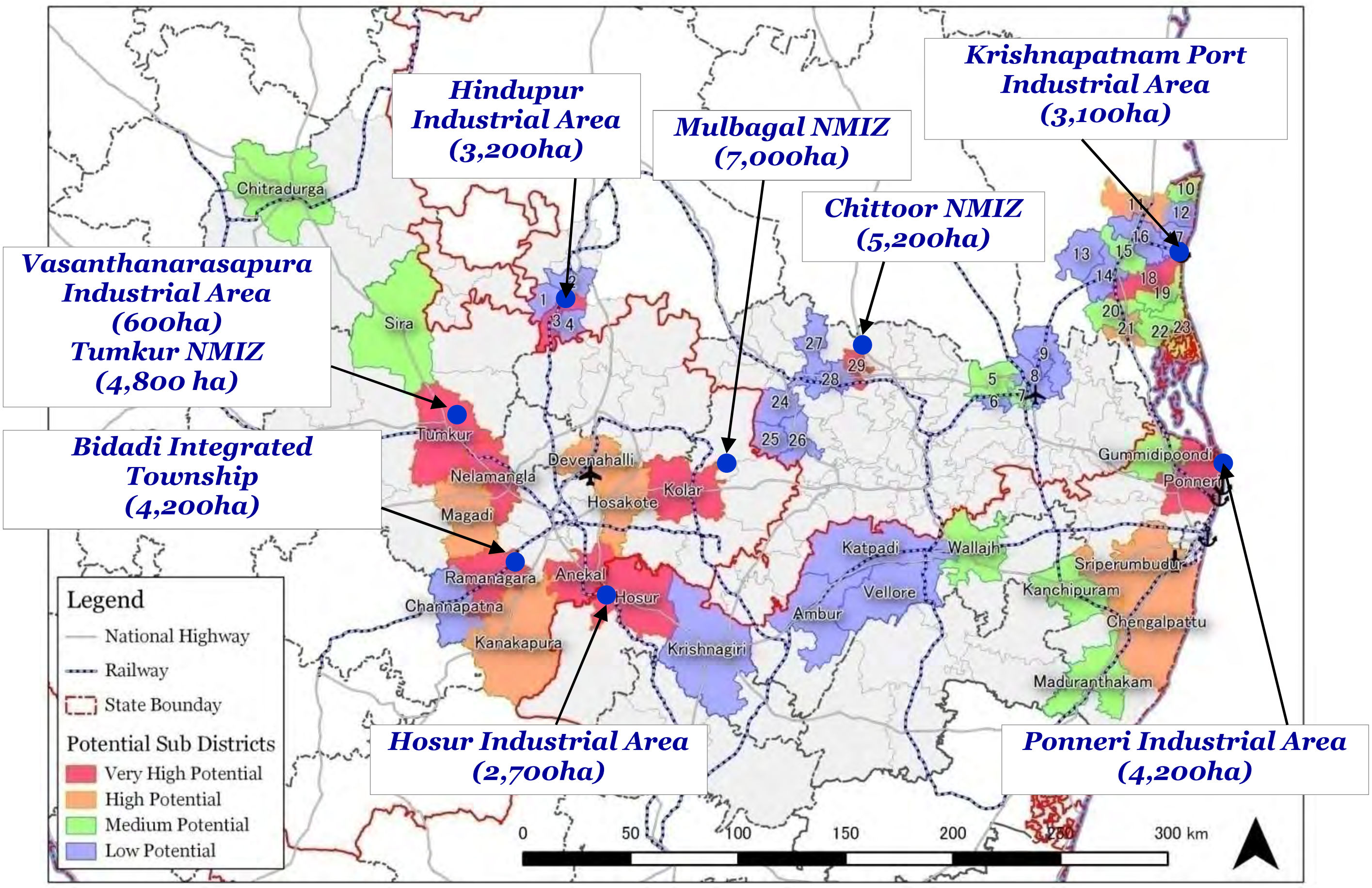
Robust MSME base – vibrant base of MSMEs accounting for about 15% of India's MSME units

8.3 Development Plan

8.3.1 Node Development

One of the objectives of the JICA CBIC study is to identify suitable nodes for industrial development within the CBIC area. In this regard, the JICA study team undertook i) an analysis of node development potential including the potential zones at a broad level, ii) an assessment of potential areas at a sub-district level for development of industrial nodes, iii) a confirmation of the ground situation and potential of shortlisted nodes including prospects of investment from Japanese Companies, and iv) proposition of industrial nodes for the master plan.

The detailed assessment at sub-district level was done considering: i) accessibility to regional trunk roads, ii) existence of protected/restricted areas, iii) government land availability and availability of proposed industrial development areas, iv) water availability, v) assessment of urban planning strategy, vi) existing and planned industrial areas, vii) accessibility to major transport facilities (port and airport), and viii) accessibility to electricity network. Subsequent to the detailed assessment, sub-districts that had very high potential for industrial nodes were identified through discussion with the state governments and 8 nodes were shortlised as shown in the follwing map.



Source: JICA Study Team Analysis

Figure 8.3.1: Location of Shortlist Nodes

Additional land development of the industry area of 20,000 ha will be required for the CBIC region to achieve BAU (Business as Usual Scenario) and the development of all 8 nodes, amounting to about 35,000 ha, are considered to be necessary and high priority. The total estimated industrial land demand is estimated to be 79,000 ha under BIS case.

8.3.2 *Infrastructure Development*

Importance of Infrastructure Development

Availability of adequate infrastructure is critical for attaining the vision and industry potential for the corridor. The criticality of infrastructure for development and sustenance of various key focus sectors is shown as under. The strengthening of various infrastructure components such as transport (covering railways, road, ports and airports), water and power would be required for achieving the vision for the corridor.

Table 8.3.1: Criticality of Infrastructure by Industry

Industries	Water	Power	Road connectivity	Rail connectivity	Ports	Airports
Metallurgy	5	4	4	4	6	7
Medical equipment	7	4	5	5	7	7
Food processing	5	6	5	5	6	7
Textiles	4	5	5	5	4	5
Electrical machinery	6	5	5	5	5	7
Machinery	6	5	5	5	5	7
Chemicals	4	4	4	6	5	5
Pharma	4	4	4	6	5	5
Auto	5	4	5	4	5	7
Computer, electronics	7	4	5	5	6	6

Importance: 4 Critical 5 High 6 Medium 7 Low

The table above summarizes findings with regard to importance of each infrastructure component based on sector analysis and stakeholder interactions.

The development strategy of critical infrastructure elements such as transport (covering ports, roads, railways, urban transport, logistics and airports), water, energy and solid waste management are summarized below.

8.3.2.1 Transport

Availability and affordability of adequate transport infrastructure is a necessary element to enable development of industrial sector. The Global Competitiveness Report 2013-14 by the World Economic Forum assesses quality of infrastructure (including roads, railroads, ports and air transport infrastructure) as one of many different components measuring different aspects of competitiveness. On a scale of 1-7, following is India's score against competing countries for manufacturing sector investment.

Table 8.3.2: Global Competitiveness Index

Global competitiveness index	India	China	Thailand	Korea
Quality of **roads**	3.6	4.5	5.0	5.8
Quality of **railroad** infrastructure	4.8	4.4	2.6	5.6
Quality of **port** infrastructure	4.2	4.5	4.6	5.5
Quality of **air transport** infrastructure	4.8	4.5	5.7	5.2

India's score against competing countries is relatively low for road and port infrastructure. India's railroad and air transport infrastructure are relatively close to competing countries standards.

Transportation via road is significant as compared to rail in the CBIC region. The modal split of cargo, mainly containers, moving for imports and exports from Chennai port is 95% and the rail is 5%. The current rail work is heavily dominated by passenger services and less orientated towards freight traffic. Further, critical portions of the rail network in the CBIC region stands utilized at over 100% causing congestion and limited bandwidth to increase the frequency of freight trains. While this has been a cause for concern, bottlenecks in the cities of Bangalore and Chennai and poor last mile connectivity to ports have contributed to slow movement of cargo in the region. The time taken for transportation of goods from the Bangalore region to Chennai and vice versa is almost 6-7 days, rendering loss of competitiveness according to industry stakeholders.

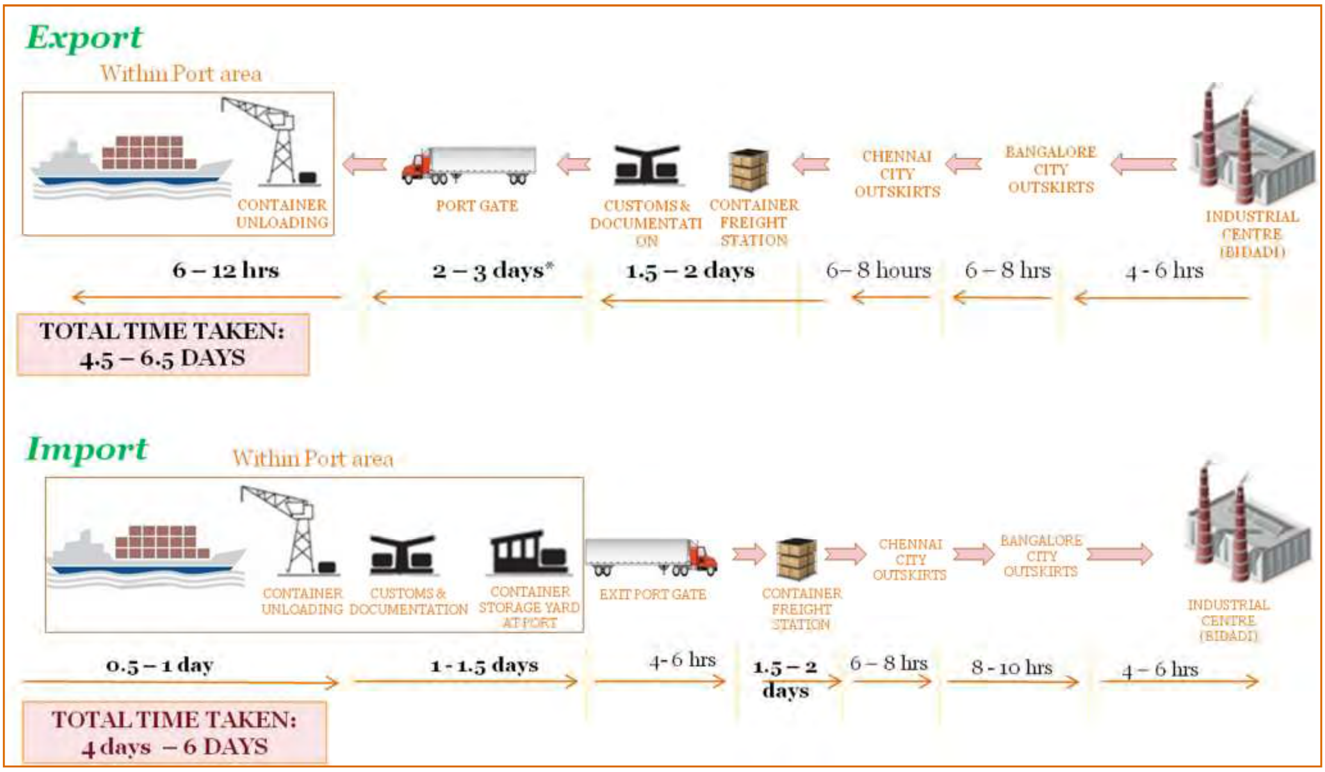


Figure 8.3.2: Time taken in movement of Export and Import containers between Chennai Port and Bidadi Industrial Area

The delays in transit of goods are caused due to inadequate infrastructure at the cities for smooth movement of cargo, poor last mile connectivity at ports causing trucks to heavily queue at the port and lengthy customs procedures at ports. These issues arguably add to loss of competitiveness of the region.

The focus of the transport sector strategy is aimed at addressing the critical bottlenecks over the short term. Over the medium to long term, the need for additional projects have been analyzed for various transport sub-sectors (covering ports, roads, railways, urban transport, logistics and airports) in order to meet future growth needs of the corridor in consideration of the future industry potential.

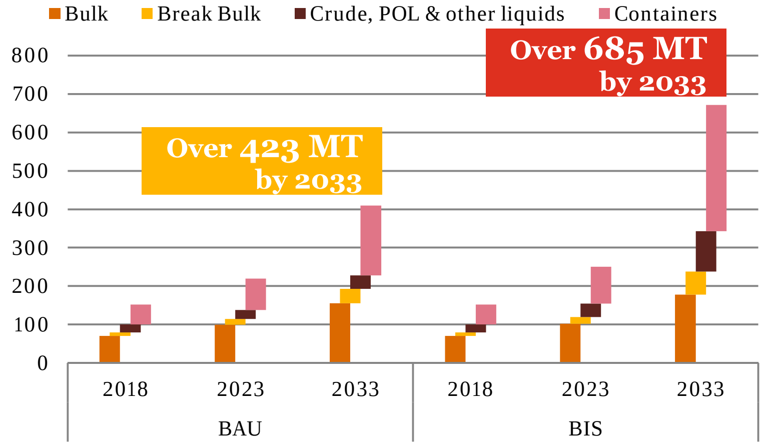
8.3.2.2 Ports

Manufacturing led growth expected to drive port traffic in the CBIC region to over 685 MT

The ports serving the CBIC region include Chennai Port, Ennore Port, Kattupalli Port and Krishnapatnam port. These ports jointly handled traffic of 92 MT in the year 2012-13. The manufacturing-led growth in the CBIC region is expected to be the major driver for increased traffic at ports in the CBIC region. The traffic at the ports is expected to reach 423 MT in the BAU scenario and to over 685 MT in the BIS case by the year 2033. This increased cargo traffic at the ports in the CBIC region are likely be comprised of the major commodity segments such as bulk and containers collectively accounting for over 75% of the total traffic at the ports in 2033 in the

BIS case. Other segments such as POL and break-bulk are expected to account for 16% and 9% respectively in 2033 in the base case. The ports of Chennai, Ennore, Kattupalli and Krishnapatnam are to jointly account for a traffic handling capacity of close to 600 MT in 2033.

The port sector strategy puts the spotlight on improving the existing infrastructure and connectivity at the ports in the CBIC region in order to maximize the use and effective use of these ports. The effective use of ports is impacted by critical parameters such as efficient road and rail connectivity to the ports that enable faster & efficient evacuation of cargo at the ports. A host of connectivity improvement projects have been committed for implementation at Chennai and Ennore ports. Timely & successful implementation of these projects is critical and central to effectively utilizing the ports. The projection of traffic and criticality of these connectivity improvements are discussed over the short and medium to long term.



Source: JICA Study Team analysis

Figure 8.3.3: Port Traffic in the CBIC Region

The overall port capacity in the region is expected to be sufficient over the short term (up to 2018) and over the medium term (up to 2023) subject to timely commissioning of planned berth side and connectivity improvement projects at Chennai & Ennore Ports and the berth side capacity expansion / new capacity creation projects at Kattupalli and Krishnapatnam ports as well.

However, as visible from the following graph, port capacity is expected to fall short of the capacity requirement over the long term (in 2023). The capacity deficit is expected to be around 134 MT for container traffic, 140 MT for dry bulk and around 105 MT for all other commodities combined.

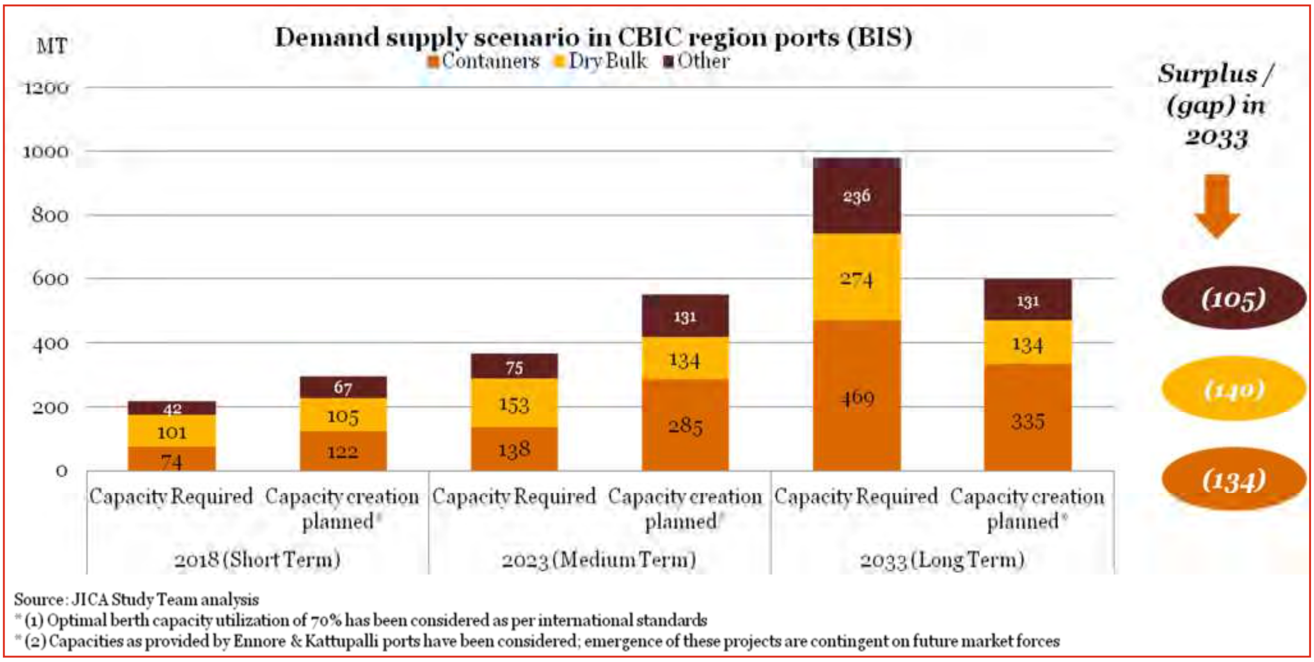


Figure 8.3.4: Demand Supply Scenario in CBIC Region Ports (BIS)

Container Traffic & Capacity in CBIC region:

Short-term scenario:

Over the short term, the major bottleneck in the transportation of containers is expected to be the limited road capacity available at the roads connecting the ports. However, there is significant capacity addition planned in enhancing road connectivity to the ports in the CBIC region. Some of these proposed projects are the ongoing elevated road corridor from Maduravoyal to Chennai Port, the Ennore – Manali Road Improvement Project, the proposed Northern Port Access Road etc. Thus the enhancement in the road-based evacuation capacity over the short term is expected to resolve the current congestion issue at the ports for the movement of road-based cargo including container cargo. The ports in the region shall also need to undertake port-gate capacity enhancement projects to meet the traffic flow requirements.

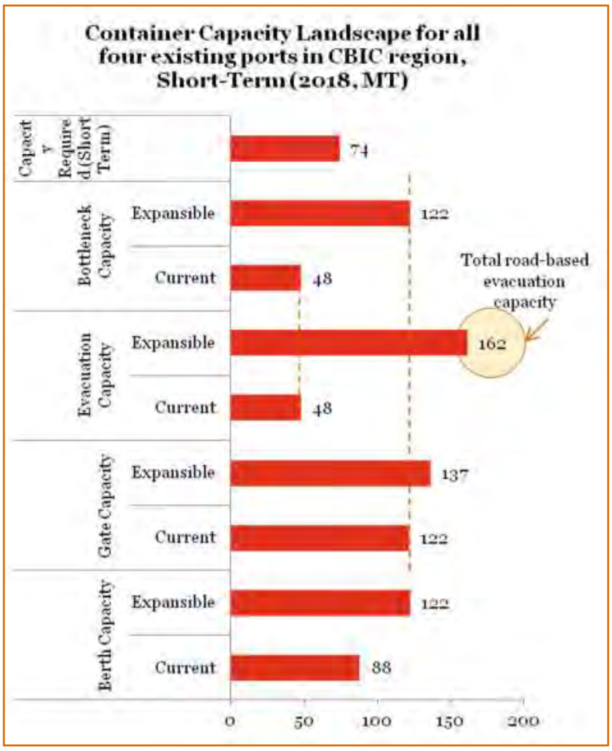


Figure 8.3.5: Container Cpacity Landscape for Four Ports in CBIC Region (Short-Term)

Medium-term scenario:

Over the medium term, the major capacity additions expected for containers in the region include the proposed Container Terminal – 2 project at Ennore Port and the conversion of the JD Dock into the Container Terminal at Chennai Port. The restructured MEGA Container Terminal Project in the form of the Project Outer Harbour is also expected to add around 0.74 MnTEUs container capacity in 2019 and a total container capacity of 1.48 Mn TEUs upto 2026 to the ports in the CBIC region.

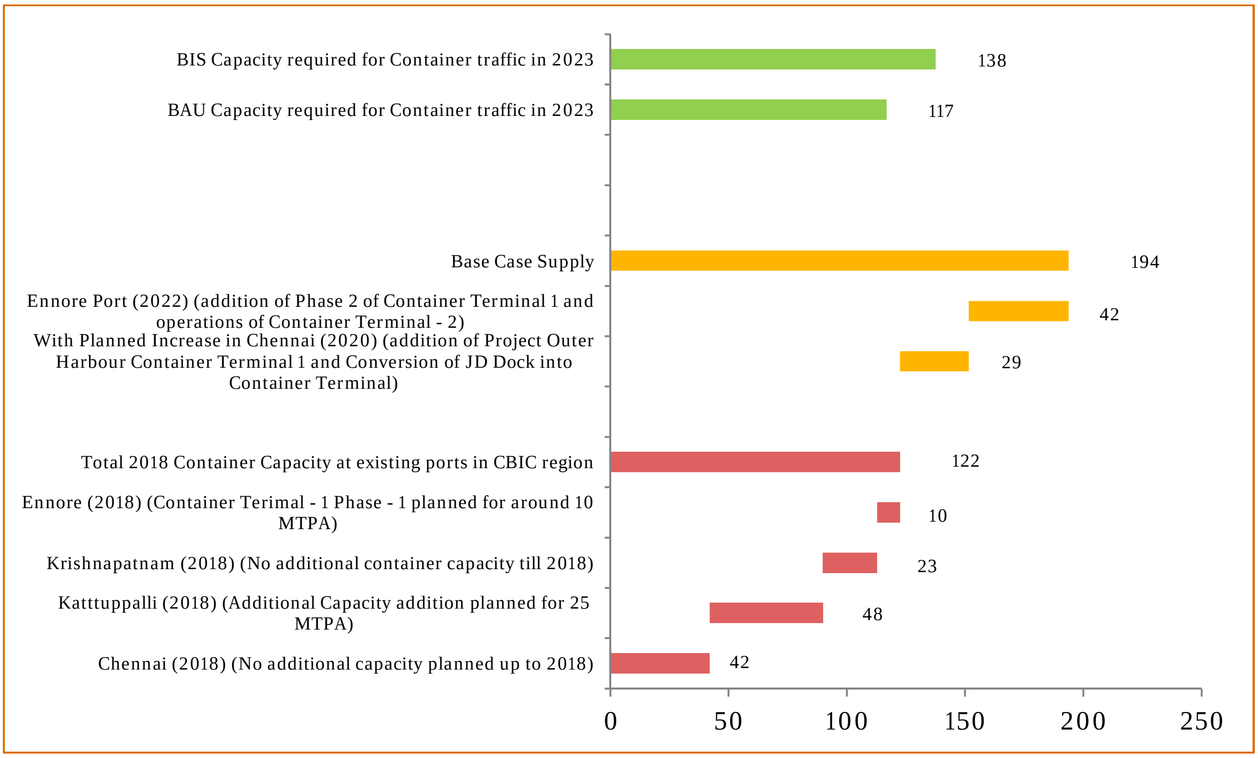


Figure 8.3.6: Major Capacity Additions for Containers in CBIC Region

As the graph above suggests, the planned additions in container capacity at the ports (Chennai, Ennore & Kattupalli) in the CBIC region are likely to be sufficient to meet the capacity requirements in the BAU and BIS scenario over the medium term. However, the container berth capacity expansion projects planned over medium term also face some risks and overcoming / mitigating these risks is essential to ensure sufficient capacity at the ports in the region. These risks pertain mainly to risk of materialization of the proposed investments in the planned infrastructure development, planned capital infusion not being targeted to handle the changing shipping trends across the world and the availability of deeper draft berths and better land-side evacuation at neighbouring ports. The materialization of these risks may have the potential to draw traffic away from the established ports of Chennai and Ennore.

Long-term scenario:

In the long run, while the ports at Chennai, Ennore, Kattupalli and Krishnapatnam shall be able to cater to the container traffic in the BAU scenario, the requirement for 1-2 additional deep sea ports for handling the container traffic in the BIS case shall arise.

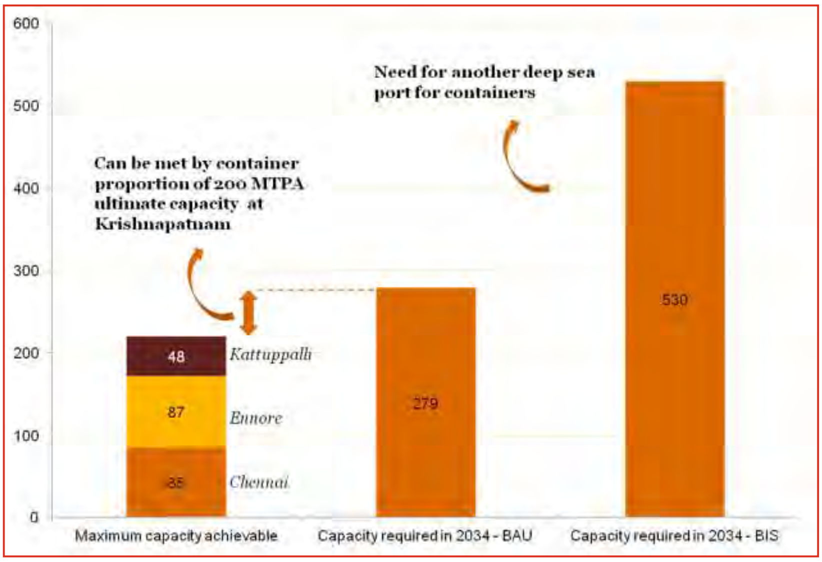


Figure 8.3.7: Container Cpacity Required in CBIC Region

Coal Traffic & Capacity in CBIC region:

Coal is the second major commodity which is expected to form a substantial portion of the port traffic inthe CBIC region. The Chennai Port has recently stopped handling thermal, coking and other coal as well as other dusty cargo due to its emphasis on handling clean cargo. Due to this, the coal traffic is likely to shift to Ennore Port which also caters to a substantial coal requirement of TNEB power plants in the region. Krishnapatnam is also likely to emerge as the port of choice for coal traffic in the CBIC region and is expected to cater to the UMPP as well as other thermal power stations in the vicinity. Cheyyur, which is planned to be developed as a captive coal handling port, is likely to cater to the requirement of the Cheyyur UMPP.

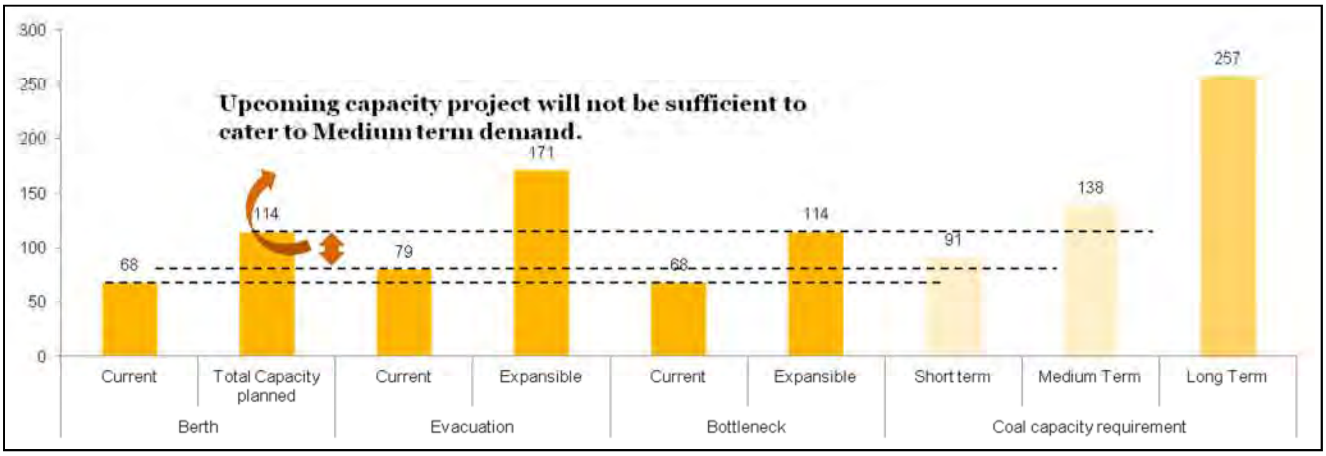


Figure 8.3.8: Coal Handling Capacity at the Ports in CBIC Region

As the figure above suggests, while the short term requirements can be met by the proposed capacity additions planned in the short term at the ports in the CBIC region, a medium-to-long term coal strategy shall be important to meet the coal handling capacity requirements in the region.

Enhancement of ports’ internal efficiency is equally important:

With the expected completion of last mile road connectivity projects such as Ennore Manali Road Improvement Project (EMRIP) and Elevated corridor to Maduravoyal and the existing rail evacuation capacity, the road based evacuation capacity of the port (coupled with rail) is expected to reach 83 MT. This evacuation capacity is expected to be sufficient for evacuation of land based cargo handling capacity of 68 MT, but could create constraints during peak times. Considering growing urbanization and rigid land use patterns, no further connectivity improvements would be practically possible around the Chennai region benefitting Chennai Port. The port target implementing the efficiency improvement measures recommended by OCDI as part of the JICA sponsored study (concluded in February 2014) which involve the below key immediate measures:

Efficiency improvement measures recommended by OCDI
Termination of export containers having insufficient documentation at CFSs and CWC
Shift trailer inspections to the off-dock parking area instead of at the port gate
Relocation of customs gate from the terminal gate to the port gate
Regulation of idling trailers in the port
Establishment of a common portal web system
Authentication of trailer’s port pass by introducing information technology systems

Over the long term, the capacity of the region’s ports turn insufficient triggering need for additional port handling capacities

Over the long term (2033), the port traffic in the region is expected to be in the range of ~430 MT to ~685 MT (BAU and BIS cases respectively) by 2033. This is expected to be largely contributed by the segments of bulk (32%), POL (12%) and containers (47%). While the short term and the medium term scenario present sufficient capacity for most commodities (except bulk in medium term), there is likely to be capacity shortfall

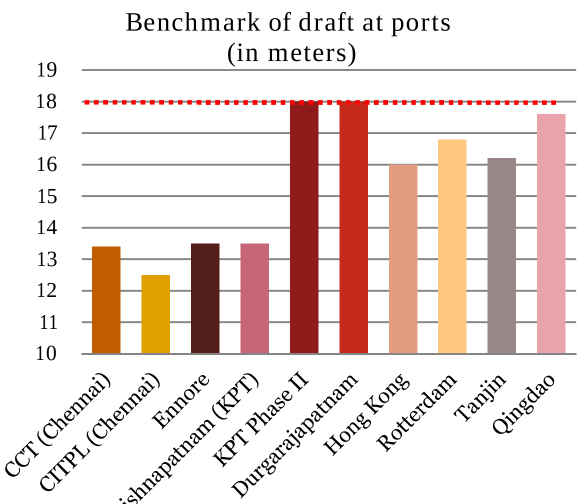
Table 8.3.3: Deficiencies in Port Handling Capacities

Deficiencies for segments (BIS)	2018	2023	2033
Bulk	-	18	140
Break Bulk	-	-	33
Crude, POL & other liquids	-	-	72
Containers	-	-	134

Krishnapatnam and Durgarajapatnam have significant potential to cater to the region’s growing demand and emerge as next generation ports

The ports of Chennai & Ennore are expected to have a joint container handling capacity of ~122 tonnes by 2023. Further, the draft in these ports are around 13.5 meters limiting their abilities to handle large sized vessels (DWT 250,000 & above).

Ports in India such as Mundra are designed to handle ships of the size of ~250,000 DWT, owing to presence of a draft of over 18 meters that considerably reduce the costs of shipping by around 30%-40% thus making sea transportation costs competitive.



Source: Research by JICA Study Team

Figure 8.3.9: Benchmark of Draft at Ports

The CBIC region exhibits critical competitive advantages for creation of large “next generation” ports having the ability to attract large vessels contributing to significant reduction in costs of transportation of cargo. Some of the key factors that are critical for creation of world class ports are presence of a deeper draft, presence of Greenfield locations to exercise freedom of planning of port infrastructure and associated storage & connectivity infrastructure, and presence of a strong economic hinterland capable of generating large volumes of cargo.

Presence of deeper draft to accommodate larger vessels

Presence of a large economic hinterland for generaing large cargo volumes

Greenfield locations to exercise freedom of planning & development of ports and connectivity infrastructure

Krishnapatnam port (phase II) and the planned Durgarajapatnam port have a draft of 18 meters, which could be one the deepest in the world and higher compared to Qingdao in China which has the deepest operating draft of 17.6 meters.

Large volumes of containers are required to attract large sized vessels. The port of Yangshan off the coast of Shanghai, which attracts large sized vessels, is preparing for a capacity expansion to 13 million TEUs by 2020. Khalifa Port in UAE, which also attracts large sized vessels, has planned a capacity expansion to 12 million TEUs by 2030. The container traffic in the CBIC region is expected to reach 10 million TEUs and 19 million TEUs in the BAU and BIS cases respectively in 2033. Almost 50% of these volumes are expected to be handed in the Krishnapatnam belt. Though the CBIC region accounts for significant volumes, the abilities of the ports of Krishnapatnam and Durgarajapatnam to adequately expand their capacities to global levels would need to be examined.

The areas around Krishnapatnam port and proposed Durgarajapatnam port are relatively less urbanized and greenfield thereby providing the advantage to develop world class port infrastructure in a phased manner with enhanced scope for evacuation at the ports. It is necessary that the development plan for these ports consider regulating the development around these ports in a manner that the efficiency of these ports is retained over a longer time horizon of 30-50 years.

Considering the above factors, Krishnapatnam and Durgarajapatnam have the potential to emerge as next generation ports potentially emulating the standards of ports such as Mundra that have the capacities to handle large sized vessels. This requires further examination from technical perspectives and it is suggested that the above competitive advantages be sufficiently considered in the expansion of Krishnapatnam port[116] and development of Durgarajapatnam port.

The Government of Karnataka plans to develop the ports on the western coast of the state with an eye on the strategic and economic benefits of these ports. Mangalore port is an important port on the western coast of the State of Karnataka. However, additional detailed studies are required to determine the issues related to seamless road and rail connectivity of the port at Mangalore to the proposed CBIC region.

8.3.2.3 Roads

Chennai and Bengaluru, the 2 major urban centres in the CBIC area, are linked by national and state highways, which also pass through many major towns. Approximately 2,942 km of national highways and 5,343 km of state highways have been identified in the CBIC area, with those lengths set to increase due to rapid urbanisation. Major road projects in the CBIC area that have been identified include: 8 ongoing projects, 5

[116] It is anticipated that the expansion plans of Krishnapatnam port shall be guided through a formal regulatory & approval process involving the State Government of Andhra Pradesh

announced projects, and 6 projects under study in Tamil Nadu, 5 ongoing projects, 7 announced projects, and 3 projects under study in Karnataka and 1 ongoing project, 2 announced projects, and 5 projects under study in Andhra Pradesh. These projects include the development of new urban ring roads and capacity improvements of major intercity roads.

Freight traffic volume in CBIC area has been increased as represent 13% average growth rate of container handling volume of Chennai port, and share of road transport in container transport is about 95% against about 5% by rail. Reliability of transit time is another major issue on road infrastructure. A lack of high grade road network connecting major logistical node and facilities and bottlenecks on road network are obstables.

Demand supply gap analysis under condition of no road development and traffic growth of BAU development scenario is carried out for year 2018, 2023, 2028, and 2033. As a result of above analysis, the share of over 1.0 vehicle congestion ratio of national highway network will reach almost 50% in Karnataka state in year 2018, in Tamil Nadu state in year 2023, respectively, while Andhra Pradesh state will maintain less than 50% of vehicle congestion ratio even in year 2033. The share of vehicle congestion ratio will rapidly grow in Karnataka state and it will exceed 90% in year 2033. The share of state highway network in Tamil Nadu and Karnataka will continuously increase as well as the national highway network of Tamil Nadu and Karnataka to reach at almost 50% in year 2028 and year 2023, respectively. It is obvious that immdediate supply of road capacity in an efficient manner is essential for the sustainable industrial development in CBIC area and comprehensive regional development.

Strategic policy measures of road sector is examined based on identified road sector issues, demand supply gap analysis result and the planning principle as follows:

- Strengthening of logistic road network

  - Formulation of major logistic network (primary logistic road network)

  - Formulation of network between primary logistic road network and major industrial node, sub centre, and logistic node / formulation of network between primary & secondary logistic road network and industrial park (secondary logistic road network / tertiary logistic road network)

  - Development of access-controlled expressway network

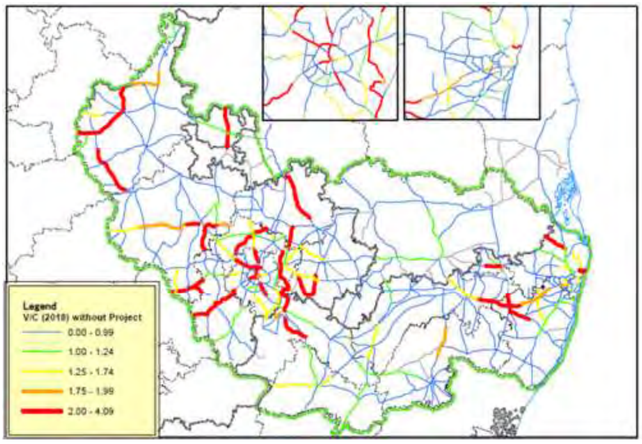
  - Congestion mitigation at metropolitan areas and major cities

- Enhancement of logistic road network capacity and level of service

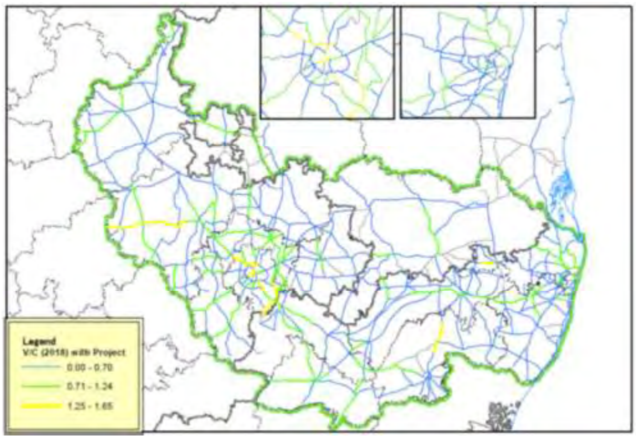
  - Widening of existing roads to respond future traffic demand

Based on examination of the strategic policy measures on road network in CBIC area, logistic road network in CBIC area is formulated. Capacity provision by widening is also examined on the logistic road network and in total, fifty four projects (including committed projects) for a length 2,975km have been proposed as strategic road infrastructure project. Seven projects are new project and forty seven projects are widening projects and total project cost of the logistic road network project is 5,871 million USD. Project costs of each term are 1,942 million USD in short-term, 2,087 million USD in medium-term, and 1,842 million USD in long-term.

In the short term, it is essential to develop urban ring roads at Metropolitan Areas. The lengths of committed and proposed road projects by implanting agencies and comparison of V/C ratio with and without projects are summarized below.



V/C rate in the short term
"Without Projects- BAU"



V/C rate in the short term –
"With Committed and Proposed Projects" - BAU

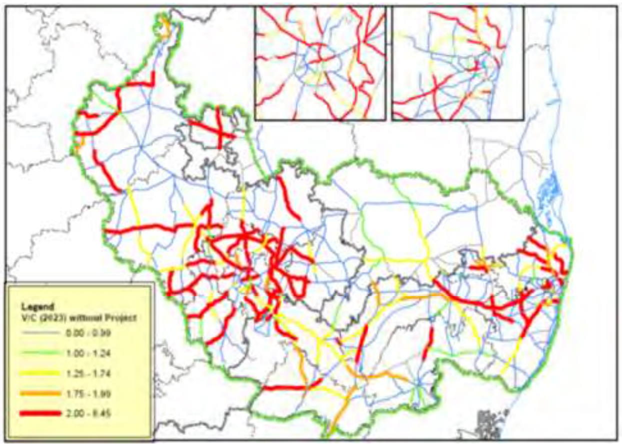
Source: JICA Study Team

Figure 8.3.10: Comparison of V/C rate in the Short Term

Table 8.3.4: Length of Committed and Proposed Projects in the Short Term

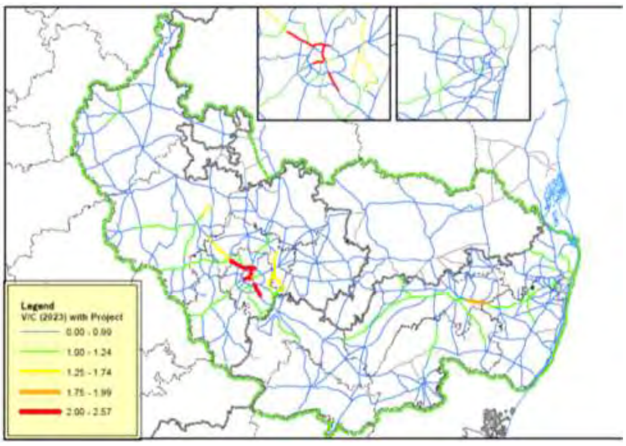
Ownership	Committed (km)	Proposed (km)
Tamil Nadu (SH)	104	39
Karnataka (SH)	65	170
Andhra Pradesh (SH)	-	33
NHAI	429	69

In the medium term, Chennai Bengaluru expressway will be needed by 2023, and Chennai peripheral ring road would also be required by 2023 to ease congestion.



V/C rate in the medium term

"Without Projects- BAU"



V/C rate in the medium term –

"With Committed and Proposed Projects" - BAU

Source: JICA Study Team

Figure 8.3.11: Comparison of V/C rate in the Medium Term

Table 8.3.5: Length of Committed and Proposed Projects in the Medium Term

Ownership	Committed (km)	Proposed (km)
Tamil Nadu (SH)	139	-
Karnataka (SH)	-	152
Andhra Pradesh (SH)	-	-
NHAI	328	416

8.3.2.4 Railways

The railway network in the CBIC area is 2,806 Km long covering three zones of the Indian Railways – Southern Railway, South Western Railway and South Central Railway. The network contains 22 routes and 66 line sections, linking Chennai and Bengaluru and providing through routes to other cities like Mumbai and Hyderabad. The network is mostly electrified within the Southern and South Central jurisdictions; however much of South Western Railway consists of single line, non electrified track (though some doubling and electrification is in progress). There are links to major industrial areas and ports at Chennai, Ennore, and Krishnapatnam.

Capacity saturation occurs when the number of trains each way per day exceeds 90% of the estimated daily train capacity. Nearly 37% of this network in terms of route km has either already reached or is fast approaching capacity saturation.

The Chennai – Bengaluru route currently carries 10.5m tonnes of through-freight. The freight includes bulk cargo (mainly coal, limestone and dolomite), break bulk (foodgrains and fertilizers) and containers. It is forecasted that in the BIS case, by year 2033, the Chennai – Bengaluru route will carry 65.2m tonnes of freight in total in both directions. It is expected that rail will also start carrying cars for export via Ennore. Coal from Ennore and Krishnapatnam is also expected to be a major driver of rail freight growth. Also, based on available data, it was estimated that 3.3m passengers (all reserved classes) travelled in 2013 in both directions on the Chennai – Bengaluru route. It is further estimated that this will grow to 29.7m by 2033. With regard to capacity saturation in the BIS case, of the 22 routes, 10 are already exceeding their capacity; another 1 will be capacity saturated by 2019/20, while another 1 will exceed their capacity before 2020/21, 1 more route by 2023/24, 2 more routes by 2024/25 and 1 more by 2027/28.

Six strategies are proposed for the development of railway infrastructure within CBIC and those are to:

- expand railway route capacity to satisfy increased freight and passenger demand;
- connect the railway to industrial nodes being proposed for accelerated development;
- improve railway connectivity of major east coast ports;
- apply rolling stock and commercial strategies to attract high potential freight customers to rail;
- consider construction of a Dedicated Freight Corridor (DFC) between Chennai/Ennore/Krishnapatnam and Bengaluru (with provision for future extension to Goa); and
- consider construction of a High Speed Passenger Railway (HSR) between Chennai and Bengaluru.

For expansion of railway route capacity, 2,133 km of additional running lines will need to be constructed over the 20 year forecast period (2013-2033) to satisfy freight and passenger demand which would be generated under the BIS case. This will include 686 km of new running lines on the Chennai – Bengaluru route and 1,447 km of new lines on all other routes. 1,653 km of additional running lines would be required even under the BAU case, with 486 km for the Chennai – Bengaluru route and 1167 km of new running lines for all other routes.

A number of short term measures may be taken to optimise the utilisation of route capacity, including: i) increasing train lengths up until the available length in crossing/passing loops and sidings; ii) providing freight rate incentives to encourage the back-loading of general purpose wagons; and iii) combining rakes of empty wagons in order to reduce train numbers. It is understood that the Railways has proactively applied these measures, although it is likely that there is scope for further action.

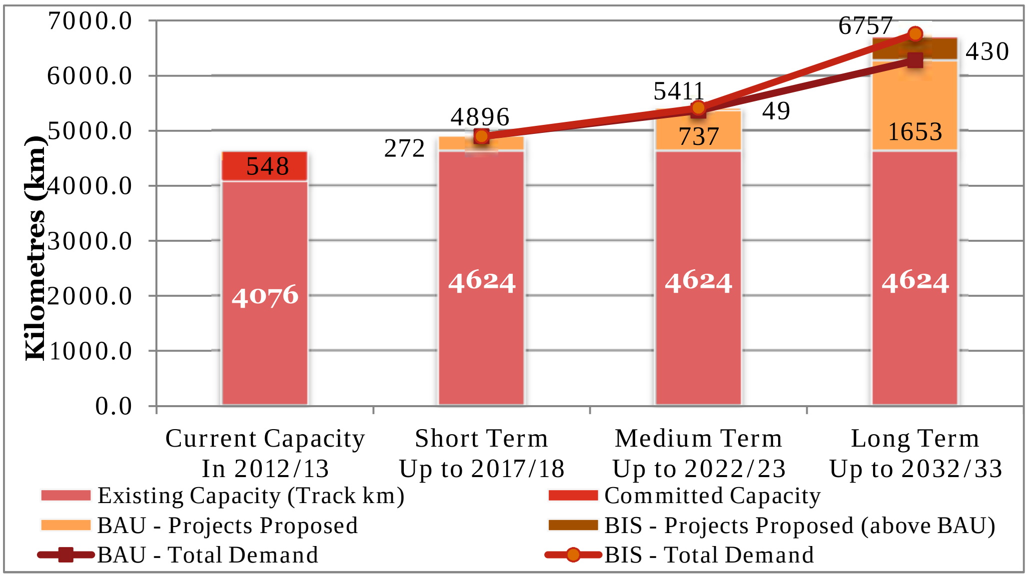


Figure 8.3.12: Suppy and Demnd of Rialway Track km

One very important measure for increasing railway capacity is the upgrading of absolute block signalling to automatic signalling. Other longer term measures can be applied to expand railway route capacity, including: increasing the number of running tracks, addition of train passing/crossing loops on single line sections, electrification, lengthening of crossing/passing loops and sidings, increasing axle loads of rolling stock and track, increasing motive power, etc. As a conclusion, other than signalling improvements, there may be few practical alternatives to increasing the number of running tracks to increase line capacity. The study estimates that over 20 years in the BAU case, 10 of the 66 line sections (15%) will need expansion beyond 4 running lines; in the BIS case, 12 out of 66 sections (18%) will need to be similarly expanded.

The railways are also constructing or planning several new lines with the CBIC area. These projects will improve connections to 5 of the 8 candidate nodes when completed. Additionally, the new line projects also include a new line to Ennore Port and improved connectivity from Krishnapatnam Port to its hinterland.

The cost of the proposed capacity expansion in the BIS case is 1,835 million USD (not counting committed investment, which is estimated to be 407 million USD). New line projects that will improve port connectivity will cost 216 million USD while new lines to nodes will cost 665 million USD. The total cost will be 3,123 million USD, which works out to 1,457 million USD in the short term, 498 million USD in the medium term and 1,168 million USD in the long term.

Table 5.2 Cost for Railway Development Project

(Unit: Million USD)

Category	Short (2013/14 – 2017/18)	Mid (2018/19 – 2022/23)	Long (2023/24 – 2032/33)	Total
Study on Comprehensive Demand Analysis	To be done in the short term	-	-	-
Route Capacity Expansion (548 km Committed)	407	-	-	407

Category	Short	Mid	Long	Total
(Estimated Cost)				
Route Capacity Expansion (BIS Case)	227	440	1,168	1,835
New Line Construction – node connections	607	58	0	665
New Line Construction – port connections	216	0	0	216
Total	1,457	498	1,168	3,123

Source: JICA Study Team (All costs in Million USD)

It is uncertain whether a Year 20 traffic volume of 65 million tonnes will be sufficient to justify the likely level of investment in a Chennai-Bengaluru DFC project. Although the required level of investment has not yet been established with any confidence, information provided to the consultants by the MoR suggests that a higher level of traffic might be needed to justify investment in the project. For this reason, it is essential that a comprehensive forecast, which is inclusive of potential freight volume from all sources of demand for a DFC is undertaken. As is also the case with the DFC project, consideration of the High Speed Railway should include a comprehensive demand analysis.

8.3.2.5 Urban / Public Transport

Chennai Metropolitan Area (CMA)

Chennai has four major National Highways which form a radial network, two ring roads with two more planned and several other key main roads that serve the city. There is a well established public transport system in Chennai, which consists of bus services run by the Metropolitan Transport Corporation and a suburban railway network consisting of three major lines and an elevated MRTS line run by Southern Railway with a 2-line Metro system under construction.

Due to the steady growth of Chennai's vehicle population, however, it is reported that the car volume is in excess of capacity on urban main roads. In addition, the current public transportation services lack ssufficient coverage of suburban areas, especially in the southern area where industrial investment has been promoted. Furthermore it is estimated that the 2008 figure for the total number of trips in CMA will be doubled by 2026, suggesting traffic demand will further increase significantly.

Chennai has an existing urban transport master plan, Chennai Comprehensive Transportation Study (prepared by Chennai Metropolitan Development Authority, 2010), and it proposed a strategy and projects for land use for transport, road network, and public transport. In addition to the existing strategies, there is a need for further strategies focusing on enhancement of connectivity to regions which will generate large freight traffic demand to/from ports and logistic facilities in CMA, where key gateways for CBIC are located. Based on the above condition, 14 projects in CMA have been selected, including both existing plans and new proposals. The projects include Outer Ring Road, Peripheral Road, and Northern Port Access Road to improve road network, and new route of BRT and suburban train to provide an access measure for passengers to/from industrial parks .The total project cost is 3,023 million USD under the BAU case broken up into 1,197 million USD in the short term, 1,725 million USD in the medium term, and 101 million USD in the long term.

Bengaluru Metropolitan Area (BMA)

Three National Highways pass through the centre of Bengaluru and an 62 km-long Outer Ring Road (ORR) is in place around the area. A Peripheral Ring Road is being planned outside the ORR to deal with the increased demand from further suburbanisation. Public transportation is provided mainly by a bus service at present, although a metro system, initially consisting of two lines, is under construction with a small section opened in 2011. There is also a proposal for a Commuter Railway system to be established.

Although urban roads in BMA are being developed, it is reported that due to rapid vehicle growth, traffic on some main roads already exceed the capacity. The Commuter railway is proposed to cover areas about 15 km from the urban centre; however, satellite towns have been proposed at around 30-50km from the city centre, suggesting the proposed rail network will not cover the satellite towns.

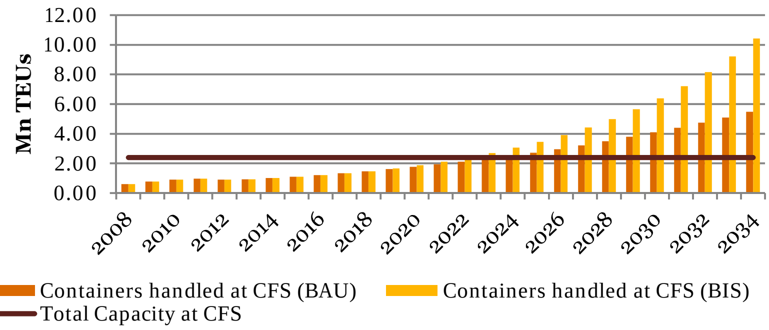
Bengaluru also formulated a transport master plan, Comprehensive Traffic and Transport Plan in Bengaluru (Karnataka Urban Infrastructure Development and Finance Corporation, 2010) and it proposed a strategy and projects including improving radial and ring roads and widening coverage of the public transport network. When considering industrial development in the CBIC area, it is also necessary to connect potential industrial areas and satellite towns around Bengaluru which contribute to economic development. Based on these strategies, 11 projects have been chosen and proposed, including both existing plans and new proposals. The projects include Peripheral Ring Road, Satellite Town Ring Road, and Expansion of NH207 to improve road network, and BRT and suburban trains to cover suburban industrial areas and satellite towns. The total project cost is 2,916 million USD under the BAU case broken down into 1,412 million USD in the short term, 1,392 million USD in the medium term, and 112 million USD in the long term.

8.3.2.6 Logistics

The major logistics infrastructure in the corridor region comprises of Container Freight Stations and the Inland Container Depots (located in and around Chennai) and one Inland Container Depot at Whitefield, Bengaluru. The modal split of the container traffic to and from Chennai Port comprises of 95% of container movement by road and only 5% by rail. At present, most of the 26 Container Freight Stations located in and around Chennai handle only around 36% of the total export container traffic movement by road to Chennai Port while the remaining container traffic comprises of factory stuffed containers.

While the present CFSs are operating at around only 45% - 50% capacity utilization the major bottleneck is present in the poor last mile connectivity to the ports. The high percentage of factory stuffed containers which do not pass through CFSs and hence take considerable time for customs clearance and documentation activities at the Port gate also add to the congestion at the Chennai port. This hinders efficient transportation of containers from the CFSs to the port. As compared to international ports where railways also have a substantial share in the transportation of containers from hinterland to the port and vice versa, the absence of last mile connectivity from the ICD to industrial centers as well as the priority accorded to passenger traffic vis-à-vis freight hampers the use of rail as a popular mode of transportation.

While cargo flow is expected to improve with anticipated last mile port connectivity, improvements to customs procedures are necessary for faster transit of cargo



Source: JICA Study Team Analysis

Figure 8.3.13: Demand and Supply of Containers Handled at CFS in CBIC Region

The last mile connectivity to Chennai, Ennore & Kattupalli ports are being improved through critical road projects (expected completion years in brackets) such as EMRIP (2015), Elevated Corridor from Maduravoyil (2018), Northern Port Access Road (2017) and NCTPS Road (2018). This, along with the expected completion of the ring roads in Chennai as noticed earlier, the last mile connectivity to Chennai, Ennore & Kattupally ports are expected to improve over the short to medium term. As per the study conducted by OCDI, the time taken for customs clearance is more than 12 hours for exports and over 38 hours for imports. Improving the efficiency of customs procedures at the ports are necessary for faster transit of cargo. It is proposed that a separate study be initiated for efficiency improvement in the customs procedures at the ports covering use of information technology solutions to enable faster movement of cargo.

Demand for container handling at logistics facilities expected to erode their capacities 2022-23

The total capacity of the infrastructure (CFSs & ICDs) in the region is 2.4 million TEUs. It is observed that the capacity is expected to be sufficient till 2022-23. Gaps in supply compared to demand are expected in 2023 under the BIS scenario and in 2024 under BAU scenario. As per the projections, the capacity required at 2034 would be 5.48 million TEUs in BAU scenario and 10.42 million TEUs in BIS scenario. Capacity augmentation should be planned for the required additional logistics facilities.

Additional logistics infrastructure are required to improve competitiveness of the region

Additional logistics infrastructure such as node-level logistics parks and large multi-modal logistics are required to improve competitiveness of the region. However, these are dependent on a variety of factors.

Firstly, the existing CFSs in around the Chennai & Ennore region are operating below their capacities by over 50% owing to connectivity issues. The efficiency and operations of the CFSs are determined by not only the infrastructure within the CFS facility, but also the connectivity within the facility and the connectivity to gateways and industrial centres. Rapid urbanization is being witnessed in most of the locations of CFSs and ICDs in the region thereby causing access and evacuation issues. In order to help improve the efficiency of the existing CFSs/ ICDs, it is recommended that a detailed analysis be undertaken to study the critical dependences and facilities at these CFSs and chalk out a plan for modernization of these facilities and improvement of last mile connectivity.

Secondly, the lead time to set up logistics infrastructure is shorter and planning for such facilities could be taken up based on the need, changing traffic patterns and the pace of shift of traffic from the Chennai / Ennore belt to Krishnapatnam belt. Development of logistics parks attached to the port in Krishnapatnam would be critical to support for faster movement of cargo from the CBIC hinterland. It is anticipated that the private sector would be able to respond to market demand and set up the required logistical infrastructure based on changing traffic patterns and need for logistics infrastructure.

Thirdly, the nodes proposed for the CBIC region should house state of the art logistics facilities to improve their competitiveness. Timely requirement of raw materials and the delivery of the finished goods is utmost important. The inclusion of the below typical facilities could be further evaluated during preparation of the master plan for the nodes.

Table 8.3.6: Typical Logistic Facilities

Facility	Description
Transport facilities	Availability of internal roads, connectivity roads and rail facilities, with inter-modal transit facilities
Information Centre	Essential for cost reduction and decision making as they provide timely and accurate information
Centres for storage, consolidation, and segregation of cargo	Availability of warehouses, cold chains & storage infrastructure and value added services like packaging, consolidation, labelling storing, etc.
Customs processing centre	Essential for processing and procuring customs clearance at the node level for direct shipment to ports / gateways
Support and Social infrastructure	Administration facility, communication facilities for the personnel, water and electricity provisions.

Lastly, large sized government planned logistics hubs may be needed, particularly with multi-modal facilities which are difficult to be developed by the private sector alone. However, a more specific Origin Destination (OD) study is necessary for development of such infrastructure which has not been undertaken at this stage. Also, such OD study should be undertaken after important projects such as the Dedicated Freight Corridor and the Bangalore Chennai Expressway are decided as these marquee projects could significantly change traffic patterns in the corridor. At this stage, three regions have broadly been identified for development of such logistics parks which include the Bengaluru outskirts, Chennai outskirts (near Sriperumbudur) and Krishnapatnam region. Development of such facilities should be undertaken outside the city limits to enable smooth last mile connectivity to the said facilities. As emphasized earlier, the planning for development of these facilities could be taken up after the alignments of the DFC and Expressway have been firmed up, backed by an OD study considering the effect of changing traffic flows in the corridor.

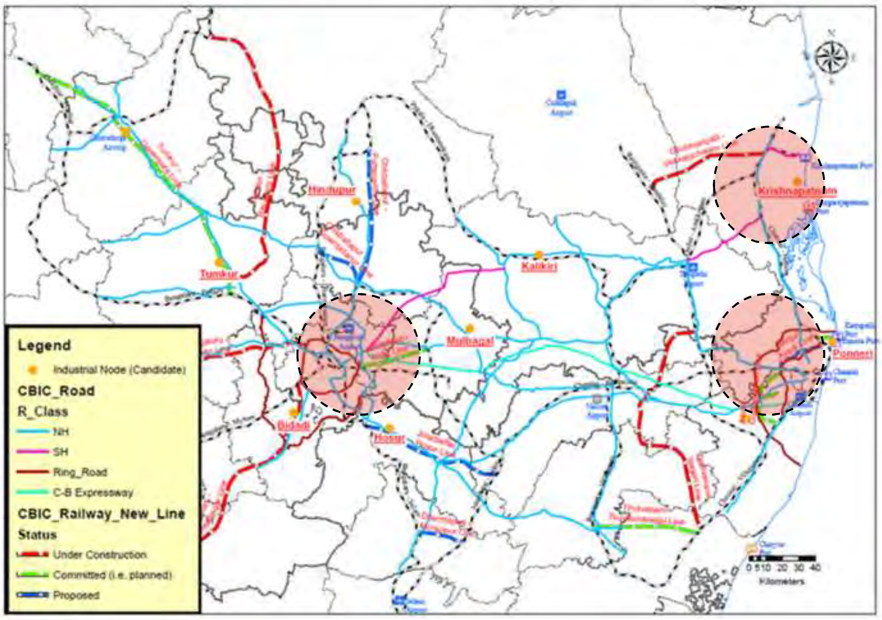


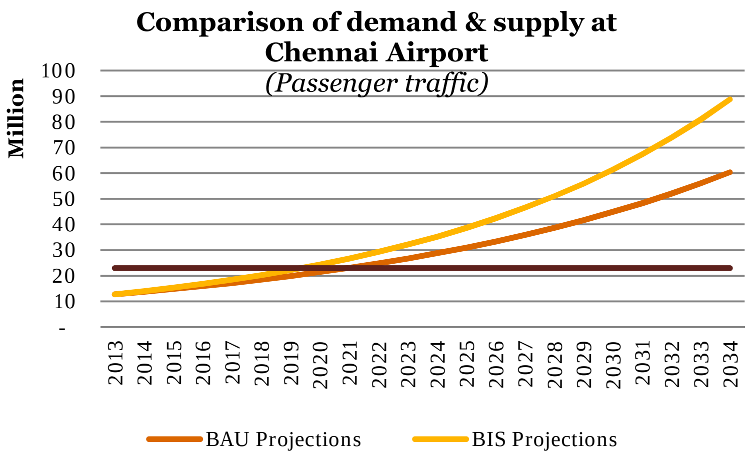
Figure 8.3.14: Three Regions for Development of Logistic Parks

8.3.2.7 Airports

Manufacturing led-growth expected to drive demand for air travel in the CBIC region

Air passenger traffic is influenced by a host of economic and social factors covering rising GDP, expanding middle-income group, increase in skilled workforce, rising urbanization, tourism and other important aviation industry related factors such as increase in low cost carriers making air travel cheaper and accessible to the rising middle & upper middle class[117]. The CBIC region is expected to increase its manufacturing output significantly; correspondingly, elements such as urbanization, migration of skilled workforce and business travel are expected to be increase significantly. The total air passenger traffic in the CBIC region (comprising of Chennai & Bangalore airports) is expected to reach 174 million passengers in the BIS case and 118 million passengers in the BAU scenario.

Additional airport in Chennai necessary as passenger demand is expected to surpass capacity in 2020-21

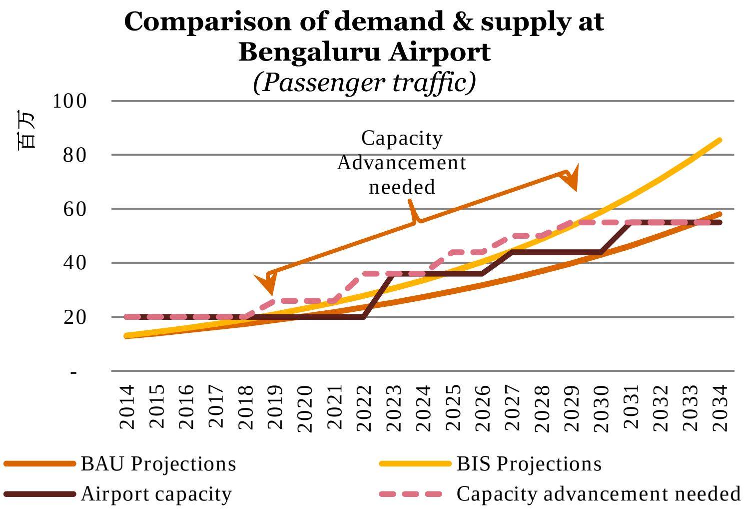


Source: JICA Study Team analysis

Figure 8.3.15: Demand and Supply at Chennai Airport

117 Report of the Working Group on Civil Aviation Sector, Ministry of Civil Aviation, 2012

The peak capacity of 23 million passengers of Chennai airport is expected to fall short of rising demand in the years 2020-21, triggering the need for an additional airport in the region. The proposed airport in Sriperumbudur at a distance of 40 kilometres from the existing Chennai airport would need to be operational by 2020-21. ***Considering a time period of 2-3 years for land acquisition and development period of 3-4 years, the efforts for creation of this airport needs to begin immediately.*** It is recommended that a separate study be commissioned at the earliest for development of the proposed airport and also determine its passenger and freight handling capacities.



Source: JICA Study Team analysis

Figure 8.3.16: Demand and Supply at Bengaluru Airport

Bengaluru airport could sustain demand in the region up to 2029-30 provided its scheduled expansion is advanced by 2-3 years

Bangaluru airport has sufficient capacity to handle the passenger demand up to 2029-30 after which the region's traffic demand surpasses 55 million in the BIS scenario. Timing issues are observed in the pattern of rise in demand compared to the airport's expansion plans. The capacity expansion may be needed earlier by 2-3 years to cater to the region and minimize demand supply gaps. Given that Bengaluru airport is a private airport guided by formal regulatory process for planning and approving its capacity expansion, it is expected that that the process would be best placed to carry out a dynamic assessment of developments and time the expansion in accordance to growing demand.

Airport at Krishnapatnam envisaged as region remains unserved by existing airports

Krishnapatnam is at a distance of 200 kilometres from Chennai airport and 134 kilometres from Tirupati airport. According to the plans of the Ministry of Civil Aviation, the annual passenger handling capacity of the airport in Tirupati is expected to be 73,000 by the end of the XII Plan. This expansion would not be sufficient to cater to the air passenger demand expected from Krishnapatnam which is one of the nodes in the CBIC region. Therefore, it is proposed that a new Greenfield airport be developed in Krishnapatnam by 2020. It is recommended that a separate study be commissioned for development of the proposed airport and also determine its passenger and freight handling capacities.

Mulbagal suitable for development of alternative airport near Bangalore over the long term

Considering the timing differences in rise in demand compared to Bangalore airport's expansion plans, the need for an additional airport could be expected in the year 2024-25. Creation of the new airport could be delayed by a 5 year period should the capacity addition at Bangalore airport happen as per the suggestions made above. However, it would be beneficial to have an additional airport by the year 2024-25 owing to growing demand in the region and reduce over-dependence on Bangalore airport to serve the hinterland.

The potential nodes in the vicinity of Bangalore (within a reach of 150 kilometres) have been shortlisted[118]. These included Mulbagal, Hosur, Bidadi, Tumkur & Hindupur. Among these nodes, the nodes where large scale developments such as the NIMZ are planned have been further shortlisted. These include Tumkur and

[118] The prevailing regulations of the Ministry of Civil Aviation prohibit development of additional Greenfield airports within a region of 150 kilometres from an existing airport. The proposed location of Sriperumbudur where an additional airport is expected to be developed to support growing demand in the Chennai region is about 40 kilometres from the existing airport in Chennai. Accordingly, it can be inferred that the Ministry of Civil Aviation regulations would not strictly apply in cases where an existing airport's capacity faces saturation triggering the need for an alternative airport.

Mulbagal. Among these locations, the Mulbagal has been chosen as it serves the maximum number of nodes within a range of 150 kilometres covering Kalikiri, Hosur, Bidadi and Hindupur). It is recommended that a separate study be commissioned for development of the proposed airport and also determine its passenger and freight handling capacities.

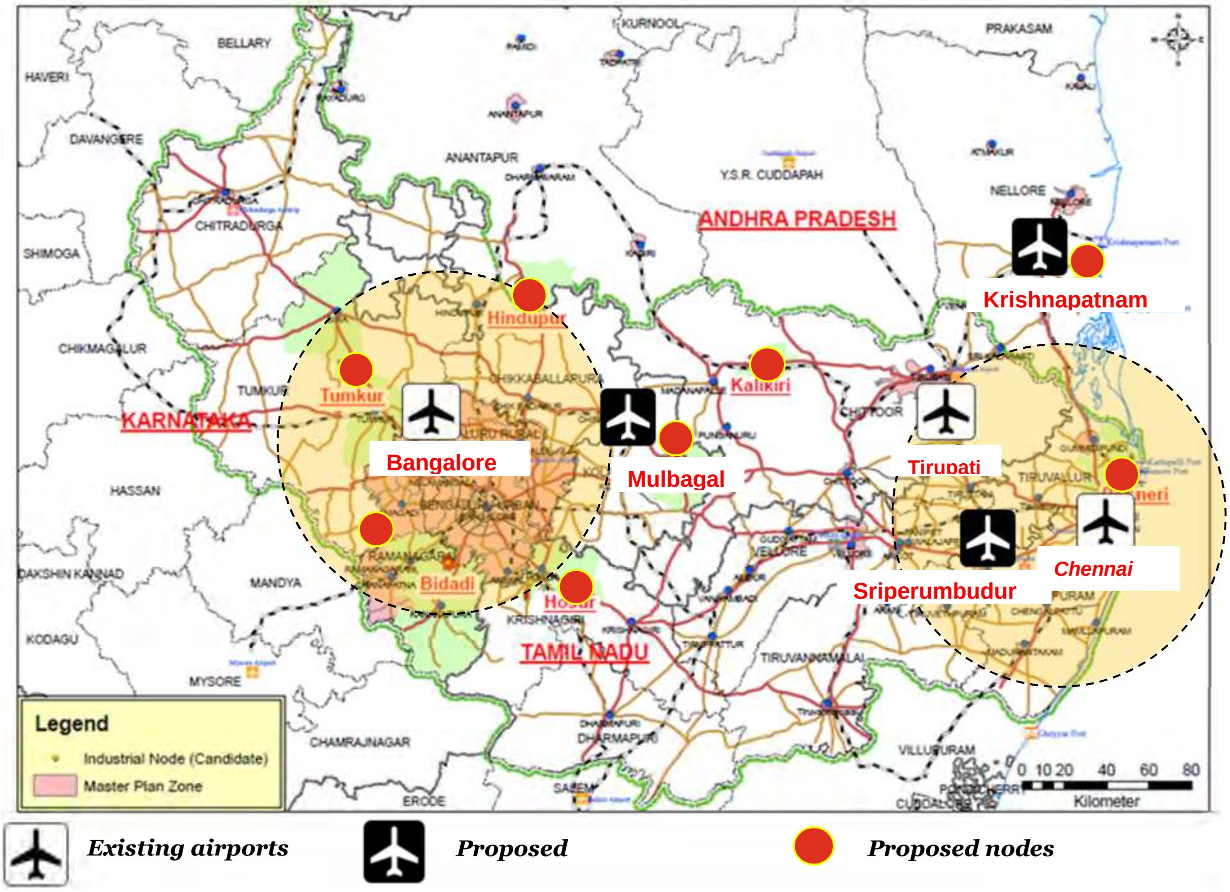
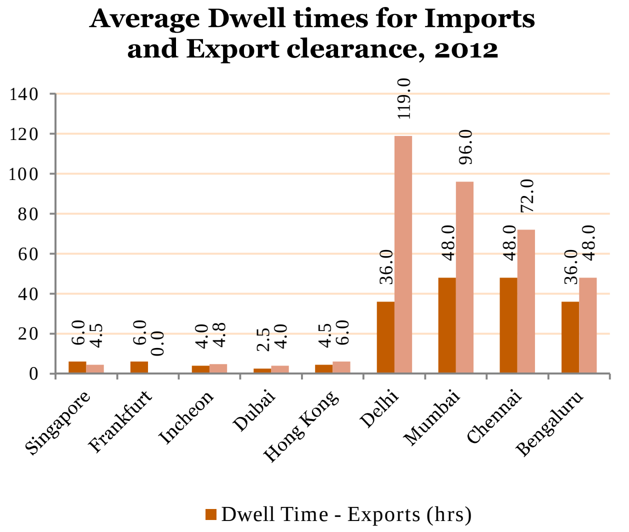


Figure 8.3.17: Existing and Proposed Airports

Airports in the corridor should target improving average handling time of cargo to international standards

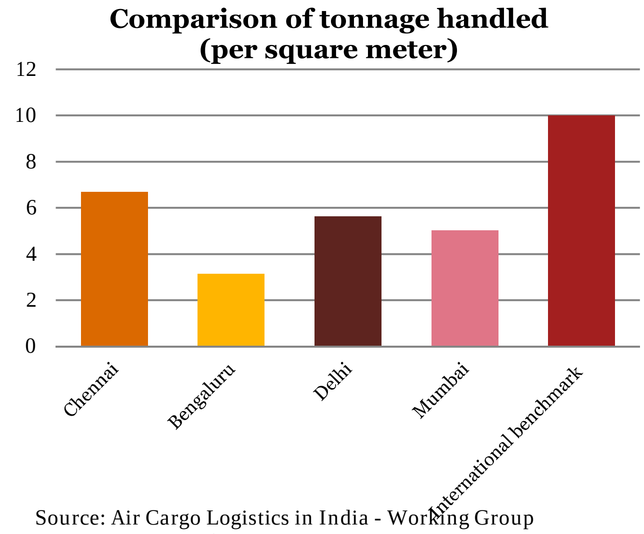
The dwell time of cargo at Chennai and Bangalore airports are significantly higher when compared to leading international airports. For instance, the dwell time of export cargo in Chennai airport is 48 hours compared to around 4.5 to 6 hours in the airports at Hong Kong, Singapore and Frankfurt. The chart below captures the dwell time of cargo at both Chennai and Bangalore airports compared to the international benchmarks.

A comparison of the average tonnage handled per square meter shows that Chennai and Bangalore handle about 6.6 and 3.14 tonnes per square meter respectively. This when compared to international benchmark of 10 tonnes per square meter is very low.



*Includes 72 hours free period both on Exports and Imports in India
(Source: *Working Group Report on Air Cargo Logistics in India*.

Figure 8.3.18: Average Dwell Times for Imports and Exports Clearance



Source: Air Cargo Logistics in India - Working Group Report, Ministry of Civil Aviation, 2012

Figure 8.3.19: Comparison of Tonnage Handled

Challenges need to be overcome for developing airport infrastructure in CBIC region:

Development of airport infrastructure requires policy-level interventions at the central level in order to incentivize investments. There is a need to attract investments in the tier 2 & 3 cities where they have existing minimal demand.

1. A comprehensive planning involving all the stake holders would develop an induced demand in these regions. A hub and spoke model can be developed in the long run with airports in metro and regional nodes around forming a hub with this network.
2. New business models can be encouraged for better private participation along with mitigation of demand risk through alternate concession models like provision of subsidies, commercialization of assets, creation of industrial hubs in the region around and development of airport cities and aerotropolis etc.
3. Measures to encourage / incentivize airline operators to fly more routes to remote locations could attract the required demand for making the non-metro airports viable.
4. Standardization of the design and specifications, functional airport infrastructure and service quality could curtail investment requirement to some extent and this capping on project cost would also help in resolving the issue of cost overrun.

Thus, while specific policy-level interventions are required to facilitate the growth of the airport infrastructure in the region, the projects aimed at efficiency improvement at existing airports should target handling of increased cargo handling and target to bring down the cargo dwell time to international benchmarks of roughly 4-6 hours. This would also entail improvement of customs procedures at the airports and management of traffic and cargo within the airports. Further the port could consider modernizing the cargo handling facility to induce a high degree of automation in order to achieve a lower dwell time of cargo. Accordingly, a separate study has been recommended to evaluate options for modernization of passenger and cargo handling facilities at Chennai and Bangalore[119] airports.

[119] The Government of Karnataka and AAI jointly own 26% of the equity stake of Bangalore airport; though majority of the stake is held by the private developer, it is recommended that the need for process improvement be emphasized by the Government of Karnataka and AAI on priority.

8.3.2.8 Town Development and Industrial Development

Urbanization

Bengaluru's urban area, which includes the Bengaluru Development Authority (BDA) area and the Bengaluru Metropolitan Region Development Authority (BMRDA) area, has the 5th biggest population in India (approximately 6 million). The city area is divided into inner and outer areas by a green belt. The city centre of Bengaluru is mixed with both residential and institutional use, similar to Chennai. Bengaluru city centre has a rich green environment including several public parks; it is called the "Garden city of India".

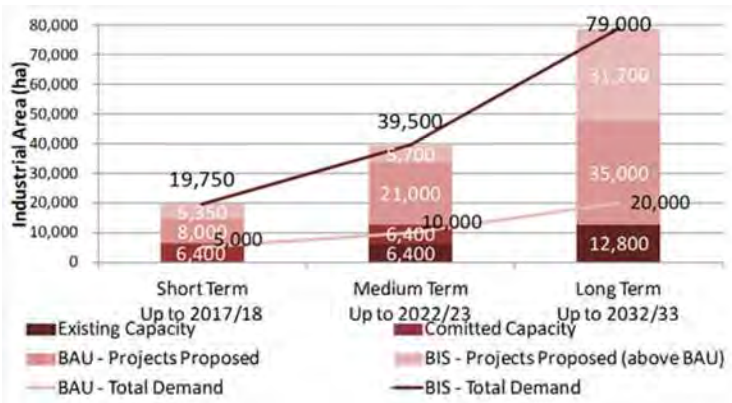
The urban areas of the CMA, the BDA and BMRDA were analysed through overlay analysis of satellite images from 2003 (based on MODIS data), 2008 (based on MODIS data) and 2013 (based on LANDSAT data). The results show that the urban area has expanded along major roads although the green belt (forests, agricultural fields and water bodies) protects some surrounding areas from the expansion.

Urbanized area as of 2013 is estimated at 1,970 sq.km. Also the increased urbanised area of CBIC was estimated at 350 sq km during the period 2003 to 2013. On the other hand, 27 million people will increase during the same term. Based on this trend, additional required urban area in 2033 will be 1,010 sq km (about 50% of current urbanized area). As total, 2,980 sq.km is required to cover the projected population. This rapid urbanization shows necessity of urban development control by urban master plans, and difficulty of finding the new lands for the development inside of metropolitan area which is already developed.

Industrial Infrastructure

The majority of the existing industrial parks in the CBIC area are situated within a 50km radius from the centres of Chennai and Bengaluru. Although some mid/small-sized industrial parks are located in other areas, there is no dense industrial zone outside of these two metropolitan cities. In the case of major industrial parks in South East Asia which have foreign capital companies as tenants, it is common to guarantee the provision of stable power supply, water supply and waste water treatment system for 24 hours a day every day. Stable infrastructure systems such as these are essential conditions for international standard industrial parks. However, infrastructure (such as water treatment plant, waste water treatment plant, power supply) at some of the existing industrial parks in CBIC area is insufficient. This creates a bottleneck for industrial development although the selling price of factory plots (Oragadam Industrial Growth Center is 32USD/sq.m and Sri City is 26 USD/sq.m, according to JETRO's data as of Sep 2013) is attractive compared to others.

According to the industry projections, the total estimated industrial land demand for the whole CBIC area is estimated to be 79,000 ha in the BIS case. And 35,000 ha will be developed by new node developments. Therefore, 44,000 ha of industrial development (2,200 ha per year) will be required in addition to node development. In BAU case, industrial land demand is projected as 20,000 ha additionally. Since the planned area of the industrial nodes is 35,000 ha, the projected land demand is covered by only the node developments. The right figure shows comparison of supply demand gap of facility's capacity in BAU and BIS cases with /without proposed projects.



Source: JICA Study Team

Figure 8.3.20:Comparison of Industrial Area Supply and Demand

It should be emphasized that currently operating foreign factories and developers for industrial parks emphasised various issues in terms of accessibility from trunk roads to industrial park, water availability, electricity availability, and accessibility to ports etc. Tamil Nadu Investment Promotion Program (TNIPP) is being carried out using JICA Yen Loan Scheme to improve such issues to promote investment. This program is mainly focusing on promotion of infrastructure developments (e.g. road development, power supply, water supply etc.). Also, a similar project for Karnataka and Andra Pradesh as well as TNIPP phase-2 should be considered and realised to create a good investment environment for foreign factories and developers.

8.3.2.9 Water Management

Current Status & Key Bottlenecks

1) At present, the ground water resources and surface water resources are utilised for a large part of domestic and industrial purposes in CBIC, however, surplus water resources are very limited. Therefore, the development of alternative water resources such as desalinated seawater and recycled sewage & industrial wastewater are necessary for additional industrial development

2) All corporations and municipalities in CBIC have piped water services and the coverage is more than 90% of population. However, the domestic water demand of CBIC is projected to increase with the future population growth; the demand in 2018 is estimated at 119% of that in 2013, the demand in 2023 is estimated to be 133% of that in 2013 and the demand in 2033 is estimated as 160% of that in 2013.

3) In CBIC, currently only two metro cities (Chennai and Bangalore) and 13 urban municipalities have sewage treatment plants (STPs). The ratio of connected population to the existing STPs is only 27%.

4) Sea Water is one of the potential water resource in the coastal areas of CBIC, especially Andhra Pradesh and Tamil Nadu States. At present, only Chennai Metropolitan Water Supply & Sewerage Board (CMWSSB) is operating desalinization plants.

5) Re-cycling of Industrial wastewater is very minimal in CBIC, most of the industries utilise the treated water for horticulture within their premises.

6) The comparison of the unit consumption of industrial water between India and Japan shows the unit water consumption of Indian industries is 3 – 7 times (5 times on average) larger than that of Japan.

Demand/Supply Gaps

1) Domestic Water

At Present, as described in Figure 5.4 and 5.5 the northeastern area of Bangalore City, including Bangalore Rural, Kolar and Chikkaballapura Districts in Karnataka State, are the most water-stressed areas in CBIC. In addition, the surrounding areas including Thiruvallur and Kancheepuruam Districts in Tamil Nadu State are water-stressed areas, which have only 50 – 70% of water supply against the water demand for drinking purpose. The water-stressed situation will become more severe in 2033 because the domestic water demand will increase with demand forecast to 160% from 2013 to 2033 due to the rapid population growth.

Source: JICA Study Team

Figure 8.3.22: District-wise demand/supply gap of domestic water in CBIC in 2013

Figure 8.3.21: District-wise demand/supply gap of domestic water in CBIC in 2033

2) Industrial Water

The present demand/supply gap of industrial water in CBIC is estimated to be approximately about 1,900 MLD and it will increase in line with the industrial development projection. Considering the district-wise industrial development trend, the demand/supply gap of industrial water will expand especially in the districts around Chennai Metro and Bangalore Metro as shown in Figure 5.6 and 5.6. The gap of Chennai District, Kancheepuram District and Bangalore Rural District will increase more than 100 MLD in 2033.

Source: JICA Study Team

Figure 8.3.23: District-wise demand/supply gap of industrial water in CBIC in 2013

Figure 8.3.24: District-wise demand/supply gap of industrial water in CBIC in 2033

3) Sewage Water

At present, only two metro cities (Chennai and Bangalore) and 13 urban municipalities have STPs in CBIC, accordingly in every district other than Chennnai District and Bangalore Urban District less than 20% of generated sewage can be treated before discharging to public water bodies.

Strategy

1) Domestic Water

In order to fill the forecast demand/supply gap and expand the water supply capacity for domestic purpose, additional water supply systems will need to be developed with on-going, planned and newly-proposed projects. This solution will contribute to meeting an approximate 80% ratio of supply/demand in 2018, 2023 and 2033. The total project cost is 2,809 million USD under BAU case. The project costs of each term are 664 million USD in short-term, 1,452 million USD in medium-term, and 693 million USD in long-term.

2) Industrial Water

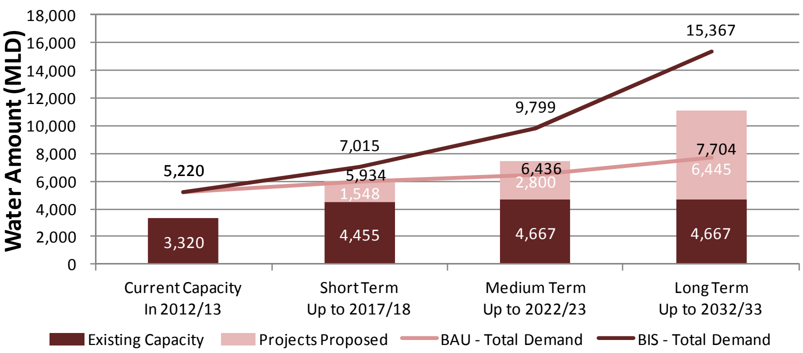
In order to fill the forecast demand/supply gap and support the expected industrial development, the following strategies are proposed.

i) Installation and expansion of sewage recycle systems with advanced treatment technologies to utilise treated sewage as alternative water resource

ii) Installation and expansion of industrial wastewater recycle systems with advanced treatment technologies to utilise treated industrial wastewater as alternative water resource

iii) Improvement of the industrial water productivity (unit consumption of industrial water) by promoting high efficient machineries and equipments in terms of water use, and capacity building of workers with Japanese technologies and investment.

These solutions will contribute to meeting a 100% ratio of



Source: JICA Study Team

Figure 8.3.25: Comparison of Industrial Water Supply and Demand

supply/demand in 2018 for the industrial development in the BAU case. The total project cost of the on-going, provisionally-planned and newly-proposed projects is 6,177 USD under BAU case. The project costs of each term are 3,244 million USD in short-term, 1,590 million USD in medium-term, and 1,343 million USD in long-term under BAU case. The right figure shows comparison of industrial water supply demand gap in BAU and BIS cases.

3) Sewage Water

In order to fill the forecast demand/supply gap and expand the sewage treatment capacity, the additional sewage treatment systems will be developed with on-going, planned and newly-proposed projects. This solution will contribute the ratio of supply/demand to meet 40% in 2018, 50% in 2023 and 65% in 2033. The total project cost is 3,829 million USD under BAU case. The project costs of each term are 593 million USD in short-term, 1,730 million USD in medium-term, and 1,506 million USD in long-term under BAU case.

Contribution of Each Solution

The expected contribution of each solution are presented as the improvement of demand/supply gap, which is summarized below.

Table 8.3.7: Improvements of Demand Supply Gap

Solution	Contribution of each solution (Effect on demand/supply gap)					
	Entire CBIC	**TN State**	**KA State**	**AP State**	**Chennai Metro. Area**	**Bangalore Metro. Area**
1) Domestic Water Expansion of domestic water supply system	56%→83%	47%→69%	63%→94%	62%→92%	43%→79%	63%→66%
2) Industrial Water Installation and expansion of sewage recycle system	19%→40%	14%→78%	20%→30%	19%→401%	14%→68%	20%→30%
Installation and expansion of industrial wastewater recycle system	40%→63%	78%→106%	30%→53%	401%→433%	68%→98%	30%→53%
Improvement of the industrial water productivity	63%→144%	106%→234%	53%→121%	433%→916%	98%→215%	53%→123%
3) Sewage Development of sewage treatment system	24%→65%	22%→79%	31%→55%	3%→55%	29%→87%	35%→55%

Source: JICA Study Team

8.3.2.10 Energy

Current power scenario

"As-is" energy scenario

In FY 2013-14, CBIC states of Andhra Pradesh, Karnataka and Tamil Nadu faced approx. 7% energy gap (18,000 MUs/annum). 71% of the total energy in the region is generated using thermal sources. In terms of equivalent coal capacity, average gap in the region was around 2.2 GW+. The scenario has improved from FY 2012-13 where the gap was more than 17% for the region*mainly due to rationalization of demand (5% decrease) *and moderate increase in supply (8% increase)* over the year. In the short term, the present gap of 7% is expected to continue for coming 1-2 years.

Impact on Industries

Due to wide energy gap, Industries in the region have been affected by unpredictable outages in grid electricity supply leading to use of costlier diesel based back up capacities. High energy gap along with pending regulatory assets of the state utilities have lead to tariff revisions of 8-10% # over the past 2-3 years in the region. This can affect the energy costs for industries and commercial organizations. In order to balance energy gap, Brown outs ("Voltage Drops") have been used for load reduction by utilities. These sudden drops in voltages can further affect the sensitive equipments at consumer end.

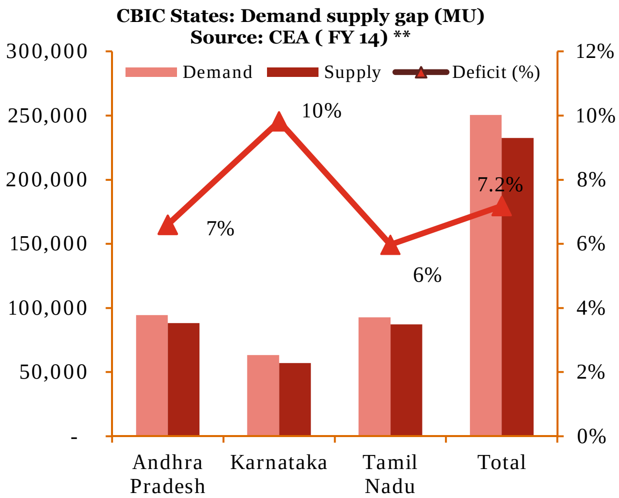


Figure 8.3.26: Generation Mix (MU), CBIC States

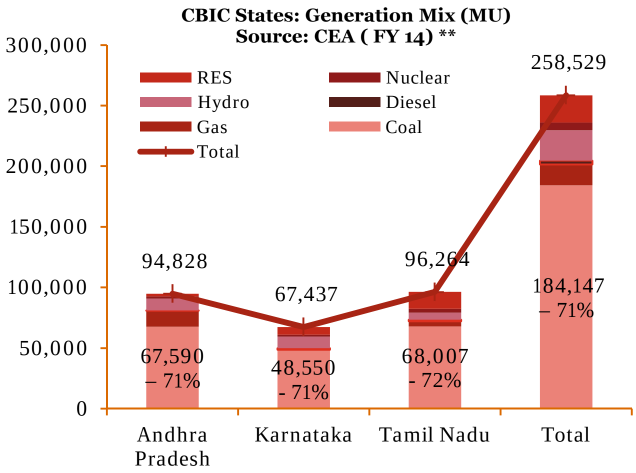


Figure 8.3.27: Demand Supply Gap (MU), CBIC States

Short term power scenario

Expected scenario by FY 18

By FY 2017-18, demand (inclusive of CBIC scenario) is expected to be met by upcoming scheduled power supply. Out of CBIC states, Karnataka is expected to remain power deficit with 5% energy gap but overall region can be expected to be more than 18% power surplus in case scheduled supply gets commissioned in time. In terms of fuel mix, thermal based capacity is expected to dominate with more than 70% share in energy generation. Hydro contributes second to the energy generation in Andhra Pradesh and Karnataka. But in Tamil Nadu, Renewable and Nuclear contribute second in energy generation after coal.

Although the region is expected to be power surplus by FY 18, but unrestricted demand is expected to contribute to usage of excess energy in the region. According to CEA (LGBR Report, 2013-14), the unrestricted demand in the southern region of the country will exceed 25% of the total requirement by FY 2018. By PwC estimates, all of the spare capacity will meet unmet latent demand in the southern region. Karnataka would need to import close to 495 MW of equivalent thermal capacity from outside sources to meet demand.

Impact on CBIC Region:

With easing demand supply gap in the region, quality of power for CBIC region is expected to improve. Also utility tariff rationalization can be expected to diminish energy cost impact on industries.

Table 8.3.8: Commissioning Status of upcoming Plants

State (FY 2018)	Demand (MW)*	Supply (MW)*	Gap (MW)*
Andhra Pradesh	15,526	20,113	+ 4,587
Karnataka	11,793	11,298	(495)
Tamil Nadu	15,198	19,268	4,070
Total	**42,518**	**50,680**	**8,162**

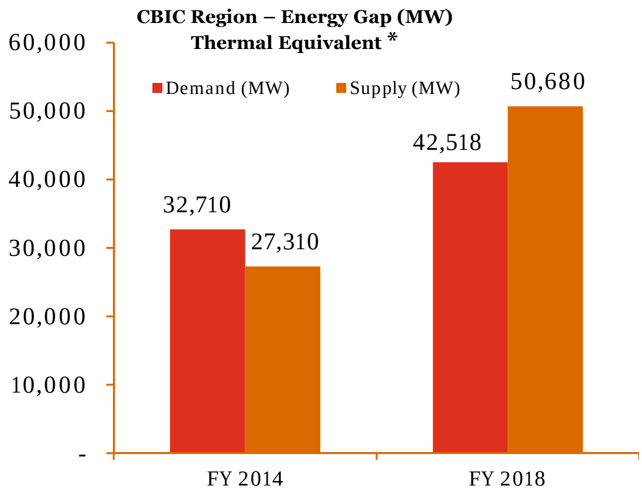


Figure 8.3.28: Expected Short Term Gap, CBIC Region

Expected plant commissioning before FY 18

Timely commissioning of upcoming projects is critical to ensure adequate supply for CBIC region in short term. In order to achieve "nil" energy gap in FY 18, supply would have to increase by 15,000 MW (Equivalent Thermal) over FY 14 base. Out of the total 21,000 MW under implementation in CBIC states, 2000 MW (Equivalent Thermal) Gas, 1000 MW Nuclear (Equivalent Thermal) and 2300 MW of Thermal Capacity would be tough to achieve before FY 17. This might create a shortfall of 5300 MW out of 21,000 MW planned by agencies. However, these supply numbers would still be 700 MW above the estimated peak demand in the region. Hence, in short term demand is expected to be met by scheduled supply.

Medium term power scenario

In medium term additional capacities of 13, 000 MW (Eq. Thermal) would be needed to fulfil CBIC's regional energy demand

Expected scenario by FY 2022

In medium term the demand in CBIC region is expected to reach close to 64,000 MW (equivalent thermal capacity). Based on present supply expectations in FY 2018, a gap of 13,000 MW (thermal equivalent) is expected in medium term (25% of present supply). As a matter of approach, supply priority has been provided to cleaner fuels in planning of generation for the region. Next priority has been provided to base load capacities like Hydro and nuclear. The remaining is expected to be filled in by thermal capacity.

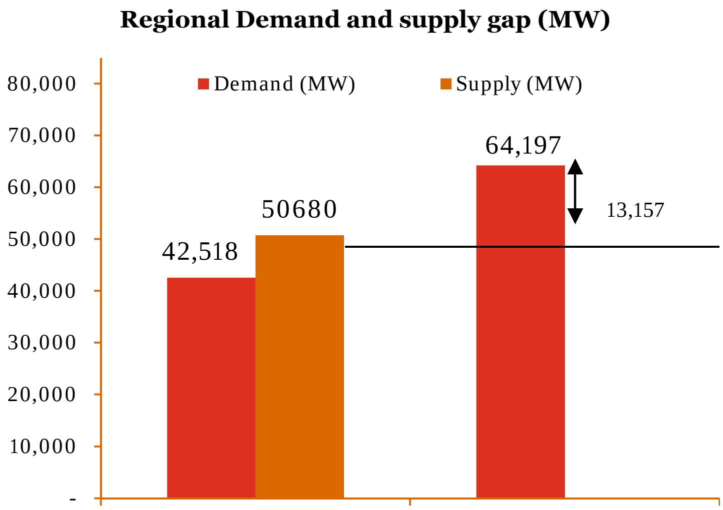


Figure 8.3.29: Expected Medium Term Gap, CBIC Region

Source wise capacity addition in medium term

In terms of equivalent coal capacity, RES is expected to meet 17% of the gap (2354 MW). Hydro and nuclear together fill 25% of the energy gap in FY 2022.Gas based capacities in addition to spinning reserves are not expected to add significantly to new capacity additions. However with Dabhol pipeline and KG 6 basin issues resolving by FY 2018, stranded assets are expected to add 1400 MW (Eq. Coal) to region. In total additional thermal based capacity needed in FY 2022 is expected to be around 6500 MW. Coal requirement for this capacity would be close to 3.41 MT/annum for the region.

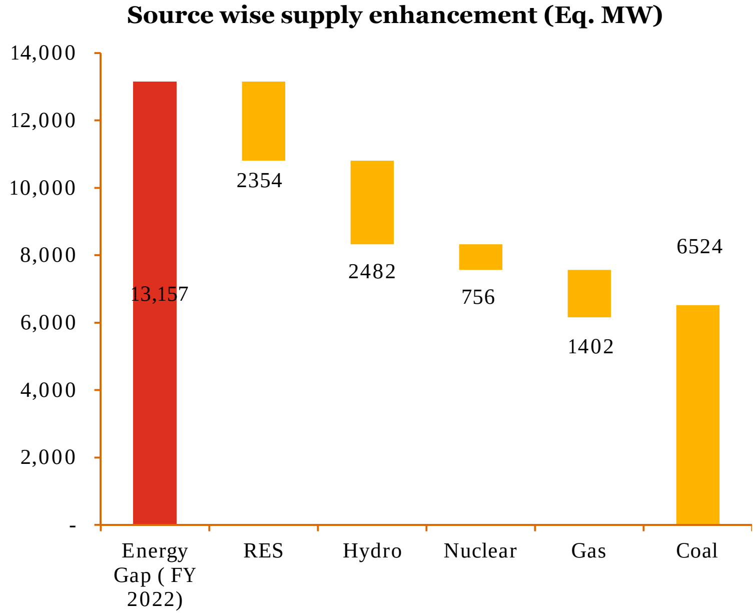


Figure 8.3.30: Source Wise Capacity Enhancement, CBIC

In medium term, renewable (wind and solar) are expected to increase in capacity in CBIC states. Wind with expected 16,000 MW would form major contributor in meeting increased demand. Overall renewable additions would be done at state level through attractive FiTs / project incentives. Hydro is also expected to increase by almost 50% in term of commissioned capacities in coming 7-8 years. In terms of potential the states can be expected to tap almost 50% of hydro potential in the region. Hydro additions would also be done at state level through central agencies or PPP in Hydro. Nuclear energy for the region (Kudankulam nuclear plant) is expected to add 2000 MW to grid by FY 2022. This has been planned centrally through NPCIL. Gas based capacities. Presently the region has a lot of stranded gas capacities due to lack of natural gas (4000 MW). But in coming 2-3 years with Dhabol gas pipeline (3000 MW capacity gas/year) and resolution to KG-6 basin, natural gas would be available for gas capacities to develop in the region. On the other had there is issues of gas pricing which makes it a clean but expensive fuel. We therefore do not foresee significant capacity addition in gas based generation. Rest of the capacity (6650 MW) will be filled by thermal sources. TN UMPP (4000 MW) is expected to play a major role in fulfilling the gap. State (State Gencos.) as well as central (NTPC) would be needed for this addition.

Table 8.3.9: Source and responsibility wise breakup of meeting demand for CBIC region in medium term, FY 2022

Fuel source (MW)	Potential	Short-term 2017	Mid-term 2022	Responsibility for additional capacity
Wind	26,029	9,880	16,387	
Solar	118,000	108	3,300	
Biomass	3,124	1,417	1,771	
Small Hydro	2,926	1,356	1,695	
Waste to Heat	425	50	250	
RES Total	150,504	12,811	23,404	STATE
% of potential		9%	16%	
Hydro	30,980	9,927	14,891	STATE
% of potential		32%	48%	
Nuclear	20,000	3,055	4,055	CENTRAL
% of potential		10%	13%	
Gas	45,000	4,396	7,200	STATE
% of potential		10%	16%	
Coal - Balance		-	6,650	MIX

Long Term power scenario

In long term, 83,000 MW of additional capacity needed for CBIC region is expected to be met majorly by thermal sources

In long term with demand expected to reach close to 147,000 MW for CBIC region, an additional capacity of 83,000 MW over FY 2022 would be needed for fulfilling demand.RES and Hydro sources are tapped first with aim of meeting the additional gap (5,226 MW Eq. Thermal Capacity). Nuclear comes next as it is a base load source and is cheaper source of generation in long term (3,400 MW Eq. Thermal Capacity). Gas based capacities would provide another 1,400 MW Eq. Thermal capacity by FY 2032. Rest of the demand will be met through thermal sources for the region. (73,000 MW – 87% of gap)

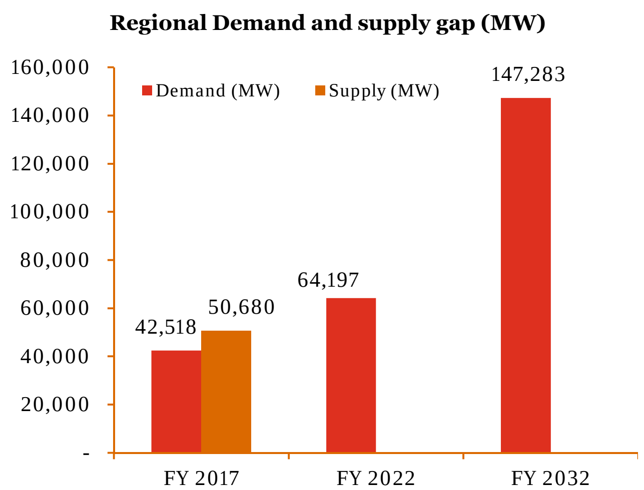


Figure 8.3.31: Expected Long Term Gap, CBIC Region

Table 8.3.10 : Source and responsibility wise breakup of meeting demand for CBIC region in long term, FY 2032

Fuel source (MW)	Potential	Mid-term 2022	Long-term 2032	Agency for capacity addition
Wind	26,029	16,387	20,484	
Solar	118,000	3,300	5,000	
Biomass	3,124	1,771	2,214	
Small Hydro	2,926	1,695	2,119	
Waste to Heat	425	250	350	
RES Total	150,504	23,404	30,167	STATE
% of potential		16%	20%	
Hydro	30,980	14,891	22,336	STATE
% of potential		48%	72%	
Nuclear	20,000	4,055	8,555	CENTRAL
% of potential		13%	28%	
Gas	45,000	7,200	10,000	STATE
% of potential		16%	22%	
Coal - Balance		**6,650**	**73,598**	**MIX**

Critical support factors: Transmission and Distribution

Transmission: Key aspects for CBIC region

Transmission plays a key role in ensuring dispatch of energy from the generation plant. A transmission line dispatching energy from a generation plant needs to be available at least 6 months before the plant is commissioned to avoid stranded capacity. Also, renewable sources need special attention due to daily variations in grid connected energy. In short term transmission projects have already been notified for upcoming generation plants in CBIC region. These projects ensure evacuation of power from the plants.

In medium term, with almost 13,000 MW of additional capacity expected to be commissioned (spread across 17% renewable and 83% conventional sources), need for strengthening of transmission network exists. Typically transmission projects can be handled both by state (Transcos.) as well as central agencies (PGCIL). In this case a mix of two would need to be utilized. Implementation of green corridor (Central scheme) would assist adequate interlinking facilities for RES. State schemes for intra state transmission would ensure last mile connectivity for generation plants. Similar would be the case for long term (83,000 MW of additional capacity - 7% renewable and 93% conventional)

In terms of investments, the ratio of generation and transmission investments for a particular project can be taken to be 1.0:0.4. Taking this measure total investments required for transmission projects would be close to 24, 068 Mn. USD over next 10-15 years in CBIC region.

Distribution: Key aspects for CBIC region

Distribution is a state specific activity and provides last mile connectivity from transmission to consumers end. The key features would be based on reliability and quality of power. Unlike generation and transmission, distribution development would not be project specific. In order to optimally and efficiently plan the development of the distribution network, the maximum generation demand for the projections period (i.e. from 2015 to 2034) has been taken

Some issues that would need handling would be high distribution losses, reliability of the system, and shortage of skilled professionals along with weak financial position of CBIC states distribution utilities. All these factors would need to be looked into before any strategy for CBIC region is finalized. Key measures like allowance of deemed distribution licensee for whole/ key parts of CBIC region can bring in new private sector participation Also technologically superior distribution systems in the form of smart cities and smart girds can also increase the quality of energy at consumers end, increase efficiency and enhance consumer satisfaction. Both these measures are state specific in nature.

In terms of investments, typically a ratio of 1:0.2 (Generation: Distribution) is used for Indian conditions. Considering the green field nature of new technologies being proposed this ratio can safely be revised to 1:0.3. Taking these measure total investments would be close to 12,000 Mn. USD over the next 10—15 years in CBIC region.

8.3.2.11 Solid Waste Management

The status of existing waste treatment and disposal facilities and planned infrastructure projects in the three states covered by the study are summarised below.

Table 8.3.11 : Exsiting and Planed Solid Waste Managment Infrastructures

States		Existing Infrastructures	Planed Infrastructures
Andhra Pradesh		• There are two TSDFs with common incinerators in Rangareddy and Visakhapatnam District.	• There are no future plans in Andhra Pradesh
Karnataka		• There is also only one TSDF and five common incinerators in Bengaluru, Tumkur and Ramanagara District.	• Another site was proposed for a TSDF, but it has not been realized yet.
	Bengaluru Metropolitan Area	• Hazardous waste generated in Bengaluru Metropolitan Area is treated in these facilities. • TSDF is located in Bengaluru Rural District. In addition, four common incinerators are located in the metropolitan area (Bengaluru Urban District: Two incinerators, Bengaluru Rural District: one incinerator, Ramanagara District: one incinerator).	
Tamil Nadu		• There is only one TSDF and one common incinerator in Tiruvalluru District.	• For other two proposed sites, public hearings are being conducted. AFR pre-processing facilities will be constructed after year 2015.
	Chennai Metropolitan Area	• Hazardous waste generated in Chennai Metropolitan Area is treated in these facilities.	

Note:
- TSDF: Treatment, Storage and Disposal Facility
- AFR: Alternative Fuels & Raw materials pre-processing facility

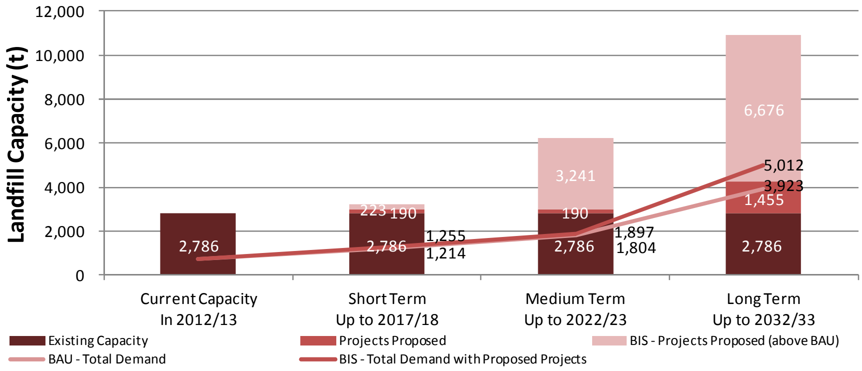
Source: Arranged by JICA Study Team based on the information collected from the state governments

The landfill capacity is insufficient compared to the amount of waste generated, creating the first gap (referred to as "Gap 1"), in all three states. However, the actual amount of hazardous waste disposed at the landfill is less than the landfill capacity, creating the second gap (referred to as "Gap 2"). Gap 1 indicates the lack of TSDFs and Gap 2 indicates that waste is temporarily stored within each factory area. Governments have promoted the development of hazardous waste treatment facilities to improve the current environmental situation. However, governments have been unable to provide sufficient treatment facilities in their states due to "Not In My Back Yard (NIMBY)" problems.

The future amount of hazardous waste generation of each waste type (landfillable, incinerable, and recycled) was calculated in BIS case. In Tamil Nadu the amount of incinerable hazardous waste will exceed the incineration capacity from year 2022, and the amount of landfillable hazardous waste will exceed the landfillable capacity from year 2029. In Karnataka, the landfillable capacity will be saturated from year 2022, and the incineration capacity does not meet even current demand as well as future demand. Since CBIC area in Andhra Pradesh does not have the facilities, there will be a supply volume gap.

In order to meet the future demand, new landfill and incineration facilities are necessary. In addition, since reduction of waste generation is also important, new AFR pre-processing facilities, which make it possible to reduce amount of waste by recycling, are required. Those facilities should be located in new industrial areas due to lower transportation cost and fewer issues related to land acquisition.

The total project cost is 206.3 million USD under the BIS case. The project costs of each term are 95.7 million USD in short-term, 50.5 million USD in medium-term, and 60.1 million USD in long-term under BIS case. The following figure shows a comparison of the supply-demand gap in BAU and BIS cases with /without proposed projects.



Source: JICA Study Team

Figure 8.3.32 Comparison of Landfill Supply and Demand

8.4 Phasing Plan

Based on the analyses of the above Chapters, the node and industry development plan, infrastructure development plan are proposed. The structure of overall phasing plan is summarized below. The implementation stage of CBIC development is divided to three phases: short-term (2014-18); medium term (2019-23); and long term (2024-3033).

In the short term, urgent needs of existing industries to improve hard and soft infrastructure will be focused. Hard and soft infrastructure development for the improvement of regional connectivity will contribute further node development to be implemented in the medium and long term. To increase investments, achieve the corridor's vision and overcome the current bottlenecks in the corridor it would be essential to focus on implementation and planning of the short and medium term projects that are planned and also those that have been proposed.

The summary of infrastructure investment is noted below and the detail project list is attached in the annex.

8.4.1 *Investments required for infrastructure development*

Investments required by phase

To meet the enormous economic growth and infrastructure development planned in the Corridor region, a total funding of around USD 174 bn shall be required over the next 20 years to meet the development goals of CBIC under BIS. These investments shall be distributed among various sectors including industrial infrastructure, logistics, ports, airports, energy, railways, roads, solid waste management, urban transport, water etc. Over the short term (i.e. upto 2018) around USD 44 bn investments in infrastructure shall be needed and the same amount of investments shall be required from the short to medium term (2018-2023) as well. Over the long term (2023-2033) around USD 87 bn shall be required to finance the infrastructure development requirements in the region.

The table below depicts the investments required over the short, medium and long term divided across various infrastructure sectors:

Table 8.4.1: Invetsments by Sector

Investments by sector (USD mn)	Short Term (up to 2018)	Medium Term (2018-23)	Long Term (2023-33)	Total
Transport	***5,357***	***10,912***	***15,938***	***32,208***
Airports	287	3,236	777	4,299
Ports	1,193	2,295	3,600	7,088
Railway	1,344	716	9,506	11,566
Roads	2,433	2,087	1,843	6,363
Logistics	-	196	-	196
Urban Transport	100	2,383	213	2,696
Energy	***25,051***	***17,270***	***66,968***	***109,289***
Utilities	***5,574***	***3,861***	***3,603***	***13,038***
Solid Waste Management	120	26	60	206
Water	5,454	3,835	3,542	12,831
Industrial infrastructure	***8,206***	***11,667***	***70***	***19,943***
Grand Total	**44,188**	**43,710**	**86,579**	**174,477**

The requirement of the investment amounts depicted in the table above shall be based on the time of actual project need and hence may be required earlier in case the project timeline is advanced to an earlier stage. Also, the investments required over the long term reflect the BIS outcome expectations and may require calibration based on the regional economic development patterns. As visible from the table above, the majority of the investments (more than USD 100 bn) are required for development of energy infrastructure in the region to meet the growing energy requirements of the region and to ensure good quality and regular supply of power to the industries in the region. Transport (especially trunk infrastructure and gateway development) is the second area where significant investments (around USD 32 bn) shall be required to ensure seamless connectivity within the corridor and to the gateways. At the same time, significant investments shall also be needed for the development of industrial infrastructure and utilities in the region.

Short-term investment requirement

Over the short-term (i.e. upto 2018) maximum investments in infrastructure development shall be required by the state of Andhra Pradesh followed by Tamil Nadu. Around 46% (i.e. around USD 20 bn) of the total investments required for infrastructure development in the corridor shall be required by the state of Andhra Pradesh with around 75% of demand for these investment requirements arising from the planned energy infrastructure creation. Government of Tamil Nadu shall require to attract around 25% of the total investments needed for infrastructure development in the region with more than 50% of these investments (around USD 5 bn) required for development of energy infrastructure only. The remaining around 15% and 14% investments shall be required for projects planned to be developed or the projects required by the state of Karnataka and the Central government respectively. Of the total investments of around USD 6 bn required for Karnataka, around 52% of these investments shall be needed for industrial infrastructure development and another 32% shall be required for utilities. Karnataka shall not require additional investments in the development of energy infrastructure over the short term as shown in the table below:

Table 8.4.2: Investments by Sector over the Short Term

Investments by sector over the short term (USD mn)	GoTN	GoK	GoAP	Central	Total
Transport	***389***	***1,036***	***1,223***	***2,709***	***5,357***
Airports	-	287	-	-	287
Ports	-	-	-	1,193	1,193
Railway	-	-	-	1,344	1,344
Roads	339	700	1,223	172	2,433
Logistics	-	-	-	-	-
Urban Transport	50	50	-	-	100
Energy	***5,946***	***-***	***15,772***	***3,333***	***25,051***
Utilities	***2,332***	***2,048***	***1,194***	***-***	***5,574***
Solid Waste Management	-	111	9	-	120
Water	2,332	1,937	1,185	-	5,454
Industrial infrastructure	***2,538***	***3,361***	***2,307***	***-***	***8,206***
Grand Total	**11,205**	**6,446**	**20,496**	**6,042**	**44,188**

Medium-term investment requirement for infrastructure development

Around USD 44 bn investments shall be required for infrastructure development over the medium term for the entire corridor region. The table below shows the approximate value of investments needed for infrastructure development over the medium term (2018-2023).

Table 8.4.3: Investments by Sector over the Medium Term

Investments by sector over the medium term (USD mn)	GoTN	GoK	GoAP	Central	TBD	Total
Transport	***3,377***	***1,180***	***2,432***	***3,772***	***150***	***10,912***
Airports	-	287	-	2,949	-	3,236
Ports	-	-	2,250	45	-	2,295
Railway	-	-	-	716	-	716
Roads	1,606	236	182	62	-	2,087
Logistics	46	-	-	-	150	196
Urban Transport	1,725	658	-	-	-	2,383
Energy	***-***	***-***	***-***	***-***	***17,270***	***17,270***
Utilities	***2,241***	***1,609***	***11***	***-***	***-***	***3,861***
Solid Waste Management	26	-	-	-	-	26
Water	2,215	1,609	11	-	-	3,835
Industrial infrastructure	***3,268***	***4,974***	***3,425***	***-***	***-***	***11,667***
Grand Total	**8,887**	**7,763**	**5,868**	**3,772**	**17,420**	**43,710**

Over the medium term, the state of Tamil Nadu shall require the maximum amount of investments for infrastructure development while another USD 17 bn is required to be allocated to the agency responsible for development of energy infrastructure in the region. At present, while the overall state-level energy requirement over the medium term has been estimated, the exact geographical location of the energy infrastructure projects is difficult to determine. The investments required for energy infrastructure represent the investments needed for energy infrastructure development for the entire states of Tamil Nadu, Andhra Pradesh and Karnataka. The exact geographical location of the energy infrastructure projects may be determined only at a later stage.

Investments for industrial infrastructure and transportation infrastructure development in the region shall account for around 27% and 25%, respectively. GoAP shall require investments of around USD 2.2 bn for development of port infrastructure in the state while the central government shall require around USD 2.9 bn investments for airport infrastructure development in the corridor region.

During the time period 2018-2023, around 20% of the total investment requirement demand shall be generated by the State of Tamil Nadu followed by around 18% of the total investment demand from the state of Karnataka. Government of Andhra Pradesh shall require around 13% of the total investments projected over the medium term while only 9% shall be required for central government projects. Another 40% of the total investment amount for infrastructure development is yet to be allocated to specific states / agencies.

Long-term investment requirement for infrastructure development

The table below depicts the investments required for infrastructure development over the long term (2023-2033) in the corridor region.

Table 8.4.4: Investments by Sector over the Long Term

Investments by sector over the long term (USD mn)	GoTN	GoK	GoAP	Central	TBD	Total
Transport	***1,192***	***499***	***574***	***13,673***	***-***	***15,938***
Airports	-	287	-	490	-	777
Ports	-	-	-	3,600	-	3,600
Railway	-	-	-	9,506	-	9,506
Roads	1,091	101	574	77	-	1,843
Logistics	-	-	-	-	-	-
Urban Transport	101	112	-	-	-	213
Energy	***-***	***-***	***-***	***-***	***66,968***	***66,968***
Utilities	***1,615***	***965***	***1,022***	***-***	***-***	***3,603***
Solid Waste Management	60	-	-	-	-	60
Water	1,555	965	1,022	-	-	3,542
Industrial infrastructure	***67***	***2***	***1***	***-***	***-***	***70***
Grand Total	**2,874**	**1,467**	**1,597**	**13,673**	**66,968**	**86,579**

While the investment requirement for energy infrastructure in the region (around USD 6 bn) is yet to be allocated to the concerned agencies. At present, while the overall state-level energy requirement over the long term has been estimated, the exact geographical location of the energy infrastructure projects is difficult to determine. The investments required for energy infrastructure represent the investments needed for energy infrastructure development for the entire states of Tamil Nadu, Andhra Pradesh and Karnataka. The geographical location of the energy infrastructure projects may be determined only at a later stage.

The transport infrastructure development shall require close to USD 14 bn funding mainly for the development of ports and railway network in the region. Additionally the need for investments in development of water infrastructure shall also reach around USD 3.5 bn by 2033.

Summary of investment requirement by Implementing Agengy:

The table below shows the infrastructure investments requirement as per the respective agencies:

Table 8.4.5: Summary of Investments Required by Implementing Agency (amount)

Investments in USD mn	Short term	Medium Term	Long Term	Total
GoTN	11,205	8,887	2,874	22,965
GoK	6,446	7,763	1,467	15,676
GoAP	20,496	5,868	1,597	27,961
Central	6,042	3,772	13,673	23,487
Unallocated *	-	17,420	66,968	84,388
Total	**44,188**	**43,710**	**86,579**	**174,477**

*Primarily energy

Out of the allocated / identified investments, the maximum investments for infrastructure development shall be required for the state of Andhra Pradesh (around 16% of total investments) over the short, medium and long term followed by the state of Tamil Nadu (13%), the investments required for central government infrastructure projects (14%) and the state of Karnataka (9%). At present around 48% of the total infrastructure investment requirement in the region cannot be allocated. This is mainly related to the investments needed for energy infrastructure development over the medium and long term in the CBIC region.

Table 8.4.6: Summary of Investments Required by Implementing Agency (%)

Total investments by stakeholders	Short term	Medium Term	Long Term	Total
GoTN	25%	20%	3%	13%
GoK	15%	18%	2%	9%
GoAP	46%	13%	2%	16%
Central	14%	9%	16%	13%
Unallocated *	0%	40%	77%	48%
Total	**100%**	**100%**	**100%**	**100%**

*Primarily energy

As visible from the table above, around 46% of the total infrastructure investment demand is likely to emanate from Andhra Pradesh while 25% of the overall investment requirement over the short term shall arise from Tamil Nadu. Over the medium term, Tamil Nadu shall lead the need for infrastructure investments in the region followed by Karnataka and Andhra Pradesh for the identified / allocated projects. Over the long term, the central government projects shall require maximum investments, around 16%, of the total investments requirements identified till date for infrastructure development in the region while around 77% of the total investment demand remains unallocated for the long term.

8.5 Policy Recommendation on Improvement of Soft Issues

As indicated in the previous chapters, despite the significant potential of the region, investors and industry players show concerns on current and future investment environment. There are various actions which are recommended by investors and industry players in order to make CBIC as a preferred destination of their investment. They can be categorized into two types due to the level of the issues and commonalities of the actions: actions need to be taken by state government, and actions need to be taken by the central government (or CBIC unit positioned at the central level). This section summarizes the latter. It is recommended to set up a necessary program to consider the detail action plans on soft issues in the next phase.

8.5.1 *Improvement of Investment Environment*

8.5.1.1 Policy support

To Provide mid- long term policy guidance for private sector

Many of the private sectors suffer from the unexpected change in the policy from the government. Especially when the leading party changes where the company invested, the incentive programme or subsidy committed by the previous authority can be altered or even cancelled, that it affects the business feasibility of the private sector. Such anxiety has become hurdle for the company to make investment on their own risk.

It is strongly recommended that the central government be involved in the discussion on the key policy that affects the private sector's business decision, and provide a certain level of necessary commitment from the central government to keep the promise to the private sector and to promote private investments and FDI even if the political party changes take place at the state level. Such commitment is expected to provide confidence to the private sector, and is to encourage them to conduct a large scale investment from their own budget.

<u>Implementing Agency:</u> DIPP, MOF, Ministries in charge of each sector

To Establish infrastructure to support IPR

The number of the patent application has increased rapidly over the 10 years, and the number of those received by the authority has reached over 40,000, four times more than that of 10 years back. The number has already reached the 8th largest in the world, following Germany and Russia, and is expected to increase more.

However, despite such sharp increase in the interest, many investors and industry players show their strong concern over the insufficient understanding of the patent system in India. Some of the reason is attributed to the lack of knowledge from investor sides, but some parts are argued that the government needs to take proactive actions if the Government of India requests manufacturing industry to shift from other countries in India, which are considered most patent related industry.

To that end, the central government is expected to take three activities to establish the solid foundation for intellectual property: i) to conduct seminars for private sectors to enhance awareness on Patent law and application process/requirement in India and to encourage IPR registration; ii) to conduct workshops for Government IPR officials to familiarize with the concepts; and iii) to play a role of PMU to appoint a point of contact person in charge of any IPR related matter including litigations, who can coordinate with relevant Government IPR officials when required. The IPR is a very complicated area from the foreign companies' point of view, those types of knowledge sharing approach are strongly in need.

<u>Implementing Agency:</u> DIPP

To Set up appropriate standards on technical and environmental aspects

Along with the increasing volume of the foreign investment and the expanding number of foreign residents, the sustainability has become one of the key issues. Especially foreign companies, who already have their footholds in the India, strongly request further approaches to be taken by central government on technical and environmental standards in order to enhance environmental friendly, sustainable development, and eventually improve the living and working conditions.

It is, however, noted that such standards will increase the cost for the installation and establishment of facilities, especially the cost of technologies utilized. Given the many of the state government suffer from the budget deficit and cost oriented decision making tends to be made, the overall direction needs to be made by the central government, and needs to start from pilot cases and to be evangelized across the country.

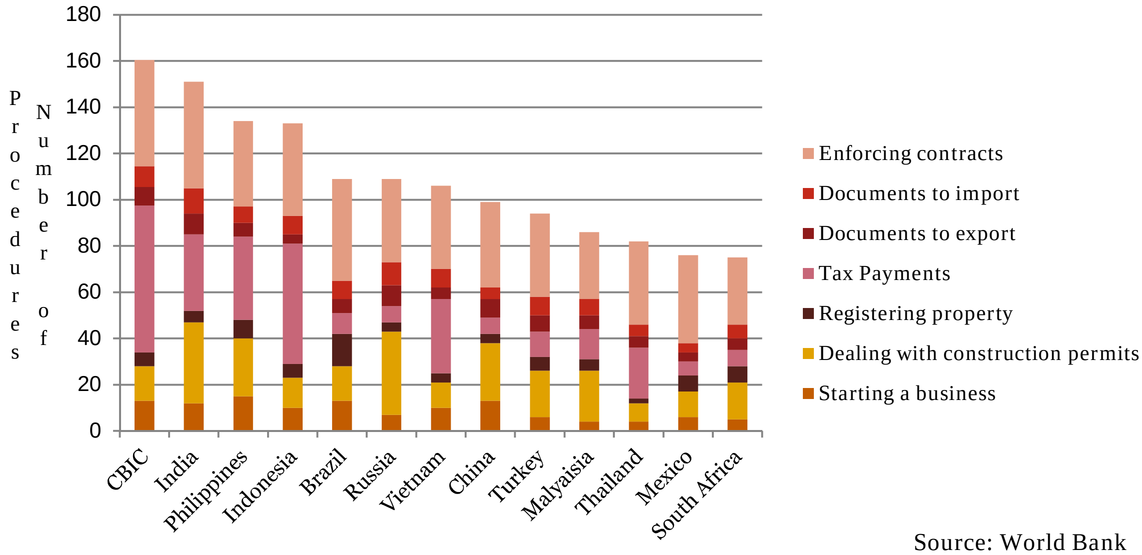
The recommendation for the central government, thus, is three steps: i) to develop the framework/guidelines for development of industrial parks with safety and environmental standards; ii) to test the above standards in specific industrial parks with governmental initiative and adjust the framework/guidelines based on the feedback; and iii) to hold a round table discussion with State's representatives on a regular basis to share successful models and the experiences

Implementing Agency: DIPP

To Reduce, Simplify and Clarify Procedures on Approval and Authorization

In order to develop CBIC to a world class investment destination, the Government of India and the related State Governments are recommended to reduce, simplify and clarify the procedures for approval and authorization.

The comparison analysis in the previous chapter shows that doing business in CBIC is highly time and cost consuming. The situation is summarised in the following figure and table.



Source: World Bank

Figure 8.5.1: Number of Procedures

The comparison of necessary periods of major administrative procedures in CBIC and 12 countries are shown in the table below. The Best Practice and Average show the most competitive practice and the average, respectively, among 12 countries. It is recommended for CBIC Region to set the target period at least at the level of the average in order to enhance the global competitiveness.

Table 8.5.1: Period of Procedures in CBIC Region

Name of Procedures	Period of Procedures in CBIC Region	Comparison with Rival Countries/Regions		Authority in Charge	
		Best Practice	Average	Gov. of India	State Gov.
Starting a business	37 days	6 days (Mexico)	31 days	√	√
Dealing with construction permits	120 days	77 days (Philippines)	181 days	√	√
Registering property	38 days	2 days (Thailand)	33 days	√	√
Trading across borders Export	25 days	11 days (Mexico)	17 days	√	
Trading across borders Import	22 days	11 days (Mexico)	18 days	√	

Name of Procedures	Period of Procedures in CBIC Region	Comparison with Rival Countries/Regions		Authority in Charge	
		Best Practice	Average	Gov. of India	State Gov.
Enforcing contracts	968 days	270 days (Russia)	533 days	√	
Paying taxes	292 hours	133 hours (Malaysia)	292 days	√	√

The interview survey for the investors in CBIC also highlighted the perception on above mentioned status. The land acquisition, import/export procedures, and environmental assessment are the most frequently identified areas where bottlenecks of soft-infrastructure exist. The challenges are summarized below.

Table 8.5.2: Key Bottlenecks in Administrative Issue in CBIC Region

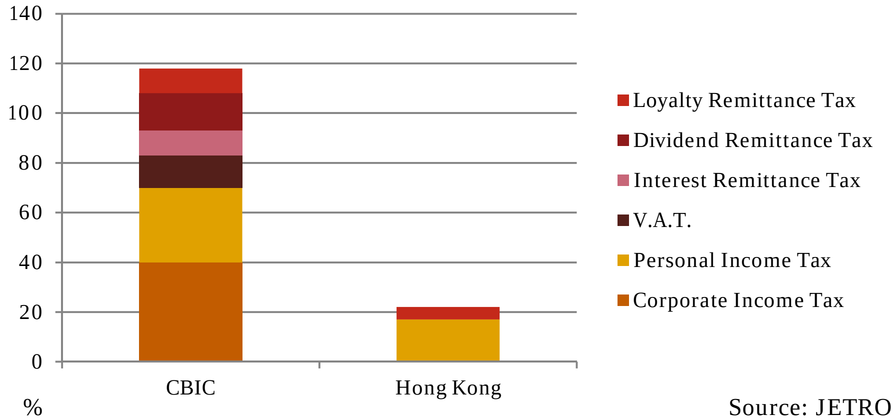
Key Issues	Bottlenecks
1. Land Acquisition on Industrial Parks	■ When serious problems occur on land acquisition in industrial park, private company has to solve by taking all responsibilities. ■ Information on industrial park is closed and difficult to know for potential investors unless they have connection with the Government officials.
2. Import/Export at Ports and Airports	■ Due to lack of integrated guidelines, rules of mandatory submitting documents and licenses for clearance are frequently changed by orders of officers at the port or airport. ■ Number of local rules and regulations which are not officially enforced by the Government exist in each port and airport. ■ One invoice needs to be provided to Taxation Bureau per part when receiving a refund on VAT. As the invoice is requested in hard copy, more than 10,000 invoices are required.
3. Environmental Assessment and Approval of New Projects	■ Environmental assessment takes too much time, i.e., 3-4 months on average. ■Approvals for new projects, such as approvals of State's high level committee and issues of official approval letters are taking too much time.

The central government can improve the situation in four ways: i) the central government coordinate the technical consultant to establish IT base solution to enable single window process and simplified procedure, which include in the area of import/export operation at ports/airports, environment approvals etc., and enhance the usability of the system; ii) along with the digitization, it can also increase the information itself accessible to the public, which is expected to enlighten the citizen and the private sector, and encourage them to proactively take action in driving the business; iii) to assign PMU to monitor the business process status regularly and evaluate based on the feedback from the field, so that the central government can provide incentives to each government to stimulate the competition, and promote the improvement of the entire states; and iv) to show strong commitment to lead the initiatives on debottlenecking, such as land acquisitions of strategic industrial parks etc.

Implementing Agency: DIPP, Ministries in charge of each sector

To Set Competitive Tax Rate

As has been identified by investors for a long time, the tax burden for foreign investors in CBIC region is more than the other rival countries and regions. The higher tax rates critically deteriorate the attractiveness of CBIC as an investment destination.



Source: JETRO

Figure 8.5.2: Comparison of Tax Rates between CBIC Region and Hong Kong

Comparison of major tax rates in CBIC and other rival countries are shown below. The Best Rate and Average Rate show the most competitive practice and the average, respectively, among 12 countries. It is considered to be necessary for CBIC Region to achieve at least the average tax rates in order to be a globally competitive investment destination which is chosen and preferred by major global investors.

Table 8.5.3: Current and Recommended Tax Rates for CBIC

Name of Tax	Current Rate	Comparison with Rival Countries/Regions		Authority in Charge	
		Best Rate	Average Rate	Gov. of India	State Gov.
Corporate Income Tax	40%	0%	17%	√	
Personal Income Tax	30%	17%	31%	√	
V.A.T.	13-15%	0%	8%		√
Interest Remittance Tax	10%	0%	8%	√	
Dividend Remittance Tax	15%	0%	9%	√	
Loyalty Remittance Tax	10%	0%	10%	√	
State Entry Tax	Varies	0%	0%		√
Import Tax	25%	10%	15%	√	

The central government can improve the situation by reviewing the optimal tax system considering the competitiveness of the CBIC region as a destination of investments.

Implementing Agency: DIPP, MOF

8.5.1.2 Business profitability

To Enable private participation in Node Development

Some of the foreign companies, especially the infrastructure related service provider, argue that it is difficult for them to establish the sustainable business model in India without the government subsidy or incentives to cover uncontrollable risks by the private sectors, such as tariff, demand etc. This means that given the government support tends to be time limited, many of the projects are not likely to be profitable for the private sectors in the long term, which make them hesitate to investment in the first place.

One of the key reasons why the above mentioned issue has often been observed is that many companies tend to be receptive to the government tender, and not be able to take part in from the planning phase. In other words, they argue that they cannot build their positions as business partner to the government, rather stay as simple vendors to individual projects. As long as such sentiment is shared and hard to be taken away in some of the key private sectors, the win-win relation between India and Japan cannot be sustainable.

One solution for the central government to take is to establish a foundation for collaboration between India and Japan from upstream phase; that is, the central government can build framework for private sectors to be involved in the development planning phase in the node, and to actively build the new business model in tight collaboration with the government. The business model can be built with integration of the various sectors businesses such as real state, power, railway etc., or in collaboration with the international financial organization.

Implementing Agency: DIPP, Ministries in charge of each sector

To Enable the infrastructure service provider to sustain the user charge based business

As described in the previous section, to build the profitable business model is difficult for some of the private sector; especially for the infrastructure related service provider, establishment of the user charge based business is crucial, but at the same time, hard to establish in India. This makes it hard for them to collect the initial investment cost, and also re-invest to maintain the business in the long term.

To support the private sector, the central government may provide guarantee funding to sustain the business at least till the private sector to collect the initial investment cost. Also, it can support the private sector to establish PPP model through assisting the operation in the initial phase. To make the user charge based business more efficiently, the government can also invest into the smart meter as common asset and deploy across the CBIC area for all the relevant service providers.

Implementing Agency: DIPP, Ministries in charge of each sector

8.5.1.3 Cross state business enhancement

To Establish interstate infrastructure

Issues that block the smooth interstate business, such as CST, stamp duty, interstate transportation system etc., have been addressed by the central government and dealt with by some approaches. Nevertheless, many of the companies still show their frustration regarding those issues by highlighting the slow progress in the remedial approaches and the insufficient information provided from the government on the progress.

To address this, it is crucial for central government to share the status of each project through online channel, and set PMU at the central level to monitor and coordinate the stakeholder to make sure the progress to be made along with the planned timeline.

Implementing Agency: Ministries in charge of each sector

To launch reform initiatives in regulation

The difference of regulation, business process, and business related law etc. are inevitable, but they are often the key blocker for the private sector to expand the business across the state. Many of the companies contend that a certain standard or unification of the process would help the smooth business operation, and would provide incentive for them to expand the business. Especially if the CBIC is addressed as the cross state industrial corridor, such support would enhance the attractiveness of the region to the investors.

The central government can provide support to them by firstly organizing the discussion committee to identify and share the key issues in current regulation/laws (especially Labour laws, environment related regulation);

and then it can encourage the state governments to hold round table discussion with representatives on regular basis to share successful models and experiences to resolve the issues.

In order to effectively improve the investment environment of CBIC by taking the above mentioned measures, the Government could consider incentivizing investors and designating CBIC as a national "special region", which allows flexible arrangement of business/investment rules and regulations beyond the regular arrangements in the other regions of India. With the status, the issues which the central Government is in charge, such as most items on taxation, import/export procedures and environment assessment, are easier to be addressed.

Implementing Agency: DIPP, Ministries in charge of each sector

8.5.2 *Investment Promotion Program*

The above mentioned issues and recommendations would be considered to be dealt under the integrated programme focusing on urgent needs of debottlenecking in hard and soft infrastructure and improve investment environment.

JICA has set up a program loan for Tamil Nadu State which deals with existing infrastructure bottlenecks as well as policy issues. The similar initiatives would be necessary for further promotion of business environment in the region.

The program loan to Tamil Nadu Government is supposed to be the concessional loan of 13 billion yen (approximately Rs. 767 Crore) in 2015 under the JICA's program entitled "Sector Program Loan for Tamil Nadu Investment Promotion Program." The main purpose of the program is the improvement of investment environment in Tamil Nadu. The expected outcome consists of the following four components: 1) improvement of investment application process, 2) enhancement of land acquisition system, 3) promotion of capacity development for industrial workers, and 4) development of the Governmental mechanism on construction of link infrastructures, e.g., road, power and water, surrounding key industrial parks where foreign companies/investors are in operation. The fund will be disbursed in stages upon the result of annual joint monitoring by the Tamil Nadu Government and JICA for evaluating the degree of improvement in investment environment. Similar arrangement and funding support from JICA should be applicable for Karnataka and Andhra Pradesh.

8.5.3 *Enhancement of the collaboration between Japan and India*

Collaboration with Japan is crucial to shift the plan into implementation and bring about the tangible result to the CBIC states. However, despite the fact that the collaboration has been driven forward at the central level, it takes a while for the decision or order from the central to the field at the state level; sometimes the private sector cannot endure the time taken for the decision to be made and to take effect. It also applies to the bottom up case; the decision agreed at the state level often takes time to reach to the central level, resulting in the missing the opportunity for the private sectors.

As the recommendation to solve the issue, the multi-layer collaboration needs to be promoted; Japanese experts are to be assigned at the multi layers of the organization as the collaboration liaison for Japanese companies and India companies as well as governments.

At the central level, the key bottleneck for the Japanese companies is that they need to negotiate with various ministries in order to obtain approval and agree on conditions, which takes a large volume of men-hours. The expert can support and facilitate the process by handling the procedure likely to take place at the central level for the CBIC projects.

At the CBIC special unit level, coordination between CBIC as a region and state government is to be a key; as the state government may have the different priority in the projects which are not aligned with CBIC, the balance of those needs to be controlled as the situation changes. If such coordination is delegated to an each private company, it is likely to block their actual business operation and discourages them to conduct further investment. Some personnel assigned as a coordinator will help both of India and Japan to build the win-win relation.

And the expert at the state level also takes important role. It is often contended that the investors or industry experts find it hard to communicate with the state government since they do not have much relationship at each state level; however, it is also told that the network at the state level is indispensable for smooth business operation in all the states in India. The expert will support to build in tight collaborative relation between India and Japan, then maximize the benefit of the collaboration.

All those experts need to work closely, exchange information, monitor the situation, and collaborate with Government of India and Japan to conduct further approach, if required.

9 Conclusion and Way forward

This master plan is expected to provide the significant value to both of Japan and India. For Japan, this can be utilized as the massive source of the valuable information for potential investors to make decision, and the comprehensive plan for existing companies to pursue more opportunity. For India, this master plan provides the blue print of the collaboration from Japanese government, and shows the direction on where the India companies should expand the business.

However, without any concrete steps, the plan stays as a plan and no execution will follow. To make the CBIC master plan as the key step for the implementation to follow, JICA Study team thinks that the following 5 actions are key milestones in the upcoming 2-3 years

1. Setting up PMUs at Central and State level for smooth collaboration

Objective:

- Support planning and implementation of Master Plan and conduct the investment facilitation in the Node

Action recommended:

- Establish PMU to support planning and implementation of Master Plan, which may include:
  - Coordination with Ministries and state governments
  - Coordination with stakeholders for SPV formulation and Node level Share Holder Agreements (SHA)
  - Supporting state governments in finalization of State Support Agreements (SSA) with the Node SPVs
  - Support for states on funding by project/program loans
  - Establishing monitoring scheme to operate PDCA with appropriate KPIs.
- Promotion of Industrial Node through developing marketing material and investor roadshows
- Enable private sector partnership for planning, implementation and O&M of the node

2. Drive Investment Environment Improvement at Central and State level

Objective:

- Provide a mid-long term Policy Guidance for private investor with improvement of the ease of doing business initiatives

Action recommended:

- Set programme for Policy Planning and Design
- Set program for implementing Procedural and Infrastructure solutions for implementing Ease of Doing Business
- Establish a panel for coordination between states at central governments
- Strengthen IPR Regime Governance

3. Enhance the industry competitiveness through government program

Objective:

- Skill Development, R&D and Technology transfer
- Encourage private participation in Industrial Node development

Action recommended:

- Set up an industrial knowledge park inside the each Node
- Incentivize industries to participate in the Training and Placement of workforce through State Policy Development
- Develop competitive and reliable utility services and pricing
- Establish indigenous support facilities such as Equipment Testing, Quality Control

4. Implement the priority project for quick win to build momentum

Objective:

- Expedite the priority project (25+19)

Action recommended:

- Establish Corridor Units in each Line Ministry
- Set up funding from GoI/State and Japan to actually drive forward the project

5. Institutionalize collaboration between India and Japan to attain mid-long term healthy growth

Objective:

- Institutionalise collaboration between Japan and India

Action recommended:

- Establish framework for multi-layer collaboration between Japan and India at Central, Corridor, and State Level
- Organise Working Groups between Japanese Agencies and State Governments

Annexes

Annexure 1: Industrial analysis

Estimation of sector output at corridor level

Methodology

The methodology adopted for estimating the output across each sector is based on the year-wise output data of each sector at the national and state level, as provided in the Annual Survey of Industries (ASI), published by Ministry of Statistics and Programme Implementation (MOSPI).

For each of the identified sectors, the sub-sectors were identified using the 3 digit NIC codes, as categorised in the ASI data, and the output data at India and state level was collected for each of these sub-sectors. This data was collected from 2008-09 to 2010-11 and the trends were identified. The data collection through ASI was limited to these 3 years, owing to the fact that NIC codes were formally re-categorized in 2008 and hence the previous year's ASI data may not represent the sector completely or over-estimate the sector size owing to inclusion of a larger number of sub-sectors. These output numbers are mentioned at current prices, and therefore, we converted them to constant prices using the Wholesale Price Index (WPI)[120] across years.

We then estimated the growth rates across each sub-sector, which would be used for projecting the sub-sector level output numbers for the next 20 years. Since we had fixed the starting point of the project as 2014-15, the projections for all the output numbers has been done till 2033-34 (20 years). The growth rates have been estimated using the following 2 scenarios:

1. **Accelerated growth scenario** – In this case, we have assumed that the growth rates in the sector (or sub-sectors) will follow the industry projections given by reliable reports. The reports used for identifying the growth projections reflect reliable market research organizations, Government publications and expert opinions shared by the industry captains. The limitation in this case was that the industry projections are mostly till 2017-2020.
2. **Business As Usual scenario (BAU)** – In this case, we have predominantly used the past performance of the sector/sub-sectors within sector to project the future growth rates. The limitation in this case is that the consideration set with actual numbers is for a very short period.

In both the scenarios, we observed that the growth rates for the period from 2011-12 to 2013-14 are coming to be very high, and are not in sync with the current economic scenario in the country and globally. We further observed that the growth in the manufacturing sector in India for the period from 2011-12 to 2013-14 was range bound between 1% and 2.7%. We factored this diminished growth rate of the manufacturing sector as a whole in the sector level (and sub-sector level) growth rates for the same period and recalculated the output numbers for this period.

Thereby, the output projection for each of the above mentioned scenarios was done at the corridor level as follows:

Scenario 1: Accelerated growth scenario

The adjusted output numbers for India, at sub-sector level or sector level, for the period 2011-12 to 2013-14 were further projected till 2019-20, using the growth rates as per industry reports. For the period between 2020-21 to 2029-30 and 2030-31 to 2033-34, we fine tuned the growth rates based on India's growth rate projections. This assumption is based on the fact that the manufacturing growth rates are closely linked to the GDP growth rates of the economy.

We used the GDP projections of India[121] for this period to fine tune the growth rates of the sub-sectors till 2033-34. The eventual output numbers were the sub-sector level output from respective sector, at India level.

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[120] *Sourced from RBI database*
[121] *Source: Standard Chartered - The Super Cycle lives: EM growth is the key (November 2013)*

On similar lines, the output numbers across sub-sectors were projected for the 3 states of Karnataka, Tamil Nadu, and Andhra Pradesh. However, for each state the output numbers were capped to a maximum limit, based on the past trends of their contribution to national output (at sub-sector level).

For estimating the contribution of the corridor districts to the state's output at sub-sector/sector level, we have assumed that the output trend for the districts will closely follow the investment trends in the district. To arrive at the investment trends in the districts, we have used the CMIE database which tracks most of the large investments across states. The limitation here is that the CMIE data does not capture all the projects that might have come into a district and is only a representative set for capturing investment trend.

The investments across each district were captured and the percentage contribution of each district to the total investments in the state was calculated. The corridor contribution to the output was further arrived at by apportioning the state's output in the proportion of the investments along the corridor districts. The eventual output numbers were the sub-sector/sector level output from the corridor.

Scenario 2: Business As Usual scenario

The adjusted output numbers for India, at sub-sector level or sector level, for the period 2011-12 to 2013-14 were used to find the CAGR of growth in output between 2008-09 and 2013-14. These growth rates were then fine tuned for the period between 2020-21 to 2029-30 and 2030-31 to 2033-34, based on India's growth rate projections. This assumption is based on the fact that the manufacturing growth rates are closely linked to the GDP growth rates of the economy.

We used the GDP projections of India[122] for this period to fine tune the growth rates of the sub-sectors till 2033-34. The eventual output numbers were the sub-sector level output from respective sector, at India level.

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The investments across each district were captured and the percentage contribution of each district to the total investments in the state was calculated. The corridor contribution to the output was further arrived at by apportioning the state's output in the proportion of the investments along the corridor districts. The eventual output numbers were the sub-sector/sector level output from the corridor.

Estimation of sector level land demand at corridor level

Methodology

The output numbers from each of the states were apportioned for the corridor level districts within the state, as mentioned in the methodology above. We further analysed the average utilization levels[123] within the sector and pegged it to reach 85% capacity utilization[124] for future years. Using this, we calculated the average maximum supply capacity available already existing with the industries within the corridor districts, for each state. We then calculated the incremental output from the corridor districts within each state, and further fine tuned it using the available maximum supply capacity.

We also created the benchmarks for output to investment ratio using ASI and investment intensities across the sector, based on existing projects. Using these benchmarks the output at the corridor level was converted to yearly land demand. Manufacturing GDP of India has the potential to grow seven folds from USD 160 billion

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[122] *Source: Standard Chartered - The Super Cycle lives: EM growth is the key (November 2013)*
[123] *Source: Index of capacity utilization for Indian manufacturing sector, Angshuman Hait & Roshin Paul*
[124] *Source: Article from New York University Stern School of Business on optimum capacity utilization factor*

(current value) to USD 1,170 billion by 2034 (considering Standard Chartered estimates on GDP growth in India during the period 2014 -2034 and assuming 25% of the GDP being generated by manufacturing sector).

Sector wise output of the corridor under both scenarios

Table 1: Sector wise output of the corridor till 2034 - under Business As Usual and Accelerated scenario

In Rs. crores

Sector		2014-15	2017-18	2020-21	2023-24	2026-27	2029-30	2031-32	2033-34
Metallurgy	Business as usual	15,868	16,216	17,397	19,899	24,890	33,612	40,598	48,694
Metallurgy	Accelerated	15,902	16,394	18,112	21,728	29,107	44,174	56,241	70,226
Medical equipment	Business as usual	1,492	1,867	2,337	2,925	3,661	4,582	5,321	6,180
Medical equipment	Accelerated	1,480	1,897	2,429	3,164	4,122	5,369	6,404	7,638
Food Processing	Business as usual	26,706	30,761	35,916	42,833	51,761	63,428	73,222	85,091
Food Processing	Accelerated	27,463	34,256	43,162	55,322	71,145	91,780	108,939	129,464
Textiles & Apparels	Business as usual	18,592	19,421	20,315	21,310	22,354	23,450	24,211	24,998
Textiles & Apparels	Accelerated	19,859	25,295	32,489	42,397	55,390	72,450	86,709	103,830
Electrical Machinery	Business as usual	24,518	28,290	33,235	40,305	49,618	62,128	72,917	86,324
Electrical Machinery	Accelerated	26,573	38,859	56,613	82,842	121,260	177,547	228,970	295,325
Machinery	Business as usual	35,839	40,110	45,236	51,793	59,328	67,991	74,477	81,598
Machinery	Accelerated	39,128	56,658	81,716	121,155	180,742	271,170	356,413	469,453
Chem.& Petrochemicals	Business as usual	26,753	30,949	36,145	42,850	51,106	61,334	69,514	79,015
Chem.& Petrochemicals	Accelerated	26,936	36,089	48,832	67,335	92,973	128,551	159,675	198,469
Pharmaceuticals	Business as usual	7,193	8,206	9,402	10,859	12,543	14,487	15,948	17,557
Pharmaceuticals	Accelerated	7,950	12,250	19,115	30,597	48,974	78,390	107,264	146,774
Auto	Business as usual	69,570	85,559	106,373	134,695	171,588	219,970	260,572	309,644
Auto	Accelerated	72,696	101,957	144,953	211,093	308,512	452,421	585,013	757,500
Computer, electronic and optical products	Business as usual	15,154	16,797	18,685	20,925	23,444	26,275	28,356	30,608
Computer, electronic and optical products	Accelerated	17,843	32,460	60,653	118,747	235,790	475,651	766,638	1,245,563
IT/ITES		165,184	223,480	311,584	438,568	620,720	882,802	1,147,872	1,457,638
Total	**Business as usual**	**406,868**	**501,656**	**636,625**	**826,963**	**1,091,012**	**1,460,060**	**1,813,008**	**2,227,345**
Total	**Accelerated**	**421,014**	**579,594**	**819,659**	**1,192,947**	**1,768,735**	**2,680,305**	**3,610,139**	**4,881,879**

Sector wise land demand of the corridor under both scenarios

Table 4: Sector wise consolidated land demand of the corridor till 2034 - under Business As Usual and Accelerated scenario

In acres

Sector		2014-15	2017-18	2020-21	2023-24	2026-27	2029-30	2031-32	2033-34
Metallurgy	Business as usual	7	44	165	414	897	2,077	3,021	4,116
Metallurgy	Accelerated	12	76	285	715	1,550	3,587	5,219	7,110
Medical equipment	Business as usual	2	10	20	32	51	80	104	131
Medical equipment	Accelerated	2	11	23	40	66	105	138	176
Food Processing	Business as usual	113	522	1,073	1,818	2,779	4,034	5,088	6,366
Food Processing	Accelerated	185	871	1,824	3,132	4,835	7,056	8,903	11,112
Textiles & Apparels	Business as usual	22	91	168	255	346	442	508	576
Textiles & Apparels	Accelerated	124	577	1,201	2,065	3,197	4,684	5,927	7,420
Electrical Machinery	Business as usual	4	182	539	1,049	1,721	2,624	3,403	4,371
Electrical Machinery	Accelerated	58	945	2,226	4,119	6,892	10,954	14,665	19,454
Machinery	Business as usual	-	170	523	975	1,494	2,091	2,538	3,028
Machinery	Accelerated	120	1,310	3,036	5,753	9,858	16,088	21,960	29,747
Chem.& Petrochemicals	Business as usual	43	256	538	903	1,354	1,915	2,365	2,892
Chem.& Petrochemicals	Accelerated	83	567	1,275	2,303	3,727	5,704	7,433	9,588
Pharmaceuticals	Business as usual	-	76	226	408	618	862	1,044	1,245
Pharmaceuticals	Accelerated	44	582	1,440	2,875	5,172	8,849	12,459	17,397
Auto	Business as usual	257	1,156	2,327	3,920	5,994	8,715	10,998	13,757
Auto	Accelerated	433	2,079	4,496	8,216	13,694	21,786	29,242	38,942
Computer, electronic and optical products	Business as usual	16	70	137	216	306	407	481	561
Computer, electronic and optical products	Accelerated	99	583	1,580	3,646	7,809	16,340	26,690	43,724
IT/ITES		123	584	1,226	2,271	3,728	5,836	7,971	10,478
Total	**Business as usual**	**587**	**3,162**	**6,943**	**12,262**	**19,290**	**29,082**	**37,520**	**47,521**
Total	**Accelerated**	**1,284**	**8,185**	**18,614**	**35,136**	**60,529**	**100,990**	**140,606**	**195,148**

The vacant land availability in the industrial parks in the corridor amounts to 53,371 acres. Hence, additional land requirement in the corridor under the accelerated scenario is 141,777 acres.

District wise output under accelerated scenario

Table 5: District wise output of the corridor till 2034 - under Accelerated scenario

In Rs. crores

Sector	2014-15	2017-18	2020-21	2023-24	2026-27	2029-30	2031-32	2033-34
Chennai	98,154	137,323	199,001	298,497	459,664	730,026	1,021,981	1,440,212
Tiruvallur	10,857	14,536	19,829	28,011	40,384	59,607	78,246	103,851
Kancheepuram	98,286	138,886	200,092	297,548	449,530	692,339	936,495	1,279,483
Tiruvannamalai	3,101	3,797	4,732	6,035	7,785	10,179	12,161	14,521
Vellore	3,641	4,809	6,519	9,001	12,547	17,651	22,578	28,477
Dharmapuri	10,210	13,878	19,071	26,844	38,045	54,279	69,033	88,039
Krishnagiri	5,182	7,296	10,314	14,743	21,165	30,520	39,060	50,109
Bengaluru urban	118,209	161,292	226,998	325,395	472,955	698,778	932,241	1,233,141
Bengaluru Rural	25,276	34,498	47,827	67,943	97,354	140,793	181,421	234,237
Ramnagara	885	1,294	1,885	2,758	4,036	5,910	7,622	9,831
Kolar	2,170	3,088	4,522	6,923	10,910	17,785	25,135	36,167
Chikkaballapura	112	172	269	430	688	1,102	1,507	2,063
Tumkur	1,139	1,522	2,070	2,876	4,041	5,738	7,257	9,182
Chitradurga	3,025	3,857	4,963	6,495	8,517	11,192	13,442	16,159
Chittoor	19,895	27,999	39,534	57,165	83,273	122,136	158,139	205,223
Nellore	17,256	21,457	27,553	36,705	50,235	70,841	89,225	112,794
Ananthapur	3,617	3,889	4,480	5,579	7,604	11,426	14,596	18,390
Total	**421,014**	**579,594**	**819,659**	**1,192,947**	**1,768,735**	**2,680,305**	**3,610,139**	**4,881,879**

District wise land demand under accelerated scenario

District wise land demand of the corridor till 2034 - under Accelerated scenario

In acres

Sector	2014-15	2017-18	2020-21	2023-24	2026-27	2029-30	2031-32	2033-34
Chennai	229	1,432	3,358	6,633	12,056	21,457	31,412	46,049
Tiruvallur	48	305	680	1,250	2,089	3,368	4,555	6,128
Kancheepuram	419	2,728	6,230	11,793	20,369	33,860	47,045	65,234
Tiruvannamalai	19	90	190	331	520	787	1,007	1,269
Vellore	10	52	113	203	329	513	677	878
Dharmapuri	55	314	685	1,235	2,019	3,146	4,162	5,463
Krishnagiri	17	177	408	743	1,226	1,923	2,554	3,363
Bengaluru urban	172	1,052	2,379	4,523	7,828	13,167	18,588	26,069
Bengaluru Rural	125	675	1,470	2,666	4,396	6,933	9,253	12,258
Ramnagara	2	31	74	137	229	365	488	648
Kolar	12	65	147	279	489	832	1,183	1,688
Chikkaballapura	1	8	20	40	73	124	175	244
Tumkur	5	34	77	139	229	362	479	627
Chitradurga	18	87	183	315	490	720	913	1,145
Chittoor	72	657	1,501	2,784	4,675	7,482	10,070	13,444
Nellore	75	445	1,004	1,845	3,075	5,029	6,727	8,846
Ananthapur	5	33	98	219	438	921	1,320	1,794
Total	**1,284**	**8,185**	**18,614**	**35,136**	**60,529**	**100,990**	**140,606**	**195,148**

The vacant land availability in the industrial parks in the corridor amounts to 53,371 acres. Hence, additional land requirement in the corridor under the accelerated scenario is 141,777 acres.

Annexure 2: Ports

1. Commodity wise capacity at each port

(Capacity in MTPA)

COMMODITY -> PORT	Iron Ore	Coal (Thermal)	POL	Fertilizers	Gen / Break Bulk Cargo	Containers	TOTAL CAPACITY
CHENNAI PORT	8.0	-	17.67	-	17.92	42.00	85.59
ENNORE PORT	6.0	21.0	3.0	-	1.0	-	31.0
KATTUPALLI PORT	-	-	-	-	-	22.92	22.92
KRISHNAPATNAM PORT			52.08			22.92	75.00
Total cargo handling capacity at existing four ports in the CBIC region							**214.51**

Source: IPA data 2012, websites of respective ports

2. Historical Traffic Data (commodity-wise for each port in CBIC region)

a. CHENNAI PORT

(In '000 Tonnes)

COMMODITIES		2012-13	2011-12	2010-11	2009-10	2008-09	2007-08
POL	**Crude**	9221	9815	10031	9887	9695	9833
	Product	4154	3475	3960	3434	3437	2880
	LPG	0	0	0	0	0	0
Edible Oil		1063	1125	1077	1080	821	518
Other Liquid		218	178	138	138	207	846
Iron ore	**Raw**	0	51	2115	7131	6846	7657
	Pellets	52	46	198	896	1512	3125
Other Ore		882	563	584	848	753	595
Fertilizers		190	394	434	357	516	585
Fert. Raw Mat.	**Dry**	232	249	337	254	267	266
	Liquids	31	37	8	11	0	0
Food Grains	**Rice**	0	0	0	0	0	4
	Wheat	140	0	0	0	0	51
	Others	174	190	85	0	22	28
Coal	**Thermal**	0	610	1417	1269	2446	1909
	Coking	0	351	606	1790	1656	1838
	Others	0	2232	5692	6699	5746	5951
Iron/Steel		1115	1007	880	656	633	510
Salt		0	80	40	44	75	0
Sugar		173	112	333	517	136	58
Cement		4	0	0	4	0	0
Newsprint		0	0	0	0	0	0
Other Cargo	**Dry Bulk**	4573	3145	2153	1115	491	441
	Break Bulk	1474	1971	1950	1450	1652	2009
Cars	**Tonnage**	272	253	235	274	249	138

COMMODITIES		2012-13	2011-12	2010-11	2009-10	2008-09	2007-08
	(in Nos.)	272345	252640	234762	273917	248697	137971
Container	**TEUs (in Nos.)**	1540	1558	1524	1216	1144	1128
	Tonnage	29708	30076	29422	23477	20580	18050
Total		53676	55960	61695	61331	57740	57292
Transhipment	**Container**	0	0	0	0	0	0
	POL:CRUDE: PRODUCT	0	0	0	0	0	0
	Others	0	0	0	0	0	0
Grand Total		53676	55960	61695	61331	57740	57292

Source: IPA data 2012, websites of respective port

b. KAMARAJAR PORT

(In '000 Tonnes)

COMMODITIES		2012-13	2011-12	2010-11	2009-10	2008-09	2007-08
POL	**Crude**	0	0	0	0	0	0
	Product	521	502	509	395	241	319
	LPG	603	0	0	0	0	0
Edible Oil		0	0	0	10	0	0
Other Liquid		95	96	80	83	41	3
Iron ore	**Raw**	0	0	401	936	1111	2190
	Pellets	0	0	0	0	0	0
Other Ore		0	0	0	0	0	0
Fertilizers		0	0	0	0	0	0
Fert. Raw Mat.	**Dry**	0	0	0	0	0	0
	Liquids	0	0	0	0	0	0
Food Grains	**Rice**	0	0	0	0	0	0
	Wheat	0	0	0	0	0	0
	Others	0	0	0	0	0	0
Coal	**Thermal**	14240	12646	9265	9279	9708	9051
	Coking	685	465	103	0	0	0
	Others	0	0	0	0	0	0
Iron/Steel		0	0	0	0	0	0
Salt		0	0	0	0	0	0
Sugar		0	0	0	0	0	0
Cement		0	0	0	0	0	0
Newsprint		0	0	0	0	0	0
Other Cargo	**Dry Bulk**	0	0	0	0	0	0
	Break Bulk	1741	1247	651	0	0	0
Cars	**Tonnage**	145	104	54	0	0	0
	(in Nos.)	145053	103667	54264	0	0	0
Container	**TEUs (in Nos.)**	0	0	0	0	0	0
	Tonnage	0	0	0	0	0	0
Total		18030	15060	11063	10703	11101	11563
Transhipment	**Container**	0	0	0	0	0	0
	POL:CRUDE: PRODUCT	0	0	0	0	0	0

COMMODITIES		2012-13	2011-12	2010-11	2009-10	2008-09	2007-08
	Others	0	0	0	0	274	0
Grand Total		18030	15060	11063	10703	11375	11563

Source: IPA data 2012, websites of respective ports

c. KATTUPALLI PORT

(In '000 Tonnes)

COMMODITIES		2012-13	2011-12
Container	**TEUs (in Nos.)**	1	1
	Tonnage (MTPA)	12	10
Total		12	10
Transhipment	**Container**	0	0
	POL:CRUDE: PRODUCT	0	0
	Others	0	0
Grand Total		12	10

Source: IPA data 2012

d. KRISHNAPATNAM PORT

(In '000 Tonnes)

COMMODITIES		2012-13	2011-12	2010-11	2009-10	2008-09	2007-08
POL	**Crude**	0	0	0	0	0	0
	Product	0	0	0	0	0	0
	LPG	0	0	0	0	0	0
Edible Oil		1030	50	370	10	0	0
Other Liquid		0	0	0	0	0	0
Iron ore	**Raw**	149	116	80	41	6	0
	Pellets	0	0	0	0	0	0
Other Ore		0	0	0	0	0	0
Fertilizers		0	0	0	0	0	0
Fert. Raw Mat.	**Dry**	0	0	0	0	0	0
	Liquids	0	0	0	0	0	0
Food Grains	**Rice**	852	548	2340	4448	2996	0
	Wheat	0	0	0	0	0	0
	Others	0	0	0	0	0	0
Coal	**Thermal**	16015	12486	8649	4467	642	0
	Coking	0	0	0	0	0	0
	Others	0	0	0	0	0	0
Iron/Steel		0	0	0	0	0	0
Salt		0	0	0	0	0	0
Sugar		0	0	0	0	0	0
Cement		0	0	0	0	0	0
Newsprint		0	0	0	0	0	0
Other Cargo	**Dry Bulk**	0	0	0	0	0	0
	Break Bulk	0	0	0	0	0	0
Container	**TEUs (in Nos.)**	218	158	318	509	324	0
	Tonnage	3074	2222	4480	7173	4566	0

COMMODITIES		2012-13	2011-12	2010-11	2009-10	2008-09	2007-08
Total		21120	15422	15919	16139	8210	0
Transhipment	**Container**	0	0	0	0	0	0
	POL:CRUDE: PRODUCT	0	0	0	0	0	0
	Others	0	0	0	0	0	0
Grand Total		21120	15422	15919	16139	8210	0

Source: Krishnapatnam port website for traffic data 2012-13, secondary research for other years

List of proposed projects

Name / Description of the Committed / Confirmed Projects	Port	Present Status of the Project	Likely year of commissioning / capacity addition	Capacity addition	Estimated project cost (approx. In Rs. crores)
CHENNAI PORT					
Conversion of Bharathi Dock - 2 (BD-2) berth to a Ro-Ro terminal	Chennai Port	Feasibility study in progress	2016	Around 7,000 cars	Around 5 crores
Development of Container Terminal 3 by Conversion of Jawahar Dock (JD) East berths 2,4& 6	Chennai Port	Feasibility study in progress	2017*	0.8 Mn TEU	Around 450 crores
Liquid Berth as part of Project Outer Harbour at Chennai Port	Chennai Port	Chennai Port Trust is in process of restructuring the erstwhile MEGA Container Terminal Project and has appointed a Financial & Transactional Advisor. The consultant has submitted traffic study report and costs for the project will be finalised after tariff assessment.	2018	2.31 MTPA	@
Two Multi-purpose berths as part of Project Outer Harbour at Chennai Port	Chennai Port		2021	4.62 MTPA	@
Container Terminal 1 as part of Project Outer Harbour at Chennai Port	Chennai Port		2019	14.13 MTPA	@
Container Terminal 2 as part of Project Outer Harbour at Chennai Port	Chennai Port		2026	14.13 MTPA	@
Ro-Ro Berth as part of the Project Outer Harbour at Chennai Port	Chennai Port		2020	0.25 mn cars	@
Development of Barge handling facilities for bunkering at Chennai Port under PPP mode	Chennai Port	Project Awarded. Financial closure awaited. Environmental clearance yet to be received	--		Around 25 crores
Creation of Dry dock facilities OR Extension of West Quay to south at Chennai Port	Chennai Port	Ideation	--	--	#
Development of new Container Terminal at West Quay at Chennai Port	Chennai Port	Currently at Ideation stage. Project to be taken up after completion of Container Terminal 3 project depending upon traffic demand	--	Approx. 0.52Mn TEUs	#
Development of new Ro-Ro Terminal at Chennai Port	Chennai Port	Currently at Ideation stage. Chennai Port to decide on the project depending upon demand scenario after completion of conversion of BD-2 to Ro-Ro terminal	--	--	#
KAMARAJAR PORT					
Upgradation of existing coal handling facility at Kamarajar Port (due to mechanization of Coal Berth – 2) for TNEB	Kamarajar Port	Under construction	2015	4 MTPA	Around 10 crores
New Container Terminal – 1 at Kamarajar Port	Kamarajar Port	Awarded	Phase I : 2017; Phase II: 2019^	16.8 MTPA	1270 crores
Development of LNG import terminal at Kamarajar Port	Kamarajar Port	Under construction	2018	5 MTPA	Around 4512 crores
Development of Coal Berth III for TNEB at Kamarajar Port	Kamarajar Port	To be developed by EPL^. Approval for Rail sidings received.	2017	9.5 MTPA	Around 250 crores

Name / Description of the Committed / Confirmed Projects	Port	Present Status of the Project	Likely year of commissioning / capacity addition	Capacity addition	Estimated project cost (approx. In Rs. crores)
Multi-purpose cargo terminal at Kamarajar Port	Kamarajar Port	Concession Agreement signed with SPV of M/s Chettinad International Bulk Terminal Pvt. Ltd.	2016	2 MTPA	Around 151 crores
Development of SBM facility for Crude Oil handling	Kamarajar Port	Preliminary DFR has been prepared by CPCL	2020	15 MTPA	
Dredging (18 m CD) Phase-II at iron ore terminal in Kamarajar Port	Kamarajar Port	Project in progress at present. To be completed in 2014-15	2015		Around 225 crores
Dredging (15 m CD) Phase-III at container terminal in Kamarajar Port	Kamarajar Port	To start after completion of Phase II dredging		-	Around 75 crores
Capacity addition to the Common User Iron Ore Terminal at Kamarajar Port	Kamarajar Port	Ideation	--	6 MTPA	#
Container Terminal – 2 at Kamarajar Port	Kamarajar Port	Ideation	2022	35 MTPA	#
Container Terminal – 3 at Kamarajar Port	Kamarajar Port	Ideation	2027	35 MTPA	#
Additional Coal Berth (Coal Berth IV) for TNEB	Kamarajar Port	Ideation	2019	9.5 MTPA	#
Additional Common user Coal Terminal on BOT Basis	Kamarajar Port	Ideation	2018	10 MTPA	#
Additional Common user Multi-Liquid Terminal on BOT basis	Kamarajar Port	Ideation	2018	3 MTPA	#
Additional Car Export Terminal – 1	Kamarajar Port	Ideation	2018	Approx. 3 lac car units	#
Additional Car Export Terminal – 2	Kamarajar Port	Ideation	2022	Approx. 3 lac car units	#
KATTUPALLI PORT					
Container Berths 3 & 4 at Kattupalli Port	Kattupalli Port	Ideation	25 MTPA expected in FY 2018	Container Berths 3 & 4 at Kattupalli Port	#
Berth 5 – Ro-Ro Terminal	Kattupalli Port	Ideation	8 MTPA expected in FY 2018	Berth 5 – Ro-Ro Terminal	#
Mutli-purpose Berth at Kattupalli Port	Kattupalli Port	Ideation	8 MTPA expected in FY 2019	Mutli-purpose Berth at Kattupalli Port	#
Liquid / POL Terminal at Kattupalli Port	Kattupalli Port	Ideation	8 MTPA expected in FY 2022	Liquid / POL Terminal at Kattupalli Port	#
LNG Terminal at Kattupalli Port	Kattupalli Port	Ideation	8 MTPA expected in FY 2022	LNG Terminal at Kattupalli Port	#

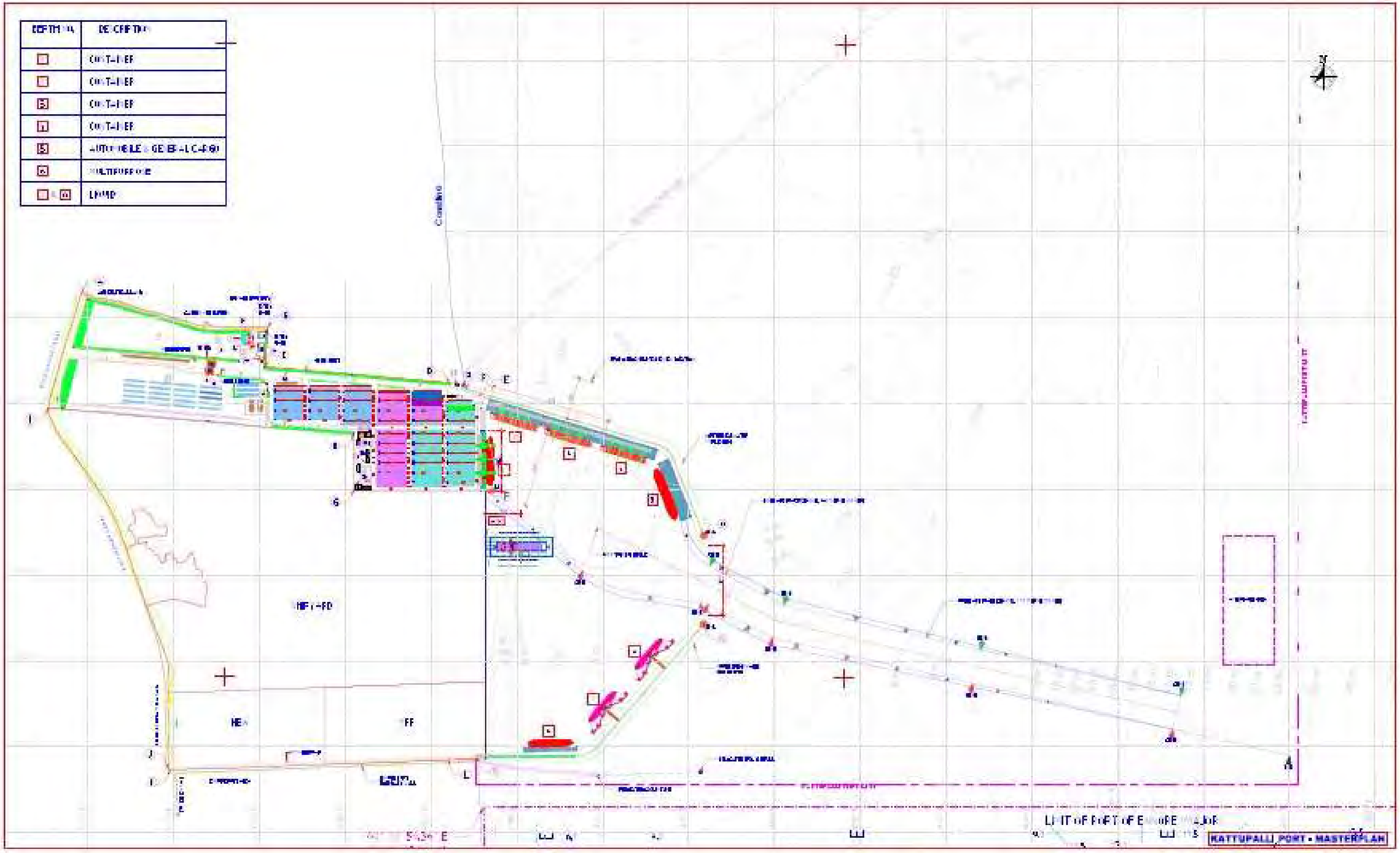
** Port's estimate is 2017. However, the JICA Study Team assumes that 2020 is the likely date of commissioning considering current legal issues surrounding the project*
^ Phasing for Phase II assumed by JICA Study Team
@ Project cost yet to be finalized for the project
 # Estimates of the project cost not available as the project is in ideation stage
Source: Stakeholder interactions

Port Layout Map

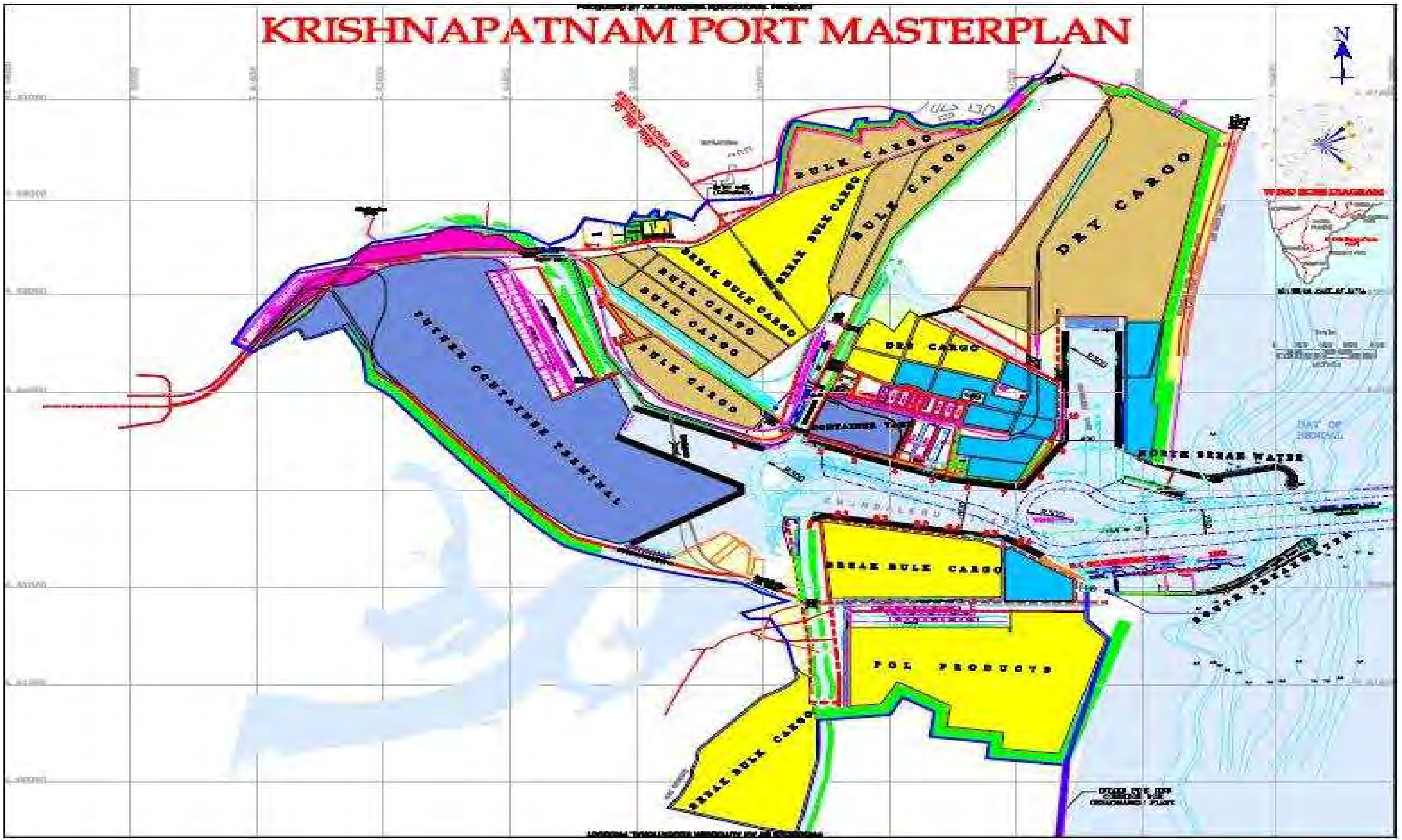
a. Chennai Port

b. Kamarajar Port

c. Kattupalli Port



d. Krishnapatnam Port



Annexure 3: Roads

Major Road Project within the CBIC Area

The following tables, table A.1.1, A.1.2 and A.1.3, indicate major road projects currently under construction, planned or under study across the whole CBIC area, split by State. As part of the analysis of the CBIC road network, a road logistic network has been identified. This logistic network, consisting of major roads connecting cities, towns, industrial areas and ports, is subdivided into primary, secondary and urban primary sub-networks. Proposed projects over the 20-year time period for this logistic network are indicated in Table below.

Table 1:Existing Major Projects in Tamil Nadu

Status	Category	ID	Project Name	Length (km)	Project Cost (10 mil. INR)	Investor	Type	Term	Progress/Schedule
Ongoing	Intercity	TO1	Chennai-TadaSection of NH-5	43.4	353.37	NHAI (BOT)	Widening 6 lanes	Short	Under construction. Expected completion is June2014
		TO2	Hosur – Krishnagiri Section of NH 7 (GQ)	52	535	NHAI (BOT)	Widening 6 lanes	Short	Under Construction. Expected completion is June 2014
		TO3	Krishnagiri-Walahjpet Section of NH-46 (GQ)	148.3	1250	NHAI (BOT)	Widening 6 lanes	Short	Expected completion is Junel 2014
		TO4	Poonamalee to Wallajahpet Section of NH-4 (GQ)	93 .00	1287.95	NHAI (BOT)	6 lanes	Short	Contract Awarded. Expected completion is Nov 2015.
		TO5	Thirutani- Chennai Section of NH-205 (Two laning from 0/0 to 43/950 and four laning from 43/950 to 61/470 in TN; two laning from 318/300 to 338/030 and four laning from 274/800 to 318/300 in AP)	124.7	571	NHAI (BOT)	2/4 lanes	Short	Under Construction. Expected completion is May 2014
	Urban Arterial	TO6	Chennai Port-Maduravoyal Four Lane Elevated Road Project	19	1655	NHAI (BOT)	New 4 lanes	Short	30% work complete. No progress from April 2012. Re-alignment issue.
		TO7	Oragadam Industrial Corridor	58.00	462	TNRIDC	Widening	Short	Phase I expected to

Status	Category	ID	Project Name	Length (km)	Project Cost (10 mil. INR)	Investor	Type	Term	Progress/Schedule
									be completed by March 2014 Phase II expected to be completed by Mid 2015
		TO8	Ennore Manali Road Improvement Project(EMRIP)	30	600	NHAI, Ennor port, TN	Improvement+ Widening	Short	Delayed due to land acquisition issues. Expected completion is by June 2014
		TO9	Outer Ring Road (ORR) (Phase I)	29.65	1,081	TN Govt. (BOT-Annuity)	New 6 lanes	Short	Expected to be completed by May 2014
Announced Plan	Intercity	TA1	Bangalore-Chennai Expressway Project	260	6000	NHAI (BOT)	New 6 lanes	Short	Waiting for Environmental Clearance. land acquisition process has been initiated; however Expressway is not immediate priority for NHAI.
		TA2	Six laning of Tambaram-Tindivanam NH-45	93		NHAI (BOT)	Widening 6 lanes	Medium	Project yet to be awardedsince current concessionaire has a contract till 2019.
		TA3	Tindivanam-Krishnagiri(NH-66) Two-Laning with paved shoulder	176.5	624	NHAI	Two-Laning with paved shoulder	Medium	Expected to be completed by September 2014
	Urban Arterial	TA4	Elevated Circular Bus Corridor Project	N.A.	3,000	GoTN	New	Short	
		TA5	Outer Ring Road (ORR) Phase II	33.1	985.44	TN Govt. (DBFOT)	New 6 lanes	N.A	Project awarded to concessionaire
Under Study	Intercity	TU1	AP Border – Ranipet Section of NH-4			NHAI	Widening 4 lanes	N.A	
		TU2	New 4 Lane Road	25.50	374		New 4	Short	Under Study

Status	Category	ID	Project Name	Length (km)	Project Cost (10 mil. INR)	Investor	Type	Term	Progress/Schedule
			from Northern Gate of Ennore Port to Thatchur (NH-5)				lanes		
		TU3	Krishnagari-Hoskote Road Project (Road connect between TN and KT)	N.A.	N.A.	TNRDC	New	N.A	Proposed by TN/ Current Status unknown
	Urban Arterial	TU4	East Coast Road	N.A.	N.A.	TNRDC	Widening 4 lanes	N.A	Current Status unknown
		TU5	Rajiv Gandhi Salai (IT Corridor)–Phase II, (Siruseri –Mahabalipuram)	26.80	N.A.	TNRDC	Improvement+ Widening 6 lanes		F/S / Current Status unknown
		TU6	Peripheral Ring Road from Mamallapuram to Ennore	162	1420	GoTN	New + Widening	N.A	DPR will be prepared May 2013

Table 2 Existing Major Projects in Karnataka

Status	Category	ID	Project Name	Length (km)	Project Cost (10 mil. INR)	Investor	Type	Term	Progress/Schedule
Ongoing	Inter city	KO1	4 laning of Hoskote to Dobbaspet section of NH207	80.02	720.69	NHAI (BOT)	Widening (DBFOT) 4 lanes	Short	Construction to be started in May 2014
		KO2	Karnataka State Highways Improvement Project	Total 3,400km State Road in KT	WB Loan 2 bil USD	KRDCL	Improvement + Widening.	Short and Medium	
		KO3	Mulbagal - Karnataka Border Section of NH-4	22	141.11	NHAI (BOT)	Widening 4 lanes	Short	Under Construction. Expected completion by July 2014.
Announced Plan	Inter city	KA1	4 laning of Development of Road Tamilnadu Border to Attibele-Sarjapur – Hoskote -Jangamakote-Shidlgatta Join SH-58 and Other Connecting Roads	89.12	356.48	KRDCL	New (DBOT)	N.A	Bidding
		KA2	4 laning of Sira-Madugiri-	351.61	1,432.4	KRDCL	New	N.A	Bidding

Status	Category	ID	Project Name	Length (km)	Project Cost (10 mil. INR)	Investor	Type	Term	Progress/Schedule
			Gowribidanur-Chikkaballapura-Shdalgatta- Chithamani-Sronivasapur-Mulbagal(SH-58) and Other Connecting Roads				(DBOT)		
		KA3	Development of Road from AP Border Near Kothadoddi- Yaragara-Purthipalli to join SH-23 Near Kapgal and Other Connecting Roads		468.68	KRDCL	New (DBOT)	N.A	Bidding
		KA4	Development of road from Chikkaballapur NH-7 Vijipur-Vemagal-Kolar-Nandi cross and other connecting roads	131	320	BOT-Toll	N.A	N.A	Bidding
		KA5	Development of road from Chikkaballapura-Nandi-Doddaballapur-Maduray-Nelamangala-Taverekere-Kengeri-Kanakapura road - Jigani- Anekal and other connecting roads	N.A	406	BOT-Toll	N.A	N.A	Bidding
		KA6	Development of road from Hoskote-Mallur-Tekal-Bangarpet-Baythmangal-AP Border SH-95 and connecting roads	N.A	585	BOT-Toll	N.A	N.A	Bidding
	Urban Arterial	KA7	Construction of Peripheral Ring Road around Bangalore City	65	5,000	BDA	New (BOT)	N.A	DPR preparation
Under Study	Intercity	KU1	Chikkanayakanahalli-Hassan Road	74	241	N.A.	New 4 lanes	N.A	Under Study
	Urban Arterial	KU2	Construction of Expressway (State Highway, Special) from Outer Ring Road to International Airport in Devanahalli Taluk	21.2	1,000	N.A.	New (BOT)	N.A	Under Study
		KU3	Satellite Township Ring Road (Bengaluru) and Individual Town Ring Roads	N.A.	N.A.	GoKT	New + Widening	N.A	

Table 3Existing Major Projects in Andhra Pradesh

Status	Category	ID	Project Name	Length (km)	Project Cost (10 mil. INR)	Investor	Type	Term	Progress/Schedule
Announced Plan	Intercity	AA1	Design Construction Finance Operation and Maintenance of Puthalapattu Naidupeta Road SH 61 from Km 0 to 41 and Km 59 to 116 under PPP on BOT Basis	98	528	APRDC	BOT (Toll) 4 lanes	Short and Medium	Bidding
		AA 2	4 laning of Chennai-Chittoor – Bangalore Road from Karnataka/A.P Border to A.P/Tamilnadu Border from Km 133/360 to 216/975 section of NH 4 in A.P state	84	865	AP Roads & Buildings Dept	DBFOT (Widening) 4 lanes	short	DPR yet to be submitted.
Under Study	Intercity	AU 1	Kalahasti-Pitchatur Road	42.60	81	N.A	BOT (annuity)	N.A	N.A
		AU 2	Molakacheruvu – Knadlamadugu road	41.3	64	N.A	BOT (annuity)	N.A	N.A
		AU 3	B.Kothakota – Beerangi Road	9.5	19	N.A	BOT (annuity)	N.A	N.A
		AU 4	Punganur-Sankarayalapet-Baireddypalli Road	33.29	69	N.A	BOT (annuity)	N.A	N.A
		AU 5	Gangadhara Nellore – Balijikandriga Road	32.30	88	N.A	BOT (annuity)	N.A	N.A

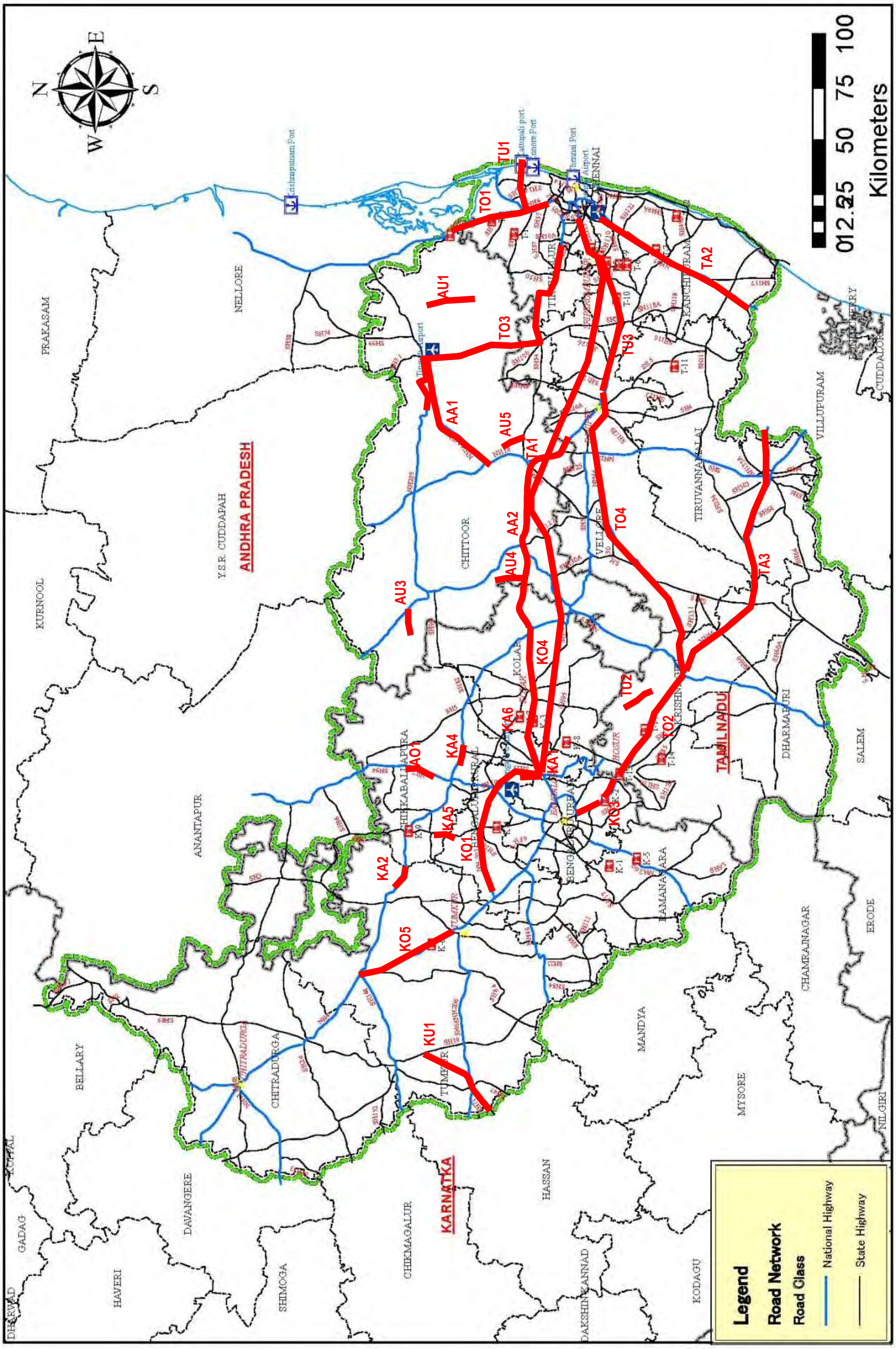


Figure1 Location Map of Existing Major Road Projects in CBIC Area

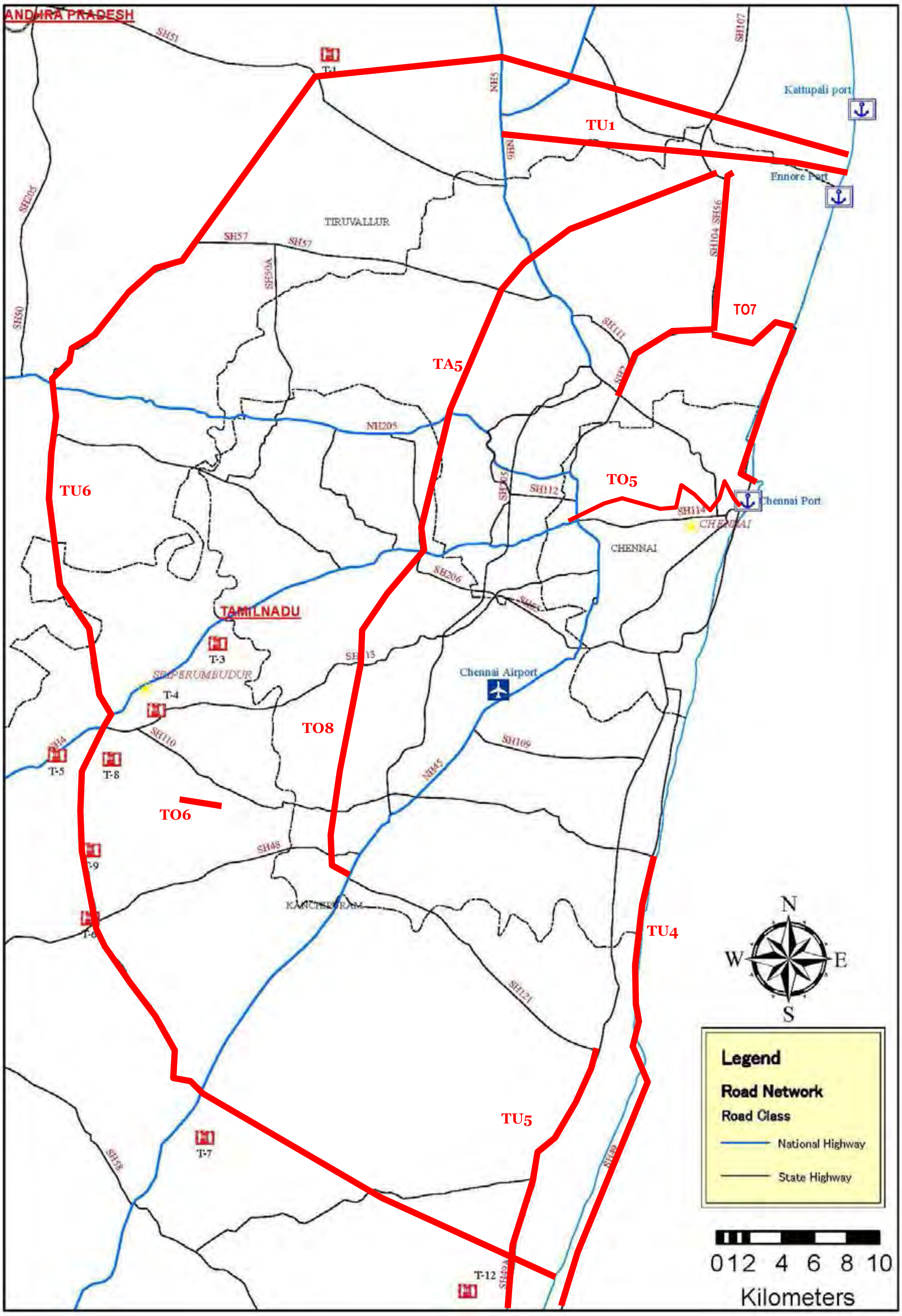


Figure2 Location Map of Existing Major Road Projects in Chennai Metropolitan Area

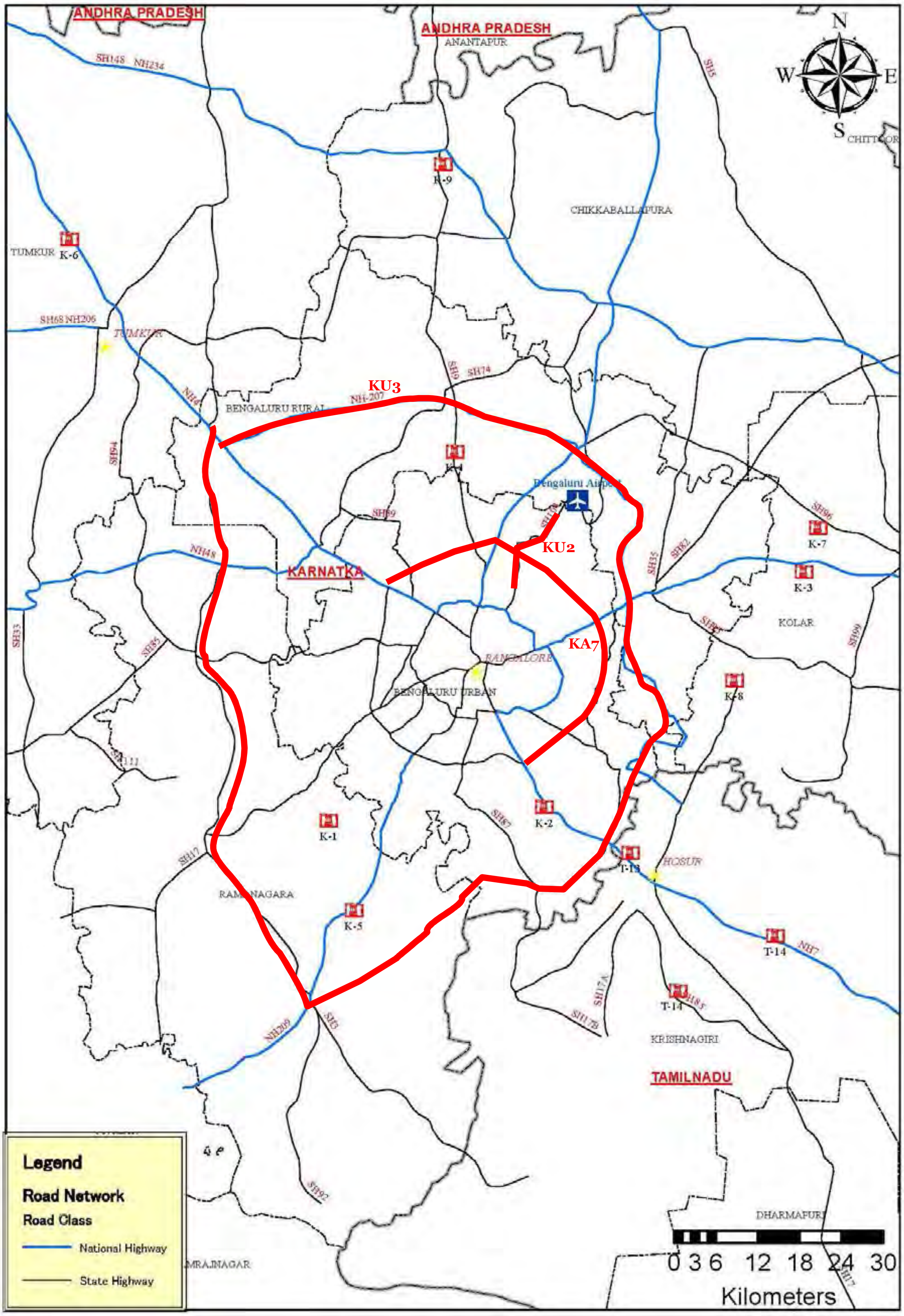


Figure3 Location Map of Exisitng Major Road Projects in Bengaluru Metropolitan Area

Current and Proposed Projects on identified Logistic corridors withinCBIC Area

A network of primary, secondary and urban primary roads has been identified as the main logistic corridors within the CBIC area. The following table indicates the current and proposed projects over 20 years on these corridors only

Table 4:Current and Proposed Projects on identified Logistic corridors withinCBIC Area

Classification	Corridor ID		Road Name	Section		Length (km)	Number of Lanes						Project Cost (mil. USD)			
							Present	Committed Project	Proposed							
									2018	2023	2028	2033	2018	2023	2028	2033
Primary	P1	a	NH4	Chitradurga	Hiriyur	75	6	-	6	6	8	8	0	0	90	0
		b		Hiriyur	Tumkur	87	6	-	6	6	6	8	0	0	0	104.4
		c		Tumkur	Bangalore North	60	6	-	6	8	8	8	0	72	0	0
	P2	a	NH4	Bangalore East	Kolar	40	6	-	6	6	6	6	0	0	0	0
		b		Kolar	Palamaner	72	4	4	4	4	4	4	0	0	0	0
		c		Palamaner	Chittoor	44	2	4	4	4	4	4	52.8	0	0	0
	P3	a	NH4	Wallajah	Kancheepuram	37	4	6	8	8	8	8	81.4	0	0	0
		b		Kancheepuram	Chennai	47	4	6	6	6	8	8	56.4	0	56.4	0
	P4	a	NH5	Nellore	Chilakur	47	4	-	4	4	4	4	0	0	0	0
		b		Chilakur	Pnneri	89	6	6	6	6	6	6	0	0	0	0
		c		Pnneri	Mathavaram	22	6	-	6	6	6	6	0	0	0	0
	P5	a	NH7	Penukonda	Gorantla	33	4	-	4	4	4	4	0	0	0	0
		b		Gorantla	Chikkaballapura	58	4	-	4	4	4	4	0	0	0	0
		c		Chikkaballapura	Bangalore North	51	6	-	6	6	8	8	0	0	61.2	0
	P6	a	NH7	Bangalore South	Anekal	23	6	-	6	8	8	8	0	27.6	0	0
		b		Anekal	Krishnagiri	58	6	-	6	6	6	6	0	0	0	0
		c		Krishnagiri	Dharmapuri	42	6	-	6	6	6	6	0	0	0	0
		d		Dharmapuri	Dharmapuri	26	6	-	6	6	6	6	0	0	0	0
	P7	a	NH46	Krishnagiri	Vellore	112	6	6	6	6	8	8	0	0	134.4	0
		b		Vellore	Wallajah	36	6	6	6	8	8	8	0	43.2	0	0
	P8	a	NH18	Chittoor	Puthalapattu	18	2	-	2	2	2	2	0	0	0	0
		b	NH18A	Puthalapattu	Renigunta (Urban)	66	2	4	4	4	4	4	79.2	0	0	0
		c	NH205-SH61	Renigunta (Urban)	Chittamur	52	2	-	2	4	4	4	0	62.4	0	0
	P9	a	Bangalore-Chennai Expressway	Bangalore East	Chennai	270	-	6	-	6	6	6		1100		
Secondary	S1	a	NH206	Tumkur	Chiknayakanhalli	58	2	4	4	4	8	8	0	69.6	127.6	0
		b		Chiknayakanhalli	Tiptur	35	2	4	4	4	6	8	0	42	42	42
	S2	a	NH48	Nelamangala	Knigal	70	4	-	4	6	8	8	0	84	84	0
	S3	a	SH96	Gorantla	Dod Ballapur	86	2	-	2	4	4	4	0	103.2	0	0
		b	SH96	Dod Ballapur	Bangalore North	27	2	-	4	4	8	8	32.4	0	59.4	0
	S4	a	NH209	Bangalore South	Kanakapura	60	2	-	2	4	6	8	0	72	72	72
	S5	a	SH82	Hoskote	Kolar	21	2	-	2	4	6	8	0	25.2	25.2	25.2
		b	SH82	Kolar	Srinivaspur	40	2	-	2	2	4	4	0	0	48	0
		c	SH99	Srinivaspur	Madanapalle	42	2	-	2	2	2	2	0	0	0	0
		d	NH205	Madanapalle	Pileru	55	2	-	2	2	2	2	0	0	0	0
		e	NH205	Pileru	Renigunta (Urban)	73	2	-	2	2	2	2	0	0	0	0
	S6	a	NH205	Mulakalacheruvu	Madanapalle	40	2	-	2	2	2	2	0	0	0	0
		b	NH219	Madanapalle	Palamaner	58	2	-	2	2	2	2	0	0	0	0
	S7	a	NH18	Kalakada	Pileru	32	2	-	2	2	2	2	0	0	0	0
		b		Pileru	Puthalapattu	35	2	-	2	2	2	2	0	0	0	0
	S8	a	NH205	Renigunta (Urban)	Tiruttani	57	4	4	4	4	4	4	0	0	0	0
		b	SH58	Tiruttani	Kancheepuram	39	2	-	4	4	4	4	46.8	0	0	0
	S9	a	NH205	Tiruttani	Tiruvallur	40	2	4	4	4	4	4	48	0	0	0
		b		Tiruvallur	Chennai	15	4	4	4	4	4	4	0	0	0	0
	S1	a	New	Nellore	Muthukur	33	2	-	4	4	4	4	39.6	0	0	0

Classification	Corridor ID		Road Name	Section		Length (km)	Number of Lanes						Project Cost (mil. USD)			
							Present	Committed Project	Proposed							
									2018	2023	2028	2033	2018	2023	2028	2033
	0															
	S11	a	NH219	Palamaner	Venkatagirikota	38	2	-	2	2	2	2	0	0	0	0
		b		Venkatagirikota	Krishnagiri	64	2	-	2	2	2	4	0	0	0	76.8
	S12	a	NH4-New	Chittoor	Katpadi	32	2	-	4	4	4	4	38.4	0	0	0
		b	NH234	Katpadi	Vellore	20	2	-	2	2	2	2	0	0	0	0
		c		Vellore	Polur	25	2	-	2	4	8	8	0	30	55	0
		d		Polur	Tiruvannamalai	41	2	-	2	2	2	2	0	0	0	0
	S13	a	NH4	Gudipala	Wallajah	35	2	4	4	4	6	8	42	0	42	42
	S14	a	SH116-SH5	Kancheepuram	Tindivanam	84	2	-	2	2	2	4	0	0	0	100.8
	S15	a	NH66	Krishnagiri	Uthangarai	48	2	-	2	2	2	2	0	0	0	0
		b	NH66	Uthangarai	Tiruvannamalai	55	2	-	2	4	4	6	0	66	0	66
		c	NH45	Maduranthakam	Chengalpattu	46	4	6	6	6	6	6	55.2	0	0	0
		d	NH45	Chengalpattu	Chengalpattu	15	4	6	6	6	6	6	18	0	0	0
Urban Primary	U1	a	Peripheral Ring Road	Bangalore North	Bangalore South	65	-	8	-	8	8	8	900			
		b		Bangalore South	Bangalore North	45	4	-	4	4	4	4	0	0	0	0
	U2	a	Satellite Ring Road NH207	Nelamangala	Hoskote	99	2	4	4	4	6	8	118.8	0	118.8	118.8
		b		Hoskote	Hosur	45	2	-	4	6	8	8	54	54	54	0
		c	New	Hosur	Kanakapura	52	-	-	-	4	6	8	0	0	62.4	62.4
		d	SH3	Kanakapura	Nelamangala	98	2	-	4	4	4	4	117.6	0	0	0
	U3	a	Outer Ring Road	Ponneri	Poonamallee	30	-	6	6	6	6	6	161			
		b		Poonamallee	Chennai	31	-	6	6	6	6	6				
	U4	a	Peripheral Ring Road	Ponneri	Uthukkottai	41	-	-	-	4	4	4	0	90.2	0	0
		b		Uthukkottai	Chengalpattu	70	2	-	2	4	4	4	0	84.0	0	0
		c		Chengalpattu	Chengalpattu	28	-	-	-	4	4	4	0	61.6	0	0
						3,488							1,942	2,087	1,132	710
													5,871			

Note: 3 Port Access projects are not included in this list – Northern Port Access Road, Maduravoyal – Chennai Port Elevated Expressway and the Ennore – Manali Road Improvement Project.

Source: JICA Study Team

Source: JICA Study Team

Figure4: Current and Proposed Projects on identified Logistic corridors within CBIC Area

Annexure 4: Railway

Table 1:Railway Projects in CBIC Area

Source: JICA Study Team

Source: JICA Study Team

Figure1: Location Map of Major Railway Project in CBIC Area

Annexure 5: Airports

A. Historical Traffic Data for airports in the CBIC region:

a. Chennai International Airport

Passengers								
Years	International				Domestic			Grand total
	Embark	Disembark	Transit	Total	Embark	Disembark	Total	Total
2002-2003	955392	939762	52783	1947937	1124906	1088503	2213409	4161346
2003-2004	1014817	990824	48402	2054043	1295624	1206154	2501778	4555821
2004-2005	1184808	1158211	57651	2400670	1659954	1573302	3233256	5633926
2005-2006	1351414	1235460	19764	2606638	2113429	2059916	4173345	6779983
2006-2007	1501651	1388118	6161	2895930	3032683	3045513	6078196	8974126
2007-2008	1758853	1640676	10724	3410253	3653328	3596173	7249501	10659754
2008-2009	1865076	1782497	16335	3663908	3087259	3092023	6179282	9843190
2009-2010	1937004	1897674	25732	3860410	3344514	3326361	6670875	10531285
2010-2011	2147500	2074124	24212	4245836	3921074	3882769	7803843	12049679
2011-2012	2191041	2104296	12701	4308038	4297438	4319742	8617180	12925218
2012-2013	2284318	2139313	38788	4462419	4139651	4174690	8314341	12,776,760.00

Freight								in tonnes
Years	International				Domestic			Grand total
	load	unload	Transit	total	load	unload	total	
2002-2003	63265	43571	-	106836	15987	13837	29824	136660
2003-2004	68443	51120	-	119563	20152	14408	34560	154123
2004-2005	82285	64158	-	146443	23066	16361	39427	185870
2005-2006	89436	78417	-	167853	21796	16322	38118	205971
2006-2007	99296	95899	-	195195	25058	18072	43130	238325
2007-2008	107530	120174	-	227704	24994	17910	42904	270608
2008-2009	105663	113899	-	219562	29652	23154	52806	272368
2009-2010	128812	120710	-	249522	40830	30416	71246	320768
2010-2011	159725	135772	-	295497	54247	39089	93336	388833
2011-2012	150128	122333	-	272461	48506	36224	84730	357191
2012-2013	134588	102517		237105	44659	34115	78774	315,879.00

Aircraft Movement								
Years	international				domestic			grand total
	schedule	non schedule	Transit	total	schedule	non schedule	total	
2002-2003	11178	3312	-	14490	29863	0	29863	44353
2003-2004	11605	2897	-	14502	36749	0	36749	51251

2004-2005	15591	2520	-	18111	43122	0	43122	61233
2005-2006	17877	3278	-	21155	47900	0	47900	69055
2006-2007	23567	0	-	23567	76208	0	76208	99775
2007-2008	27690	0	-	27690	88175	0	88175	115865
2008-2009	30199	254	-	30453	84969	489	85458	115911
2009-2010	31172	502	-	31674	77974	517	78491	110165
2010-2011	31500	711	-	32211	78145	422	78567	110778
2011-2012	32723	812	-	33535	86246	346	86592	120127
2012-2013	33377	725	-	34102	83020	296	83316	117418

b. Bengaluru International Airport

Passengers								
Years	**International**				**Domestic**			**grand total**
	Embark	**Disembark**	**Transit**	**Total**	**Embark**	**Disembark**	**Total**	**total**
2002-2003	181491	185699	-	367190	1217159	1179934	2397093	2764283
2003-2004	242284	235350	-	477634	1344891	1358723	2703614	3181248
2004-2005	341143	337063	-	678206	1746743	1688434	3435177	4113383
2005-2006	438256	424396	-	862652	2444111	2347940	4792051	5654703
2006-2007	635512	637940	-	1273452	3458906	3405059	6863965	8137417
2007-2008	779459	768973	-	1548432	4393481	4197307	8590788	10139220
2008-2009	817479	824226	-	1641705	3603082	3517376	7120458	8762163
2009-2010	943894	998257	-	1942151	3988637	4013575	8002212	9944363
2010-2011	1079307	1144117	-	2223424	4639804	4729037	9368841	11592265
2011-2012	1167136	1186685	-	2353821	5082286	5262236	10344522	12698343
2012-2013	1260972	1243708	-	2504680	4608340	4880867	9489207	11,993,887.00

Freight								**in tonnes**
Years	**International**				**Domestic**			**grand total**
	load	**unload**	**Transit**	**total**	**load**	**unload**	**total**	
2002-2003	22519	19013	-	41532	23586	17910	41496	83028
2003-2004	21924	25305	-	47229	22266	21638	43904	91133
2004-2005	30885	33548	-	64433	24977	21166	46143	110576
2005-2006	39645	42346	-	81991	27414	22772	50186	132177
2006-2007	46465	52927	-	99392	35404	28970	64374	163766
2007-2008	51554	56606	-	108160	39432	30555	69987	178147
2008-2009	49292	50398	-	99690	29578	28732	58310	158000
2009-2010	54956	47795	-	102751	37663	34230	71893	174644
2010-2011	73692	61571	-	135263	47293	40222	87515	222778

Freight								in tonnes
2011-2012	74956	66737	-	141693	41740	41516	83256	224949
2012-2013	83098	60904	-	144002	40814	41732	82546	226,548.00

Years	international				domestic			grand total
	schedule	non schedule	Transit	total	schedule	non schedule	total	
2002-2003	3693	200	-	3893	34382	1794	36176	40069
2003-2004	4508	706	-	5214	40058	1651	41709	46923
2004-2005	6409	623	-	7032	48481	34	48515	55547
2005-2006	7931	346	-	8277	61331	72	61403	69680
2006-2007	9982	564	-	10546	83755	125	83880	94426
2007-2008	10934	766	-	11700	101770	128	101898	113598
2008-2009	13566	354	-	13920	90724	333	91057	104977
2009-2010	13268	241	-	13509	90861	326	91187	104696
2010-2011	15063	524	-	15587	95813	83	95896	111483
2011-2012	17046	582	-	17628	100803	0	100803	118431
2012-2013	17731	609	-	18340	86299	3	86302	104642

c. Tirupati Airport

Passengers								
Years	international				domestic			grand total
	Embark	Disembark	Transit	total	Embark	Disembark	total	
2002-2003	-	-	-	-	8133	10775	18908	18908
2003-2004	-	-	-	-	6828	10107	16935	16935
2004-2005	-	-	-	-	22422	27916	50338	50338
2005-2006	-	-	-	-	38186	42644	80830	80830
2006-2007	-	-	-	-	73029	79938	152967	152967
2007-2008	-	-	-	-	80559	88774	169333	169333
2008-2009	-	-	-	-	76922	78124	155046	155046
2009-2010	-	-	-	-	77712	80079	157791	157791
2010-2011	-	-	-	-	85346	88516	173862	173862
2011-2012	-	-	-	-	118850	121831	240681	240681
2012-2013	-	-	-	-	141992	144556	286548	286548

Freight								in tonnes
Years	international				domestic			grand total
	Load	Unload	Transit	total	Load	Unload	total	
2002-2003	-	-	-	-	0	3	3	3
2003-2004	-	-	-	-	1	1	2	2
2004-2005	-	-	-	-	0	2	2	2

Freight								in tonnes
2005-2006	-	-	-	-	0	2	2	2
2006-2007	-	-	-	-	1	4	5	5
2007-2008	-	-	-	-	15	6	21	21
2008-2009	-	-	-	-	14	13	27	27
2009-2010	-	-	-	-	12	11	23	23
2010-2011	-	-	-	-	7	5	12	12
2011-2012	-	-	-	-	11	15	26	26
2012-2013	-	-	-	-	7	9	16	16

Aircraft Movement								
Years	international				domestic			grand total
	schedule	non schedule	Transit	Total	schedule	non schedule	total	
2002-2003	-	-	-	-	351	0	351	351
2003-2004	-	-	-	-	396	2	398	398
2004-2005	-	-	-	-	1038	46	1084	1084
2005-2006	-	-	-	-	1208	42	1250	1250
2006-2007	-	-	-	-	2578	113	2691	2691
2007-2008	-	-	-	-	3702	104	3806	3806
2008-2009	-	-	-	-	3568	138	3706	3706
2009-2010	-	-	-	-	2680	224	2904	2904
2010-2011	-	-	-	-	2208	66	2274	2274
2011-2012	-	2	-	2	3020	60	3080	3082
2012-2013	-	-	-	-	3588	64	3652	3652

d. Salem Airport

Passengers								
Years	international				domestic			grand total
	Embark	Disembark	Transit	Total	Embark	Disembark	Total	total
2002-2003	-	-	-	-	63	52	115	115
2003-2004	-	-	-	-	68	73	141	141
2004-2005	-	-	-	-	0	0	0	0
2005-2006	-	-	-	-	1	0	1	1
2006-2007	-	-	-	-	24	23	47	47
2007-2008	-	-	-	-	0	0	0	0
2008-2009	-	-	-	-	0	0	0	0
2009-2010	-	-	-	-	5124	3977	9101	9101
2010-2011	-	-	-	-	5982	4652	10634	10634
2011-2012	-	-	-	-	2035	1631	3666	3666
2012-2013	-	-	-_	-	6	7	13	13

Freight								in tonnes
Years	international				domestic			grand total
	load	unload		total	load	unload	total	
2002-2003	-	-	-	-	-	-	-	-
2003-2004	-	-	-	-	-	-	-	-
2004-2005	-	-	-	-	-	-	-	-
2005-2006	-	-	-	-	-	-	-	-
2006-2007	-	-	-	-	-	-	-	-
2007-2008	-	-	-	-	-	-	-	-
2008-2009	-	-	-	-	-	-	-	-
2009-2010	-	-	-	-	-	-	-	-
2010-2011	-	-	-	-	-	-	-	-
2011-2012	-	-	-	-	-	-	-	-
2012-2013	-	-	-	-	-	-	-	-

Aircraft Movement								
Years	international				domestic			grand total
	schedule	non schedule		total	schedule	non schedule	total	
2002-2003	-	-	-	-	-	56	56	56
2003-2004	-	-	-	-	-	64	64	64
2004-2005	-	-	-	-	-	0	0	0
2005-2006	-	-	-	-	-	4	4	4
2006-2007	-	-	-	-	-	10	10	10
2007-2008	-	-	-	-	-	0	0	0
2008-2009	-	-	-	-	-	0	0	0
2009-2010	-	-	-	-	258	0	258	258
2010-2011	-	-	-	-	312	2	314	314
2011-2012	-	-	-	-	148	12	160	160
2012-2013	-	-	-	-	0	8	8	8

e. Coimbatore Airport

Passengers								
Years	international				domestic			grand total
	Embark	Disembark	Transit	total	Embark	Disembark	total	
2002-2003	5964	4937	0	10901	125238	122825	248063	258964
2003-2004	5947	5480	2361	13788	133810	131726	265536	279324
2004-2005	5233	4900	3010	13143	192577	185455	378032	391175
2005-2006	4841	4574	5343	14758	277085	282048	559133	573891
2006-2007	5056	4708	4966	14730	425753	426486	852239	866969
2007-2008	25049	22218	5021	52288	506826	503691	1010517	1062805
2008-2009	46259	43276	0	89535	460285	460997	921282	1010817

Passengers								
2009-2010	48557	45989	0	94546	499375	515416	1014791	1109337
2010-2011	51965	48389	0	100354	571859	571610	1143469	1243823
2011-2012	52545	49729	0	102274	624748	618359	1243107	1345381
2012-2013	57417	54980	0	112397	589691	595716	1185407	1297804

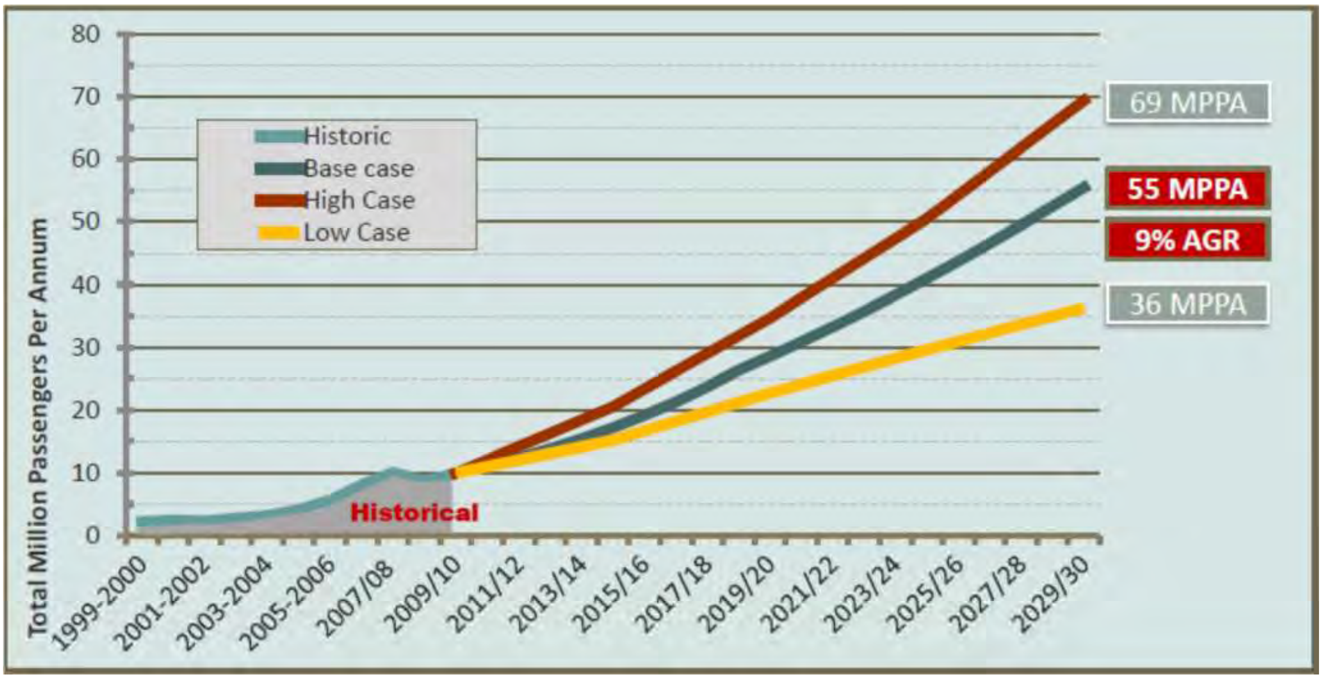
Freight								in tonnes
Years	international				domestic			grand total
	Load	Unload	Transit	total	Load	Unload	total	
2002-2003	808	139	-	947	1061	1456	2517	3464
2003-2004	1600	264	-	1864	1069	1682	2751	4615
2004-2005	808	157	-	965	1800	1920	3720	4685
2005-2006	1359	590	-	1949	1478	1794	3272	5221
2006-2007	1311	301	-	1612	1606	2039	3645	5257
2007-2008	1026	150	-	1176	1519	2098	3617	4793
2008-2009	785	132	-	917	2482	2134	4616	5533
2009-2010	601	101	-	702	4290	1995	6285	6987
2010-2011	362	28	-	390	3591	3046	6637	7027
2011-2012	455	12	-	467	3044	4237	7281	7748
2012-2013	567	16	-	583	2359	3738	6097	6680

Aircraft Movement								
Years	international				domestic			grand total
	schedule	non schedule	-	total	schedule	non schedule	total	
2002-2003	519	2	-	521	3811	0	3811	4332
2003-2004	624	0	-	624	4752	17	4769	5393
2004-2005	618	0	-	618	6473	13	6486	7104
2005-2006	782	1	-	783	8520	8	8528	9311
2006-2007	674	0	-	674	12840	18	12858	13532
2007-2008	915	0	-	915	15438	4	15442	16357
2008-2009	926	0	-	926	14355	0	14355	15281
2009-2010	850	0	-	850	14346	0	14346	15196
2010-2011	850	3	-	853	13423	0	13423	14276
2011-2012	858	4	-	862	13710	0	13710	14572
2012-2013	842	4	-	846	12006	0	12006	12852

Source: AAI

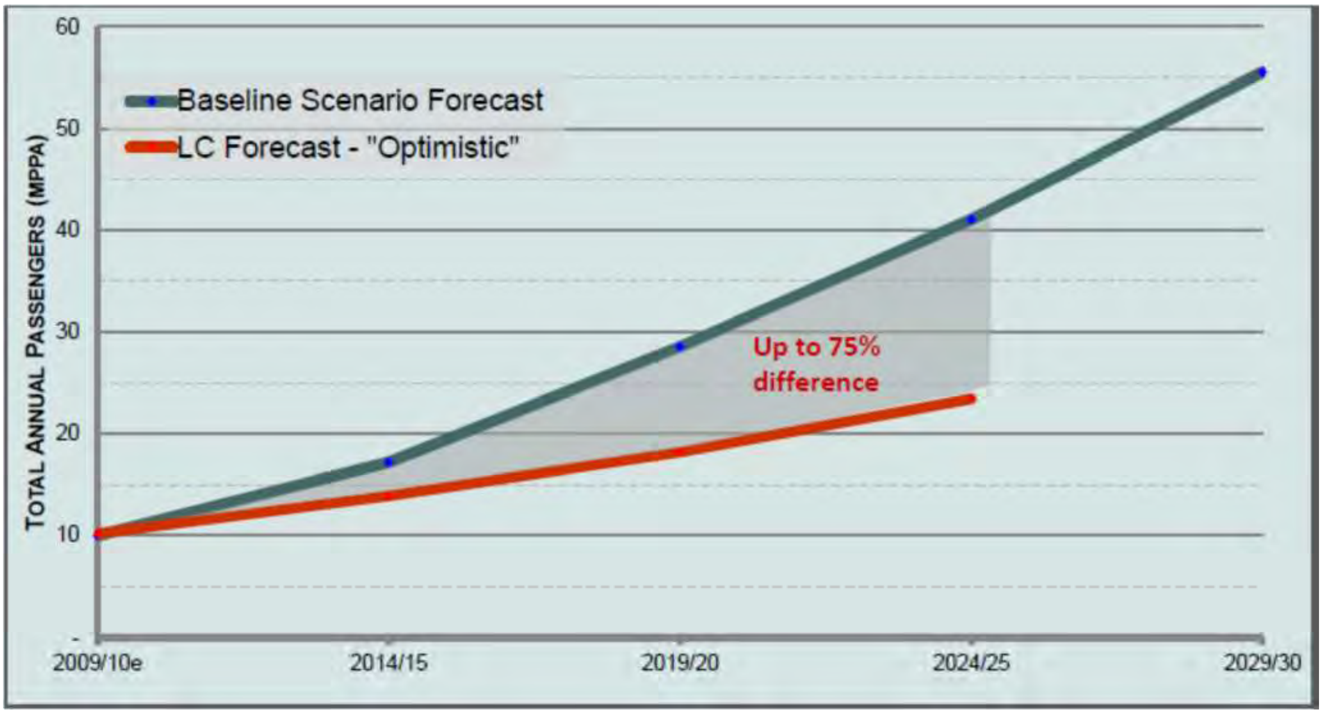
B. Traffic Forecasts by the Bengaluru International Airport:

a. Revised traffic forecasts for Bengaluru International Airport:



(Source: Bengaluru International Airport)

b. 2010 Baseline Forecast compared to old forecast:



(Source: Bengaluru International Airport)

C. Highlights of the 'Techno-Economic Feasibility Study for Chennai Dual Airport operations' by AAI :

- Government of Tamil Nadu appointed TIDCO to undertake the study on various possible sites where a second airport could be located in the Chennai region. The report suggested development of a green0field airport at Sriperumbudur over the long-term.

- Government of Tamil Nadu thus, directed AAI to undertake the Techno-Economic Feasibility Study for the site at Sriperumbudur. AAI appointed ICAO (who further delegated Louis Berger Group Inc.) for the study on the possibility of dual airport operations in the Chennai region.

- The Techno-Economic feasibility study analysed key issued regarding the physical topography of the region, weather, services availability; Airspace – ATC, interactions with existing civil and military operations in the region; Access & Connectivity – road and rail connectivity; Planning & Environment – noise, population, disturbance etc.; and the overall financial cost of the proposed project.

- ICAO Study suggested the following Airport Development Plan:

    - Out of a total area of around 7,000 acres identified by the State government, 4,816 acres has been identified for the development of the proposed airport at Sriperumbudur.
    - The Development Plan is divided into three phases:
        - Phase 1 (2022 – 2026) – 9.2 million passenger capacity
        - Phase 1 (2027 – 2031) – 17 million passenger capacity
        - Phase 1 (2032 – 2041) – 38.7 million passenger capacity
    - Airport is to be designed to cater to the Super Jumbo (Code 4F) aircrafts
    - Phase I was planned to be commissioned by 2019-2020 to handle traffic as the existing Chennai International Airport is expected to reach its operating capacity by 2020.
    - The anticipated development cost (Capex) for the proposed airport as per the Development Plan is:
        - Phase 1 – Rs. 4000 crores
        - Phase 2 – Rs. 1475 crores
        - Phase 3 – Rs. 4125 crores

Traffic projections at the proposed airport:

Source: AAI

D. Key features of airports in the CBIC region :

Sr. No.	Name of Airport	Location & State	Status (Operational / Non-operational)	Land Area	Number of Existing Runways at the airport	Details of existing runways	Operational Hours	Expected / Proposed No. of Runways
1	**Cuddapah Airport**	Andhra Pradesh	Non operational	229.05 Acres	Runway : 1	3600 ft X 75 ft	Nil	--
2	**Tirupati Airport**	Andhra Pradesh	Operational	312 Acres	Runway : 2	Length-7500 ft	13 hrs (8 AM to 9 PM)	--
3	**Chennai International Airport**	Tamil Nadu	Operational	1301.28 Acres	Runway : 4 (7,25,30,12) 7&25-available 30&12-Not available	Length- 12001 ft	24 hrs	Secondary Runway-2035m was closed in 2009; New runway proposed-3445 m (Presently on hold as Sriperumbudur airport is under consideration)
4	**Vellore Airport**	Tamil Nadu	Non operational	51.50 Acres	Runway : 1	2600 ft X 500 ft	Nil	--
5	**Coimbatore International Airport**	Tamil Nadu	Operational	420.33 Acres	Runway : 1	Length-9760 ft	24 hrs	This runway is further planned for extension to the length of

Sr. No.	Name of Airport	Location & State	Status (Operational / Non-operational)	Land Area	Number of Existing Runways at the airport	Details of existing runways	Operational Hours	Expected / Proposed No. of Runways
								12500 ft.
6	**Sriperumbudur airport**	Tamil Nadu	(Proposed)	4,800 acres	To be decided	To be decided	Nil	--
7	**Salem Airport**	Tamil Nadu	Operational	136.29 Acres	Runway : 1	6000 ft X 150 ft	3 PM to 5 PM (2 hrs) except Tuesdays and Saturdays	--
8	**Bangaluru International Airport**	Karnataka	Operational	4000 Acres	The passenger terminal for both domestic and international passengers, a runway of four thousand meters length, 3 rapid exits and a taxiway system, 42 aircraft stands and 8 passenger boarding bridges including one double arm aerobridge, a four lane main access road, the central access	4120 m (13520 ft)	24 hrs	Planning for second runway and expecting to start the work in last quarter of this year.

Sr. No.	Name of Airport	Location & State	Status (Operational / Non-operational)	Land Area	Number of Existing Runways at the airport	Details of existing runways	Operational Hours	Expected / Proposed No. of Runways
					road, a secondary access road and an airside service road, approximately 2,000 car parks, various auxiliary buildings, a fuel farm, 2 major general cargo warehouses and flight kitchens.			
9	**Mysore Airport**	Karnataka	Operational	661 Acres	Runway : 1 Taxiway : 23M	1740 X 30m (6098 ft)	10 AM to 5 PM (8 hrs) except Tuesdays and Saturdays	planning to upgrade the length to anywhere between 7870 ft and 8530 ft.

Additional green-field airport development has been proposed at Mulbagal and Krishnapatnam. The detailed information such as the required number of runways, length of the runways at these proposed airports etc. can be ascertained by undertaking a more detailed traffic study for these proposed airports at a later stage. However, these airports, once developed, must reflect the international norms to promote regional development in the CBIC region.

Annexure 6: Urban Transportation

Table 1: Major Projects for Urban/Public TransportSector (Chennai Metropolitan Area)

ID	Project Title	Project Description	Status	Project Cost (Million USD)	Implementing Agency	Fund Source if any	Priority
Urban Road							
CUR 01	Outer Ring Road (ORR): -Phase I: Vandalur (NH45) – Nemilicheri (NH205): 29.65 km -Phase II: Nemilicheri (NH205) – Minjur: 33.1 km	-To provide heavy trucks with alternative detour routes to/from Ports and from/to industrial areas, such as Sriperumbudur, Oragadam, and Mahindra World City, etc. -Total length: 62km, ROW: 122m (6 lanes+2 lane service road) with land for railway at the center.	Phase I (South section:29.65 km) On-going (under construction) Phase II(North section) 80% of land acquisition completed	(Phase I) 202 (Phase II) 184	GoTN	DBFOT	A
CUR 02	Peripheral Ring Road (PRR) From Mamallapuram to Ennore	-To provide heavy trucks with alternative detour routes to/from Ports and from/to industrial areas, such as Sriperumbudur, Oragadam, and Mahindra World City, etc. -To Increase connectivity between industrial parks each other so as to smooth delivery of raw material and product of suppliers and assemblers. -110 km, New & Widening (to 4 lanes)	DPR prepared (May 2013)	266	GoTN	N.A.	A
CUR 03	Northern Port Access Road	-Contribution to capacity augmentation for access to the Ennore Port. -New 4-lane road from Northern Gate of the Ennore Port to Thatchur at NH5, 25.5 km	Under Study	70	NHAI	N.A.	A
CUR 04	Ennore Manali Road Improvement Project (EMRIP) including Bridges	-To enhance connectivity to the both Chennai Port and Ennore Port. -30 km, Improvement & Widening (from 2 lanes to 4 lanes)	On-going Delayed due to land acquisition issue	112	NHAI, Ennore Port, GoTN	N.A.	A
CUR 05	Elevated Freight Corridor (along the banks of Cooum river from Chennai Port to Maduravoyal)	-Direct connection to the Chennai Port from Maduravoyal at NH4 with an elevated expressway to reduce transport time. -Total length: 19 km, ROW:20 m, 4-lanes	On-going (30% of work completed) Re-alignment issue	310	NHAI	BOT	A
Public Transport							
CPT01	BRT (1) on ORR (Phase I section)	-To serve the north – south movements of passengers connecting	Proposed in existing Master Plan	84	BRT SPV		B

ID	Project Title	Project Description	Status	Project Cost (Million USD)	Implementing Agency	Fund Source if any	Priority
		the Vandalur railway station to Pattabiram railway station via. ORR.-Length: 23 km, pphpd = 8000					
CPT02	BRT (2) on ORR (Phase II section)	-To extend the BRT service on the ORR Phase II section from Pattabiram to Minjur -Length: 32 km, pphpd = 8000	Proposed by the Study Team	90	BRT SPV		B
CPT03	BRT (3) along costal road Tiruvanmiyur to Kelambakkam IT-Corridor	-To provide an access measure for passengers to/from industrial parks in southern areas - 23km long	Proposed in existing Master Plan	65	BRT SPV		B
CPT04	Monorail/LRT From Sriperumbadur to Luz Church Road via. Poonamallee	-To connect passenger movements directly from the industrial core areas to the city center. 42 km	Proposed in existing Master Plan	1,179	Monorail /LRT SPV		B
CPT05	Inter-City Bus Terminals at the intersection of ORR and National Highways. 1) Redhills 2) Thirunindravur 3) Varadharajapuram 4) Vandalur	-To accommodate long distance passengers for transfer to intra city buses.	Proposed in existing Master Plan	150	GoTN		B
Suburban Trains							
CST01	From Thiruvanmiyur to Mamallapuram	-To provide suburban commuter services for industrial parks. -42 km operation length	Proposed in existing Master Plan	157	Southern Railway		B
CST02	From Chengalapattu to Mallapuram	- To provide suburban commuter services for industrial parks. -27 km operation length	Propsed in existing Master Plan	101	Southern Railway		C
Others							
CITS	Introduction of ITS to Ring Roads and inter modal systems	-To realize effective and smooth connectivity to/from the sea ports and industrial cores.	Proposed by the Study Team	50	Unified Metropolitan Transport Authority (UMTA)		A
CTR	Capacity Building for Public Transport and ITS	-To maintain and realize the effective use/operation of existing and planned transport facilities	Proposed by the Study Team	3	Unified Metropolitan Transport Authority (UMTA)		A

Source: JICA Study Team
Base Map: Provided by JETRO

Figure 1: Location Map of Major Urban Road Project in Chennai Metropolitan Area

Source: JICA Study Team
Base Map: Provided by JETRO

Figure 2: Location Map of Major Public Transport Project in Chennai Metropolitan Area

Table 2 Major Projects for Urban/Public TransportSector (Bengaluru Metropolitan Area)

No	Project Title	Project Description	Status	Project Cost (Million USD)	Implementing Agency	Fund Source if any	Priority
Urban Road							
BUR 01	Peripheral Ring Road (PRR): Phase I	-To mitigate traffic congestion in the city and to prevent through traffic to enter city center. -65 km (Phase I), 8 lanes (4x2)	DPR preparation	936	BDA	BOT	A
BUR 02	Peripheral Ring Road (PRR): Phase II	- To mitigate traffic congestion in the city and to prevent through traffic to enter city center. -51 km (Phase II)	Possibility of alternative use of the existing NICE road	734 (Estimate)	BDA	N.A.	B
BUR 03	Satellite Towns Ring Road	-To support the development of Satellite Towns and mitigate excessive concentration to the Bengaluru city. -To connect industrial parks by the Ring Road with Satellite Towns. Total length 204 km, + 8 city rings 163 km New & widening	On-going (Dobbasapete – Hoskote 80 km widening)	344 (Estimate) On-going 80 km section = 135	GoKT	DBFOT	A
BUR 04	Widening of NH207 (between NH4 and NH7)	-A key access road to NH7 from industrial parks located in surrounding areas of Bengaluru -To ensure a smooth transport route for suppliers in Hosur to the industrial parks located in Hoskote and Kolar. -Approximately 47 km	New	(Estimate) 79	GoKT	N.A.	A
Public Transport							
BPT01	BRT on PRR (Hosur Road to Tumkur Road ; Western PRR)	-To provide circular services for passengers inside city area. -Dedicated bus lane available on either side of corridor. -42.9 km length	Proposed in existing Master Plan	112	BRT SPV	N.A.	C
BPT02	BRT on PRR (Tumkur Road to Hosur Road; Eastern PRR)	-The same as above. -78.5 km	Proposed in existing Master Plan	206	BDA	N.A.	B
Suburban Trains							
BST01	Kengeri – Ramanagaram 32 km	-To provide with Townships commuter service for Townships, Industrial Nodes such as Ramanagara, Hosur, Tumkur, and Doddaballapur.	Propsed in existing Master Plan	90	South Western Railway	N.A.	B
BST02	Baiyyappanahalli – Hosur 41 km		Proposed in existing Master Plan	115	South Western Railway	N.A.	B
BST03	Yeshwantpur – Tumkur 64 km		Proposed in existing Master Plan	180	South Western Railway	N.A.	B
BST04	Yelahanka – Doddaballapur		Proposed in existing	67	South Western	N.A.	B

No	Project Title	Project Description	Status	Project Cost (Million USD)	Implementing Agency	Fund Source if any	Priority
	24 km		Master Plan		Railway		
Others							
BITS	Introduction of ITS to Ring Roads and inter modal systems	-To realize effective and smooth connectivity to/from the airport and industrial cores.	Proposed by the Study Team	50			A
BTR	Capacity Building for Public Transport and ITS	-To maintain and realize the effective use/operation of existing and planned transport facilities	Proposed by the Study Team	3	GoKT		A

Source: JICA Study Team

Figure3 Location Map of Major Urban/ Public Transport Project in Bengaluru Metropolitan Area

Annexure 7: Logistics

a. Container Freight Stations in and around Chennai

Sl.No.	Name	Notifed Area	Stacking Area	Handling Capacity (TEUs per month)	Container Traffic (2011-12*)	Container Traffic (2012-13*)	Equipments	
		Area (in acres)	Area (in lacs sq. ft.)	Capacity			Rubber Tired Gantry Cranes(RTG)	Reach Stacker (RS)
1	A. S Shipping	37.0	5	11,250	38176	32030	4	3
2	ALL CARGO	25.0	8	18,000	81187	60283	2	6
3	BALMER LAWRIE	22.0	6	13,500	44731	35118		6
4	GDL II	6.5	2	3,375	70402	73228		2
5	Continental - Mad	12.0	2	3,375	14657	19960		3
6	Continental - Red	16.9	4	9,000	-	16086		3
7	DR LOGISTICS	10.0	2	4,500	9530	9787		2
8	E C C T	16.0	5	11,250	39703	32386	2	3
9	GDL	20.0	5	11,250	70402	73228		7
10	German Express	18.0	4	9,000	40448	30286		4
11	ICBC	14.0	3	5,625	17535	15125		1
12	KAILASH	9.0	3	6,750	24417	25906		2
13	APM TER	32.0	8	18,000	-	-		3
14	SANCO		8		64176	49422	4	5

Sl.No.	Name	Notifed Area	Stacking Area	Handling Capacity (TEUs per month)	Container Traffic (2011-12*)	Container Traffic (2012-13*)	Equipments	
		18.0		18,000				
15	SATTVA	18.0	6	13,500	51707	41736	1	5
16	SATTVA - Vichur	10.0	3	6,750	34662	33450	1	2
17	SICAL	55.0	8	18,000	76438	60422		6
18	SUN GLOBAL	5.0	1	2,250	10839	10616		
19	TRIWAY	24.0	5	11,250	33372	27155	5	2
20	Tiru Rani	7.5	1.5	3,375	21081	15930		2
21	VIKING	6.0	2	4,500	20620	10853	1	
22	VISHRUTHA	31.0	1	2,250	7667	9401		1
23	GLOVIS	9.0	2	3,375	-	-		2

*Calendar year

(Source: National Association of Container Freight Stations)

b. Inland Container Depots (ICD) in the CBIC region

Sl.No.	ICD Name	Place	Total Capacity	Container Traffic (2011-12)	Container Traffic (2012-13)
			In TEUs	**In TEUs**	**In TEUs**
1	Harbour of Madras	Chennai	10000	67183	79074
2	Thondiarpet	Chennai	25000	96993	100146
3	Whitefield	Bangalore	30000	72652	92313

Source: Indian Ports Association data 2012, 2013

c. Free Trade Warehousing Zone (FTWZ)

Sl.No.	FTWZ Name	Place	Total Area In Hectare
1	DHL	Sriperumbudur	2.415
2	J Matadee	Chennai	40.6250
3	Shipco Infrastructure	Karnataka	120
4	Jafza Chennai Business Parks Private Ltd	Vallur Village	136.38

(Source: http://www.ftwz.com)

CASE STUDY: A Logistic Hub in China

The manufacturing industry in China has grown significantly and has made China into one of the fastest growing economies in the world. It has been observed that industrial added value of China has increased at a rate of 9.5% year on year and annual growth of manufacturing industry is nearly 14% and contributes 32% to GDP of the country. The country's manufacturing sector has resulted in the development of the logistics sector in China as well. Also, the manufacturing enterprises which were scattered migrated to the accessible locations which helped in reshaping the supply chain in the country.

Today's global economic climate reflects many similarities between India and China. Both the countries have greatly expanded their role in sourcing of manufacturing goods. Manufacturing sector in India contributes 16% to India's GDP which is aimed to contribute 25% to the country's GDP in 2025. The development of the Chennai Bengaluru Industrial Corridor is planned to develop world class infrastructure in the region and thereby provide an impetus to the growth of manufacturing industry in southern parts of India. The objective to establish a logistic park in CBIC region is to integrate various facilities to obtain the utmost efficiency in the supply-chain. Though, the production rates are comparatively similar to China, India lags behind in term sof productivity, delivery frequency and stock turn ratios. In CBIC region, the transportation of cargo is heavily dependent on roads. Around 95% of the cargo is transported through road (both imports and exports) and rest is through rail. On the other hand the road network in China is less extensive. Multiple options in the form of rail, air and waterways are together used for achieving the maximum efficiency. Therefore, a suitable benchmarking would be China where one of the most able facilities exist with respect to manufacturing and trading hubs.

1. LOGISTIC SECTOR IN CHINA

The expansion in manufacturing and trading hub in domestic market, huge growth in organised retail sector, emergence of e-commerce and improvement in value chain provided a strong push to the logistics sector of China. Logistics in China contribute to 30% in new orders, 25% in improving business volume, 15% in capacity utilisation, 20% in employment and 10% in turnovers. Based on these five indicators, Logistic prosperity index is calculated by China Federation of Logistics and Purchasing (CFLP) which turned out to be 52.4 in July 2013. This (>50) indicates that there is overall expansion in logistic sector as per their norms.

1.1 Key enablers of logistic hubs in China

The enablers of logistic hub in China are:

- The Government in China took the initiative in development of logistics parks and around 85% of the parks have been developed by the government.

- Large investments for development of transport infrastructure (roads and inland waterways) to connect the cities in western and central China have also spurred the growth of logistics infrastructure in the country.

- Sufficient land availability across the country is also a major factor for the growth of logistics infrastructure in the region.

- Cluster-based development which results in high synergy for the manufacturing facilities have also resulted in greater demand for logistics infrastructure in the country.

Shanghai, Tianjin, Shenzhen, Beijing and Guangzhou are top five hubs prevailing in the country which are treated as primary hubs in China. The geographic location benefits inland waterway shipping and road transport by truck. This resulted in the establishment of inland logistic hubs in other parts of the country improving connectivity and other facilities for trading. To understand the facilities provided in the logistic hubs developed, let us explore a well developed hub prevailing in the region.

1.2 Shenzhen South-China International Centre- A Case Study

This is one of the seven logistic parks in Shenzhen. It is situated in the central Shenzhen and next to Meiguan Expressway. It is easily accessible by motor vehicles. It serves China mainland with its services. As shown in the map below, the places in blue towards north and domestic destinations (to and fro of cargo) and the places towards south are its points from/to the cargo is imported/ exported

6 km from Huanggang Check Point

25 km from Yantian Port

20 km from Shekau Port

30 km from Shenzhen Airport

Source: An overview presented by Shenzhen SILC-Vanquish Logistics Co. Ltd.

Figure 1: Connectivity to the Logistics hub

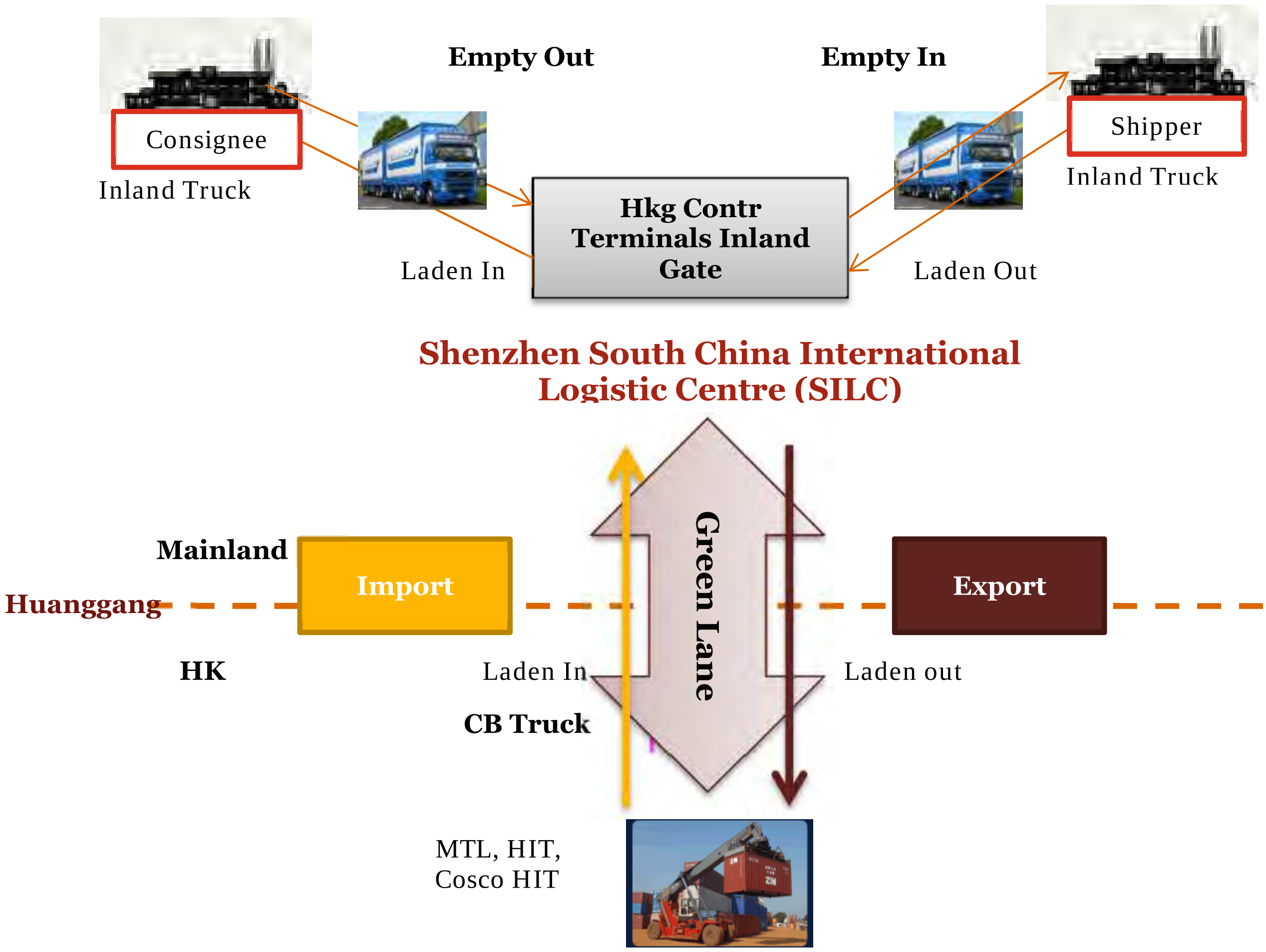
1.3 Key Features of Shenzhen Logistic Park

Total development area is 650,000 sqm. The operations prevailing in this park are:

Sno	Operation	Facilities
1	Empty Container Depot	100,000 sqm serving more than 20 shipping lines.
2	Cargo Inter-change	30,000 sqm. Allows cargo carried by cross-boundary truck which then will be transferred into a local truck for delivery to inland provinces
3	Bonded Warehouse	Total development area is 250,000 sqm. Provides export supervised and import bonded warehouse services under custom control. Practices integrated management services like storage, inventory management, picking, packing and value added services.

Sno	Operation	Facilities
		Real time (24/7) monitoring of inventory through online warehouse management system (WMS). Export supervised warehouse where an immediate processing of Tax Rebate and FOREX collection is done. Maximum storage period is 1 year. Friendly for regional distribution centres. Import Bonded Warehouse where import duties and VAT is deferred until the release of cargo from warehouse. Maximum storage is 2 years.
4	Express Customs Clearances and services	It is a part of 'Rapid cross boundary Clearance' initiative by China where Green and Green Express services are provided. Custom function place d at boundary checkpoint at the park. This includes the use of electronic manifest declaration and electronic truck surveillance (GPS and e-seal).

The following picture explains the flow of activities with various facilities available in the park.



Source: An overview presented by Shenzhen SILC-Vanquish Logistics Co. Ltd.

Figure 2: Flow of activities in SILC

The container cargo dealt here is tackled using different transport facilities together like road, inland waterways and air. The integration between these facilities play a key role in achieving efficiency. It is observed that about 18% losses are attributed to the logistics cost as per the integrated services in China. Whereas in India it is accounting to 31% losses which is the a major proportion leading to increase in cost. We can utilize the rail transportation in CBIC region on similar lines to inland transportation provision in China. Therefore, our primary infrastructural development required in the region would be with respect to rail transportation. Various nodes selected in CBIC region are accessible to different transportation facilities (like roads and ports) in as is condition. The facilities described in the above logistic park, can be established by integrating the existing facilities with the advance logistic facilities. As and when the alignment of DFC and Expressway is frozen, these could be evaluated in further study as a part of planning for logistic facilities in the region.

Annexure 8: Industrial Development

Table 1Major Project for Town Development and Industrial Development

No	Project Title	Project Description	Status	Project Cost (Million US$)	Project Type	Fund Source if any	Priority[1] /
01	Urban Master Plan Planning (Upgrading/Newly Planning)	Urban master plan for high-populated area which is identified as town to facilitate urban development	New	15	Public work	Public Fund	A, B & C
02	Priority Industrial Node Development (short-term)	Integrated urban development for short list of node to promote the investment and attract CBIC area	New	5,200	Public work/PPP	Public and Private Fund	A& B
03	Second Priority Industrial Node Development (Middle-term)	Integrated urban development for short list of node by public private partnership	New	8,800	Public work/PPP	Public and Private Fund	B & C
04	Other Industrial Development (Long-term)	Industrial development without industrial node development to fill land demand gap between projected land demand and planned node development	New	13,200	PPP / Private	Public and Private Fund	A, B & C
05	Tamil Nadu Investment Promotion Program (Phase-1)	The project to improve related policy and regulations to promote investment to infrastructure development for Tamil Nadu State	Ongoing	125	Public work and ODA	Public Fund	A &B
06	Tamil Nadu Investment Promotion Program (Phase-2)	The project to improve related policy and regulations to promote investment to infrastructure development for Tamil Nadu State	New	150	Public work/Development aide if required	Public Fund	A &B
07	Investment Promotion Project for Karnataka	The project to improve related policy and regulations to promote investment to infrastructure development for Karnataka State	New	200	Public work/Development aide if required	Public Fund	B&C
08	Investment Promotion Project for Andra Pradesh	The project to improve related policy and regulations to promote investment to infrastructure development for Andhra Pradesh	New	200	Public work/Development aide if required	Public Fund	B&C

No	Project Title	Project Description	Status	Project Cost (Million US$)	Project Type	Fund Source if any	Priority[1] /
09	Skill development improvement project in Tamil Nadu	Improvement of skill development program for Labor & Employment Department of Tamil Nadu State and TNSDC	New	5	Public work/Development aide	Public Fund	A &B
10	Industrial development management strengthening program for Tamil Nadu State Government	Institutional strengthening for industrial/urban development and Urban facility (infrastructure) management strengthening for Tamil Nadu State	New	5	Public work/Development aide	Public Fund	A &B
11	Industrial development management strengthening program for Karnataka State Government	Institutional strengthening for industrial/urban development and Urban facility (infrastructure) management strengthening for Karnataka State	New	5	Public work/ Development aide	Public Fund	A &B
12	Industrial development management strengthening program for Andhra Pradesh	Institutional strengthening for industrial/urban development and Urban facility (infrastructure) management strengthening for Andhra Pradesh	New	5	Public work/ Development aide	Public Fund	A &B
	Total			***27,910***			

Annexure 9: Water

List of ongoing, provisional-planned and newly-proposed projects

A. Domestic Water Supply projects

State/District	Project Title	Supply Capacity (MLD)	Status	Cost (Million US$)	Priority[1/]
Tamil Nadu					
Chennai	Nemmeli WTP II development project (Seawater Desalination)	150.0	Planned	132	B
	Peruru WTP development project (Seawater Desalination)	400.0	Planned	353	B
Kancheepuram	Nandivaram – Guduvansheri WTP development project	1.9	Ongoing	46	A
	Thiruporur WTP development project	1.0	Ongoing	132	B
	Kancheepuram water supply project	229.6	New	286	C
Tiruvallur	Tiruvallur water supply project	266.9	New	322	C
Tiruvannamalai	Water supply project to Thiruvannamalai municipality in Thiruvannamalai District	28.2	Ongoing	6	A
Vellore	CWSS to Vellore Corporation, 11 municipalities and 944 rural habitations water supply project	181.0	Ongoing	212	A
Dharmapuri	Dharmapuri water supply project	1.9	New	3	C
Krishnagiri	Krishnagiri water supply project	6.7	New	10	C
Karnataka					
Bangalore Urban	Bangalore urban district water supply project	49.7	New	72	C
Bangalore Rural	Doddaballapura remodelling of Distribution system development project	10.0	Planned	8	B
Ramanagara	CWSS to Ramanagara – Channapatna water supply project	13.0	Ongoing	4	A
Kolar	Kolar, Mulur, Bangarpet, Mulbagal and enroute villages water supply project	43.4	Ongoing	26	A
Chikkaballapura	Chikkaballapura remodeling of Distribution project	14.9	Ongoing	2	A
Tumkur	WTP at Antherasanahallii. A 2nd phase	5.0	Ongoing	5	A
	Tipur water supply project	10.0	Planned	11	B
Chitradurga	Hiriyur – Challaker water supply project	38.8	Ongoing	28	A
Andhra Pradesh					
Anantapur	Anantapur water supply improvement project	61.0	Ongoing	85	A
	Dharmavaram water supply improvement project	24.0	Ongoing	33	A
	Kadiri water supply improvement project	15.6	Ongoing	22	A
Chittoor	Chittoor drinking water supply project	184.0	Planned	948	B
	Development project of water supply system to Nagiri town	9.0	Ongoing	6	A
	Development project of water supply system to Madanapalle town	10.0	Ongoing	10	A
	Development project of water supply system to Punganur town	7.0	Ongoing	5	A
Nellore	Development project of water supply system to Gudur town	10.0	Ongoing	10	A

State/District	Project Title	Supply Capacity (MLD)	Status	Cost (Million US$)	Priority1/
	Nellore water supply project	18.0	Ongoing	3	A
	Atmakur CWSIS water supply project	5.0	Ongoing	11	A
	Development project of water supply system toVenkatagiri town	5.0	Ongoing	12	A
	Development project of water supply system to Kavali town	5.7	Ongoing	3	A
	Development project of water supply system to Srikalahasti town	5.0	Ongoing	3	A

1/ "A" refers to projects for implementation before 2018, "B" refers to projects for implementation in 2018 – 2022, and, "C" refers to projects for implementation after 2023.

B. Industrial Water Supply projects

B-1 Sewage Recycle Project

State/District	Project Title	Supply Capacity (MLD)	Status	Cost (Million US$)	Priority1/
Tamil Nadu					
Chennai	Chennai sewage recycle project	45.0	Planned	22	A
	Chennai sewage recycle project-2	635.3	New	312	A
Kancheepuram	Kancheepuramu sewage recycle project	534.0	New	262	A
Tiruvallur	Tiruvallur sewage recycle project	536.2	New	263	A
Tiruvannamalai	Tirvannamalai sewage recycle project	142.3	New	70	C
Vellore	Vellore sewage recycle project	302.0	New	148	C
Dharmapuri	Dharmapuri sewage recycle project	87.8	New	43	C
Krishnagiri	Krishnagiri sewage recycle project	121.2	New	59	C
Karnataka					
Bangalore Urban	Bangalore Urban sewage recycle project phase-1	969.6	New	476	A
	Bangalore Urban sewage recycle project phase-2	969.6	New	476	B
Bangalore Rural	Bangalore Rural sewage recycle project	65.3	New	32	A
Ramanagara	Ramanagara sewage recycle project	30.0	Ongoing	15	A
	Ramanagara sewage recycle project-2	39.0	New	19	A
Kolar	Kolar sewage recycle project	60.0	Ongoing	29	A
	Kolar sewage recycle project-2	108.4	New	53	C
Chikkaballapura	Chikkaballapura sewage recycle project	20.0	Planned	10	C
	Chikkaballapura sewage recycle project-2	76.7	New	38	C
Tumkur	Tumur sewage recycle project	25.0	Planned	12	C
	Tumkur sewage recycle project-2	117.8	New	58	C
Chitradurga	Chitradurga sewage recycle project	95.3	New	47	C
Andhra Pradesh					
Anantapur	Anantapur sewage recycle project	278.3	New	137	C
Chittoor	Chittoor sewage recycle project	285.9	New	140	C
Nellore	Nellore sewage recycle project	210.5	New	103	C

1/ "A" refers to projects for implementation before 2018, "B" refers to projects for implementation in 2018 – 2022, and, "C" refers to projects for implementation after 2023.

B-2 Industrial Wastewater Recycle Project

State/District	Project Title	Supply Capacity (MLD)	Status	Cost (Million US$)	Priority1/
Tamil Nadu					
Chennai	Chennai industrial wastewater recycle project	45.4	New	37	A
Kancheepuram	Kancheepuram industrial wastewater recycle project	333.8	New	273	A
Tiruvallur	Tiruvallur industrial wastewater recycle project	240.6	New	197	A
Tiruvannamalai	Tiruvannamalai industrial wastewater recycle project	8.7	New	7	C
Vellore	Vellore industrial wastewater recycle project	55.5	New	45	C
Dharmapuri	Dharmapuri industrial wastewater recycle project	6.4	New	5	C
Krishnagiri	Krishnagiri industrial wastewater recycle project	15.1	New	12	C
Karnataka					
Bangalore Urban	Bangalore Urban industrial wastewater recycle project phase-1	1362.5	New	1,114	A
	Bangalore Urban industrial wastewater recycle project phase-2	1362.5	New	1,114	B
Bangalore Rural	Bangalore Rural industrial wastewater recycle project	160.9	New	132	A
Ramanagara	Ramanagara industrial wastewater recycle project	74.1	New	61	A
Kolar	Kolar industrial wastewater recycle project	8.9	New	7	C
Chikkaballapura	Chikkaballapura industrial wastewater recycle project	0.5	New	0.4	C
Tumkur	Tumkur industrial wastewater recycle project	306.8	New	251	C
Chitradurga	Chitradurga industrial wastewater recycle project	78.7	New	64	C
Andhra Pradesh					
Anantapur	Anantapur industrial wastewater recycle project	18.9	New	15	C
Chittoor	Chittoor industrial wastewater recycle project	6.6	New	5	C
Nellore	Nellore industrial wastewater recycle project	17.0	New	14	C

1/ "A" refers to projects for implementation before 2018, "B" refers to projects for implementation in 2018 – 2022, and, "C" refers to projects for implementation after 2023.

C. Sewage treatment projects

State/District	Project Title	Supply Capacity (MLD)	Status	Cost (Million US$)	Priority1/
Tamil Nadu					
Chennai	CWSSB sewage treatment project	454.0	Planned	742	B

State/District	Project Title	Supply Capacity (MLD)	Status	Cost (Million US$)	Priority[1/]
Kancheepuram	Kancheepuramu UGD project	2.9	Ongoing	5	A
	Sewage treatment for 13 schemes	53.4	Planned	87	B
	Sewage treatment for 5 schemes	207.0	Planned	339	B
	Kancheepuram sewage treatment project	11.9	New	19	C
Tiruvallur	Sewage treatment for 8 schemes	23.0	Planned	38	B
	Sewage treatment for 4 schemes	43.0	Planned	70	B
	Tiruvallur sewage treatment project	222.7	New	364	B
Tiruvannamalai	Sewage treatment for 14 schemes	45.7	Planned	74	B
	Tiruvannamalai sewage treatment project	23.9	New	39	C
Vellore	Sewage treatment for 27 schemes	121.0	Planned	199	B
	Vellore sewage treatment project	45.1	New	74	C
Dharmapuri	Sewage treatment for 11 schemes	35.7	Planned	81	B
	Dharmapuri sewage treatment project	7.7	New	13	C
Krishnagiri	Sewage treatment for 8 schemes	35.5	Planned	100	B
	Krishnagiri sewage treatment project	22.2	New	36	C
Karnataka					
Bangalore Urban	Sewage treatment for 12 schemes	345.4	Ongoing	565	A
Bangalore Rural	Bangalore Rural sewage treatment project	35.9	New	59	C
Ramanagara	Ramanagara sewage treatment project	30.5	New	50	C
Kolar	Sewage treatment for 11 schemes	8.0	Ongoing	5	A
	Kolar sewage treatment project	38.4	New	63	C
Chikkaballapura	Sewage treatment for 1 schemes	14.3	Ongoing	3	A
	Chikkaballapura sewage treatment project	18.4	New	30	C
Tumkur	Sewage treatment for 1 schemes	10.6	Ongoing	7	A
	Tumkur sewage treatment project	43.4	New	71	C
Chitradurga	Sewage treatment for 1 schemes	3.3	Ongoing	3	A
	Chitradurga sewage treatment project	49.1	New	80	C
Andhra Pradesh					
Anantapur	Anantapur sewage treatment project	153.1	New	250	C
Chittoor	Sewage treatment for 2 schemes	29.0	Ongoing	5	A
	Chittoor sewage treatment project	103.2	New	169	C
	Nellore sewage treatment project	115.8	New	189	C

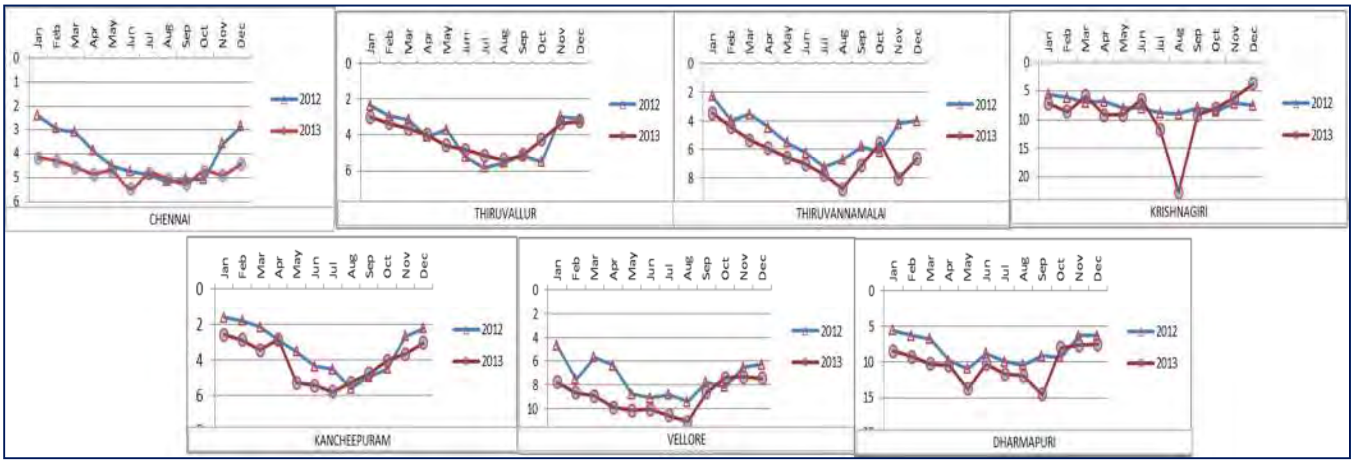
1/ "A" refers to projects for implementation before 2018, "B" refers to projects for implementation in 2018 – 2022, and, "C" refers to projects for implementation after 2023.

Annex for Detailed Data of Existing Ground Water

(1) Tamil Nadu State

1) Development Status of Ground Water

As per the Block wise categorization and state of ground water development as on march 2009, Tamil Nadu State has been classified into 139 Nos. as Over Exploited, 33 Blocks as Critical, 67 Blocks as Semi-critical Blocks and 136 Blocks as Safe out of 386 assessed blocks. Also, ground water depths in the districts of the state covered in CBIC are continuously depleting from year 2012 to the year 2013. The fall for average ground water depths (GWD) for the years 2012 & 2013 for the districts Chennai, Kancheepuram, Tiruvallur, Vellore, Thiruvannamalai, Dharmapuri & Krishnagiri are compared and presented in the figure below. The average ground water fall ranges from 0.04m (minimum) in Tiruvallur district to 2.02m (maximum) in Dhramapuri district for the years 2012 & 2013.



Source: JICA Study Team

Figure 1 Fall of Avg. GWD from 2012 to 2013

Ground Water situation in the seven (7) districts of Tamil Nadu State covered in CBIC area is presented in the following Table 1.

Table 1 Ground water situation in the seven districts of Tamil Nadu State in CBIC

Sl.No	District	Current Status			
		Safe (<70%)	Semi Critical (>70% & <90%)	Critical (>70% & <90%)	Over Exploited (>100%)
1	Chennai	-	-	-	1
2	Tiruvallur	7	1	-	6
3	Vellore	2	1	3	14
4	Thiruvannamalai	-	6	4	8
5	Kancheepuram	5	4	1	3
6	Krishnagiri	2	2	1	5
7	Dhramapuri	-	1	-	7

Source: Dynamic Ground Water Resources of India, November-2011, CGWB

2) Ground Water Quality

Possible ground water contaminants in the State of Tamil Nadu & for the districts covered in CBIC are presented in the table 2.

Table 2 Ground water quality in seven districts of Tamil Nadu State in CBIC

Sl.No	Contaminants	Districts affected in Tamil Nadu State (in part)	CBIC Project Area (in part)
1	**Salinity** (EC > 3000 µS/cm at 25 ° C)	Dharmapuri, Pudukkottai, Thoothukkudi, Coimbatore, Dindigul, Ramanathanpuram, Salem, Karur, Namakkal, Perambalor, Thiruvannamalai, Vellore, Villupuram, Cuddalore	1. Dharmapuri 2.Thiruvannamalai 3. Vellore
2	**Fluoride** (>1.5 mg/l)	Coimbatore, Dharmapuri, Dindigul, Erode, Karur, Krishnagiri, Namakkal, Perambalor, Puddukotai, Ramanathanpuram, Salem, Sivaganga, Theni, Thiruvannamalai, Trichurapally, Vellore, Virudhunagar	1. Dharmapuri 2. Krishnagiri 3.Thiruvannamalai 4. Vellore
3	**Chloride** (> 1000 mg/l)	Pudukkottai, Thoothukkudi, Ramanathanpuram, Namakkal, Cuddalore, Thirunamalai, Thanjavur, Shivaganga	1. Thiruvannamalai
4	**Iron** (>1.0 mg/l)	Namakkal, Salem,	
5	**Nitrate** (>45 mg/l)	Chennai, Coimbatore, Cuddalore, Dharmapuri, Dindigul, Erode, Kancheepuram, Kanyakumari, Karur, Madurai, Namakkal, Nilgiris, Perambalor, Puddukotai, Ramanathanpuram, Salem, Sivaganga, Theni, Thiruvannamalai,Thanjavur, Tirunelveli, Tiruvallur, Trichi, Tuticorin, Vellore, Villupuram, Virudhunagar	1. Chennai 2. Dharmapuri 3. Kancheepuram 4. Thiruvannamalai 5. Tiruvallur 6. Vellore

Source: Central Ground Water Board

(2) Karnataka State

1) Development Status of Ground Water

As per the categorization of blocks by Central Ground Board (CGWB) (As on March 2009), total of 270 Nos. of blocks have been assessed, out of which 154 are Safe, 34 are Semi-Critical, 11 are Critical and 71 blocks are classified as Over Exploited.

Ground Water situation in the seven (7) districts of Karnataka State covered in CBIC area is presented in the following Table 3.

Table 3 Ground water situation in the seven districts of Karnataka State in CBIC

Sl.No	District	Current Status			
		Safe (<70%)	Semi Critical (>70% & <90%)	Critical (>70% & <90%)	Over Exploited (>100%)
1.	Bangalore Urban		-	-	4
2.	Bangalore Rural		-	-	4
3.	Chikballapur		1	-	5
4.	Chitradurga		-	2	3
5.	Kolar		-	-	5
6.	Ramnagara		1	1	3
7.	Tumkur		2	-	7

Source: Dynamic Ground Water Resources of India, November-2011, CGWB

2) Ground Water Quality

Possible ground water contaminants in the State of Karnataka & for the districts covered in CBIC are presented in the table 4.

Table 4 Ground water quality in seven districts of Tamil Nadu State in CBIC

Sl.No	Contaminants	Districts affected (in part)	CBIC Project Area
1	**Salinity** (EC > 3000 µS/cm at 25 ° C)	Bagalkot, Belgaun, Bellary, Davangiri,Gadag, Gulburga, Raichur	NIL
2	**Fluoride** (>1.5 mg/l)	Bagalkot, Bangalore, Belgaun, Bellary, Bidar, Bijapur, Chamarajanagara, Chikmagalur, Chitradurga, Davanagere, Dharwad, Gadag, Gulburga, Haveri, Kolar, Koppala, Mandya, Mysore, Raichur, Tumkur	1. Bengaluru 2. Chitradurga 3. Kolar 4. Tumkur
3	**Chloride** (> 1000 mg/l)	Bagalkot, Belgaum, Gadag, Dharwar	NIL
4	**Iron** (>1.0 mg/l)	Bagalkot, Bangalore, Belgaum, Bellary, Bidar, Bijapur, Chikmagalur, Chitradurga, Dakshina Kannada, Davanagere, Gulburga, Hasan, Haveri, Kodagu, Kolar, Koppala, Mysore, Raichur, Shimoga, Tumkur, Udupi, Uttar Kannada	1. Bengaluru 2. Chitradurga 3. Kolar 4. Tumkur
5	**Nitrate** (>45 mg/l)	Bagalkot, Bangalore, Belgaum, Bellary, Bidar, Bijapur, Chamarajanagara, Chikmagalur, Chitradurga, Davanagere, Dharwad, Gadag, Gulburga, Hassan, Haveri, Kodagu, Kolar, Koppala, Mandya, Mysore, Raichur. Shimoga, Udupi, Uttar Kannada	1. Bengaluru 2. Chitradurga 3. Kolar

Source: Central Ground Water Board

(3) Andhra Pradesh State

1) Development Status of Ground Water

As per the categorization of blocks by Central Ground Board (CGWB) (As on March 2009), total of 1108 Nos. of blocks have been assessed, out of which 867 are Safe, 93 are Semi-Critical, 26 are Critical and 84 blocks are classified as Over Exploited. Latest average ground water rise from October-2012 to October-13 in Ananthapur & Chittoor districts are 0.84m and 2.18m respectively. The average ground water fall is recorded in Nellore District about 0.31m from October-12 to October-13.

Ground Water situation in the three (3) districts of Andhra Pradesh State covered in CBIC area is presented in the following Table 5.

Table 5 Ground water situation in the three districts of Andhra Pradesh State in CBIC

Sl.No	District	Current Status			
		Safe (<70%)	Semi Critical (>70% & <90%)	Critical (>70% & <90%)	Over Exploited (>100%)
1.	Nellore		-	-	-
2.	Chittoor		9	7	13
3.	Ananthapur		20	5	19

Source: Dynamic Ground Water Resources of India, November-2011, CGWB

2) Ground Water Quality

Possible ground water contaminants in the State of Karnataka & for the districts covered in CBIC are presented in the table 6.

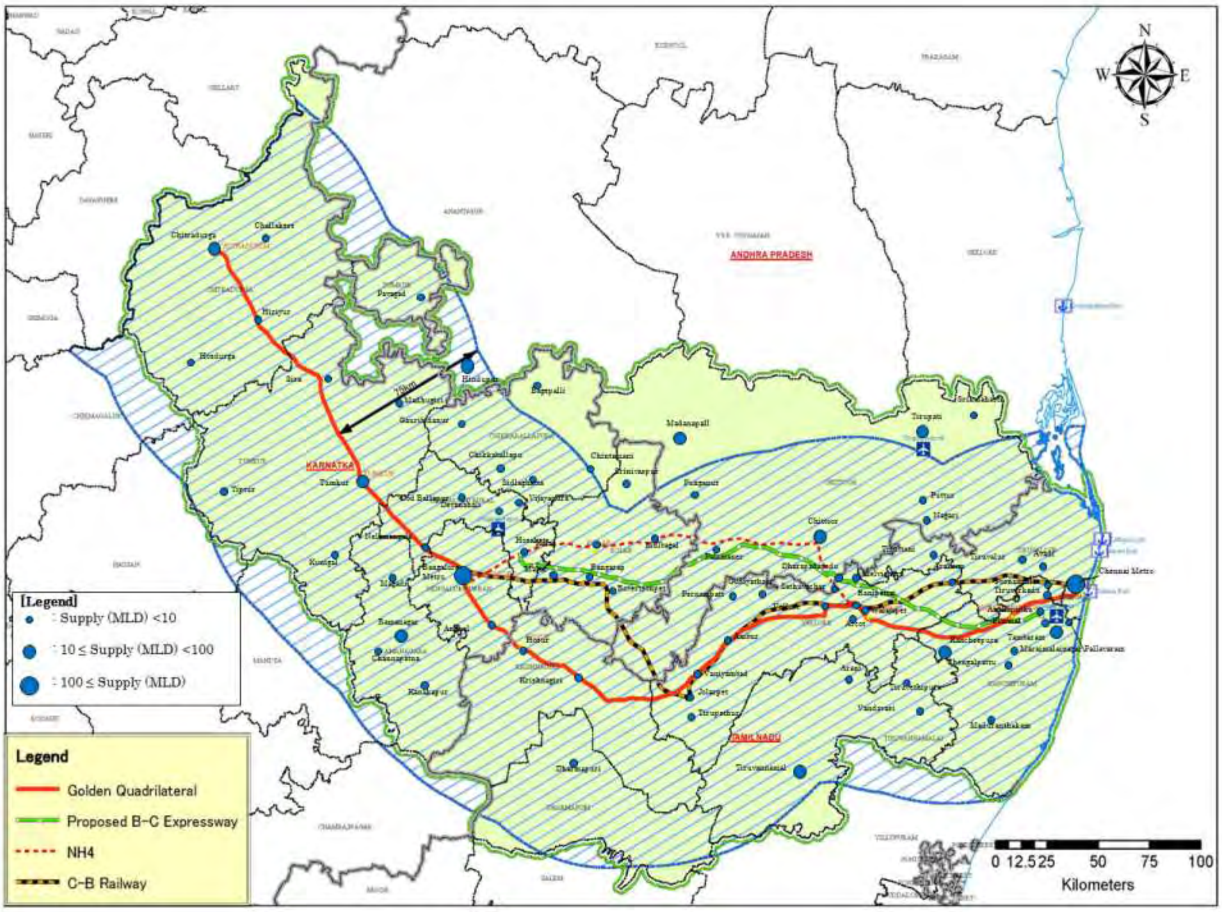
Table 6 Ground water quality in three districts of Andhra Pradesh State in CBIC

Sl.No	Contaminants	Districts affected (in part)	CBIC Area
1	**Salinity** (EC > 3000 µS/cm at 25 ° C)	Anantapur, Kurnool, Kadapa, Nellore, Prakasam, Guntur, Mahabubnagar, Nalgonda, Krishna, Khammam, Warangal, Medak, East Godavari, Srikakulam, Visakhapatnam, Vizianagaram	1. Ananthapur 2. Nellore
2	**Fluoride** (>1.5 mg/l)	Adilabad, Anantpur, Chittoor, Guntur, Hyderabad, Karimnagar, Khammam, Krishna, Kurnool, Mahabubnagar, Medak, Nalgonda, Nellore, Prakasam, Ranga Reddy, Visakhapatnam, Vizianagaram, Warangal, West Godavari	1. Ananthapur 2. Chittoor 3. Nellore
3	**Chloride** (> 1000 mg/l)	Prakasam , Nellore, Guntur, Mahaboobnagar, Nalgonda, Krishna, Khammam, Warangal, Srikakulam	1. Nellore
4	**Iron** (>1.0 mg/l)	Adilabad, Chittoor, Kadapa, Guntur, Hyderabad, Karimnagar, Krishna, Kurnool, Mahabubnagar, Medak, Nalgonda, Nellore, Nizamabad, Ranga Reddy, Visakhapatnam,	1. Chittoor 2. Nellore
5	**Nitrate** (>45 mg/l)	Adilabad, Anantpur, Chittoor, Kadapa, East Godavari, Guntur, Hyderabad, Karimnagar, Khammam, Krishna, Kurnool, Mahabubnagar, Medak, Nalgonda, Nellore, Nizamabad, Prakasam, Ranga Reddy, Srikakulam, Visakhapatnam, Vizianagaram, Warangal, West Godavari	1. Ananthapur 2. Chittoor 3. Nellore

Source: Central Ground Water Board

CGWB has analysed the ground water resources availability, utilization and stage of development as on March 2009 for each district in a State. The net ground water availability is assessed for future irrigation use considering the net water availability (from ground water recharge) and groundwater draft including the projected demand for domestic & industrial uses up to 2025. However, the latest status of net water availability for domestic & industrial purposes is to be confirmed as on 2013. Such ground water availability can be treated as a potential water resource for domestic or industrial purposes in future depending on the potential ground water recharge and the subsequent ground water quality in the area under consideration.

Annex for Existing Domestic Water Supply Scheme of Each Municipality in CBIC



Tamilunadu State

District	Corporation/ Municipality	Actual Supply (MLD)
Chennai	Chennai	830.0
Thiruvallur	Tiruttani	2.3
Thiruvallur	Thiruvallur	5.0
Thiruvallur	Avadi	5.5
Thiruvallur	Tiruverkadu	4.3
Thiruvallur	Poonamallee	3.3
Thiruvallur	Ambattur	0.0
Thiruvallur	Maduravoyal	0.0
Thiruvallur	Valasaravakkam	0.0
Thiruvallur	Kattivakkam	0.0
Thiruvallur	Tiruvottiyur	0.0
Thiruvallur	Manali	0.0
Thiruvallur	Madavaram	0.0
Kancheepuram	Tambaram	12.2
Kancheepuram	Alandur	0.0
Kancheepuram	Anakaputhur	2.3
Kancheepuram	Pammal	3.4
Kancheepuram	Pallavaram	5.2
Kancheepuram	Pallavaram (Part)	0.0
Kancheepuram	Puzhithivakkam (Ul	0.0
Kancheepuram	Maraimalainagar	4.0
Kancheepuram	Chengalpattu	4.3
Kancheepuram	Kancheepuram	12.8
Kancheepuram	Maduranthakam	2.2

Tamilunadu State

District	Corporation/ Municipality	Actual Supply (MLD)
Vellore	Gudiyatham	6.9
Vellore	Pernampattu	2.9
Vellore	Dharapadavedu	0.0
Vellore	Walajapet	3.0
Vellore	Ranipettai	3.6
Vellore	Melvisharam	3.1
Vellore	Arakonam	4.9
Vellore	Arcot	4.6
Vellore	Sathuvachari	0.0
Vellore	Vellore	9.1
Vellore	Vaniyambadi	6.4
Vellore	Ambur	5.3
Vellore	Jolarpet	2.3
Vellore	Tirupathur	7.4
Tiruvannamalai	Arani	4.6
Tiruvannamalai	Tiruvethipuram	2.4
Tiruvannamalai	Vandavasi	2.1
Tiruvannamalai	Tiruvannamalai	14.5
Krishnagiri	Hosur	5.3
Krishnagiri	Krishnagiri	4.7
Dharmapuri	Dharmapuri	3.4

Karnataka State

District	Corporation/ Municipality	Actual Supply (MLD)
Bangalore Urban	Anekal	2.7
Bangalore Urban	BBMP	900.0
Bangalore Rural	Nelamangala	2.4
Bangalore Rural	Dod Ballapur	5.3
Bangalore Rural	Vijayapura	2.0
Bangalore Rural	Devanahalli	2.0
Bangalore Rural	Hosakote	2.0
Ramanagara	Magadi	2.7
Ramanagara	Ramanagara	12.8
Ramanagara	Channapatna	7.2
Ramanagara	Kanakapura	5.4
Chitradurga	Challakere	1.8
Chitradurga	Chitradurga	14.0
Chitradurga	Hosdurga	1.7
Chitradurga	Hiriyur	5.1
Kolar	Srinivaspur	1.5
Kolar	Kolar	6.9
Kolar	Malur	2.4
Kolar	Bangarapet	1.4
Kolar	Robertson Pet	8.1
Kolar	Mulbagal	2.9
Tumkur	Chiknayakanhalli	1.2
Tumkur	Sira	4.0
Tumkur	Pavagada	0.5
Tumkur	Madhugiri	1.6
Tumkur	Tumkur	25.7
Tumkur	Tiptur	5.8
Tumkur	Kunigal	2.4
Chikbalapur	Gauribidanur	1.8
Chikbalapur	Chikkaballapura	2.7
Chikbalapur	Bagepalli	1.9
Chikbalapur	Sidlaghatta	1.5
Chikbalapur	Chintamani	2.3

Andhra Pradesh State

District	Corporation/ Municipality	Actual Supply (MLD)
Chittoor	Tirupati	33.3
Chittoor	Srikalahasti	6.0
Chittoor	Madanapalle	10.5
Chittoor	Nagari	4.5
Chittoor	Puttur	3.8
Chittoor	Punganur	0.0
Chittoor	Chittoor	12.7
Chittoor	Palamaner	3.8
Anantapur	Rayadurg	6.6
Anantapur	Guntakal	8.5
Anantapur	Tadpatri	6.9
Anantapur	Anantapur	36.1
Anantapur	Dharmavaram	16.5
Anantapur	Kadiri	6.7
Anantapur	Hindupur	11.2
Nellore	Kavali	0.0
Nellore	Nellore	58.0
Nellore	Gudur	4.8
Nellore	Venkatagiri	2.4

Source: JICA Study Team

Annex for District-Wise Analysis for Demand/Supply Gap of Domestic Water Supply in CBIC

(1) Tamil Nadu State

District	Level	Population				Unit Water Supply		Supply					Demand				Gap							
		2013	2018	2023	2033	Current	Target	2013	On-going	2018	Planned	2023-	2013	2018	2023	2033	2013		2018		2023		2033	
						(lpcd)		(mld)	(mld)	(mld)	(mld)	(mld)	(mld)	(mld)	(mld)	(mld)	(mld)	(%)	(mld)	(%)	(mld)	(%)	(mld)	(%)
Chennai	Corp.	4,816,341	5,043,465	5,232,028	5,669,313	123	150	571.5		571.5	550.0	1121.5	697.0	756.5	784.8	850.4	125.5	82	185.0	76	0.0	100	0.0	100
	Municipality						135																	
	Town						70																	
	Rural						40																	
Kancheepuram	Corp.						150										105.7	66	196.0	51	269.3	43	463.2	31
	Municipality	1,190,632	1,421,409	1,681,424	2,370,334	54	135	58.9		58.9		58.9	147.2	191.9	227.0	320.0								
	Town	1,581,862	1,888,470	2,233,924	3,149,204	58	70	84.0	2.9	86.9		86.9	101.4	132.2	156.4	220.4								
	Rural	1,594,591	1,903,666	2,251,900	3,174,545	40	40	58.4		58.4		58.4	58.4	76.1	90.1	127.0								
Thiruvallur	Corp.						150										158.0	52	249.4	40	319.6	35	501.5	25
	Municipality	1,751,806	2,063,885	2,409,312	3,307,504	36	135	58.0		58.0		58.0	217.7	278.6	325.3	446.5								
	Town	886,627	1,044,577	1,219,405	1,673,999	72	70	58.8		58.8		58.8	57.1	73.1	85.4	117.2								
	Rural	1,412,124	1,663,690	1,942,137	2,666,166	40	40	52.0		52.0		52.0	52.0	66.5	77.7	106.6								
Tiruvannamalai	Corp.						150										17.6	87	3.2	98	13.0	92	35.8	80
	Municipality	286,147	307,087	327,925	376,195	85	135	23.6	28.2	51.8		51.8	37.5	41.5	44.3	50.8								
	Town	223,172	239,504	255,757	293,403	53	70	11.5		11.5		11.5	15.2	16.8	17.9	20.5								
	Rural	2,027,141	2,175,488	2,323,112	2,665,067	40	40	78.8		78.8		78.8	78.8	87.0	92.9	106.6								
Vellore	Corp.	191,352	205,765	220,167	253,587	49	150	9.1	49.0	58.1		58.1	27.9	30.9	33.0	38.0	74.8	73	0.0	100	0.0	100	0.0	100
	Municipality	843,938	907,506	971,025	1,118,424	70	135	57.4	132.0	189.4		189.4	110.6	122.5	131.1	151.0								
	Town	717,523	771,568	825,572	950,892	66	70	46.0		46.0		46.0	48.8	54.0	57.8	66.6								
	Rural	2,301,067	2,474,389	2,647,578	3,049,474	40	40	89.4		89.4		89.4	89.4	99.0	105.9	122.0								
Dharmapuri	Corp.						150										3.1	96	13.5	84	21.4	77	40.3	63
	Municipality	71,327	78,502	85,973	103,749	90	135	6.2		6.2		6.2	9.3	10.6	11.6	14.0								
	Town	199,882	219,988	240,924	290,738	70	70	13.5		13.5		13.5	13.5	15.4	16.9	20.4								
	Rural	1,295,102	1,425,373	1,561,028	1,883,788	40	40	49.8		49.8		49.8	49.8	57.0	62.4	75.4								
Krishnagiri	Corp.						150										8.5	92	22.9	80	33.8	73	59.8	61
	Municipality	195,569	215,241	235,726	284,465	90	135	16.9		16.9		16.9	25.4	29.1	31.8	38.4								
	Town	249,699	274,816	300,971	363,200	70	70	16.8		16.8		16.8	16.8	19.2	21.1	25.4								
	Rural	1,508,728	1,660,487	1,818,518	2,194,517	40	40	58.1		58.1		58.1	58.1	66.4	72.7	87.8								

(2) Karnataka State

District	Level	Population				Unit Water Supply		Supply					Demand				Gap							
		2013	2018	2023	2033	Current	Target	2013	On-going	2018	Planned	2023-	2013	2018	2023	2033	2013		2018		2023		2033	
						(lpcd)		(mld)	(mld)	(mld)	(mld)	(mld)	(mld)	(mld)	(mld)	(mld)	(mld)	(%)	(mld)	(%)	(mld)	(%)	(mld)	(%)
Bangalore Urban	Corp.	9,165,965	11,239,957	13,326,164	15,439,218	160	150	1470.0		1470.0		1470.0	1266.6	1686.0	1998.9	2315.9	0.0	100	238.9	87	566.3	73	898.1	63
	Municipality	48,046	58,918	69,853	80,929	60	135	2.7		2.7		2.7	6.0	8.0	9.4	10.9								
	Town	284,422	348,778	413,514	479,082	70	70	18.3		18.3		18.3	18.3	24.4	28.9	33.5								
	Rural	946,166	1,160,256	1,375,607	1,593,729	40	40	34.9		34.9		34.9	34.9	46.4	55.0	63.7								
Bangalore Rural	Corp.						150										20.3	68	25.8	63	19.6	73	28.1	66
	Municipality	256,343	271,906	286,369	319,789	55	135	13.8		13.8	10.0	23.8	33.8	36.7	38.7	43.2								
	Town	18,962	20,113	21,183	23,655	55	70	1.0		1.0		1.0	1.3	1.4	1.5	1.7								
	Rural	739,810	784,724	826,466	922,915	40	40	28.9		28.9		28.9	28.9	31.4	33.1	36.9								
Ramanagara	Corp.						150										8.7	87	1.5	98	5.4	93	14.5	83
	Municipality	254,800	270,269	284,646	317,864	100	135	24.9	13.0	37.9		37.9	33.6	36.5	38.4	42.9								
	Town	19,496	20,679	21,779	24,321	70	70	1.3		1.3		1.3	1.3	1.4	1.5	1.7								
	Rural	834,771	885,451	932,550	1,041,380	40	40	32.6		32.6		32.6	32.6	35.4	37.3	41.7								
Kolar	Corp.						150										40.6	62	6.3	95	12.4	90	26.4	81
	Municipality	481,008	509,898	536,690	598,584	49	135	23.0	30.4	53.4		53.4	63.4	68.8	72.5	80.8								
	Town	10,665	11,305	11,899	13,271	49	70	0.5	13.0	13.5		13.5	0.7	0.8	0.8	0.9								
	Rural	1,081,851	1,146,828	1,207,088	1,346,296	40	40	42.3		42.3		42.3	42.3	45.9	48.3	53.9								
Chikkaballapura	Corp.						150										24.3	68	15.8	81	20.1	77	30.1	69
	Municipality	262,019	277,756	292,350	326,066	40	135	10.2	14.9	25.1		25.1	34.5	37.5	39.5	44.0								
	Town	25,893	27,448	28,890	32,222	70	70	1.8		1.8		1.8	1.8	1.9	2.0	2.3								
	Rural	997,518	1,057,430	1,112,993	1,241,350	40	40	39.0		39.0		39.0	39.0	42.3	44.5	49.7								
Tumukur	Corp.						150										29.4	82	31.0	81	24.5	86	33.0	82
	Municipality	540,601	556,049	567,849	596,129	76	135	40.6	5.0	45.6	10.0	55.6	72.1	75.1	76.7	80.5								
	Town	65,603	67,478	68,910	72,342	102	70	6.6		6.6		6.6	4.5	4.7	4.8	5.1								
	Rural	2,104,644	2,164,784	2,210,726	2,320,821	40	40	83.2		83.2		83.2	83.2	86.6	88.4	92.8								
Chitradurga	Corp.						150										16.6	83	0.0	100	0.0	100	1.9	98
	Municipality	292,341	308,844	323,964	358,860	79	135	22.6	38.8	61.4		61.4	38.6	41.7	43.7	48.4								
	Town	44,695	47,218	49,530	54,865	58	70	2.5		2.5		2.5	3.1	3.3	3.5	3.8								
	Rural	1,360,202	1,436,989	1,507,338	1,669,702	40	40	53.2		53.2		53.2	53.2	57.5	60.3	66.8								

(3) Andhra Pradesh State

District	Level	Population				Unit Water Supply		Supply					Demand				Gap							
		2013	2018	2023	2033	Current	Target	2013	On-going	2018	Planned	2023-	2013	2018	2023	2033	2013		2018		2023		2033	
						(lpcd)		(mld)	(mld)	(mld)	(mld)	(mld)	(mld)	(mld)	(mld)	(mld)	(mld)	(%)	(mld)	(%)	(mld)	(%)	(mld)	(%)
Anantapur	Corp.	274,518	293,571	312,649	354,948	135	150	36.1		36.1		36.1	40.1	44.0	46.9	53.2	37.0	86	0.0	100	0.0	100	22.3	94
	Municipality	677,322	724,333	771,404	875,768	85	135	56.0	100.6	156.6		156.6	89.0	97.8	104.1	118.2								
	Town	225,421	241,067	256,733	291,466	70	70	15.4		15.4		15.4	15.4	16.9	18.0	20.4								
	Rural	3,016,273	3,225,623	3,435,242	3,899,997	40	40	117.4		117.4		117.4	117.4	129.0	137.4	156.0								
Chittoor	Corp.	342,056	364,693	387,219	436,946	100	150	33.3		33.3	60.0	93.3	50.0	54.7	58.1	65.5	58.7	79	58.4	80	0.0	100	0.0	100
	Municipality	663,074	706,956	750,623	847,019	70	135	45.2		45.2	120.0	165.2	87.2	95.4	101.3	114.3								
	Town	258,638	275,755	292,787	330,387	70	70	17.6	26.0	43.6	4.0	47.6	17.6	19.3	20.5	23.1								
	Rural	3,020,063	3,219,929	3,418,815	3,857,863	40	40	117.7		117.7		117.7	117.7	128.8	136.8	154.3								
Nellore	Corp.	561,641	597,795	633,641	712,581	106	150	58.0	18.0	76.0		76.0	82.1	89.7	95.0	106.9	42.2	79	12.2	95	25.3	89	54.5	79
	Municipality	222,375	236,690	250,883	282,138	57	135	12.4	20.7	33.1		33.1	29.3	32.0	33.9	38.1								
	Town	95,571	101,723	107,822	121,255	57	70	5.3	10.0	15.3		15.3	6.5	7.1	7.5	8.5								
	Rural	2,159,842	2,298,874	2,436,724	2,740,296	40	40	84.2		84.2		84.2	84.2	92.0	97.5	109.6								

(4) Summary

State	District	Supply			Demand				Demand/Supply Gap							
		2013	2018	2023-	2013	2018	2023	2033	2013		2018		2023		2033	
		(mld)	(mld)	(mld)	(mld)	(mld)	(mld)	(mld)	(mld)	(%)	(mld)	(%)	(mld)	(%)	(mld)	(%)
Tamil Nadu	Chennai	571.5	571.5	1121.5	697.0	756.5	784.8	850.4	125.5	82	185.0	76	0.0	100	0.0	100
	Kancheepuram	201.3	204.2	204.2	307.0	400.2	473.5	667.4	105.7	66	196.0	51	269.3	43	463.2	31
	Thiruvallur	168.8	168.8	168.8	326.8	418.2	488.4	670.3	158.0	52	249.4	40	319.6	35	501.5	25
	Tiruvannamalai	113.9	142.1	142.1	131.5	145.3	155.1	177.9	17.6	87	3.2	98	13.0	92	35.8	80
	Vellore	201.9	382.9	382.9	276.7	306.4	327.8	377.6	74.8	73	0.0	100	0.0	100	0.0	100
	Dharmapuri	69.5	69.5	69.5	72.6	83.0	90.9	109.8	3.1	96	13.5	84	21.4	77	40.3	63
	Krishnagiri	91.8	91.8	91.8	100.3	114.7	125.6	151.6	8.5	92	22.9	80	33.8	73	59.8	61
	State-Total	1418.7	1630.8	2180.8	1911.9	2224.3	2446.1	3005.0	493.2	74	670.0	70	657.1	73	1100.6	63
Karnataka	Bangalore Urban	1525.9	1525.9	1525.9	1325.8	1764.8	2092.2	2424.0	0.0	100	238.9	87	566.3	73	898.1	63
	Bangalore Rural	43.7	43.7	53.7	64.0	69.5	73.3	81.8	20.3	68	25.8	63	19.6	73	28.1	66
	Ramanagara	58.8	71.8	71.8	67.5	73.3	77.2	86.3	8.7	87	1.5	98	5.4	93	14.5	83
	Kolar	65.8	109.2	109.2	106.4	115.5	121.6	135.6	40.6	62	6.3	95	12.4	90	26.4	81
	Chikkaballapura	51.0	65.9	65.9	75.3	81.7	86.0	96.0	24.3	68	15.8	81	20.1	77	30.1	69
	Tumukur	130.4	135.4	145.4	159.8	166.4	169.9	178.4	29.4	82	31.0	81	24.5	86	33.0	82
	Chitradurga	78.3	117.1	117.1	94.9	102.5	107.5	119.0	16.6	83	0.0	100	0.0	100	1.9	98
	State-Total	1953.9	2069.0	2089.0	1893.7	2373.7	2727.7	3121.1	139.9	93	319.3	87	648.3	76	1032.1	67
Andhra Pradesh	Anantapur	224.9	325.5	325.5	261.9	287.7	306.4	347.8	37.0	86	0.0	100	0.0	100	22.3	94
	Chittoor	213.8	239.8	423.8	272.5	298.2	316.7	357.2	58.7	79	58.4	80	0.0	100	0.0	100
	Nellore	159.9	208.6	208.6	202.1	220.8	233.9	263.1	42.2	79	12.2	95	25.3	89	54.5	79
	State-Total	598.6	773.9	957.9	736.5	806.7	857.0	968.1	137.9	81	70.6	91	25.3	97	76.8	92
CBIC-Total		3971.2	4473.7	5227.7	4542.1	5404.7	6030.8	7094.2	771.0	83	1059.9	80	1330.7	78	2209.5	69

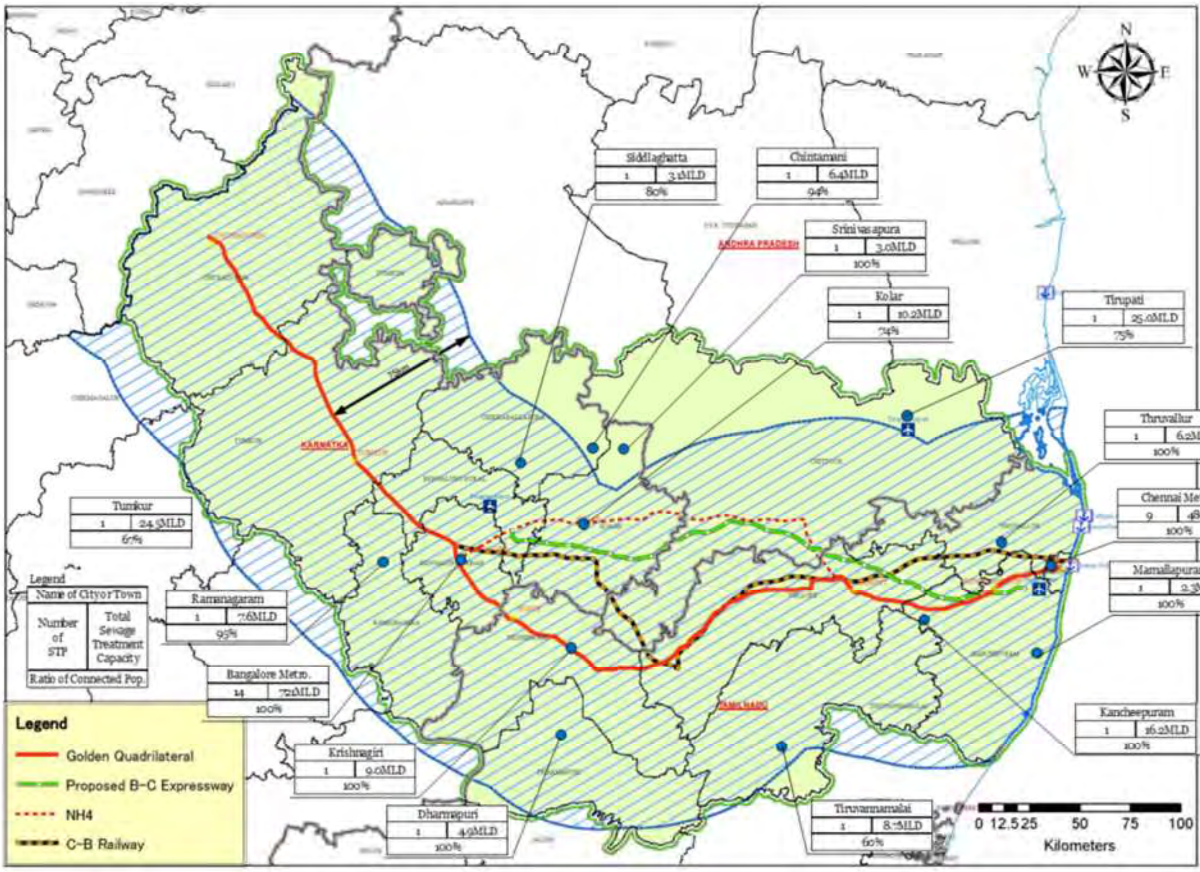
Source: JICA Study Team

Annex for Existing Sewage Treatment System in CBIC

Table List of Existing Sewage Treatment System in CBIC

State	Name of City or Town	Number of STP	Total Capacity of STP(MLD)	Ratio of Connected Population (%)
Tamil Nadu	Chennai	9	486.0	100
	Thiruvallur	1	6.2	100
	Tiruvannamalai	1	8.7	60
	Kancheepruam	1	16.2	100
	Mamallapuram	1	2.3	100
	Krishnagiri	1	9.0	100
	Dharmapuri	1	4.9	100
Karnataka	Bangalore	14	721.0	100
	Ramanagara	1	7.6	96
	Tumkur	1	24.5	67
	Kolar	1	10.2	74
	Srinivasapura	1	3.0	100
	Chintamani	1	6.4	94
	Siddlaghatta	1	3.1	80
Andhra Pradesh	Tirupati	1	25.0	75
CBIC Total			1334.1	27

Source: JICA Study Team



Source: JICA Study Team

Figure Development Status of Existing Sewage Treatment System in CBIC

Annex for District-Wise Analysis for Demand/Supply Gap of Sewage Treatment in CBIC

(1) Tamil Nadu State

District	Level	Population				Target Unit Water Supply	Sewage Treatment Capacity					Sewage Generation				Gap							
		2013	2018	2023	2033		2013	On-going	2018	Planned	2023-	2013	2018	2023	2033	2013		2018		2023		2033	
						(lpcd)	(mld)	(mld)	(mld)	(mld)	(mld)	(mld)	(mld)	(mld)	(mld)	(mld)	(%)	(mld)	(%)	(mld)	(%)	(mld)	(%)
Chennai	Corp.	4,816,341	5,043,465	5,232,028	5,669,313	150	486.0		486.0	454.0	940.0	578.0	605.2	627.8	680.3	92.0	84	119.2	80	0.0	100	0.0	100
	Municipality					135																	
	Town					70																	
	Rural					40																	
Kancheepuram	Corp.					150										249.7	7	298.8	7	97.0	74	252.2	53
	Municipality	1,190,632	1,421,409	1,681,424	2,370,334	135	16.2		16.2	240.5	256.7	128.6	153.5	181.6	256.0								
	Town	1,581,862	1,888,470	2,233,924	3,149,204	70	2.3	2.9	5.2	19.9	25.1	88.6	105.8	125.1	176.4								
	Rural	1,594,591	1,903,666	2,251,900	3,174,545	40	0.0		0.0		0.0	51.0	60.9	72.1	101.6								
Thiruvallur	Corp.					150										277.9	2	328.4	2	318.4	19	464.0	14
	Municipality	1,751,806	2,063,885	2,409,312	3,307,504	135	6.2		6.2	54.0	60.2	189.2	222.9	260.2	357.2								
	Town	886,627	1,044,577	1,219,405	1,673,999	70	0.0		0.0	12.0	12.0	49.7	58.5	68.3	93.7								
	Rural	1,412,124	1,663,690	1,942,137	2,666,166	40	0.0		0.0		0.0	45.2	53.2	62.1	85.3								
Tiruvannamalai	Corp.					150										99.6	8	107.5	8	69.6	44	87.9	38
	Municipality	286,147	307,087	327,925	376,195	135	8.7		8.7	28.1	36.8	30.9	33.2	35.4	40.6								
	Town	223,172	239,504	255,757	293,403	70	0.0		0.0	17.6	17.6	12.5	13.4	14.3	16.4								
	Rural	2,027,141	2,175,488	2,323,112	2,665,067	40	0.0		0.0		0.0	64.9	69.6	74.3	85.3								
Vellore	Corp.	191,352	205,765	220,167	253,587	150	0.0		0.0	10.3	10.3	23.0	24.7	26.4	30.4	227.9	0	245.1	0	141.2	46	181.0	40
	Municipality	843,938	907,506	971,025	1,118,424	135	0.0		0.0	85.1	85.1	91.1	98.0	104.9	120.8								
	Town	717,523	771,568	825,572	950,892	70	0.0		0.0	25.6	25.6	40.2	43.2	46.2	53.2								
	Rural	2,301,067	2,474,389	2,647,578	3,049,474	40	0.0		0.0		0.0	73.6	79.2	84.7	97.6								
Dharmapuri	Corp.					150										55.4	8	61.5	7	32.2	56	47.2	46
	Municipality	71,327	78,502	85,973	103,749	135	4.9		4.9	8.5	13.4	7.7	8.5	9.3	11.2								
	Town	199,882	219,988	240,924	290,738	70	0.0		0.0	27.2	27.2	11.2	12.3	13.5	16.3								
	Rural	1,295,102	1,425,373	1,561,028	1,883,788	40	0.0		0.0		0.0	41.4	45.6	50.0	60.3								
Krishnagiri	Corp.					150										74.4	11	82.7	10	56.1	44	76.7	37
	Municipality	195,569	215,241	235,726	284,465	135	9.0		9.0	19.6	28.6	21.1	23.2	25.5	30.7								
	Town	249,699	274,816	300,971	363,200	70	0.0		0.0	15.9	15.9	14.0	15.4	16.9	20.3								
	Rural	1,508,728	1,660,487	1,818,518	2,194,517	40	0.0		0.0		0.0	48.3	53.1	58.2	70.2								

(2) Karnataka State

District	Level	Population				Target Unit Water Supply	Sewage Treatment Capacity					Sewage Generation				Gap							
		2013	2018	2023	2033		2013	On-going	2018	Planned	2023-	2013	2018	2023	2033	2013		2018		2023		2033	
						(lpcd)	(mld)	(mld)	(mld)	(mld)	(mld)	(mld)	(mld)	(mld)	(mld)	(mld)	(%)	(mld)	(%)	(mld)	(%)	(mld)	(%)
Bangalore Urban	Corp.	9,165,965	11,239,957	13,326,164	15,439,218	150	721.0	339.0	1060.0		1060.0	1099.9	1348.8	1599.1	1852.7	430.3	63	345.4	76	607.4	64	872.8	55
	Municipality	48,046	58,918	69,853	80,929	135	0.0	6.4	6.4		6.4	5.2	6.4	7.5	8.7								
	Town	284,422	348,778	413,514	479,082	70	0.0		0.0		0.0	15.9	19.5	23.2	26.8								
	Rural	946,166	1,160,256	1,375,607	1,593,729	40	0.0		0.0		0.0	30.3	37.1	44.0	51.0								
Bangalore Rural	Corp.					150										52.5	0	55.6	0	58.5	0	65.3	0
	Municipality	256,343	271,906	286,369	319,789	135	0.0		0.0		0.0	27.7	29.4	30.9	34.5								
	Town	18,962	20,113	21,183	23,655	70	0.0		0.0		0.0	1.1	1.1	1.2	1.3								
	Rural	739,810	784,724	826,466	922,915	40	0.0		0.0		0.0	23.7	25.1	26.4	29.5								
Ramanagara	Corp.					150										47.7	14	51.1	13	54.1	12	61.4	11
	Municipality	254,800	270,269	284,646	317,864	135	7.6		7.6		7.6	27.5	29.2	30.7	34.3								
	Town	19,496	20,679	21,779	24,321	70	0.0		0.0		0.0	1.1	1.2	1.2	1.4								
	Rural	834,771	885,451	932,550	1,041,380	40	0.0		0.0		0.0	26.7	28.3	29.8	33.3								
Kolar	Corp.					150										73.9	15	71.2	23	76.1	22	87.2	20
	Municipality	481,008	509,898	536,690	598,584	135	13.2	8.0	21.2		21.2	51.9	55.1	58.0	64.6								
	Town	10,665	11,305	11,899	13,271	70	0.0		0.0		0.0	0.6	0.6	0.7	0.7								
	Rural	1,081,851	1,146,828	1,207,088	1,346,296	40	0.0		0.0		0.0	34.6	36.7	38.6	43.1								
Chikkaballapura	Corp.					150										52.2	15	41.5	36	45.0	35	52.9	31
	Municipality	262,019	277,756	292,350	326,066	135	9.5	14.3	23.8		23.8	28.3	30.0	31.6	35.2								
	Town	25,893	27,448	28,890	32,222	70	0.0		0.0		0.0	1.5	1.5	1.6	1.8								
	Rural	997,518	1,057,430	1,112,993	1,241,350	40	0.0		0.0		0.0	31.9	33.8	35.6	39.7								
Tumukur	Corp.					150										104.9	19	98.1	26	100.8	26	107.7	25
	Municipality	540,601	556,049	567,849	596,129	135	24.5	10.6	35.1		35.1	58.4	60.1	61.3	64.4								
	Town	65,603	67,478	68,910	72,342	70	0.0		0.0		0.0	3.7	3.8	3.9	4.1								
	Rural	2,104,644	2,164,784	2,210,726	2,320,821	40	0.0		0.0		0.0	67.3	69.3	70.7	74.3								
Chitradurga	Corp.					150										77.6	0	78.7	4	82.7	4	92.0	4
	Municipality	292,341	308,844	323,964	358,860	135	0.0		0.0		0.0	31.6	33.4	35.0	38.8								
	Town	44,695	47,218	49,530	54,865	70	0.0	3.3	3.3		3.3	2.5	2.6	2.8	3.1								
	Rural	1,360,202	1,436,989	1,507,338	1,669,702	40	0.0		0.0		0.0	43.5	46.0	48.2	53.4								

(3) Andhra Pradesh State

District	Level	Population				Target Unit Water Supply	Sewage Treratment Capacity					Sewage Generation				Gap							
		2013	2018	2023	2033		2013	On-going	2018	Planned	2023-	2013	2018	2023	2033	2013		2018		2023		2033	
						(lpcd)	(mld)	(mld)	(mld)	(mld)	(mld)	(mld)	(mld)	(mld)	(mld)	(mld)	(%)	(mld)	(%)	(mld)	(%)	(mld)	(%)
Anantapur	Corp.	274,518	293,571	312,649	354,948	150	0.0		0.0		0.0	32.9	35.2	37.5	42.6	215.2	0	230.1	0	245.1	0	278.3	0
	Municipality	677,322	724,333	771,404	875,768	135	0.0		0.0		0.0	73.2	78.2	83.3	94.6								
	Town	225,421	241,067	256,733	291,466	70	0.0		0.0		0.0	12.6	13.5	14.4	16.3								
	Rural	3,016,273	3,225,623	3,435,242	3,899,997	40	0.0		0.0		0.0	96.5	103.2	109.9	124.8								
Chittoor	Corp.	342,056	364,693	387,219	436,946	150	0.0		0.0		0.0	41.0	43.8	46.5	52.4	198.7	11	184.6	23	199.4	21	231.9	19
	Municipality	663,074	706,956	750,623	847,019	135	25.0	29.0	54.0		54.0	71.6	76.4	81.1	91.5								
	Town	258,638	275,755	292,787	330,387	70	0.0		0.0		0.0	14.5	15.4	16.4	18.5								
	Rural	3,020,063	3,219,929	3,418,815	3,857,863	40	0.0		0.0		0.0	96.6	103.0	109.4	123.5								
Nellore	Corp.	561,641	597,795	633,641	712,581	150	0.0		0.0		0.0	67.4	71.7	76.0	85.5	165.9	0	176.6	0	187.1	0	210.5	0
	Municipality	222,375	236,690	250,883	282,138	135	0.0		0.0		0.0	24.0	25.6	27.1	30.5								
	Town	95,571	101,723	107,822	121,255	70	0.0		0.0		0.0	5.4	5.7	6.0	6.8								
	Rural	2,159,842	2,298,874	2,436,724	2,740,296	40	0.0		0.0		0.0	69.1	73.6	78.0	87.7								

(4) Summary

State	District	Sewage Treatment Capacity (Supply)			Sewage Generation (Demand)				Demand/Supply Gap							
		2013	2018	2023-	2013	2018	2023	2033	2013		2018		2023		2033	
		(mld)	(mld)	(mld)	(mld)	(mld)	(mld)	(mld)	(mld)	(%)	(mld)	(%)	(mld)	(%)	(mld)	(%)
Tamil Nadu	Chennai	486.0	486.0	940.0	578.0	605.2	627.8	680.3	92.0	84	119.2	80	0.0	100	0.0	100
	Kancheepuram	18.5	21.4	281.8	268.2	320.2	378.8	534.0	249.7	7	298.8	7	97.0	74	252.2	53
	Thiruvallur	6.2	6.2	72.2	284.1	334.6	390.6	536.2	277.9	2	328.4	2	318.4	19	464.0	14
	Tiruvannamalai	8.7	8.7	54.4	108.3	116.2	124.0	142.3	99.6	8	107.5	8	69.6	44	87.9	38
	Vellore	0.0	0.0	121.0	227.9	245.1	262.2	302.0	227.9	0	245.1	0	141.2	46	181.0	40
	Dharmapuri	4.9	4.9	40.6	60.3	66.4	72.8	87.8	55.4	8	61.5	7	32.2	56	47.2	46
	Krishnagiri	9.0	9.0	44.5	83.4	91.7	100.6	121.2	74.4	11	82.7	10	56.1	44	76.7	37
	State-Total	533.3	536.2	1554.5	1610.2	1779.4	1956.8	2403.8	1076.9	33	1243.2	30	714.5	63	1109.0	54
Karnataka	Bangalore Urban	721.0	1066.4	1066.4	1151.3	1411.8	1673.8	1939.2	430.3	63	345.4	76	607.4	64	872.8	55
	Bangalore Rural	0.0	0.0	0.0	52.5	55.6	58.5	65.3	52.5	0	55.6	0	58.5	0	65.3	0
	Ramanagara	7.6	7.6	7.6	55.3	58.7	61.7	69.0	47.7	14	51.1	13	54.1	12	61.4	11
	Kolar	13.2	21.2	21.2	87.1	92.4	97.3	108.4	73.9	15	71.2	23	76.1	22	87.2	20
	Chikkaballapura	9.5	23.8	23.8	61.7	65.3	68.8	76.7	52.2	15	41.5	36	45.0	35	52.9	31
	Tumukur	24.5	35.1	35.1	129.4	133.2	135.9	142.8	104.9	19	98.1	26	100.8	26	107.7	25
	Chitradurga	0.0	3.3	3.3	77.6	82.0	86.0	95.3	77.6	0	78.7	4	82.7	4	92.0	4
	State-Total	775.8	1157.4	1157.4	1614.9	1899.0	2182.0	2496.7	839.1	48	741.6	61	1024.6	53	1339.3	46
Andhra Pradesh	Anantapur	0.0	0.0	0.0	215.2	230.1	245.1	278.3	215.2	0	230.1	0	245.1	0	278.3	0
	Chittoor	25.0	54.0	54.0	223.7	238.6	253.4	285.9	198.7	11	184.6	23	199.4	21	231.9	19
	Nellore	0.0	0.0	0.0	165.9	176.6	187.1	210.5	165.9	0	176.6	0	187.1	0	210.5	0
	State-Total	25.0	54.0	54.0	604.8	645.3	685.6	774.7	579.8	4	591.3	8	631.6	8	720.7	7
CBIC-Total		1334.1	1747.6	2765.9	3829.9	4323.7	4824.4	5675.2	2495.8	35	2576.1	40	2370.7	51	3169.0	44

Source: JICA Study Team

Annexure 10: Solid Waste Management

Table 1: Major Project for Solid Waste Management

No	Project Title	Project Description	Status	Project Cost (Million US$)	Project Type	Fund Source if any	Priority[1/]
01	Tamil Nadu state Regional AFR pre-processing facility construction Project	The regional AFR pre-processing facility development for CBIC area to improve the recycling rateand to reduce the load of incineration facilities and Landfill in Tamil Nadu.	New	261	PPP	Public and Private Fund	B
02	Tamil Nadu state Regional incineration facility construction project	Development of the regional hazardous waste incineration facility that is expected to be insufficient due to an increase of incinerable hazardous waste within CBIC area in the future.	New	222	PPP	Public and Private Fund	C
03	Tamil Nadu state Regional landfill facility construction project	Development of new regional hazardous waste Landfill facility for the capacity shortage of landfill within CBIC area in the future.	New	379	PPP	Public and Private Fund	C
04	Karnataka state Regional AFR pre-processing facility	The regional AFR pre-processing facility development for CBIC area to improve the recycling rateand to reduce the load of incineration facilities and Landfill in Karnataka.	New	345	PPP	Public and Private Fund	A
05	Karnataka state Regional incineration facility construction project	The regional hazardous waste incineration facility development for the lack of supplyto reduce temporary storage of the company waste and illegal dumping.	New	524	PPP	Public and Private Fund	A
06	Karnataka state Regional landfill facility construction project	Development of new regional hazardous waste Landfill facility for the capacity shortage of landfill within CBIC area in the future.	New	267	PPP	Public and Private Fund	B
07	Andhra PradeshState Regional AFR pre-processing facility	The regional AFR pre-processing facility development for CBIC area in Andhra Pradesh to improve the recycling rate and reduce the load of landfillable and incinerable waste.	New	55	PPP	Public and Private Fund	A

No	Project Title	Project Description	Status	Project Cost (Million US$)	Project Type	Fund Source if any	Priority[1/]
08	Andhra PradeshState Regional landfill facilityconstruction project	Development of the regional hazardous waste Landfill facility that not exist within the CBIC area in Andhra Pradesh	New	33	PPP	Public and Private Fund	A

Annexure 11: Node Selection

Key Strengths of the Potential Zones

Analysis of Key Strengths of the Potential Zones

Southern area in Karnataka / Western area in Tamil Nadu

Proposed zone name (Zone 1)	Key Location within zone	District	State
Southern area in Karnataka / Western area in Tamil Nadu	Magadi	Ramnagara	Karnataka
	Ramnagara	Ramnagara	Karnataka
	Channapatana	Ramnagara	Karnataka
	Kanakapura	Ramnagara	Karnataka
	Anekal	Bangalore Urban	Karnataka
	Hosur	Krishnagiri	Tamil Nadu

The first proposed zone comprises of several locations in Karnataka, namely Magadi, Ramnagara, Channapatana, Kanakapura of Ramnagara district in Karnataka, Anekal of Bangalore Urban district in Karnataka and Hosur of Krishnagiri district in Tamil Nadu.

Bangalore Urban is the most progressive district of Karnataka, widely known as the Silicon Valley of India and Technology base in Asia, with GDDP of Rs. 86,832 crore[125] (2010-11) that contributes 31% to the State Gross Domestic Product. Key industries present in the district include computer software/ITeS and other knowledge based industries, engineering and aerospace industries, and food processing.

The district attracted 24.39% of the total investments in completed projects and projects under implementation.

It pioneered in the concept of industrial clusters with established Industrial clusters like Whitefield, Electronics City, Peenya, etc.

The most prominent industrial icons are located in the district and include Ascendas Services (India) Pvt. Ltd., Tata Consultancy Services Ltd., Infosys Ltd., Wipro Ltd, H C L Technologies Ltd., Philips, BOSCH, Pepsi, Oracle, UB Group, Mind Tree, General Motors, ABB, HAL, Boeing, etc.

Anekal has been identified as one of the most promising locations in the district. It is home to the famous Electronics city and the Jigani Industrial Estate. Electronics City was established by Keonics, Karnataka Electronics. Keonics Electronics City has a world class infrastructure which has housed major IT /ITES companies such as Bosch, Wipro, Tech Mahindra, Hewlett-Packard, Infosys, HCL Technologies, Patni Computer Systems, CGI, Siemens, Tejas Networks, Yokogawa Electric, Genpact, Intel, Tata Consultancy Services etc. There are approximately 187 IT/ITES companies located in Electronics City. Anekal is also known for its silk industry and a number of skilled weavers.

MSMEs have prominent presence in the following sectors - electrical machinery and transport equipment, textiles and apparels, chemicals and plastics. The key aspects which need Government's intervention in further developing the MSME sector within the district include support to MSMEs in financing aspects (high interest rates have been identified as one of the major hurdles). Also focus on developing a framework for effective implementation of collateral free loan.

Ramnagara is one of the fast developing districts of Karnataka. It includes the Bidadi industrial area, which houses the manufacturing units of Toyota and Coca-Cola, and a 1400 MW combined cycle gas-based power plant. Its GDDP amounted to Rs. 5,313 crore in 2010-1 having contributed to 2% of the state's GDP.

[125] Government of Tamil Nadu

The key locations identified within Ramnagara district include ***Magadi, Ramnagara, Channapatana, Kanakapura.***

Textiles, metallurgy (steel fabrication), wood and wooden furniture, food processing and chemicals and plastics witness large presence of MSME units. The key areas that require government's support are around creation of adequate infrastructure facilities, including maintenance of roads and other infrastructure in the industrial area, improvement of communication network and expansion of transportation facilities in the industrial areas.

Krishnagiri is one of the progressive districts of Tamil Nadu. With GDDP of Rs. 11,101 crore in 2010-11 it contributed 3% to the state's GDP. The key industries include automobile and auto ancillaries, computer software, chemicals and petrochemicals, electrical machinery and food processing. It is a home to many industrial majors, namely TVS Motor Company, Ashok Leyland, Hindustan Motors, FAIVELEY Transport India, Caterpillar India, Electronics Corporation of Tamil Nadu Ltd., Kansai Nerolac Paints Ltd., Supreme Industries, Exide Industries, Base Corporation Ltd., Luminous Power Technologies Pvt. Ltd, Fieldfresh Foods Pvt. Ltd.

Hosur is an industrial hub for several automobile and manufacturing industries. The major industries are like TVS Motor Company Ltd, Ashok Leyland Limited, Titan Industries, Hindustan Motors, Faiveley, Caterpillar India Pvt Ltd, Carborundum Universal Limited, Taneja Aerospace and Aviation Limited, Exide Industries Ltd, Hindustan Motors, Hindustan Lever Ltd, TTK Prestige Limited, Bata India Ltd, Kansai Nerolac Paints, INEL-India Nippon Electricals Ltd, Sundaram Fasteners Ltd, Easun Reyrolle Ltd. are several companies which have their manufacturing units in Hosur.

MSMEs in Krishnagiri are present across the following sectors: Textiles, Repairing and services, Food processing, Metallurgy (Metal fabrication), Chemicals and plastics, Electrical machinery and engineering. Major issues that are faced by MSME units in Krishnagiri which require adequate government attention include inadequate availability of power and power fluctuation, bankers reluctance to finance MSMEs, insufficient skilled manpower, labour training and promotion of integrated tribal development in the tribal region.

The overall analysis suggests that the zone may focus on developing knowledge based sectors and services as well as industrial sectors likecomputer software/ITeS, knowledge based industries, automobile and automobile ancillaries, food processing, electronics, textiles and silk products, electrical machinery.

Eastern area in Karnataka

Proposed zone name (Zone 2)	Key Location within zone	District	State
Eastern area in Karnataka	Hoskote	Bangalore Rural	Karnataka
	Kolar	Kolar	Karnataka

The second proposed zone comprises of Hoskote located in Bangalore Rural district and Kolar area which is a part of Kolar district in Karnataka.

The second most populous district of Karnataka, **Bangalore Rural** contributes 2% to the State GDP (Its GDDP in 2010-11 was Rs. 6,763 crore)[126] and attracted almost 5% of the state's total investments. Major industries located in Bangalore rural district include Aerospace, Sericulture, Agro & Food Processing, IT, Pharmaceuticals, Automobiles and Textiles.

Strong MSME base of the state includes units operating across Textiles, Food processing, Chemicals and plastics.Aerospace, Engineering & Allied Industries are another prominent sectors with large potential for MSMEs development, at present more than 12 % of the total MSME units in the district are engaged in these sectors.

Kolar, situated in the south eastern part of Karnataka, is popularly known as the "Golden Land" of India, because of the presence of the Kolar Gold fields. Kolar's GDDP was Rs. 6,190 crore in 2010-11, which contributed 2% to the state's GDP. Kolar is an emerging hub for Agro and food processing industries

[126] Government of Karnataka

because of the vibrant agricultural base in the district. The Narasapura Industrial Area is best for its infrastructure for motor vehicle factories such as Honda, Mahindra Aerospace, Volvo, etc. District also hosts a handloom cluster and a readymade garment cluster making the sector very vibrant in the district.

MSME sector of the district is represented by the units operating across Textiles, Mineral based industries, Food processing, Chemicals and plastics, Wood and wooden furniture, Electrical machinery and engineering and Metallurgy (steel fabrication).

The overall analysis suggests that the zone may focus development of Food Processing, automobiles and auto ancillaries and engineering sectors.

Northern area in Karnataka

Proposed zone name (Zone 3)	Key Location within zone	District	State
Northern area in Karnataka	Tumkur	Tumkur	Karnataka
	Sira	Tumkur	Karnataka
	Nelamangala	Bangalore Rural	Karnataka

This proposed zone consists of two locations (Tumkur and Sira) in Tumkur district and Nelamangala in Bangalore district of Karnataka.

Tumkur district contributed 3% to the state GDP in 2010-11 having generated GDDP of Rs. 9,262 crore[127]. It attracted almost 3% of the total investment of the state in Auto ancillaries, Metallurgy, Textiles, and Food processing sectors over the past 5 years.

The district is rich in Iron ore Resources: Ready resource of Iron ore in large quantities from the hillsides and major raw material provider to Steel and other allied industries.

Focus sectors of the district include Food Processing, IT & BT, Textile, Steel and Cement Mines, Aerospace, Granite stone cutting and Polishing, Coir Products, Machinery Components, Mining, represented by large number of industrial majors - BYCHEM - Bayir Group, Maini, Johnson Ceramics, Mann & Hummel Filters Pvt. Ltd., M H B Filter India Pvt. Ltd., Vijayaa Steels Ltd., Sunvik Steels Pvt. Ltd., Kurlon Sealy Ltd., Neo Foods Pvt. Ltd. Karuturi Global Ltd.

Its MSME based is mainly spread across Food processing, Reparing and servicing, Wood and wooden furniture, Apparels, Chemicals and plastics, Electrical machinery and engineering, Metallurgy (steel fabrication), Leather based industries. The government should focus on the following areas to boost development of MSME sector in the district - basic infrastructure facilities to be provided in new industrial areas, investment subsidy sanctioned to MSMEs to be released timely.

Analysis of Bangalore Rural district is given above.

The overall analysis suggests that the zone may focus development of Metallurgy, Food Processing, Textile, Steel and Cement Mines, Aerospace, Engineering and Machinery Components.

Northern area in Karnataka

Proposed zone name (Zone 4)	Key locations within zone	District	State
Northern area in Karnataka	Chitradurga	Chitradurga	Karnataka
	Challakere area	Chitradurga	Karnataka

The key locations within this zone include Chitradurga and Challakere area, which are all part of the Chitradurga district in the state of Karnataka. The Chitradurga district contributes to 1.8%[128] of the GSDP

[127] Government of Karnataka

[128] *Source: Govt of Tamil Nadu*

of the state of Karnataka. The district is rich in mineral resources like Copper, Quartz, Building stone, Iron ore and Granite and is emerging as a stronghold in the steel and cement sectors.

The key large scale industries in the district include cement, electricity generation, chemicals and food processing, with investments from some of the big industry houses like Ramco Cements Ltd., Grasim Industries Ltd., Wind World Wind Farms (Karnataka) Ltd., Welspun Solar Kannada Pvt. Ltd., B E M L Ltd., VSL Steels Ltd., Akshay Food Park, etc. Chitradurga has accounted for 1.5% of total investments in the state. Textile constitutes second highest number of Large & Medium industries in the district and around 12% of SSI units in the district.

The MSME sector in the district has stronghold in sectors like Food processing, Textiles, Wood & Furniture products, Leather, Metal based (Fabrication), and Engineering. A Large number of SSI units are engaged in food processing sector creating an eco system and supply of skilled labour. More than 20% of the SSI units in the district are engaged in Agro and food processing activities. Power shortage and transportation facilities have been the key areas which troubled the MSME sector in the district in the past, and Government would need to focus on improving these areas.

Our analysis suggests that the key sectors to be developed in this zone include chemicals, food processing, electricity generation, cement and textiles and handloom industry.

Southern area in Andhra Pradesh 1

Proposed zone name (Zone 5)	Key Location within zone	District	State
Southern area in Andhra Pradesh	Hindupur	Anantapur	Andhra Pradesh
	Lepakshi	Anantapur	Andhra Pradesh

This zone is proposed in Anantapur district of Andhra Pradesh and includes two locations - Hindupur and Lepakshi.

Anantapur, the largest district of Andhra Pradesh, contributed 4% to the state GDP (GDDP of Rs. 15,063 crore) in 2010-11[129]. Its major industrial sectors include Metallurgy, Cement and Electronics. It is a home for several major, namely Ultratech Cement, Gerdau Steel India Ltd, Biop Steels & Power Pvt. Ltd., Larsen & Toubro Ltd., Empi Innovation Park Pvt. Ltd.

MSME sector of Anantapur district is predominantly concentrated across the following sectors: Food & Agro based, Metal based (fabrication), Mineral based, Textiles and Chemicals.

The overall analysis suggests that the zone may focus on development of metallurgy and allied industries, cement, engineering and electronics sectors.

Southern area in Andhra Pradesh 2

Proposed zone name (Zone 6)	Key Location within zone	District	State
Southern area in Andhra Pradesh	Venkatagiri	Nellore	Andhra Pradesh
	Srikalahasti	Chittoor	Andhra Pradesh
	Tirupati	Chittoor	Andhra Pradesh
	Pileru	Chittoor	Andhra Pradesh

The key locations in this zone include Venkatagiri in Nellore and Srikalahasti, Tirupati and Pileru in Chittoor. Although Chittoor currently contributes to 4% of the state's GSDP and less than 1% of investments in the state of Andhra Pradesh, the district has inherent strength in sectors like electrical machinery, electronics and wood processing & furniture products with key investments from companies like Amaron Batteries, Greenply industries, Alstom India, NHK Springs among others. Additionally, a NIMZ is also being planned in this district. Food Processing, textiles, mineral based industries and leather industries constitute majority of the MSMEs in the district.

[129] Government of Andhra Pradesh

Nellore contributes to over 3% of Andhra Pradesh's GSDP and over 6% of the investment in the state. The district is rich in mineral resources and has a long coastline which is the major factor for spurring industrial development in the marine sector. Some of the key companies which have made investments in this district include Krishnapatnam Port Co. Ltd., Kineta Power Pvt. Ltd., SBQ Steels Ltd., and Power Grid Corporation India Ltd. among others.

South eastern area in Andhra Pradesh

Proposed zone name (Zone 7)	Key Location within zone	District	State
South eastern area in Andhra Pradesh State	Kavali	Nellore	Andhra Pradesh
	Nellore	Nellore	Andhra Pradesh
	Naidupeta	Nellore	Andhra Pradesh

The key locations within this zone include Kavali, Naidupeta and Nellore, which are all part of the Nellore district in the state of Andhra Pradesh. The Nellore district contributes to 3.1% of the GSDP of the state of Andhra Pradesh and is one of the progressive districts of the state. The Nellore district is rich in mineral resources and many mineral based industries exist within this district, for mica, quartz, lime shell, silica, copper and barytes.

The Nellore district has 4 industrial estates and 3 industrial areas under its belt and boasts of strength in sectors like electricity generation, shipping transport infrastructure services and metallurgy in the large scale industry category. Nellore accounts for 6.4% of the total investments in the state of Andhra Pradesh[130]. Some of the key companies which have made investments in this district include Krishnapatnam Port Co. Ltd., Kineta Power Pvt. Ltd., SBQ Steels Ltd., and Power Grid Corporation India Ltd. among others.

Nellore district is blessed with a long coastline which supports aquaculture and marine based industries in the district. The MSME sector in the district is dominated by food and agro based industries owing to raw material availability of marine foods along with agricultural raw material of rice, tobacco, groundnut, chillies, sugarcane, etc. Nellore is an attractive destination for food processing based industries which include aqua processing units, feed mills and ice plants. The other key sectors present in the district under the MSME category include engineering, textiles and building material.

In order to further enhance the MSME sectors within the district, one of the key areas where Government will have to focus will be to provide adequate financial and marketing support to the players, in terms of working capital credit, financing during initial years, easy credit facilities, marketing centres, etc. The Government may also focus on ensuring uninterrupted power supplies to industries in the district.

The overall analysis suggests that the zone may focus on developing sectors like food processing, metallurgy and electricity generation.

Southern area in Andhra Pradesh 3

Proposed zone name (Zone 8)	Key Location within zone	District	State
Southern area in Andhra Pradesh	Madanapalle	Chittoor	Andhra Pradesh
	Punganur	Chittoor	Andhra Pradesh

The key locations within this zone include Madanapalle and Punganur, which are all part of the Chittoor district in the state of Andhra Pradesh. The Chittoor district contributes to 4.0% of the GSDP of the state of Andhra Pradesh and is one of the progressive districts of the state. The Chittoor district is known for its rich horticulture produce, especially mango, and has a major concentration of horticulture produce.

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[130] CMIE CAPEX database

Although Chittoor currently accounts for only 0.8% of the investments in Andhra Pradesh[131], the district has inherent strength in sectors like electrical machinery, electronics, and wood processing & furniture products with key investments from companies like Amaron Batteries, Greenply industries, Alstom India, NHK Springs among others.

The MSME sector within the zone is also dominated by the food and agro-based industry followed by textiles, mineral based industries, engineering and leather industry. The key aspects which need Government's intervention in further developing the MSME sector within the district include ensuring adequate credit to MSMEs along with uninterrupted power supply.

Our analysis suggests that Government should focus on developing the food processing and electrical machinery sectors within this zone.

Central area in Tamil Nadu State

Proposed zone name (Zone 9)	Key locations within zone	District	State
Central area in Tamil Nadu State	Vaniyambadi	Vellore	Tamil Nadu
	Ambur	Vellore	Tamil Nadu
	Serkadu	Vellore	Tamil Nadu
	Gudiyattam	Vellore	Tamil Nadu
	Vellore	Vellore	Tamil Nadu

The key locations within this zone include Vaniyambadi, Ambur, Serkadu, Gudiyattam and Vellore, which are all part of the Vellore district in the state of Tamil Nadu. The Vellore district contributes to 5.8% of the GSDP of the state of Tamil Nadu and is one of the industrialized districts of the state. The Vellore District has a dominant presence in the Leather and leather based industries.Vellore District accounts for more than 37% of the county's export leather and leather related products such as finished leather, shoe uppers, shoes, garments, gloves, etc.

The proximity to Chennai, the State capital, good transport with well-connected roads, availability of power, raw materials and abundant cheap labour are the contributing factors to the industrial development in Vellore. The entire District is electrified and all the villages are connected with roads. There are 12 large and 300 medium scale industries are functioning in Vellore District.

The SIPCOT industrial complex at Ranipet is one of the key industrial locations within the district, which has industries from various sectors like pharmaceuticals, machinery, chemicals, food processing and others. Some of the key investing companies in the region include EID Parry, Brakes India, Mitsubishi Heavy Inds. India Precision Tools Ltd, BHEL, Cethar Ltd., etc. Vellore is also seeing a lot of interest from IT services sector with key investment coming from players like Steria India Ltd. among others.

The MSME sector within the Vellore district is strong in traditional industries of Leather, textiles and handloom, and engineering products. The MSME sector players in the district need specific support from the Government to further strengthen their base, especially in marketing and resource building. The Government may provide specific support like project specific allocation for introducing hybrid business development, SOPs to MNCs and large companies for marketing products manufactured by MSMEs, establishment of industrial township, establishing common facilities, establishment of common display centre under PPP mode at regional/district level, developing linkages between MSMEs and R&D institutions and educational institutions, and forward linkages with user groups, etc.

Our analysis suggests that this zone should focus on developing the leather, machinery, textiles and IT services sectors.

131 CMIE CAPEX database

Kanchipuram district area

Proposed zone name (Zone 10)	Key locations within zone	District	State
Kanchipuram district area	Kanchipuram	Kanchipuram	Tamil Nadu

This zone covers the district of Kanchipuram within the state of Tamil Nadu. Kanchipuram is renowned for being highly industrial in nature, especially in the sector of automobile and auto ancillary manufacturing with investments from several global majors like Ford, Hyundai, Renault and Daimler. Kanchipuram accounts for 6.8% of the GDP of the state of Tamil Nadu and has a significant share of 19.1% in the total investments that have come to the state of Tamil Nadu.

The major industrial parks present within the zone include Maraimalainagar, Alanthur, Irungattukottai, Sriperumbudur, Siruseri, Oragadam and Paranur. The key sectors which are present in the district include automobiles and auto ancillaries, textiles, chemicals & petrochemicals, food processing and IT services. Key companies which have invested in the district include Renault Nissan Automotive India Pvt. Ltd., Apollo Tyres Ltd., Hyundai Motor India Ltd., Ford India Pvt. Ltd., CPCL, Sona Steering, Brakes India, Saint Gobain, TCS, Cognizant, and Infosys among others.

The key MSME sectors within the district include the sectors of textiles, mineral based industries, fabrication industries, chemicals and plastics and engineering products. The key area of improvement for further strengthening the MSME sector in the region include providing high quality uninterrupted power, fund support for the sector, reducing time gap for processing and sanctioning CFC proposals, and match making of technologies between existing micro players and MNCs leading to lack of support by MNCs, among others.

Our analysis suggests that the key sectors that can be developed in this region include auto and auto components, chemicals & petrochemicals, food processing, textiles and IT services.

North eastern area in Tamil Nadu

Proposed zone name (Zone 11)	Key locations within zone	District	State
North eastern area in Tamil Nadu	Ponneri	Tiruvallur	Tamil Nadu
	Tiruvallur	Tiruvallur	Tamil Nadu

The key locations within this zone include Ponneri and Tiruvallur, which are all part of the Tiruvallur district in the state of Tamil Nadu. The Tiruvallur district contributes to 6.9%[132] of the GSDP of the state of Tamil Nadu and is one of the progressive districts of the state. Agriculture is the mainstay of the economy of Tiruvallur District. As substantial portion of population are dependent on income from agriculture for livelihood, agricultural development holds the key to overall economic development of the District though the peripheral areas of the district has well developed industrial units.

The key sectors in the district include electricity generation, auto ancillaries, electrical machinery,machinery, and textiles, with investments from companies like N T P C Tamilnadu Energy Co. Ltd., Michelin India Tamilnadu Tyres Pvt. Ltd., L & T Shipbuilding Ltd., Toshiba J S W Turbine & Generator Pvt. Ltd., Caterpillar India Pvt. Ltd., etc.

The key MSME sectors include the traditional industries of food & agro, chemicals & plastics, textiles, engineering, and fabrication. Lack of availability of skilled labour in the region has been one of the major issues in the region, which can be tackled by Government through focus on developing skilling and

[132] *Source: Govt of Tamil Nadu*

training institutes in the region. The district also has shortage of power as another challenge which the Government will have to tackle in order to strengthen the MSMEs in the region.

Our analysis suggests that Auto & Auto ancillaries, machinery, electrical machinery and electricity generation are the key sectors which can be developed in this proposed zone.

Annexure 12: Strategic Environment Assessment

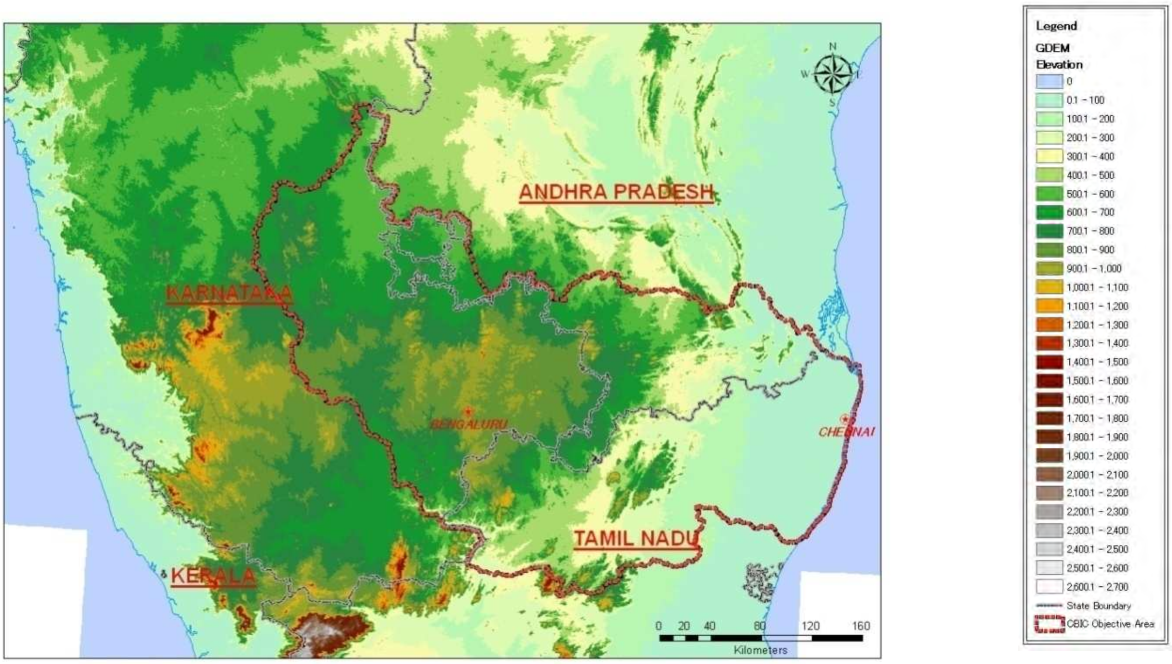
Environmental Conditions

(1) Topographic Conditions

The total area of Karnataka is 191,791 Sq. km. It is situated on a table land where the Western and Eastern Ghat ranges converge. The State is bounded by Maharastra and Goa States in the north and northwest; by the Arabian Sea in the west; by Kerala and Tamil Nadu States in the south and by the States of Andhra Pradesh in the east. The State is divided into three major physiographic divisions-the Deccan Plateau, hill ranges and the coastal plain. The plateau is divided into Malnad and Maidan. Malnad is an undulating upland covering 6.2 Million hectare. The Maidan lies east of the Malnad and has a rolling surface with gentle slopes.

Tamil Nadu covers an area of 130,058 Sq.km. The bordering states are Kerala to the west, Karnataka to the North West and Andhra Pradesh to the north. The western, southern and the north western parts of the state are hilly and rich in vegetation. The Western Ghats and the Eastern Ghats and they both meet at the Nilgiri hills. The eastern parts are fertile coastal plains and the northern parts are a mix of hills and plains. The central and the south central regions are arid plains and receive less rainfall than the other regions. Tamil Nadu has a coastline of about 910 km which is the country's third longest coastline.

Andhra Pradesh has an area of 275,045 Sq km. Andhra Pradesh bordered on the south by Tamil Nadu state, on the west by Karnataka state, on the north and northwest by Maharashtra state, on the northeast by Madhya Pradesh and Orissa states, and on the east by the Bay of Bengal. The Eastern Ghats Mountains run the length of the state. East of the mountains lies the coastal plain; to the west of the mountains is the upland Telangana Plateau. Andhra Pradesh is crossed by several rivers, most importantly the Godavari and Krishna. The alluvial soils laid down by these rivers are highly fertile when irrigated and have made Andhra Pradesh one of India's leading agricultural areas.



Source: ASTER GDEM(METI and NASA)

Figure 1 Topographical Map

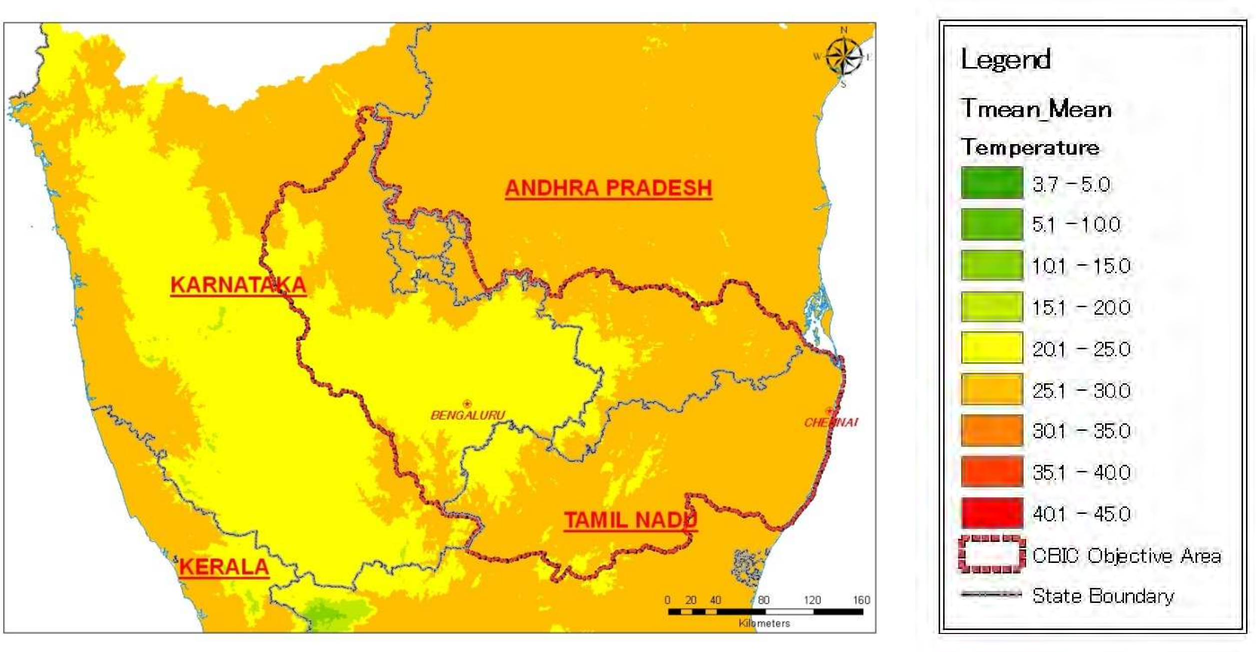
(2) Climate Conditions

1) Temperature

Karnataka state temperature is the lowest in the beginning of January and increases thereafter gradually at first and rapidly after the middle of February or the beginning of March. In Bengarule, the mean daily temperature is approximately 25°C.

The climate of the Tamil Nadu state is tropical monsoon type. In Chennai, the mean daily temperature is approximately 29°C.

The Andhra Pradesh state is summer from March to June, July-to-September season of tropical rains, and a winter from October to February constitutes the three seasons. In Tirupathi and Nellore, the mean daily temperature is approximately 29°C to30°C ((refer to Table 6.1.1 to Table 6.1.3)).

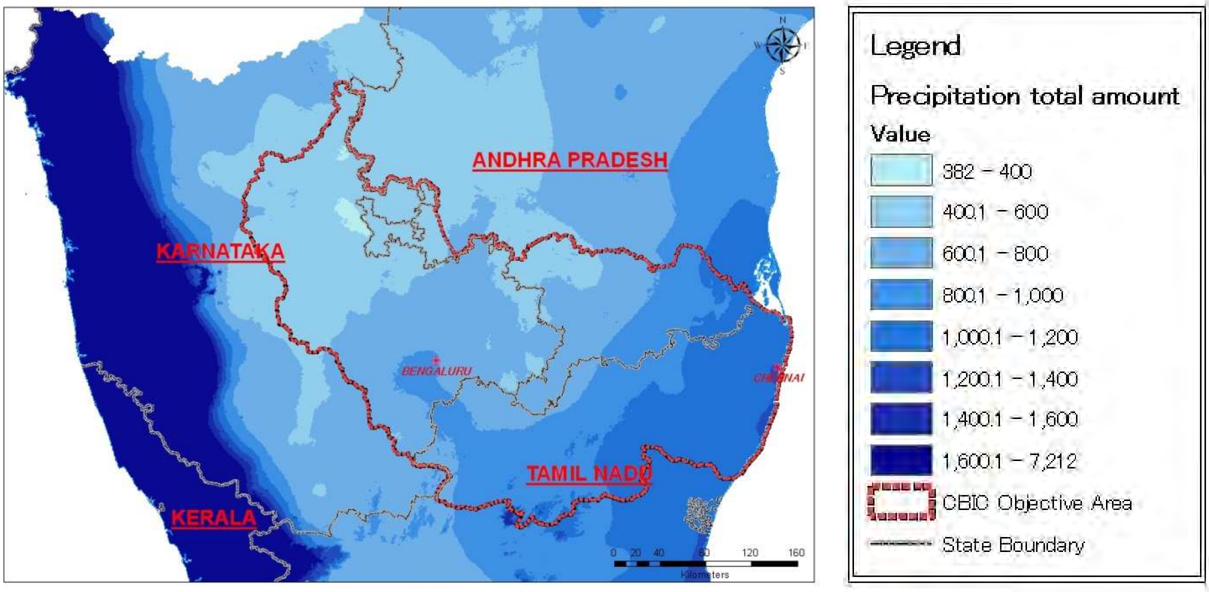


Source: Worldclim

Figure.2 Mean Temperature

2) Precipitation

The average total precipitation in Bengulure is approximately 1,000 mm and in Chennai, it is approximately 1,100 mm. While, in Tirupathi and Nellore in Andhra Pradesh, it is 1,000 to 1,100 mm (refer to Table 6.1.1 to Table 6.1.3).



Source: Worldclim

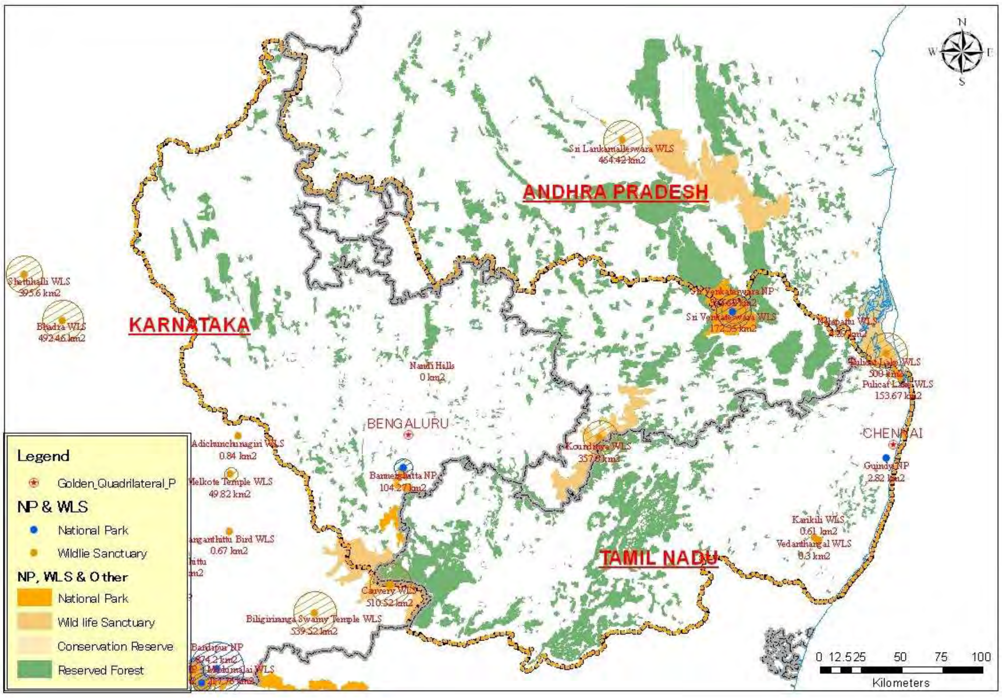
Figure.3Total Precipitation

(2) Protected Areas

There are 102 existing national parks in India covering an area of 40,075 Sq. km, which is 1.22% of the geographical area of the country (National Wildlife Database, Feb. 2013).There are 526 existing wildlife sanctuaries in India covering an area of 124,239 Sq. km, which is 3.78% of the geographical area of the country (National Wildlife Database, Feb. 2013).

1) Protected Area

The Karnataka has 5 National Parks and 25 Wildlife Sanctuaries covering an area of 5590.14 sq. kms and the Tamil NaduState has 5 National parks and 23 wildlife sanctuaries one conservation reserve. The Andhra Pradesh State has 6 National Parks, 21 Wildlife Sanctuaries, which includes 2 Tiger Reserves. The locations of protected areas inside and the vicinity of CBIC corridor is refer to Figure 6.1.4.



Source: Ministry of Environment and Forestry

Figure.4Protected Areas

2) Biodiversity

India is one of the 17 identified mega diverse countries of theworld. From about 70% of the total geographical areasurveyed so far, 45,500 plant species (including fungi and lowerplants) and 91,000 animal species, representing about 7% of the world's flora and 6.5% of the world's fauna,respectively. From the biodiversity standpoint, India has some 59,353 insectspecies, 2,546 fish species, 240 amphibian species, 460 reptilespecies, 1,232 bird species and 397 mammal species, of which18.4% are endemic and 10.8% are threatened.[133]According to IUCN, the threatened species in India and in State-wise are shown in Table 6.1.1. The detail of those data is referred to Table 6.1.4.

Table1The Number of the Threatened Species

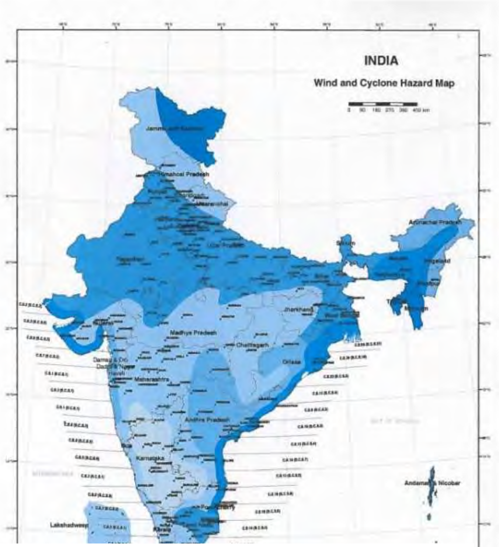
Item	State	Critically Endangered	Endangered
Fauna	Tamil Nadu	23	33
	Karnataka	11	4
	Andhra Pradesh	3	3
	Total of Three State	27	40
	Whole India	72	202
Flora	Tamil Nadu	18	72
	Karnataka	3	12
	Andhra Pradesh	1	2
	Total	22	86
	Whole India	60	148

Source: Prepared by JST based on IUCN Red List, 2013

[133]State of Environment Report,India-2009

(4) Natural Disaster

1) Cyclones



Source: BMTPC: Vulnerability Atlas

Figure.5Wind and Cyclone Hazard Map

Andhra Pradesh

Cyclones on the east coast originate in the Bay of Bengal, the Andaman Sea or the South China Sea, and usually reach the coastline of Tamil Nadu, Andhra Pradesh, Orissa and West Bengal, which are most vulnerable to this type of hazards.

Karnataka

The coastal districts of the state, namely Dakshina Kannada, Udupi, Uttara Kannada with a coastal line of 322 Sq. km and coastal population of 4,364,000 are under the threat of cyclones originating in Arabian Sea.

Tamil Nadu

Tropical depressions commonly develop in the Bay of Bengal with some intensifying into tropical cyclones that significantly affects the synoptic wind pattern surrounding the state.

2) Flood

Andhra Pradesh

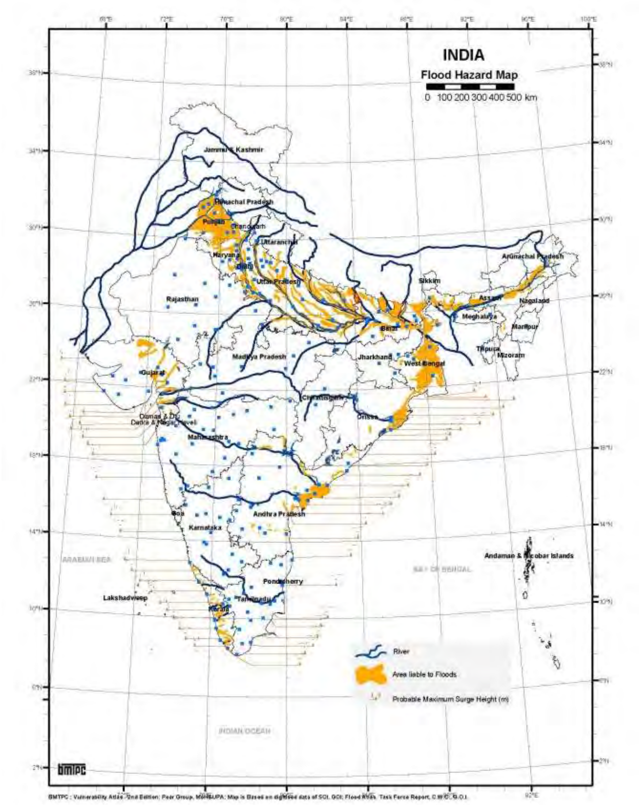
It is estimated that 44% of AP's total territory is vulnerable to tropical storms and related hazards, while its coastal belt is most vulnerable region; Khammam district in Telangana region is most prone to monsoon floods along with five districts in coastal region. Along the coastline, the section between Nizampatnam and Machilipatnam is the most prone to storm surges.

Karnataka

Almost all the districts in Karnataka are facing the brunt of moderate to severe floods. Floods are associated with cloud bursts, cyclones or depressions in the Bay of Bengal and Arabian Sea.

Tamil Nadu

Out of the total annual rainfall in the state, 90% is concentrated over short monsoon season of three months. As a result, heavy discharges from the rivers during this period causing widespread floods in the delta regions. Floods occur mainly in the coastal districts basin that carries 100% of the state total river flows.



Source: BMTPC: Vulnerability Atlas

Figure.6Flood Hazard Map

3) Earthquake

Andhra Pradesh

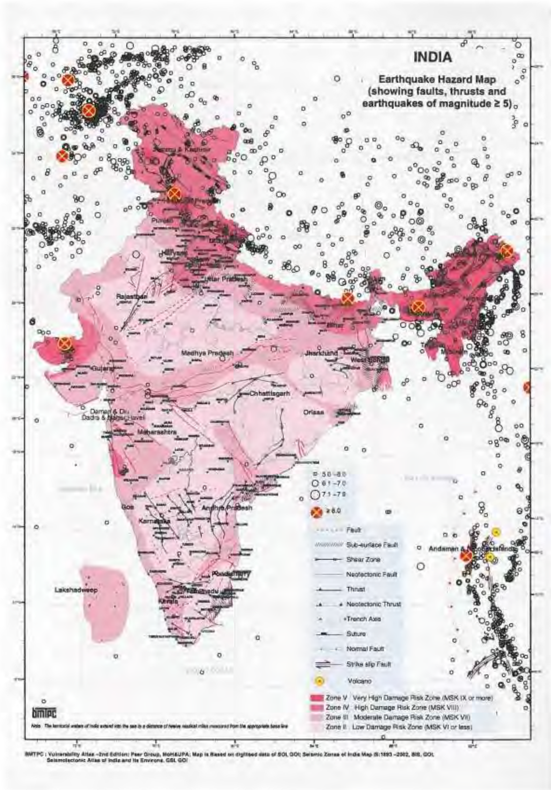
Andhra Pradesh lies in the central part of the Peninsular Indian Shield and is considered as stable and not prone to earthquakes.

Karnataka

As per the Revised Earthquake Hazard Mapping, 22.13% of the total geographical area is under Moderate earthquake damage risk zone & remaining area of the state is under low damage risk zone.

Tamil Nadu

Though not as seismically active as states in the northern and western parts of the country, small to moderate earthquakes have occurred in the state of Tamil Nadu. The frequency of earthquakes is low.



Source: BMTPC: Vulnerability Atlas

Figure.7Earthquake Hazard Map

Table.1 Meteorological data for Bengaluru in Karnataka State

Year	Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2009	Temperature (^0C)	Mean Max	28.1	31.8	33.1	34.5	32.8	29.7	27.9	28.6	28.1	28.8	27.4	27.0
		Mean Min.	15.3	17.7	20.4	22.2	21.6	20.4	20.1	20.3	20.2	19.4	19.3	17.7
	Rainfall (mm)		0.2	0.0	18.9	49.7	151.8	204.6	18.2	152.4	345.8	25.4	64.8	26.1
	Mean of Av. Wind speed for 24 hrs. in kmph		5.2	4.7	3.4	4.2	5.4	7.0	9.5	6.7	5.5	3.7	3.9	4.7
	Relative Humidity (%)	08:30 hrs.IST	78	63	66	70	79	84	86	87	88	77	84	84
		17:30 hrs.IST	38	26	28	30	53	61	66	65	73	53	67	62
2010	Temperature (^0C)	Mean Max	28.1	31.8	34.5	34.5	33.0	29.9	27.5	27.4	27.8	28.5	26.4	26.4
		Mean Min.	17.1	18.2	21.3	22.7	22.3	21.2	20.3	20.5	20.2	20.4	19.3	16.9
	Rainfall (mm)		0.3	0.0	5.9	101.7	108.2	105.2	100.3	137.6	190.3	141.3	145.3	3.3
	Mean of Av. Wind speed for 24 hrs. in kmph		4.6	4.1	3.3	3.0	4.9	6.7	7.2	6.6	5.8	4.6	3.5	4.4
	Relative Humidity (%)	08:30 hrs.IST	82	72	68	71	78	86	89	88	89	87	88	85
		17:30 hrs.IST	41	29	27	43	52	66	72	69	67	69	74	56
2011	Temperature (^0C)	Mean Max	28.9	30.1	33.1	33.1	32.4	29.0	28.1	27.5	28.3	29.3	27.3	27.4
		Mean Min.	15.7	16.9	19.4	21.6	21.3	20.4	20.1	20.1	20.1	20.3	17.9	16.3
	Rainfall (mm)		0.0	44.1	0.2	217.1	150.5	57.7	92.8	278.2	111.1	170.0	49.9	7.2
	Mean of Av. Wind speed for 24 hrs. in kmph		4.5	4.2	4.1	3.6	4.6	8.6	7.9	6.7	6.5	3.6	4.9	4.1
	Relative Humidity (%)	08:30 hrs.IST	71	64	61	78	80	88	88	89	86	87	78	77
		17:30 hrs.IST	34	29	22	44	55	69	68	73	62	71	61	47
2012	Temperature (^0C)	Mean Max	28.9	31.4	34.4	34.9	33.0	30.9	28.8	28.5	29.2	28.5	28.1	28.0
		Mean Min.	16.2	17.2	20.6	22.6	22.1	21.0	20.4	20.2	20.3	19.6	17.7	16.9
	Rainfall (mm)		0.4	0.0	0.7	13.4	143.6	7.2	66.7	189.1	68.4	83.2	125.0	26.9
	Mean of Av. Wind speed for 24 hrs. in kmph		4.4	4.5	3.8	3.8	5.5	8.2	8.0	7.3	5.9	4.3	4.9	4.6
	Relative Humidity (%)	08:30 hrs.IST	78	69	66	72	79	77	84	86	82	81	75	81
		17:30 hrs.IST	38	25	23	34	47	51	59	66	56	61	52	48
2013	Temperature (^0C)	Mean Max	29.6	31.2	33.8	35.4	33.9	28.4	27.2	27.5	27.9	28.3	28.3	27.6
		Mean Min.	16.4	18.1	20.8	23.0	22.2	21.0	20.0	20.1	19.8	20.1	18.5	15.9
	Rainfall (mm)		0.0	2.9	0.6	23.3	151.0	177.1	139.7	94.3	352.6	100.2	143.7	0.3
	Mean of Av. Wind speed for 24 hrs. in kmph		2.2	2.4	2.7	3.0	4.3	6.3	6.3	5.4	4.6	3.9	1.2	1.7
	Relative Humidity (%)	08:30 hrs.IST	72	72	62	69	75	85	88	88	88	83	81	76
		17:30 hrs.IST	31	31	24	36	48	69	75	68	69	64	61	50

Table.2 Meteorological data in Tamil Nadu State(Chennai, Vellore)

Location: Chennai

Period: year 2013

1. MONTHLY MEAN MAXIMUM TEMPERATURE (DEG C)											
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
29.9	30.7	32.6	34.8	37.7	37.5	34.3	34.2	33.5	33.2	31.0	29.5
2. MONTHLY MEAN MINIMUM TEMPERATURE (DEG C)											
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
21.0	22.5	24.1	27.6	28.7	28.3	26.0	26.1	25.9	25.9	24.3	22.1
3. MONTHLY MEAN R.H. AT 0830 HRS IST (%)											
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
88	84	80	77	73	61	80	83	82	86	86	80
4. MONTHLY MEAN R.H. AT 1730 HRS IST (%)											
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
75	72	69	77	74	60	76	76	78	81	81	73
5. MONTHLY TOTAL RAINFALL (MM)											
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Trace	14.3	11.9	3.6	3.6	34.0	146.6	195.1	240.1	157.2	193.7	85.9

Location: Vellore

Period: year 2013

1. MONTHLY MEAN MAXIMUM TEMPERATURE (DEG C)

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
30.6	32.5	35.3	38.5	40.9	35.8	34.5	34.0	33.0	32.6	30.6	29.7

2. MONTHLY MEAN MINIMUM TEMPERATURE (DEG C)

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
18.4	20.7	21.7	26.2	27.8	26.7	25.9	25.1	24.5	24.4	22.6	19.5

3. MONTHLY MEAN R.H. AT 0830 HRS IST (%)

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
88	90	84	76	68	67	70	77	84	85	89	86

4. MONTHLY MEAN R.H. AT 1730 HRS IST (%)

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
65	61	53	39	37	50	54	61	69	71	70	90

5. MONTHLY TOTAL RAINFALL (MM)

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0.0	36.7	45.0	21.6	19.2	143.9	61.7	202.2	224.3	76.5	25.1	3.2

6. MONTHLY MEAN WINDSPEED (KMPH)

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
4	5	5	6	8	12	11	8	6	5	4	5

Table.3 Meteorological data in Andhra Pradesh State(Nellore, Anantapur, Tirupathi)

Location : Nellore

Year	Month	MAX	MIN	RH I	R.H. II	RF	AWS
2009	JAN	30.5	21.0	84	62	0	3
	FEB	33.0	22.2	82	58	0	5
	MAR	35.1	24.3	80	61	0.2	6
	APR	38.1	26.6	73	61	0	8
	MAY	40.1	28.7	66	56	10.3	9
	JUN	39.1	29.4	59	47	44.5	10
	JUL	37.0	28.7	60	49	33.7	8
	AUG	36.1	27.4	70	55	185.8	4
	SEP	35.1	26.8	75	62	119.2	NA
	OCT	34.6	26.2	75	61	21.6	NA
	NOV	30.4	24.4	89	80	488.8	NA
	DEC	28.5	22.4	90	76	189.6	6
2010	JAN	29.8	21.9	88	67	5.9	4
	FEB	32.7	22.8	83	62	0	4
	MAR	36.5	24.7	80	62	0	6
	APR	39.3	27.6	72	62	0	8
	MAY	39.1	28.6	68	58	134.3	9
	JUN	36.8	28.0	71	62	100.2	7
	JUL	33.9	26.4	78	65	84.2	8
	AUG	34.4	26.4	80	67	215.7	7
	SEP	33.4	26.2	78	67	37.9	6
	OCT	33.6	25.8	83	72	463.5	4
	NOV	30.6	24.4	88	80	303.5	5
	DEC	28.8	22.1	89	75	101.4	6
2011	JAN	30.4	21.0	86	62	3.5	5
	FEB	32.0	21.9	84	60	1	5
	MAR	35.0	23.6	79	58	0	5
	APR	36.5	26.2	77	65	40.7	6
	MAY	40.8	28.7	66	52	0.3	7
	JUN	38.0	28.1	65	51	87.5	10
	JUL	36.7	27.3	68	55	63.3	9
	AUG	35.2	26.9	72	61	130	8
	SEP	35.9	26.7	71	56	52.1	7
	OCT	34.3	25.4	81	71	414.9	5
	NOV	31.0	23.2	86	74	342.6	6
	DEC	30.4	22.1	86	72	44.9	6
2012	JAN	30.0	21.3	84	71	49.0	4
	FEB	32.6	21.8	82	61	0.0	4
	MAR	36.2	24.7	78	66	0.0	6
	APR	37.7	26.6	73	64	0.5	7
	MAY	41.1	29.5	62	51	17.6	8
	JUN	38.9	29.4	56	45	17.3	10
	JUL	35.7	27.1	69	54	118.1	9
	AUG	35.9	26.8	68	55	40.5	9
	SEP	36.0	27.0	71	59	40.8	7
	OCT	34.2	25.5	79	68	152.5	6
	NOV	32.7	23.6	79	67	91.1	6
	DEC	30.5	22.6	86	72	179.4	5
2013	JAN	31.4	21.9	87	66	0	4
	FEB	32.7	22.7	85	62	20.6	4
	MAR	35.3	24.1	81	62	1.3	6
	APR	38.5	27.1	77	65	5.4	8
	MAY	41.2	29.5	65	53	0	9
	JUN	38.1	28.6	60	47	101.9	10
	JUL	32.9	26.5	76	63	188.6	8
	AUG	34.0	26.5	75	59	131.9	8
	SEP	34.6	26.2	77	64	108.2	6
	OCT	34.0	25.9	81	69	270.4	7
	NOV	31.1	23.6	85	75	168.6	6
	DEC	30.7	21.6	79	64	1.6	7

Location : Anantapur

Year	Month	MAX	MIN	RH I	R.H. II	RF	AWS
2009	JAN	31.3	14.5	73	31	0	6
	FEB	35.6	17.1	57	22	0	5
	MAR	38.4	20.7	54	24	0.3	6
	APR	40.3	23.8	55	26	14.7	8
	MAY	39.1	24.4	62	31	119.8	13
	JUN	35.6	23.3	67	43	22.7	17
	JUL	33.9	24.5	70	54	10	24
	AUG	33.7	23.7	76	54	112.8	17
	SEP	32.5	23.3	80	62	161	12
	OCT	33.0	21.5	68	46	66.5	8
	NOV	30.3	21.4	83	65	74.8	5
	DEC	29.9	18.7	84	50	3.6	6
2010	JAN	31.2	18.4	78	39	50	5
	FEB	35.8	19.0	65	25	0	5
	MAR	39.6	22.3	54	20	0	6
	APR	40.8	25.9	55	29	25.2	7
	MAY	39.1	26.3	62	36	60.7	12
	JUN	36.1	25.2	69	47	61.8	15
	JUL	32.6	23.8	76	63	217.1	16
	AUG	32.2	23.2	78	60	145.5	13
	SEP	32.3	23.3	78	59	39.6	10
	OCT	32.8	22.8	78	57	110.6	7
	NOV	30.3	21.2	83	68	97.6	5
	DEC	29.5	17.6	85	52	8.2	5
2011	JAN	31.7	14.3	79	34	0.1	4
	FEB	33.6	16.9	73	30	0.2	4
	MAR	37.8	20.3	62	18	0	5
	APR	38.4	23.9	63	27	66.8	5
	MAY	38.4	25.3	65	29	117.6	10
	JUN	34.5	24.1	69	48	84	19
	JUL	33.9	23.7	75	54	157.7	19
	AUG	32.5	23.3	78	56	109.8	14
	SEP	33.6	22.6	74	50	22.7	12
	OCT	32.8	22.8	80	57	120.1	3
	NOV	30.6	18.7	79	51	21.8	4
	DEC	30.6	16.5	79	45	4.7	4
2012	JAN	32.4	15.9	71	27	0.0	5
	FEB	35.0	17.8	67	27	0.0	5
	MAR	38.0	21.5	57	20	4.0	6
	APR	39.0	24.9	61	28	58.3	6
	MAY	38.9	25.9	64	27	7.6	14
	JUN	37.1	25.1	66	39	25.7	22
	JUL	34.1	24.2	74	52	121.5	20
	AUG	33.6	23.7	75	53	87.8	19
	SEP	33.3	22.8	74	49	91.3	10
	OCT	32.0	21.3	76	52	70.7	2
	NOV	31.0	18.9	77	45	50.0	4
	DEC	31.1	17.4	79	39	5.5	4
2013	JAN	33.1	17.0	74	26	0	6
	FEB	34.3	19.7	65	26	10.6	6
	MAR	38.1	22.3	55	22	0	6
	APR	40.7	25.9	57	26	9.8	5
	MAY	40.4	26.4	67	29	34.9	13
	JUN	34.5	24.1	73	46	99.9	21
	JUL	32.5	23.6	76	58	32	21
	AUG	32.7	23.1	78	56	56.6	18
	SEP	32.0	22.2	84	64	245.2	10
	OCT	32.1	22.9	78	64	49.9	8
	NOV	31.3	20.0	74	54	0.6	5
	DEC	30.8	16.7	74	45	0	5

Location : Tirupathi

Year	Month	MAX	MIN	RH I	R.H. II	RF	AWS
2009	JAN	30.6	18.3	80	53	4.8	6
	FEB	34.7	19.2	69	37	0.0	5
	MAR	37.3	22.6	67	37	0.2	6
	APR	40.2	25.6	63	35	7.6	7
	MAY	41.7	27.9	59	38	18.9	7
	JUN	39.4	27.3	57	46	89.6	7
	JUL	37.3	27.1	61	51	81.8	8
	AUG	35.8	26.4	68	54	258.7	5
	SEP	35.5	26.2	68	59	33.3	4
	OCT	35.2	24.1	67	50	86.8	4
	NOV	30.0	23.1	86	79	287.3	4
	DEC	28.8	21.7	84	76	145.4	5
2010	JAN	30.2	19.8	83	64	0.9	4
	FEB	33.4	20.6	78	52	0.0	4
	MAR	38.6	23.7	69	36	0.0	7
	APR	41.0	27.7	65	34	18.4	7
	MAY	40.5	28.2	61	39	115.9	7
	JUN	36.9	26.9	67	55	87.5	6
	JUL	34.3	25.2	76	64	170.3	5
	AUG	34.3	25.3	76	64	135.2	4
	SEP	33.9	24.9	77	64	140.3	3
	OCT	33.5	24.3	79	70	187.7	3
	NOV	30.6	22.7	86	80	255.2	4
	DEC	28.2	20.0	86	75	93.9	4
2011	JAN	30.2	17.9	80	59	0.8	4
	FEB	32.5	18.2	77	49	25.0	5
	MAR	36.1	20.9	66	37	0.0	6
	APR	38.8	25.8	68	47	14.4	6
	MAY	41.4	28.4	58	38	2.9	7
	JUN	38.9	27.8	57	44	74.3	7
	JUL	36.7	26.0	69	51	134.4	6
	AUG	34.6	25.1	76	59	168.4	5
	SEP	35.7	25.0	69	52	91.5	5
	OCT	34.2	24.4	80	69	119.1	3
	NOV	30.3	21.1	82	70	322.1	4
	DEC	30.2	19.9	84	66	144.0	5
2012	JAN	31.3	18.9	84	59	1.5	4
	FEB	33.8	18.9	76	46	0.0	6
	MAR	38.7	24.0	65	32	0.0	7
	APR	40.1	26.3	66	41	38.7	6
	MAY	41.7	28.6	54	37	1.3	6
	JUN	39.8	28.0	52	36	78.6	7
	JUL	36.3	25.9	66	50	118.8	5
	AUG	36.1	25.1	67	57	147.4	5
	SEP	35.5	24.9	72	61	115.5	4
	OCT	33.9	24.0	79	64	278.3	5
	NOV	31.6	20.7	79	64	259.1	6
	DEC	30.0	20.3	85	69	256.0	5
2013	JAN	30.9	18.5	86	58	0.0	5
	FEB	32.4	19.6	80	53	56.4	6
	MAR	35.5	22.2	73	44	89.6	5
	APR	39.5	26.6	68	45	43.8	6
	MAY	41.2	28.6	61	40	14.0	6
	JUN	38.1	27.9	57	41	53.4	6
	JUL	35.0	25.6	71	56	127.2	4
	AUG	34.4	25.2	74	57	156.0	4
	SEP	34.6	25.1	72	61	136.0	3
	OCT	34.0	24.3	75	65	231.8	4
	NOV	30.9	22.1	80	71	137.6	5
	DEC	29.9	19.5	79	60	2.6	6

Table.4 List of Endangered Species from IUCN

Critically Endangered Species

Fauna

(Tamil Nadu:23)

(Karnataka:11)

(Andhra Pradesh: 3)

1. Holothuria fuscogilva
2. Nilssonia leithii (Leith's Softshell Turtle)
3. Ophiophagus hannah (King Cobra)

Flora

(Tamil Nadu:18)

1 Actinodaphne lanata
2 Berberis nilghiriensis
3 Cinnamomum walaiwarense
4 Dipterocarpus bourdilloni
5 Elaeocarpus gaussenii
6 Eugenia singampattiana
7 Ficus angladei
8 Hildegardia populifolia
9 Hopea erosa
10 Hygrophila madurensis
11 Memecylon sisparense
12 Meteoromyrtus wynaadensis
13 Nothopegia aureo-fulva
14 Pittosporum viridulatum
15 Poeciloneuron pauciflorum
16 Pseudoglochidion anamalayanum
17 Syzygium courtallense
18 Vateria indica

(Karnataka:3)

1 Dipterocarpus bourdilloni
2 Hopea erosa
3 Vateria indica

(Andhra Pradesh:1)

1 Hildegardia populifolia

Endangered Species

Fauna

(Tamil Nadu:33)

1. Ahaetulla perroteti (Perrotet's Vine Snake)
2. Dasia subcaerulea (Boulenger's Dasia)
3. Devario neilgherriensis (Nilgiri Danio)
4. Garra hughi (Cardamon Garra)
5. Garra kalakadensis (Kalakad Stone Carp)
6. Glyptothorax anamalaiensis (Anamalai Sucker Catfish)
7. Glyptothorax housei
8. Haploclastus kayi (Parambikulam Large Burrowing Spider)
9. Homaloptera montana (Anamalai Loach)
10. Horalabiosa joshuai (Lipped Algae Eater)
11. Hypselobarbus curmuca
12. Hypselobarbus dubius (Nilgiri Barb)
13. Hypselobarbus micropogon
14. Hypselobarbus mussullah (Hump Backed Mahseer)
15. Idionyx galeata
16. Lamiopsis temmincki (Broadfin Shark)
17. Latidens salimalii (Salim Ali's Fruit Bat)
18. Longischistura striatus
19. Macaca silenus (Lion-tailed Macaque)
20. Nemacheilus pulchellus
21. Otocryptis beddomii (Indian Kangaroo Lizard)
22. Platyplectrurus madurensis (Travancore Hills Thorntail Snake)
23. Poecilotheria formosa (Finely Formed Parachute Spider)
24. Poecilotheria rufilata (Reddish Parachute Spider)
25. Pterocryptis wynaadensis (Malabar Silurus)
26. Puntius arulius
27. Puntius sharmai
28. Puntius tambraparniei
29. Rhinophis travancoricus (Travancore Earth Snake)
30. Schismatorhynchos nukta (Nukta)
31. Sphyrna mokarran (Squat-headed Hammerhead Shark)
32. Tor khudree (Black Mahseer)
33. Tor malabaricus (Malabar Mahseer)

(Andhra Pradesh:4)

1. Lamiopsis temmincki (Broadfin Shark)
2. Poecilotheria Formosa (Finely Formed Parachute Spider)
3. Sphyrna mokarran (Squat-headed Hammerhead Shark)
4. Tor khudree (Black Mahseer)

(Karnataka:3)

1. Lamiopsis temmincki (Broadfin Shark)
2. Sphyrna mokarran (Squat-headed Hammerhead Shark)
3. Torkhudree(Black Mahseer)

Flora

(Tamil Nadu:72)

1. Actinodaphne bourneae

2. Actinodaphne salicina
3. Anacolosa densiflora
4. Ardisia blatteri
5. Atuna indica
6. Atuna travancorica
7. Byrsophyllum tetrandrum
8. Canthium ficiforme
9. Chionanthus linocieroides
10. Cinnamomum chemungianum
11. Cinnamomum filipedicellatum
12. Cleistanthus travancorensis
13. Cryptocarya anamallayana
14. Cyathea crinita
15. Cycas circinalis
16. Cynometra travancorica
17. Dalbergia congesta
18. Dimorphocalyx beddomei
19. Dipterocarpus indicus
20. Drypetes porteri
21. Elaeocarpus blascoi
22. Eugenia discifera
23. Eugenia floccosa
24. Eugenia indica
25. Euodia lunuankenda
26. Euonymus paniculatus
27. Euonymus serratifolius
28. Euphorbia santapauii
29. Farmeria indica
30. Fimbristylis crystallina
31. Glochidion pauciflorum
32. Glochidion sisparense
33. Glochidion tomentosum
34. Goniothalamus rhynchantherus
35. Homalium jainii
36. Hopea glabra
37. Hopea parviflora
38. Hopea ponga
39. Hopea utilis
40. Humboldtia bourdillonii
41. Hydrocotyle conferta
42. Isonandra villosa
43. Ixora saulierei
44. Kingiodendron pinnatum
45. Koilodepas calycinum
46. Kyllinga pluristaminea
47. Lindernia minima
48. Litsea beddomei
49. Litsea nigrescens
50. Melicope indica
51. Memecylon flavescens
52. Memecylon subramanii
53. Microtropis densiflora
54. Nostolachma crassifolia
55. Orophea thomsoni
56. Palaquium ravii
57. Polyalthia rufescens
58. Popowia beddomeana
59. Psychotria globicephala
60. Psychotria macrocarpa
61. Rotala ritchiei
62. Shorea roxburghii (White Meranti)

63. Sophora wightii
64. Symplocos anamallayana
65. Symplocos barberi
66. Symplocos nairii
67. Symplocos oligandra
68. Syzygium beddomei
69. Syzygium microphyllum
70. Syzygium myhendrae
71. Syzygium parameswaranii
72. Tarenna monosperma

(Andhra Pradesh:2)

1. Dalbergia congesta
2. Shorea roxburghii (White Meranti)

(Karnataka:12)

1. Cycas circinalis
2. Cynometra travancorica
3. Dalbergia congesta
4. Dipterocarpus indicus
5. Glochidion pauciflorum
6. Glochidion tomentosum
7. Hopea glabra
8. Hopea Parviflora
9. Hopea ponga
10. Kingiodendron pinnatum
11. Rotala ritchiei
12. Shorea Roxburghii (White Meranti)

Annexure 13: Power

S no.	Project title	Project Description (MW)	Status	Project Cost (USD million)	Implementing agency	Source of funds	Priority
1	Tuticorin NLC	2 x 500MW coal thermal	Under Construction	1,000	Neyveli Lignite Corporation/ TANGEDCO	Term-loan agreement with consortium of nine banks led by Bank of Baroda. It has tied up USD 417 Million	Yes
2	Yermarus	2 x 800MW coal thermal	Under construction	1,600	KPCL/BHEL	PFC: 918 Million USD, 195 million USD from commercial banks	Yes
3	Bhavnapadu I	2 x 660MW coal thermal	Under Construction	1,320	East Coast Energy	75:25 debt equity ratio: USD 859 million from loans	Yes
4	Samalkot II	2262 MW gas thermal	Under Construction	2,400	Reliance	Debt: USD 1168 million	Yes
5	Sri Damodaram	2 x 800 MW coal thermal	Under Construction	1,600	Andhra Pradesh Generation Corporation	USD 312 million from Tripartite Loan, PFC: 798 million	Yes
6	Thermal Powertech I	2 x 660MW coal thermal	Under Construction	1,320	Gayatri Projects/Sembcorp	Debt component will be financed through a consortium of Rural Electrification Corporation, Power Finance Corporation, ICICI Bank, Life Insurance Corp. of India, Punjab National Bank, United Bank of India, Bank of Baroda, Syndicate Bank, Oriental Bank of Commerce and PTC India Financial Services Ltd.	Yes
7	Vishakhapattnam	2 x 520MW coal thermal	Under Construction	1,040	Hinduja National Power	Project achieved financial closure with SBI as lead banker of consortioum of 14 public sector banks.	Yes
8	Cheyyur UMPP	5 x 800MW coal thermal	Under Bidding stage	4,000	Not Decided (PFC bidding agency)	As per the bidder	Yes

S no.	Project title	Project Description (MW)	Status	Project Cost (USD million)	Implementing agency	Source of funds	Priority
9	Solar UMPP	In conceptualization stage with MNRE. No details in public domain.	Under conceptualization	5,500	Not Decided (MNRE bidding agency)	As per the bidder	Yes
10	Lignite based capacity – 1000 MW Tamil Nadu	In conceptualization stage with TANGEDCO. Expected to be bid out by FY 2016.	Under conceptualization	890	NA	As per the bidder	Yes
11	Krishnapatnam UMPP	Part A: Krishnapatnam – Gooty transmission line, Part B: Associated Transmission System, Part-C1: Associated Transmission System	Under Construction	Part B - 321 million USD, Part C1 – 54 million USD	PGCIL	Part B: loan from the International Bank for Reconstruction and Development	Yes
12	Greenko Hydro plant 100 MW - Cauvery Basin	a cluster of 25 MW run-of-river hydro projects totaling 100MW	Under construction	150	Greenko, KPCL, KERC	Private Developer	Yes
13	Transmission system for LTA of 400 MW for 2x500 MW Neyveli Lignite Corporation Ltd. TS-I (Replacement) (NNTPS) in Neyveli	Transmission system for LTA of 400 MW for 2x500 MW Neyveli Lignite Corporation Ltd. TS-I (Replacement) (NNTPS) in Neyveli	Under implementation	1000	NA	NA	Yes
14	Simhapuri TPS II	300	Under Construction	300	Madhucon Projects Limited	entire debt of USD 200 million from consortium of 13 bankers with SBI as the lead.	No
15	Lower Jurala	320	Under Construction	240	Andhra Pradesh Power Generation Corporation Limited	Loan of USD 121 million from PFC	No
16	Rajahmundry	768	Under Construction	768	GMR Energy limited	USD 412 million with IDBI	No

S no.	Project title	Project Description (MW)	Status	Project Cost (USD million)	Implementing agency	Source of funds	Priority
17	Kondapalli III	742	Under Construction	742	Lanco Power	Debt: USD 305 million	No
18	Panduranga I	110	Under Construction	110	Panduranga Energy Systems Private Limited	-	No
19	Biccavolu I	225	Under Construction	225	KPR Chemicals Limited	-	No
20	Meenakshi Thamminapatnam II	700	Under Construction	700	Meenakshi Energy Private Limited	-	No
21	Kakatiya II	600	Under Construction	600	Andhra Pradesh Power Generation Corporation Limited	-	No
22	Nagarjuna Sagar Tail	67	Under Construction	50	Andhra Pradesh Power Generation Corporation Limited	-	No
23	Rayalseema IV	600	Under Construction	600	Andhra Pradesh Power Generation Corporation Limited	-	No
24	Pulichintala	160	Under Construction	120	Andhra Pradesh Power Generation Corporation Limited	-	No
25	Bellary (Partly Commissioned)	700	Under Construction	700	Karnataka Power Corporation Limited	-	No
26	Vadlur	450	Under Construction	420	Surana Power Limited	-	No
27	Mutiara	150	Under Construction	120	Coastal Energen Private Limited	-	No

S no.	Project title	Project Description (MW)	Status	Project Cost (USD million)	Implementing agency	Source of funds	Priority
28	Ind Barath Thootukudi (Partly Commissioned)	150	Under Construction	150	Ind Barath Power Infra Limited	-	No
29	Kudankulam II	3,333	Under Construction	1690	Nuclear Power Corporation of India Limited	-	No
30	Neyveli TPS II Ext (Partly Commissioned)	250	Under Construction	250	Neyveli Lignite Corporation Limited	-	No
31	Vallur II	500	Under Construction	500	Tamilnadu Electricity Board	-	No
32	Chennai IV	160	Under Construction	160	OPG Power Gen Limited	-	No
33	Ennore II	660	Under Construction	660	Tamilnadu Electricity Board	-	No
34	Ind Barath Madras I	660	Under Construction	660	Ind Barath Power Infra Limited	-	No
35	Nagai	300	Under Construction	300	KVK Energy and Infrastructure Private Limited	-	No
36	Gummidipoondi	126	Under Construction	126	Kaveri Gas Power Limited	-	No
37	Coal power plant commissioning in FY 2022 – Capacity: 4,000 MW *	4,000	Under Construction	4000	CBIC Region	-	No
38	Nuclear power plant commissioning in FY 2032 – Capacity: 3,400 MW	5,780	Under Construction	3400	CBIC Region	-	No

S no.	Project title	Project Description (MW)	Status	Project Cost (USD million)	Implementing agency	Source of funds	Priority
39	RES power plant commissioning in FY 2032 – Capacity:1,500 MW - UMPP	1,950	Under Construction	1500	CBIC Region	-	No
40	Gas Based plant commissioning in FY 2022 – Capacity 2000 MW	1,600	Under Construction	2000	CBIC Region	-	No
41	Gas Based plant commissioning in FY 2032 – Capacity 1400 MW	1,120	Under Construction	1400	CBIC Region	-	No
42	Gas Based plant commissioning in FY 2032 – Capacity 3500 MW	2,800	Under Construction	3500	CBIC Region	-	No
43	Hydro based plant capacity in FY 2032 – Capacity 3500 MW	4,550	Under Construction	3500	CBIC Region	-	No
44	Coal power plant commissioning in FY 2032 – Capacity: 4,000 MW	4,000	Under Construction	4000	CBIC Region	-	No
45	Coal power plant commissioning in FY 2032 – Capacity: 4,000 MW	4,000	Under Construction	4000	CBIC Region	-	No
46	Coal power plant commissioning in FY 2032 – Capacity: 4,000 MW	4,000	Under Construction	4000	CBIC Region	-	No
47	Coal power plant commissioning in FY 2032 – Capacity: 4,000	4,000	Under Construction	4000	CBIC Region	-	No

S no.	Project title	Project Description (MW)	Status	Project Cost (USD million)	Implementing agency	Source of funds	Priority
	MW						
48	Coal power plant commissioning in FY 2032 – Capacity: 4,000 MW	4,000	Under Construction	4000	CBIC Region	-	No
49	Coal power plant commissioning in FY 2032 – Capacity: 4,000 MW	4,000	Under Construction	4000	CBIC Region	-	No
50	Coal power plant commissioning in FY 2032 – Capacity: 4,000 MW	4,000	Under Construction	4000	CBIC Region	-	No
51	Simhapuri Coastal-KPTNM: 570 MW	570	Under Construction	-	APTRANSCO	-	No
52	Meenakshi Energy ST-I +	900	Under Construction	-	APTRANSCO	-	No
53	II: 900 MW	900	Under Construction	-	APTRANSCO	-	No
54	Thermal Powertech Corp: 1980 MW	1980	Under Construction	-	APTRANSCO	-	No
55	Krishnapatnam Navyuga 1320 MW	1320	Under Construction	-	APTRANSCO	-	No
56	Kineta Power 1980 MW	1980	Under Construction	-	APTRANSCO	-	No
57	East Coast 1320 MW	1320	Under Construction	-	APTRANSCO	-	No
58	GMR Rajmundry 768 MW	768	Under Construction	-	APTRANSCO	-	No
59	Spectrum-Vemagiri-Gas 1400 MW	1400	Under Construction	-	APTRANSCO	-	No

S no.	Project title	Project Description (MW)	Status	Project Cost (USD million)	Implementing agency	Source of funds	Priority
60	Reliance-Vemagiri-Gas 2400 MW	2400	Under Construction	-	APTRANSCO	-	No
61	GVK-Gautmi-Vemagiri-Gas 800 MW	800	Under Construction	-	APTRANSCO	-	No
62	GVK-Jegrupadu-Vemagiri-Gas 800 MW	800	Under Construction	-	APTRANSCO	-	No
63	Hinduja Vizag 1040 MW	1040	Under Construction	-	APTRANSCO	-	No
64	Lanco Kondapally St-III 740 MW	740	Under Construction	-	APTRANSCO	-	No
65	Rayalseema St -III (U-6) 600 MW	600	Under Construction	-	APTRANSCO	-	No
66	Pulichintala 120 MW	120	Under Construction	-	APTRANSCO	-	No
67	Lower Jurala U1-6 240 MW	240	Under Construction	-	APTRANSCO	-	No
68	Krishnapatnam (1600) 1600 MW	1600	Under Construction	-	APTRANSCO	-	No
69	Kakatiya TPP I +II 600 MW	600	Under Construction	-	APTRANSCO	-	No
70	Torangallu U 3 300 MW	3300	Under Construction	-	KPCL	-	No
71	Gundia HEP 400 MW	400	Under Construction	-	KPCL	-	No
72	Bellary DGPP +TPP U1,U2, U3 600 MW	3600	Under Construction	-	KPCL	-	No
73	Yermarus TPP 1600 MW	1600	Under Construction	-	KPCL	-	No
74	Edlapur 800 MW	800	Under Construction	-	KPCL	-	No
75	New projects – 230 kV Sub Stations	230	Under Construction	218	TANTRANSCO	-	No

S no.	Project title	Project Description (MW)	Status	Project Cost (USD million)	Implementing agency	Source of funds	Priority
76	New projects – 110 kV Sub Stations	110	Under Construction	81	TANTRANSCO	-	No
77	Power evacuation link lines – 400 kV Sub Stations	400	Under Construction	538	TANTRANSCO	-	No
78	Power evacuation link lines – 230 kV Sub Stations	230	Under Construction	239	TANTRANSCO	-	No
79	Power evacuation link lines – 110 kV Sub Stations	110	Under Construction	91	TANTRANSCO	-	No
80	Improvement of sub-station lines – Substations	NA	Under Construction	32	TANTRANSCO	-	No
81	Improvement of sub-station lines – 400 kV lines	400	Under Construction	385	TANTRANSCO	-	No
82	Improvement of sub-station lines – 230 kV lines	230	Under Construction	42	TANTRANSCO	-	No
83	Improvement of sub-station lines – 110 kV lines	110	Under Construction	67	TANTRANSCO	-	No
84	Improvement of sub-station lines – HTLS	NA	Under Construction	31	TANTRANSCO	-	No
85	Enhancements / Additional Power Transformers	NA	Under Construction	50	TANTRANSCO	-	No
86	Transmission project for nuclear power plant commissioning in FY 2032 – Capacity: 3,400 MW	3400	Under Construction	2,312	CBIC Region	-	No

S no.	Project title	Project Description (MW)	Status	Project Cost (USD million)	Implementing agency	Source of funds	Priority
87	Transmission project for Coal power plant commissioning in FY 2022 – Capacity: 4,000 MW	4000	Under Construction	1,600	CBIC Region	-	No
88	Transmission project for RES power plant commissioning in FY 2022 – Capacity:2,500 MW - UMPP	2500	Under Construction	1,300	CBIC Region	-	No
89	Transmission project for RES power plant commissioning in FY 2032 – Capacity:1,500 MW - UMPP	1500	Under Construction	780	CBIC Region	-	No
90	Transmission project for Gas Based plant commissioning in FY 2022 – Capacity 2000 MW	2000	Under Construction	640	CBIC Region	-	No
91	Transmission project for Gas Based plant commissioning in FY 2032 – Capacity 1400 MW	1400	Under Construction	448	CBIC Region	-	No
92	Transmission project for Gas Based plant commissioning in FY 2032 – Capacity 3500 MW	3500	Under Construction	1,120	CBIC Region	-	No
93	Transmission project for Hydro based plant capacity in FY 2022- Capacity 2400 MW	2400	Under Construction	1,248	CBIC Region	-	No

S no.	Project title	Project Description (MW)	Status	Project Cost (USD million)	Implementing agency	Source of funds	Priority
94	Transmission project for Hydro based plant capacity in FY 2032 – Capacity 3500 MW	3500	Under Construction	1,820	CBIC Region	-	No
95	Transmission project for Hydro based plant capacity in FY 2022- Capacity 2400 MW	4000	Under Construction	1,600	CBIC Region	-	No
96	Transmission project for Coal power plant commissioning in FY 2032 – Capacity: 4,000 MW	4000	Under Construction	1,600	CBIC Region	-	No
97	Transmission project for Coal power plant commissioning in FY 2032 – Capacity: 4,000 MW	4000	Under Construction	1,600	CBIC Region	-	No
98	Transmission project for Coal power plant commissioning in FY 2032 – Capacity: 4,000 MW	4000	Under Construction	1,600	CBIC Region	-	No
99	Transmission project for Coal power plant commissioning in FY 2032 – Capacity: 4,000 MW	4000	Under Construction	1,600	CBIC Region	-	No
100	Transmission project for Coal power plant commissioning in FY 2032 – Capacity: 4,000 MW	4000	Under Construction	1,600	CBIC Region	-	No

S no.	Project title	Project Description (MW)	Status	Project Cost (USD million)	Implementing agency	Source of funds	Priority
101	Transmission project for Coal power plant commissioning in FY 2032 – Capacity: 4,000 MW	4000	Under Construction	1,600	CBIC Region	-	No
102	Transmission project for Coal power plant commissioning in FY 2032 – Capacity: 4,000 MW	4000	Under Construction	1,600	CBIC Region	-	No

Disclaimer

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