Andhra Pradesh Capital Region Development Authority
The Republic of India

Comprehensive Traffic and Transportation Study (CTTS) for Andhra Pradesh Capital Region Development Authority (APCRDA) Jurisdiction in the Republic of India

Final Report

March 2022

Japan International Cooperation Agency (JICA)

Oriental Consultants Global Co., Ltd.
Nippon Koei Co., Ltd.
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USD	1.00 = JPY	115.555
INR	1.00 = JPY	1.54190

(March 2022)

Comprehensive Traffic and Transportation Study for Andhra Pradesh Capital Region Development Authority Jurisdiction in the Republic of India

Final Report

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List of Abbreviations

Abbreviations	Full Form
AAI	Airports Authority of India
ACC	Amaravati Capital City
ADB	Asian Development Bank
AMRCL	Amaravati Metro Rail Corporation Limited;
APADCL	Andhra Pradesh Airports Development Corporation Ltd.
APCR	Andhra Pradesh Capital Region
APCRDA	Andhra Pradesh Capital Region Development Authority
APCRUTA	APCR Unified Transport Authority
APIA	Andhra Pradesh State Investment Authority
APIDEA	Andhra Pradesh State Investment Development Attraction Act
APIIC	Andhra Pradesh Industrial Infrastructure Corporation
APPCB	Andhra Pradesh Pollution Control Board
APRDC	Andhra Pradesh Road Development Corporation
APRIDCL	Andhra Pradesh Rail Infrastructure Development Corporation Limited
APSRTC	Andhra Pradesh State Road Transport Corporation
ATF	Amaravati Transport Fund
B/C	Benefit to Cost Ratio
BAU	Business as Usual
BCG	Boston Consulting Group
BMLTA	Bangalore Metropolitan Land Transport Authority
BMLTA	Bangalore Metropolitan Land Transport Authority
BOD	Biochemical Oxygen Demand
BOT	Build Operate and Transfer
BRT	Bus Rapid Transit
CAD	Command Area Development
CMP	Concept Master Plan
CPCB	Central Pollution Control Board
CPWD	Central Public Works Department
CRN	Core Road Network
CTTS	Comprehensive Traffic and Transport Study
DBFOT	Design Build Finance Operate and Transfer
DFC	Dedicated Freight Corridor
DFCCIL	Dedicated Freight Corridor Corporation Limited
DGCA	Directorate General of Civil Aviation
DMP	Detailed Master Plan
DMRC	Delhi Metro Rail Corporation
DPP	Draft Perspective Plan

Abbreviations	Full Form
DPR	Detailed Project Report
DULT	Directorate of Urban Land Transport
ECEC	East-Coast Economic Corridor
EIRR	Economic Internal Rate of Return
ENPV	Economic Net Present Value
EOI	Expression of Interest
EPC	Engineering, Procurement, Construction;
FDI	Foreign Direct Investment
FIRR	Financial Internal Rate of Return
FSR	Feasibility Study Report
GHG	Greenhouse Gas
GIS	Geographic Information System
GO	Government Order
GoAP	Government of Andhra Pradesh
GoI	Government of India
GoK	Government of Karnataka
GRDP	Gross Regional Domestic Product
GST	Goods and Services Tax
HGV	Heavy Goods Vehicle
HIS	Household Interview Survey
HMDA	Hyderabad Metropolitan Development Authority
HSCR	High Speed Circular Rail
HSRC	High Speed Rail Corporation
IAP	Immediate Action Plan
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IDF	Infrastructure Debt Fund
IFC	International Finance Corporation
INR	Indian Rupee
InvIT	Infrastructure Investment Trust
IPT	Intermediate Public Transport
IR	Indian Railways
IRC	Indian Roads Congress
IRR	Inner Ring Road
IRSDC	Indian Railways Station Development Corporation Limited
ITS	Intelligent Transport System
IWAI	Inland Waterways Authority of India
IWAI	Inland Waterways Authority of India
IWT	Inland Water Transport

Abbreviations	Full Form
JBIC	Japan Bank of International Cooperation
JCC	Joint Coordination Committee
JICA	Japan International Cooperation Agency
JOIN	Japan Overseas Infrastructure Investment
JVC	Joint Venture Corporation
LIC	Life Insurance Corporation
LRT	Light Rail Transit
LVC	Land Value Capture
MA&UD	Municipal Administration & Urban Development
MDBs	Multilateral Development Banks
MDR	Major District Road
MFF	Multiannual Financial Framework
MoHUA	Ministy of Housing and Urban Affairs
MoRTH	Ministry of Road Transport and Highways
MPC	Metropolitan Planning Committee
MRT	Mass Rapid Transit
MUDA	Machilipatnam Urban Development Authority;
NACs	Non-Attainment Cities
NBFC	Non-Banking Financial Company
NHAI	National Highway Authority of India
NHDP	National Highway Development Program
NHSRCL	National High Speed Rail Corporation
NIIF	National Infrastructure Investment Fund
NMT	Non-Motorized Transport
NUTP	National Urban Transport Policy
OD	Origin Destination
ODA	Official Development Assistance
ORR	Outer Ring Road
PBB	Prakasam Barrage Bridge
PCU	Passenger Car Unit
PDR	Preliminary Design Reports
PFI	Private Finance Initiative
PIU	Project Implementation Unit
PNBS	Pandit Nehru Bus Station
PPP	Public Private Partnership
PSB	Public Sector Bank
PSIF	Private Sector Investment and Finance
PWD	Public Works Department
R&B	Roads and Buildings Department, GoAP

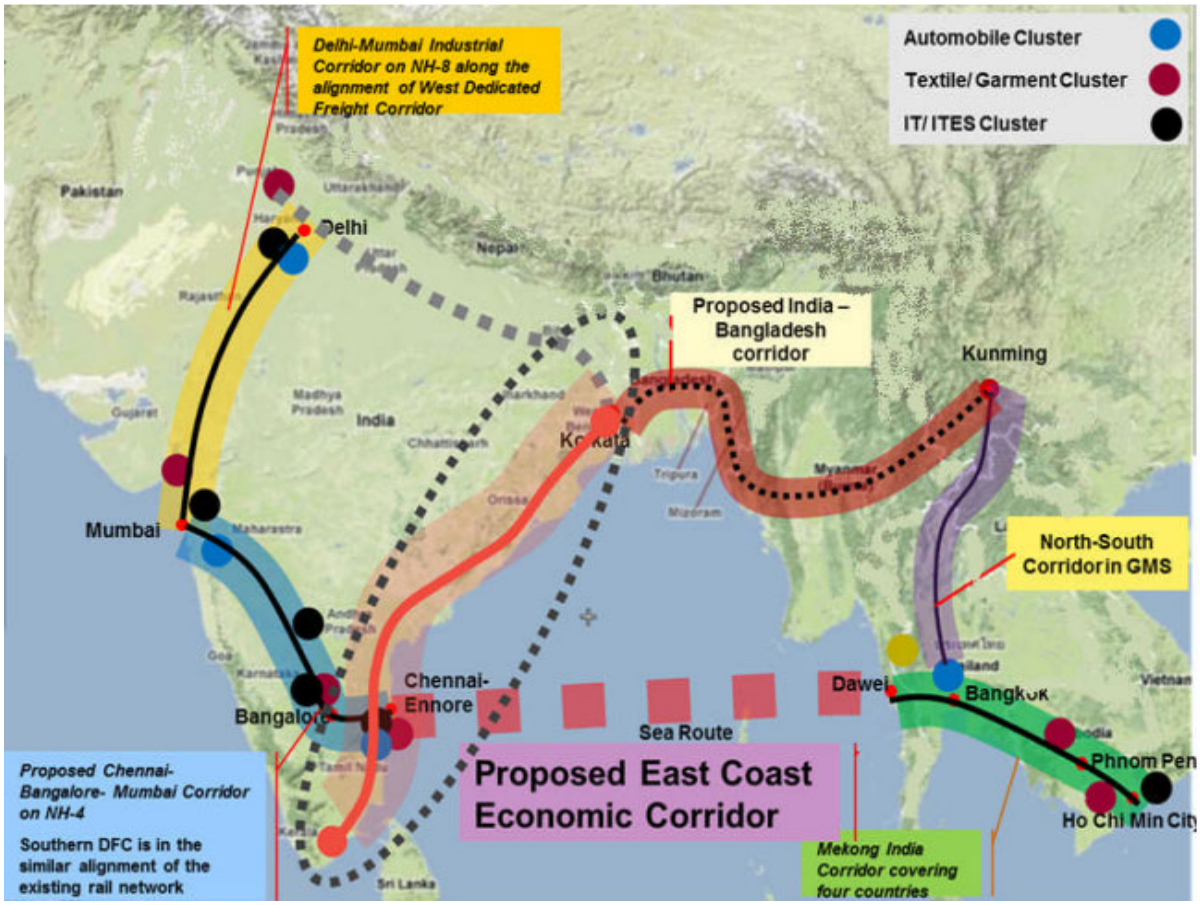
Abbreviations	Full Form
RD	Rocord of Discussion
RDP	Road Development Plan
REIT	Real Estate Investment Trust
RFP	Request for Proposal
RLDA	Rail Land Development Authority
RoW	Right of Way
RVNL	Rail Vikas Nigam Limited
SCF	Standard Conversion Factor
SCIIMP	Smart City Infrastructure Master Plan
SDGs	Sustainable Development Goals
SDL	State Development Loan
SEA	Strategic Environmental Assessment
SEMP	Socio-Economic Master Plan
SEZ	Special Economic Zone
SPV	Special Purpose Vehicle
SUTF	State Urban Transport Fund
TAC	Technical Advisory Committee
TAZ	Traffic Analysis Zone
TCPO	Town and Country Planning Organisation
TfL	Transport for London
TOD	Transit Oriented Development
TTC	Travel Time Cost
UCCRTF	Urban Climate Change Resilience Trust Fund
UDA	Urban Development Authority
UDD	Urban Development Department
ULBs	Urban Local Bodies
UMTC	Urban Mass Transit Company
UN	United Naitons
URDPFI	Urban and Regional Development Plans Formulation and Implementation
UTP	UrbanTransport Plan
VAT	Value Added Tax
VCIC	Vizag-Chennai Industrial Corridor
VGF	Viability Gap Funding
VGTM	Vijayawada, Guntur, Tadepalle and Mangalagiri
VOC	Vehicle Operating Cost
WFPR	Work Force Participation Ratio
ZDPs	Zonal Development Plans

Chapter 1 Introduction

1.1 Background, scope, and status of APCR-CTTS

1.1.1 Context of APCR-CTTS

The Andhra Pradesh Capital Region (APCR) is located midway along the East-Coast Economic Corridor (ECEC) from Kolkata to Chennai, where many strategic highways, railways, and inland waterway routes provide good interregional connectivity to major urban centers including Bengaluru, Hyderabad, and Visakhapatnam.



Source: VCIC Conceptual Development Plan Report, ADB

Figure 1.1 East-Coast Economic Corridor

Historically, growth in the region has been focused around Vijayawada on the River Krishna. Vijayawada's importance was heightened by constructing the Prakasam Barrage, nearby road and rail bridges, and irrigation canals that stimulated multi-crop agricultural growth in the region. As agro-based industries and commercial activities flourished, Vijayawada attracted migrants from surrounding areas.

Continuing development pressures combined with ad hoc enforcement of building regulations led the government to introduce Urban Development Authorities (UDA), including the VGTM UDA (Vijayawada, Guntur, Tadepalle, and Mangalagiri), to manage urban development better.

In 2014, plans were announced following state bifurcation for a new state capital to be built at Amaravati. To plan and coordinate the development of the new capital and surrounding region, the Capital Region Development Authority (AP CRDA) was set up, superseding the VGTM UDA's role.

APCRDA's activities include planning, coordinating, executing, supervising, financing, funding, promoting, and securing planned development of the 8,603 km^2 Capital Region, including 12 Urban Local Bodies (ULBs) plus the Urban Notified Area of Amaravati Capital City (217 km^2). It is one of India's largest urban development regions by area (see Figure 1.2).

Amaravati Capital City (ACC) is being designed to achieve global stature with a high standard of amenity in lifestyle, work, learning, and recreation. The capital site is located (see Figure 1.3) on predominantly flat, open land in Guntur District across the River Krishna from Vijayawada, the region's commercial and trading hub (2011 pop. 1.03m), and just north of Guntur (2011 pop. 700,000), an agri-business center and district headquarters.

Box 1.1 Status of capital city proposals (December 2019)

Dt: 18th Dec'19

THE HANS INDIA

3 capitals for AP mooted

The State Government proposes to have three capitals. This was indicated by Chief Minister Y S Jaganmohan Reddy.

Amaravati: The State Government proposes to have three capitals. This was indicated by Chief Minister Y S Jaganmohan Reddy. Intervening in a debate on progress of construction of Amaravati, the Chief Minister said construction of capital at Amaravati was not possible for various reasons. Selection of Amaravati from "No where," had created unhappiness among various section of people and regions. He said decentralisation of administration was the trend everywhere and hence the state may have three capitals. Legislative capital at Amaravati, Executive Capital at Visakhapatnam and High Court at Kurnool.

This means Legislative Assembly and Council will be in Amaravati, offices of HoDs and state Secretariat will be at Visakhapatnam and Judicial capital will be in Kurnool. The Chief Minister said that the Government had appointed two committees to examine all such issues and the report is expected in about a week's time. He felt that if establish Executive Capital in Visakhapatnam, then there will be no infrastructural problems.

"We have to seriously think about it," he said. The Chief Minister said to create the basic infrastructure at Amaravati, it will cost around Rs 1,09,000 crore, as per the estimations of the TDP government. It may increase to more than Rs 3 lakh crore. Above all these, the Government will have to spend more than Rs 1 lakh crore for developing Amaravati alone. If we mobilise the funds from loans, then the interest amount will be a bigger burden on us, he added.

Source: The Hans India

Box 1.2 Status of capital city proposals (March 2022)

THE TIMES OF INDIA

Union ministry calls Amaravati capital of Andhra Pradesh

TNN | Mar 3, 2022, 04.06 AM IST

VIJAYAWADA: The Union Ministry of Housing and Urban Affairs has mentioned Amaravati as the new capital of Andhra Pradesh and allocated funds for administrative buildings and residential quarters.
The mention and funds allocation was done in its detailed demands for grants in the 2022-23 Union Budget.

The ministry has shown Rs 1214.19 crore for "construction of common central secretariat at Amaravati, the new capital of the state of Andhra Pradesh" and allocated funds in the 2022-23 budget. Similarly, for the purchase of land for the office accommodation the ministry projected Rs 669.13 crore of which Rs 448 crore was allocated in the last two budgets.

AP State Chief Minister Mr. Y S Jagan Mohan Reddy in December 2019 announced the government's plan for the executive, judicial, and legislative capitals in Visakhapatnam, Kurnool, and Amaravati. However, the Andhra Pradesh high court ordered Amaravati's development as the state capital and ruled the government has no right to enact fresh legislation for three capitals in March 2022.

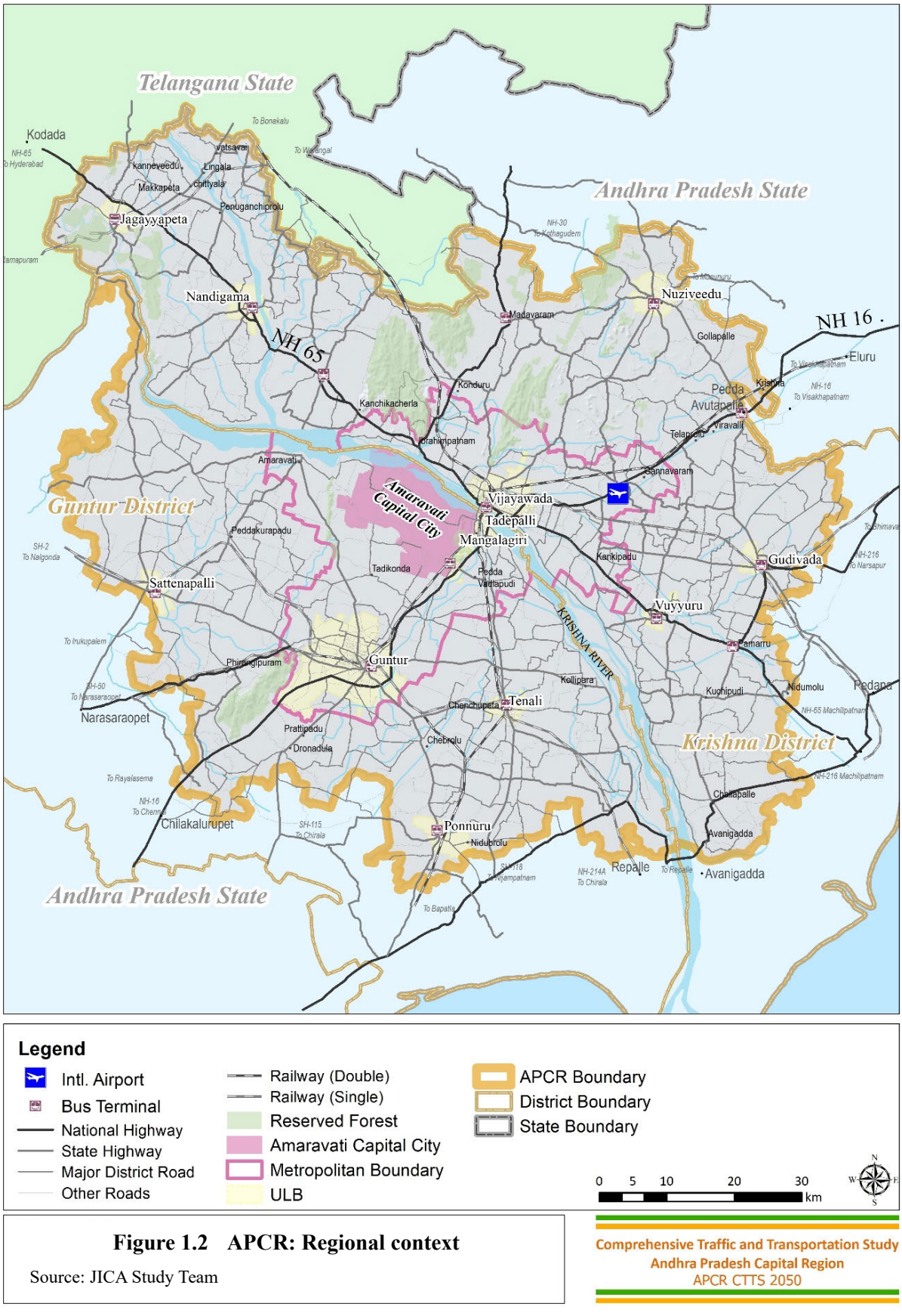


Figure 1.2 APCR: Regional context

Source: JICA Study Team

Comprehensive Traffic and Transportation Study
Andhra Pradesh Capital Region
APCR CTTS 2050

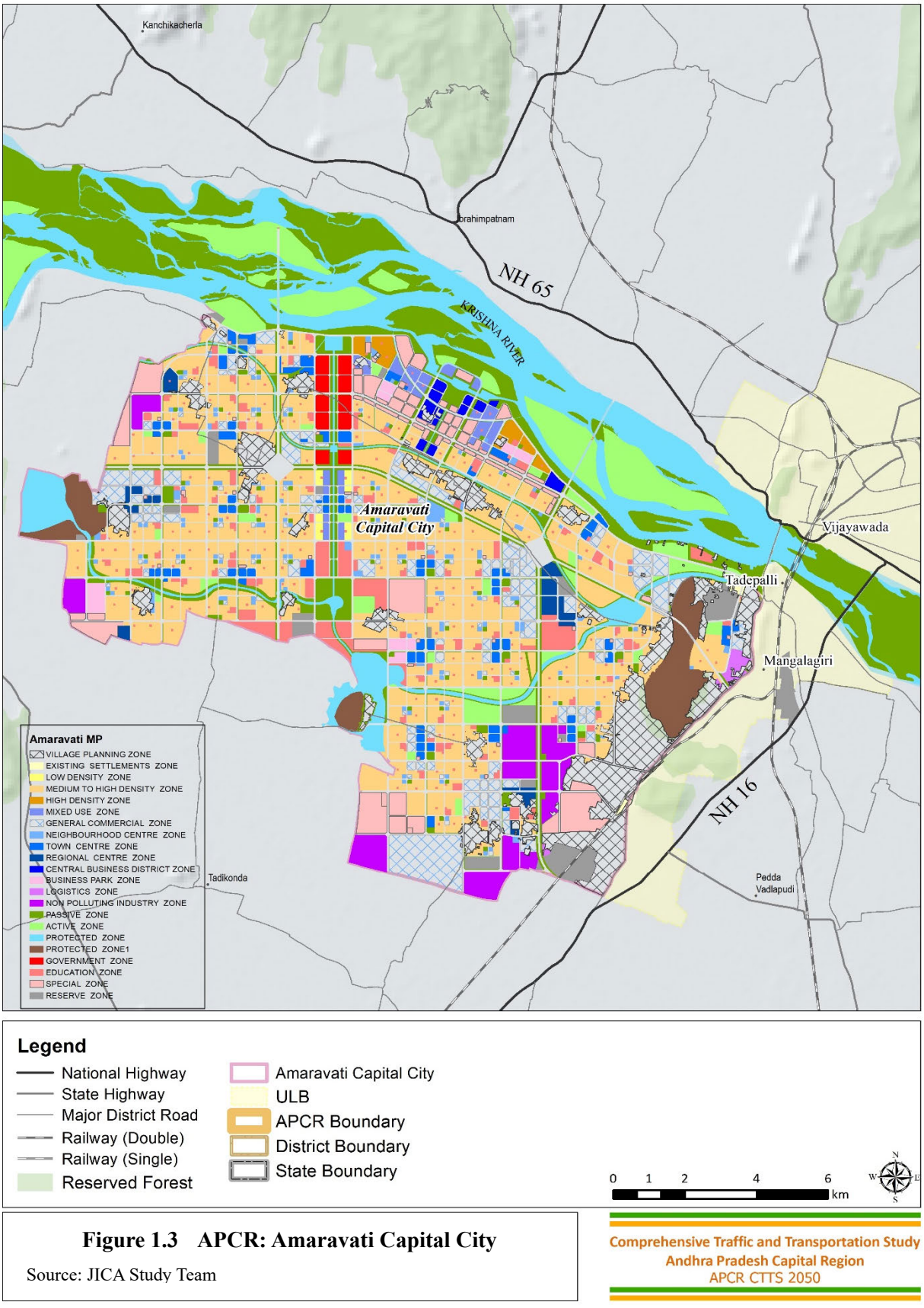


Figure 1.3 APCR: Amaravati Capital City

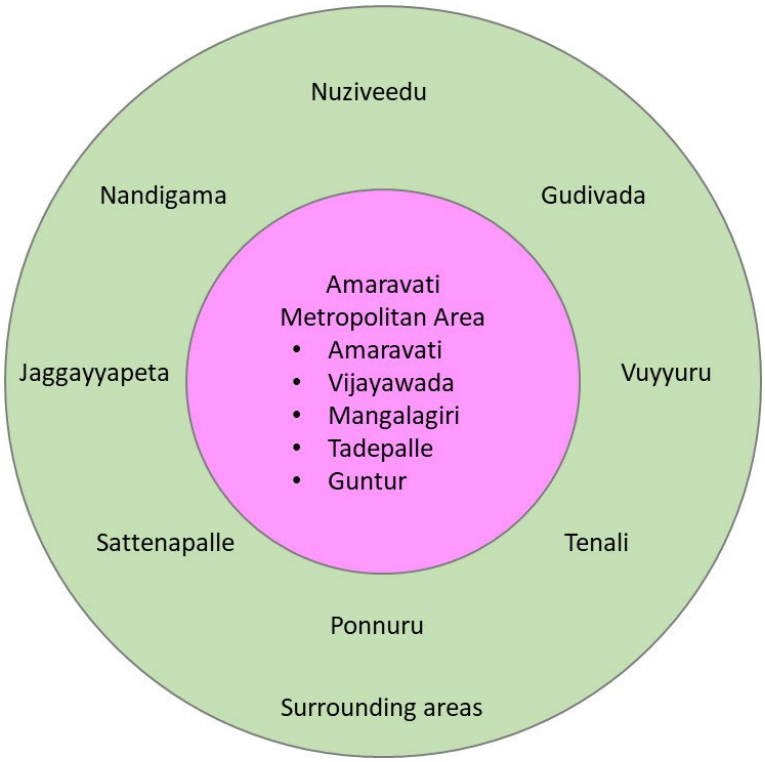
Source: JICA Study Team

The new capital area incorporates many existing small settlements. To the immediate west is the historic temple town from which the new capital takes its name: Amaravati, a center of cultural heritage and pilgrimage for Hindu and Buddhist faiths. The new capital city is also close to the municipalities of Tadepalle and Mangalagiri.

To achieve the ambitions for Amaravati, the capital city will require enhanced connectivity with existing centers such as Vijayawada and Guntur. This includes upgraded strategic highway corridors (arterials, collectors, distributors, etc.), new rapid transit systems with efficient feeder bus networks, and better access to international air services and seaports.

To ensure effective implementation and coordination of the various transportation measures being planned or undertaken by APCRDA and other agencies in the Capital Region, the state government also set up APCRUTA (APCR Unified Transport Authority) in 2015.

To support APCRDA and APCRUTA, a "Comprehensive Smart Transportation Master Plan for 2050" Study for Andhra Pradesh Capital Region Development Authority Jurisdiction (APCR- CTTS)" has been commissioned by Japan International Cooperation Agency (JICA).



Source: JICA Study Team

Figure 1.4 APCR CTTS Planning elements: Metropolitan Area and Outer ULBs

1.2 Aims for APCR-CTTS

1.2.1 Purpose of the transport study

The Ministry of Housing and Urban Affairs (MoHUA) National Urban Transport Policy 2014 (NUTP-2014) prescribes the following aims for the CTTS:

- Achievement of a desirable level of accessibility and mobility pattern for people and goods (throughout the region) and
- Integration of transport planning with land use plans and processes to meet the mobility needs of the population, businesses, and industries.

In line with a shift in transport planning emphasis to addressing urban transport problems, the Ministry's Toolkit for Comprehensive Mobility Plans (CMP-2014) focuses on improving the mobility of people rather than vehicles. It promotes better use of existing infrastructure (i.e., improving public transport, pedestrian, and NMT facilities). The overall intent of this national policy guidance is to enhance the integration of land use and transport development which is essential to building smart cities.

The Ministry's URDPFI Guidelines (URDPFI-2015) also promote an integrated land-use and transport planning approach to improve administrative responses to the need for sustainable transport infrastructure. This aims to take into account rural-urban transition and development of peri-urban areas.

Consequently, national transport guidance asserts that transport plans should be closely related to existing land-use plans where these are available and especially where the land-use plan has been approved by relevant authorities and notified in the Government Gazette.

Regional transport strategy: a national strategy for integration of transport and land-use plans

- To integrate transport planning with land-use plans and processes to meet the mobility needs of the population, businesses & industries (NUTP-2014)
- To promote better use of existing infrastructure (i.e., improvement of public transport, pedestrian & NMT facilities), which leads to the integration of land use and transport development which is essential to building smart cities (CMP-2014)
- To create an effective regional transportation system connecting existing and new urban centers with existing & new clusters of economic activities via hierarchically structured public transport networks at regional and local levels (ADB: Vizag-Chennai Industrial Corridor VCIA-2016)

1.2.2 Scope of work and deliverables

The scope of work for the APCR-CTTS has been based on National Policy Guidance with the following key deliverables or tools identified to support and enhance the capacity of APCRDA and APCRUTA and other stakeholders in carrying out their transportation planning sector responsibilities:

1. ***Regional Transport Strategy*** incorporates a long-term (to 2050) vision, strategy, and policy for APCR that proposes investments in the transport sector with long-term impacts on climate change, urban structure, technical innovation, and other issues. The strategy should focus on:
   - ✓ Advancing the region's economy through enabling structural diversification
   - ✓ Establishing the region's position as an international gateway, and
   - ✓ Realizing high mobility -
     1. between APCR and other capital regions
     2. between the Amaravati Metropolitan Area and surrounding urban centers
     3. among urban centers.

2. ***Metropolitan Area Transport Plan*** for the medium term (to 2040) with transportation policies and strategies for the Amaravati Metropolitan Area. The plan should focus on:
   - ✓ supporting new urban lifestyles of modern India
   - ✓ recommending advanced transport systems and services, and
   - ✓ promoting eco-friendly and sustainable transport systems.

3. ***The suite of ULB Transport Plans*** includes short- and medium-term (to 2040) transportation policies and proposals with 5-year implementation plans for each ULB. These UTP plans should focus on:
   - ✓ Enhancing the quality of the transport environment in each of the 12 ULBs
   - ✓ Enabling people-centered transport systems, and
   - ✓ Providing a framework for quick, implementable solutions (via Immediate Action Plans).

4. ***Immediate Action Plans (IAPs*)** The IAPs should focus on solving critical transport issues in each ULB with proposed solutions for implementation between 2018-2020, and

5. ***A set of supporting Technical Papers****.*

1.2.3 Method statement and evidence base

The Ministry of Housing and Urban Affairs (ex- Ministry of Urban Development-MoUD) is the apex authority at the national level that formulates policies, sponsors and supports programs, coordinates activities of various central ministries, state governments, and other nodal authorities, and monitors programs concerning all urban development issues (including urban transport) in the country.

In particular, the Ministry has drawn up:

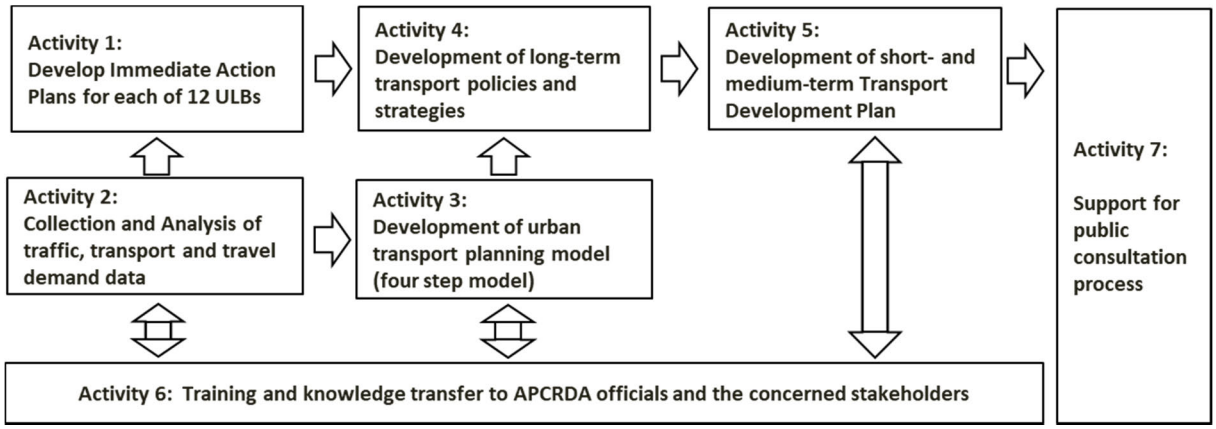
1. National Urban Transport Policy 2014 (NUTP-2014), which identifies the aims for Traffic and Transport Plans such as CTTS; and
2. Toolkit for *(preparing)* Comprehensive Mobility Plans 2015 (CMP-2014), which describes the form and content of transport plans to focus on improving the mobility of people rather than vehicles to address urban transport problems and promote better use of existing infrastructure.

In addition to the above national policy guidance, the following evidence base has been considered in drawing up a methodology for CTTS:

1. Urban and Regional Development Plans Formulation and Implementation (URDPFI) Guidelines Volume 1, Town and Country Planning Organization (TCPO), MoUD, Jan. 2015
2. Smart City Mission Statement & Guidelines, MoUD, June 2015
3. Final Operations Document for Unified Metropolitan Transport Authority in Andhra Pradesh Capital Region, MoUD, Nov. 2016.

Review of international best practices and feedback from meetings with APCRDA and AP-CRUTA stakeholders and ULB site visits and consultations have also contributed to this process.

A simplified method statement is shown below.



Note 1: Concerning Activity 7, a series of consultation meetings were made with TAC during the study period, and advice from TAC was incorporated into the final report (submitted by JICA to APCRDA).

Note 2: It is expected that Activity 7 shall be carried out by APCRDA to authorize the proposed CTTS.

Source: JICA Study Team

Figure 1.5 CTTS: Simplified method statement

1.3 Plan status and approvals

1.3.1 Plan status

According to the Scope of Work, the APCR-CTTS needs to be positioned alongside the following land-use plans: i) the "Draft Perspective Plan (DPP) 2050 for APCR", ii) the Capital City Master Plan (CCMP), and iii) the APCR Interim Draft Concept Master Plan/Detailed Master Plan (CMP/DMP).

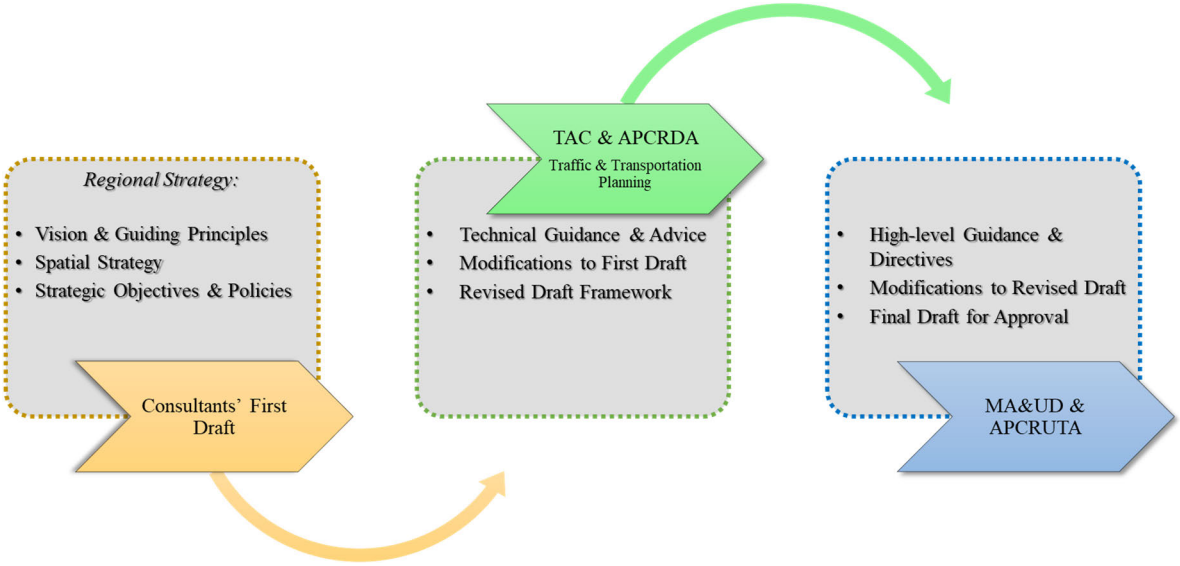
The Draft Regional CMP/DMP is the most recent master plan for the region outside the Capital City, although it is yet to be approved and notified by the state government. By contrast, the Capital City Master Plan has already been notified and thus provides the statutory basis for the management and control of development proposed in the Capital City area.

The CTTS is a non-statutory advisory document incorporating the notified CCMP's land use, density, and transport parameters as 'fixed' inputs. Proposals in the Draft APCR CMP/DMP have also been considered. Following national urban transport policy guidance, the CTTS reviews the future land-use patterns proposed in these Master Plans and makes recommendations to enhance the patterns of land-use connectivity from the perspective of transport and passenger mobility optimization.

1.3.2 Plan approval process

As the apex authority for national urban transport policy and urban transport issues generally, the Ministry of Housing and Urban Affairs would also be involved in the conduct and assessment of the

APCR-CTTS. However, for the present, APCRDA has advised that preliminary approvals for CTTS will be given by the Municipal Administration & Urban Development (MA&UD) and APCRUTA following high-level advice from the project's Technical Advisory Committee (TAC) and public consultation.



Source: JICA Study Team

Figure 1.6 Tentative process for approval of APCR-CTTS

Pending government notification of the Draft APCR DMP and approval of this APCR-CTTS, in any cases of inconsistency in respect of traffic and transportation proposals and related developments outside Amaravati Capital City, pre-existing Government Orders (GO), land uses, zoning regulations, Building Bylaws, and other regulatory provisions covered by approved Master Plan/Zonal Development Plans/Other Development Plans should prevail.

1.3.3 CTTS coordination mechanism and communication protocol

According to the Record of Discussions (RD) signed on 27 December 2016 between APCRDA and JICA, a Joint Coordination Committee (JCC) was established to carry out monitoring of CTTS together with APCRDA at appropriate milestones, including progress management of the survey, the method, and content of the examination, the interpretation of data analysis results and the direction of the plan, etc. JCC is positioned as one that monitors and provides technical advice to the Study together with the Traffic and Transport Planning wing of APCRDA and the JICA Study Team.

AP-CRUTA is the top advisory and decision-making organization. The study's progress and results are reported to AP-CRUTA through JCC and are assumed to be approved through the necessary processes within AP State Government.

The direct counterpart of the JICA Study Team is the Traffic and Transport Planning wing of APCRDA, and the project manager of the Study team exchanges various issues in relation to the survey with the head of the APCRDA Traffic & Transportation Wing. This exchange is regularly reported to the APCRDA commissioner, JICA office (Delhi and headquarters), other relevant departments, etc.

1.3.4 Subsequent events and current situation

Subsequent to the 2019 national and state elections, the future direction of Amaravati Capital City was reconsidered. AP State Government constituted an expert committee to quickly review the development

plans and suggest a comprehensive development strategy for the entire state's overall development, including Amaravati.

Accordingly, the expert committee recommended development strategies for Andhra Pradesh: that the Secretariat, the Chief Minister's camp office, summer Assembly, and a High Court Bench be set up in the Visakhapatnam region; that the legislature, a High Court Bench, and the quarters of the Governor and Ministers be located in the 'Amaravati-Mangalagiri complex'; and the High Court and allied courts be located in Kurnool as per the Sribagh Pact.

From December 2019 to January 2020, discussions were held with the Technical Advisory Committee (TAC) members on the draft final report. The final report was planned to be prepared based on the results. However, due to the spread of the corona disaster in March 2020, the APCRDA building (which had a project office in APCRDA) was closed to the public, and work was suspended from March 2020. Remote work became possible in January 2021, and this report has been finalized through remote work.

During this remote work period, the idea of developing the three capitals was revoked. According to the announcement by the AP state Chief Minister in November 2021, the idea of establishing three capitals needs to be reconsidered, and the CRDA law would be revived. It is said that it will continue to consider decentralizing various functions within the state.

Notwithstanding the above, due to timing considerations, this final Regional Transport Plan report has been written as though the Capital City proposals are unchanged from previous official government pronouncements and related approved plans and documents.

In addition to the report, the Andhra Pradesh Capital Region Development Authority (APCRDA) Transport Planning Wing has received data, including the GIS and Cube transport model for future plan update work. It is highly desired that APCRDA effectively utilize the above data, models, etc.

Chapter 2 Socio-economic framework

2.1 Regional economy and population

2.1.1 Economy and employment

Andhra Pradesh Capital Region, with an area of 8,603 km^2, covers parts of the Krishna and Guntur districts, with the Krishna River bisecting the region. The northern half is in the Krishna district and the southern half in the Guntur district. Though the Bay of Bengal borders both districts, the region's southern border is 15 km from the coast. The northern border, meanwhile, is the Telangana State line.

Table 2.1 APCR area and administrative composition

Component	Amaravati Capital City	Core region	Extended region (VGTM UDA)	Peripheral extended region	APCR
Geographic area (km^2)	217.2	1,737.4	5,235.0	1,413.7	8,603.3
Municipal Corporation	-	1) Vijayawada	-	-	1) Vijayawada
		2) Guntur			2) Guntur
Municipality & Nagar Panchayat	-	1) Tenali (M)	1) Gudivada (M)	1) Jaggayyapeta (M)	1) Tenali
		2) Mangalagiri (M)	2) Nuziveedu (M)		2) Mangalagiri
		3) Tadepalle (M)	3) Sattenapalli (M)		3) Tadepalle
			4) Ponnuru (M)		4) Gudivada
			5) Nandigama (NP)		5) Nuziveedu
			6) Vuyyuru (NP)		6) Sattenapalli
					7) Ponnuru
					8) Nandigama
					9) Vuyyuru
					10) Jaggayyapeta

Source: CMP/DMP, APCRDA 2015

The state's vision will require an enhanced level of investment in public infrastructure, including roads, rail, water, and air transport. Within APCR, it requires a high level of strategic transport connectivity in the three key sectors of agriculture, industry, and services. Combined with the region's strategic location, widespread availability of fertile soils, minerals, skilled workforce, and other natural resources, these transport enhancements can contribute to sustainable regional growth and development.

Analysis of APCR's economic situation reveals some challenges to realizing the state's vision, including low investment in the development and maintenance of the physical infrastructure, slow private sector uptake, and insufficient public sector capacity to deliver the required services. Inadequate physical infrastructure is a significant constraint to economic growth, human capital development, and exporting goods and services.

In the 2011 census, 2.34 million APCR residents were employed, translating participation rate (WFPR) of 39.9%.

Table 2.2 Population and employment by district, 2011 in APCR

Area	Population	Employment	WFPR
Guntur (study area)	2,666,057	1,116,932	41.9%
Krishna (study area)	3,207,531	1,226,311	38.2%
Study area total	**5,873,588**	**2,343,243**	**39.9%**

Source: Census 2011, Statistics Handbooks 2013 for Guntur and Krishna

Estimates were made from total employment and share of workers by sector by employment sector[1] since official data was unavailable.

Table 2.3 Employment by sector, 2011 in APCR

Area	Primary	Secondary	Tertiary	Total
Guntur (study area)	634,417	169,774	312,741	1,116,932
	56.8%	15.2%	28.0%	100%
Krishna (study area)	603,345	180,268	442,698	1,226,311
	49.2%	14.7%	36.1%	100%
Study area total	**1,237,762**	**350,042**	**755,439**	**2,343,243**
	52.8%	**14.9%**	**32.2%**	**100%**

Source: JICA Study Team 2018 based on data from the Department of Labour & Employment, Ministry of Labour & Employment

In this report, industrial sectors are divided as follows in line with census definitions:

Primary

- Agriculture (crops)
- Livestock
- Forestry and logging
- Fishing and aquaculture

Secondary

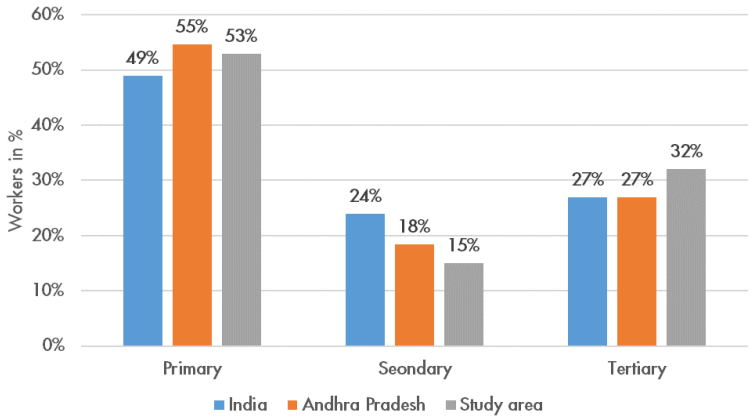
- Mining & quarrying
- Manufacturing (organized & unorganized)
- Electricity, gas, water supply & other utility services
- Construction

Tertiary

- Trade, repair, hotel/restaurant
- Transport, storage, communication & media
- Financial services
- Community, social & personal services incl. Public admin.

The primary income source for APCR residents is agriculture and allied activities, including fishing and logging: in 2011, 53% of the total working population was engaged in primary sector activities; 32% in services (e.g., trade, commerce, real estate, transport, and banking); and 15% in industrial, mining and construction-related activities. Comparing APCR share of working population by sector with state and national levels, the share of secondary workers is lower than both. By contrast, the primary sector share is higher than the national level, though less than the state level, due to the state's overall more agrarian nature.

[1] Department of Labour and Employment, MoLE India, 2012



Source: Statistical Abstract of Andhra Pradesh 2015

Figure 2.1 Sectoral employment share

2.1.2 Productivity

APCR's Gross Regional Domestic Product (GRDP) was estimated from the average productivity of AP State and employment. Productivity in primary and secondary sectors in the state was higher than the national average, mainly due to the abundance of fertile, well-irrigated land (especially in the east and southeast) and the region's strategic position within the East Coast Economic Corridor and Visakhapatnam-Chennai Industrial Corridor (VCI Corridor).

Table 2.4 India vs. AP State: Productivity (INR/employment) by sector, 2011

Unit: INR/year at 2017 rate

Area	Primary	Secondary	Tertiary	Average
AP State	106,096	386,350	319,305	214,420
India	66,238	256,446	428,383	198,708

Source: Department of Labour and Employment, and Statistical Abstract of Andhra Pradesh 2015

GRDP in the study area was estimated at around 490 billion INR in 2011, accounting for only 10.3% of Gross State Domestic Product (GSDP) in Andhra Pradesh, as shown below.

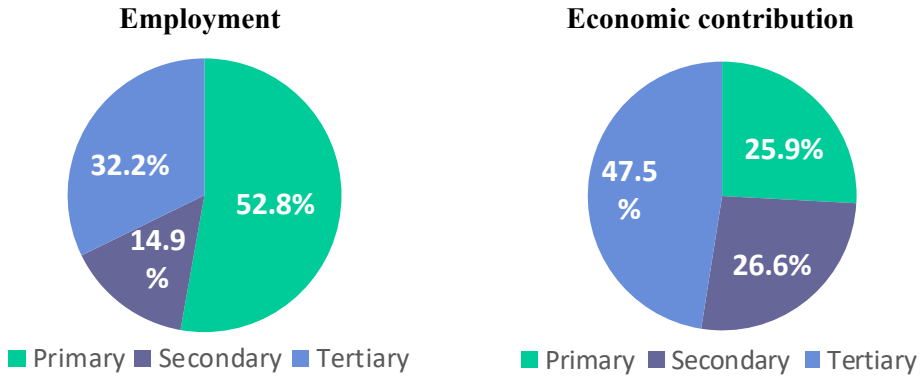
Table 2.5 AP State vs. APCR: GRDP 2011

Sector	Study area		GSDP AP State
	GRDP (1)	Share in AP State	
Primary	126.0	9.8%	1,286.9
Secondary	129.7	8.5%	1,519.3
Tertiary	231.4	11.9%	1,941,7
Total	**487.1**	**10.3%**	**4,747.9**

(1) billion INR at the constant price (2017)

Source: JICA Study Team 2018, based on employment and productivity

Primary-sector employment accounts for more than 52% of the total. However, the tertiary sector is the major contributor to the economy. In other words, productivity in the primary sector is low because mechanization and fertilizer are still not widely used. Achieving higher economic growth indicates a strong need for increased productivity and social changes, including expansion of the secondary and tertiary sectors.



Source: JICA Study Team

Figure 2.2 Composition of employment and economic contribution, 2011 in APCR

2.1.3 Primary-sector employment - agriculture and aquaculture

In 2014-15 the primary sector accounted for over half of total regional employment and 24% of regional economic output, mainly in agriculture, livestock, fisheries, forest, and logging. As APCR is a significant agriculture hub, most of the working population is dependent on agriculture.

Rice, sugarcane, chilly, cotton, and vegetables are the predominant crops, often with 2-3 crops harvested per year as the area has fertile soils and an extensive irrigation network. Produce is usually marketed through designated agricultural market yards, each serving a group of mandals: Krishna district has 12 marketing yards, and Guntur district has eight.

Aquaculture is one of the fastest-growing economic sub-sectors in India due to its proven ability to spur rural development and improve food security. APCR accounts for about 70% of the total aqua-farm area in Andhra Pradesh. Especially in the Krishna district, many paddy farmers have shifted en masse to shrimp culture, attracted by a tremendous difference in profitability. Problems with salinity also spurred this for farmers at the coastal ends of the irrigation canals, and the cost of conversion was only Rs 10,000 to Rs 15,000 per acre.

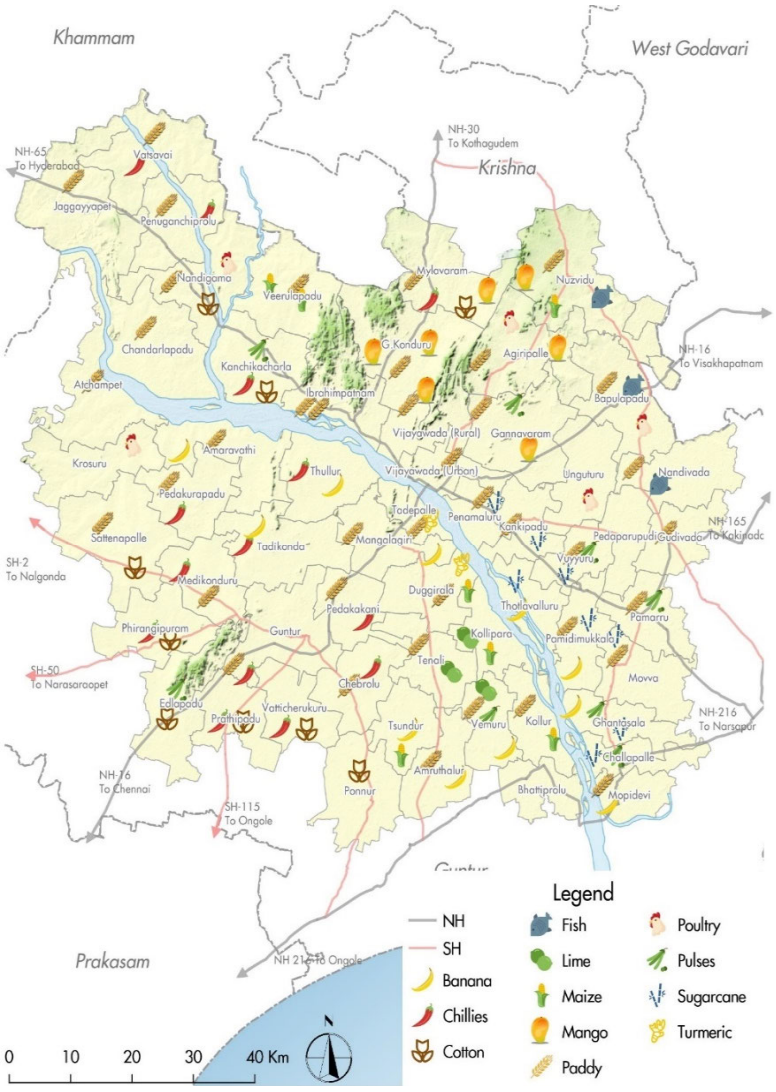
There was little aquaculture activity until the early 1990s, when large tracts of land totaling 245.4 km^2 began to be converted into aquaculture ponds. As a result, by 2000, total land under aquaculture in the study area had tripled to 735.2 km^2, and by 2010, the total had reached 810.4 km^2. Most of these farms are 5-10 acres in size, with the smallest ones being around two acres and the largest ones up to 20 acres.

Sustainable, enviro-friendly aquaculture practices are encouraged by incentives under the AP State Fishing Policies, 2015. In addition, establishing fish processing units near Nandivada/Gudivada will further strengthen aquaculture activities in this area.

Chilly Cultivation near Guntur

Maize Cultivation near Guntur

Satellite view of Fishing Ponds in Nandivada



Source: JICA Study Team

Figure 2.3 Primary-sector activities by Mandal in APCR

Table 2.6 Fisheries and aquaculture data in Krishna District

Production details in 2008-2009		Units (tons)
Inland fish production		251,312
Marine fish production		16,172
Freshwater prawn production		11,026
Brackish water aquaculture production		5,903
Total fish and prawn production		284,413
Area and farming details in 2008-2009		
	Brackish water	Freshwater
No. of farmers (persons)	3,236	7,249
Water spread area (ha)	4,063	20,647
Utilized area (ha)	2,580	5,003

Source: Department of Fisheries, Krishna Machilipatnam (2008-09)

	2016-17		2017-18	
Inland Fish Production	Tonnes	Millin Rs.	Tonnes	Millin Rs.
Prawns	37,523.0	13,133.1	57,347.0	20,644.9
Others	675,321.0	52,969.1	857,080.0	76,576.0
Sub-total	712,844.0	66,102.2	914,427.0	97,220.9
Marine Fish Production	Tonnes	Millin Rs.	Tonnes	Millin Rs.
Prawns	16,980.0	5,316.5	21,960.0	7,123.1
Others	31,709.0	2,415.5	33,979.0	2,804.2
Sub-total	48,689.0	7,731.9	55,939.0	9,927.2

Source: Handbook of Statistics 2018 Krishna District

Aqua-farming near Gudivada

Aqua-farming near Nandivada

Source: JICA Study Team

Figure 2.4 Fisheries and aquaculture in Krishna District

2.1.4 Secondary-sector employment – industry and manufacturing

Across India, industries have been moving away from core cities since the 1980s as state governments offered incentives to locate in less developed areas; polluting industries were forced to relocate outside cities; increasing land prices made urban sites less affordable, and metropolitan governments have not actively promoted industrialization.

In many Indian cities where industries moved out, but the workforce stayed, workers shifted to informal service-sector opportunities. But as many new industrial locations do not offer adequate housing, haphazard development has mushroomed around these locations. India thus faces a dual dilemma: urban areas with insufficient industry to provide jobs for the local population and industrial areas lacking adequate accommodations for skilled workers.

APCR's current industrial mix includes electricity generation, cotton yarn manufacturing, cement, tobacco, sugar, beverages and milk powder, oil and chemicals, railway wagons, auto parts, textiles, printing, and publishing. There are also many smaller enterprises, including producers of musical instruments, gold-plated ornaments, and Kondapalli toys.

Over 80% of total capital investment in the cement industry in the Krishna District, but over 55% of output comes from food processing. Major cement producers include Jaipee Balaji Cement, Ramco Cement, and KCP Cement, accounting for over 70% of Krishna District investment. Most cement producers are close to Jaggayyapeta, while food processing firms are near Gannavaram and Kankipadu. Key food-processing firms include Coca-Cola India (Vijayawada), KCP Sugars (Vuyyuru), and Balaji Agro Oils (Kankipadu).

In 2017, 17 mega and 111 large industries in the APCR employed 46,000 people. In addition, some 5,380 smaller factories and 1,000 rice mills employed a further 107,405 people.

Table 2.7 Existing industrial clusters in APCR

S. No.	Name of cluster/ULB	Industry classification
1	Auto Nagar, Vijayawada	Auto components
2	Ibrahimpatnam, Kondapalle, Vijayawada (1)	Power, oil, railway rolling stock
3	Bapulapadu, Veeravalli	Textiles, chemicals, sugar factory, oil refinery
4	Vuyyuru	Sugar factory, milling & refining
5	Jaggayyapeta	Cement, cotton spinning
6	Guntur	Textile, food & beverages, tobacco
7	Auto Nagar, Guntur	Auto components
8	Edlapadu	Textiles, beverages
9	Tenali	Auto components
10	Challapalli	Sugar factory
11	Perecherla	Quarry and crushing units, sugar factory
12	Dokiparru	Oil refinery, biomass power plant, warehouse
13	Veerapanenigudem	Auto components
14	Surampalle, Nunna, Adavinekalam, Gollagudem	Metal, footwear

Source: Draft DMP, APCRDA, 2017; www.crda.ap.gov.in

Thermal power station, Kondapalle

KCP Sugar Factory, Vuyyuru

Hindustan Coca-Cola, Mangalagiri

Cement industries, Jaggayyapeta

Source: JICA Study Team

Figure 2.5 Existing industrial clusters in APCR

Typically, industries locate where raw materials, good connectivity, and skilled human capital are conveniently available. In APCR, most industries are located along the two major National Highways, i.e., NH16 (Chennai-Visakhapatnam) and NH65 (Machilipatnam-Pune).

Table 2.8 Mega-industries (>1000 employment) in APCR

Ref.No.	Company	Total employment
1	Coca Cola Bottling SE Ltd.	4,000
2	Railway Wagon Workshop	3,361
3	Continental Coffee Ltd.	3,155
4	Mohan Spintex India Ltd.	2,860
5	Sri Jayalakshmi Spinning Mills Ltd.	2,678
6	NSL Textiles Ltd.	2,576
7	Viswateja Spinning Mills Ltd.	2,110
8	Kusalava International Ltd.	1,612
9	Narla Thatha Rao Thermal Power Station (VTPS)	1,560
10	Guntur District Milk Producers Cooperative Union (Sangam Diary)	1,520
11	Vasantha Spinners Ltd	1,225
12	Jaypee Balaji Cement Plant	1,200
13	Kallam Spinning Mills Ltd.	1,160
14	Krishna Ganga Spinning Mills (P) Ltd.	1,150
15	Sri Venkata Siva Parvathi Spinning Mills (P) Ltd.	1,120
16	Sri Lakshmi Godavari Spinning Mills (P) Ltd.	1,050
17	Ananthalakshmi Spinning Mills (P) Ltd.	1,030

Source: District Industrial Center, Krishna and Guntur Districts, 2015

The 2006 Micro, Small, and Medium Enterprise Development Act (MSME) redesignated industry categories to include service enterprises to encourage entrepreneurial development and spur employment in regions like APCR. In addition, the Act enables MMSEs to grow into large and mega enterprises.

Table 2.9 Micro, small, and medium enterprise growth, 2009-2014 in Krishna and Guntur Districts

Year	No. of MSMEs	Employment
2009	249	3,448
2010	454	7,414
2011	495	7,860
2012	434	6,516
2013	439	9,080
2014	691	7,886

Source: District Industrial Center, Krishna and Guntur Districts, 2015

Ref.No.	Name	Total Employment
1	Coca Cola Bottling SE Ltd, Atmakuru, Mangalagiri	4,000
2	Railway Wagon Workshop,	3,361
3	Continental Coffee Ltd, Duggirala	3,155
4	Mohan Spintex India Ltd, Nuziveedu	2,860
5	Sri Jayalakshmi Spinning Mills Ltd, Chebrole	2,678
6	NSL Textiles Ltd, Guntur	2,576
7	Viswateja Spinning Mills Ltd	2,110
8	Kusalava International Limited	1,612
9	Narla Thatha Rao Thermala Power Station(VTPS)	1,560

Ref.No.	Name	Total Employment
10	Guntur District Milk Producers Cooperative Union (Sangam Dairy)	1,520
11	Vasantha Spinners Ltd	1,225
12	Jaypee Balaji Cement Plant	1,200
13	Kallam Spinning Mills Ltd, Guntur	1,160
14	Krishna Gnaga Spinning Mills (P) Ltd	1,150
15	Sri Venkata Siva Parvathi Spinning Mills (P) Ltd	1,120
16	Sri Lakshmi Godavari Spinning Mills (P) Ltd	1,050
17	Ananthalakshmi Spinning Mills (P) Ltd	1,030

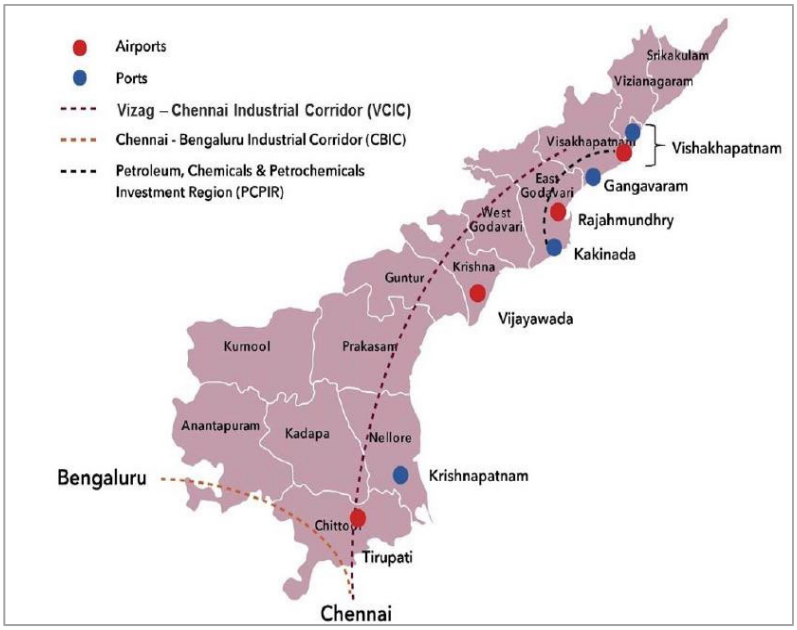
Figure 2.6 Major industrial sites

Source: JICA Study Team

Comprehensive Traffic and Transportation Study
Andhra Pradesh Capital Region
APCR CTTS 2050

2.1.5 State industrial development policy, 2015-2020

The Industrial Area Development Authority (IADA) has proposed three major industrial corridors for AP, including the Vizag-Chennai Industrial Corridor (VCIC), which will be developed with state-of-the-art infrastructure and enhanced investment, focusing on four nodes, including Gannavaram-Kankipada.
Developed in association with the Asian Development Bank (ADB), the proposed VCIC aims to spur growth across a 110,000 km^2 area.



Source: Industrial Area Development Authority (IADA)

Figure 2.7 Industrial corridors in SIDP

Visakhapatnam, the largest city in AP State and one of the fastest-growing cities in India (2011 pop. 1.728m), is expected to be an IT hub. By contrast, the new capital region aims to develop as an advanced hub of commerce and business with state-of-the-art infrastructure, a high-amenity living environment, advanced higher education, medical facilities, and entertainment, sports, and tourism functions. In addition, Amaravati capital city is also expected to significantly boost regional population growth, likely exceeding the population of Visakhapatnam.

One key contributor to growth is cluster-based development strategies, in which many enterprises produce similar and related products in the same region. These strategies aim to create a critical mass of skills and other inputs to improve productivity.

The industrial development strategy (2015-2020) proposed by the AP Industry and Commerce Department included:

- ✓ Develop a range of urban centers with solid industrial bases to generate employment opportunities and disperse economic development
- ✓ Identify and develop potential industrial clusters to boost the regional economy
- ✓ Decentralize economic activities to centers/nodes (small and medium towns) to enhance the overall spatial growth and help reduce congestion in central areas
- ✓ Emphasize MSMEs to boost urban employment
- ✓ Develop labor-based industries like light manufacturing (textile, footwear, electronic components, etc.) that provide employment opportunities for unskilled laborers
- ✓ Focus more on developing proper manufacturing-related skill training centers and educational institutions to sustain the transition from agrarian to industrial activities: the present shortage of education, skills, and training will make it difficult for the workers to transition.

2.1.6 CMP/DMP industrial proposals

Strategic allocation of industrial land and infrastructure development is one of the significant parameters for promoting regional industries. The minimum industrial land required by 2035 across the APCR was

calculated via the ratio of jobs to land required. Anticipated additional secondary sector employment by 2035 is estimated in the CMP/DMP at around 390,000. Assuming 60% of this secondary sector employment will be industrial, by 2035, the total industrial workforce will be 234,000. On average, the rule of thumb is that one acre of industrial land can sustain 15 jobs. By that measure, the additional industrial land requirement by 2035 will be around 15,500 acres (6,300 ha). By correlating this requirement with land and labor available, and existing specialization across regional ULBs, we can envision industrial clusters as below.

Table 2.10 Proposed industrial locations in APCR

No.	Region	Urban center	Industry
1	Core	Vijayawada & Gannavaram	IT, ITES, electronics, hardware, automotive, aerospace
2	Core	Guntur	Cold chains, food processing, textiles, non-metallic products
3	Core	Tenali	Manufacturing, agro, textiles, metals, and minerals
4	Extended	Nandigama	Pharmaceuticals, plastic, and packaging
5	Extended	Nuziveedu	Agro-based industries, fabrication hub
6	Extended	Gudivada	Agro-based and green industries, aquaculture
7	Extended	Pamarru	Logistics
8	Extended	Ponnuru	Textiles, food processing
9	Extended	Sattenapalli	Heavy industries, textiles, and minerals
10	Periphery	Jaggayyapeta	Cement & textiles

Source: Draft CMP & DMP - 2035, APCRDA

2.1.7 APIIC/industry proposals

Based on the APIIC (Andhra Pradesh Industrial Infrastructure Corporation) land bank, the following industrial parks are proposed in the region.

Table 2.11 Proposed industrial parks in APCR

No.	Region	Urban center	Industry
1	Extended	Mallavalli, near Nuziveedu	Mega food park
2	Peripheral	Nimmaluru, near Pamarru	Bharat Electronics Limited
3	Extended	Challapalle	Auto Nagar and industrial park

Source: APIIC

2.1.8 Tertiary-sector employment – trade and commerce

Logistics is a rapidly-growing activity today as companies aim to achieve competitive advantage via more efficient national and regional distribution networks utilizing sophisticated and integrated transport and warehousing methodologies.

APCR's location at the center of the state, with national solid transportation links and proximity to ports, makes it a good place for logistics hubs. In addition, APCR already has numerous cold chains and small-scale warehouses to serve the agricultural/food processing industry. Building on this base, State Government proposals to promote logistics clusters are expected to trigger the development of larger-scale logistics clusters in the study area.

Among the four logistics growth nodes proposed for the VCIC corridor, Gannavaram-Kankipadu has the most cities, with a population of more than 100,000. In addition, Vijayawada is the APCR regional road traffic hub where NH16 meets NH65. Furthermore, six National Highways run through APCR connect to different cities. Vijayawada is also a key hub for Indian Railways, and Gannavaram Airport has been upgraded for international flights.

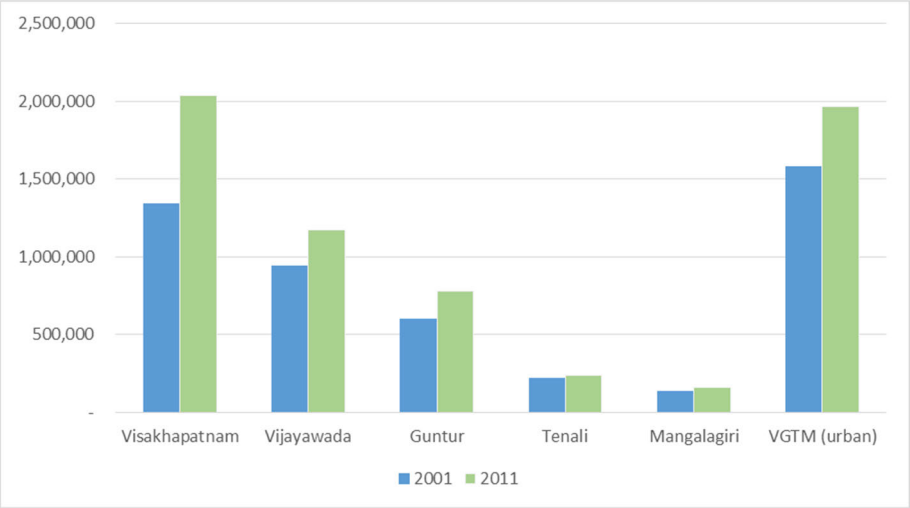
Vijayawada and Guntur are also major higher education centers with several important institutions. Other regional centers also host several universities and engineering colleges.

2.1.9 Population trends in APCR

(1) APCR population

The 2011 census reported APCR's population at 5,873,588 – up from 5,235,736 in 2001 – with 3.21m in Krishna District and 2.67m in Guntur District. With an area of 8,603 km^2, the region's population density was 682.7 people/km^2, more than double the statewide density. APCR accounts for nearly 12% of AP State's total population of 49,577,100.

In 2011, the core urban area, Vijayawada, Guntur, Tenali, and Mangalagiri (VGTM urban), had a total population of 1,964,013, slightly smaller than that Visakhapatnam of 2,035,922. The remainder of APCR's population is distributed in eight other ULBs, plus 30 mandals in the Krishna district and 26 mandals in the Guntur district.



Name of Mandal	2001	2011	Growth rate
Visakhapatnam	1,345,938	2,035,922	4.23%
Vijayawada	946,650	1,175,397	2.19%
Guntur	601,543	779,289	2.62%
Tenali	224,107	240,031	0.69%
Mangalagiri	136,264	160,303	1.64%
VGTM (urban)	1,582,848	1,964,013	2.18%
VGTM (urban+rural)	1,908,564	2,355,020	2.12%

Source: District Census Handbook 2015 Krishanna and Guntur

Figure 2.8 Major city populations in APCR

From 2001 to 2011, the APCR's annual growth rate was 1.16%, higher than the AP State average but lower than the national average. The growth rate was 0.58% per year in rural areas due to out-migration. However, in the VGTM (Vijayawada, Guntur, Tenali, and Mangalagiri) urban area, growth was slightly higher at 2.18% per year.

Table 2.12 Population and growth by area 2001-2011 in APCR

Area	Population	Population	Growth Rate (CAGR)
	2001	2011	2001-11 (%)
APCR	5,235,736	5,873,588	1.16%
12 ULBs urban population in APCR	1,941,142	2,381,358	2.06%
VGTM (urban)	1,582,848	1,964,013	2.18%
Eight other ULBs (urban) in APCR	358,294	417,345	1.54%
Other areas in APCR (rural)	3,294,594	3,492,230	0.58%
AP State	45,397,069	49,577,103	0.88%
India	1,028,737,436	1,210,569,573	1.64%

Source: Population Census of India, 2001 and 2011; Statistical Abstract AP State, 2015

(2) Urban population trends in APCR

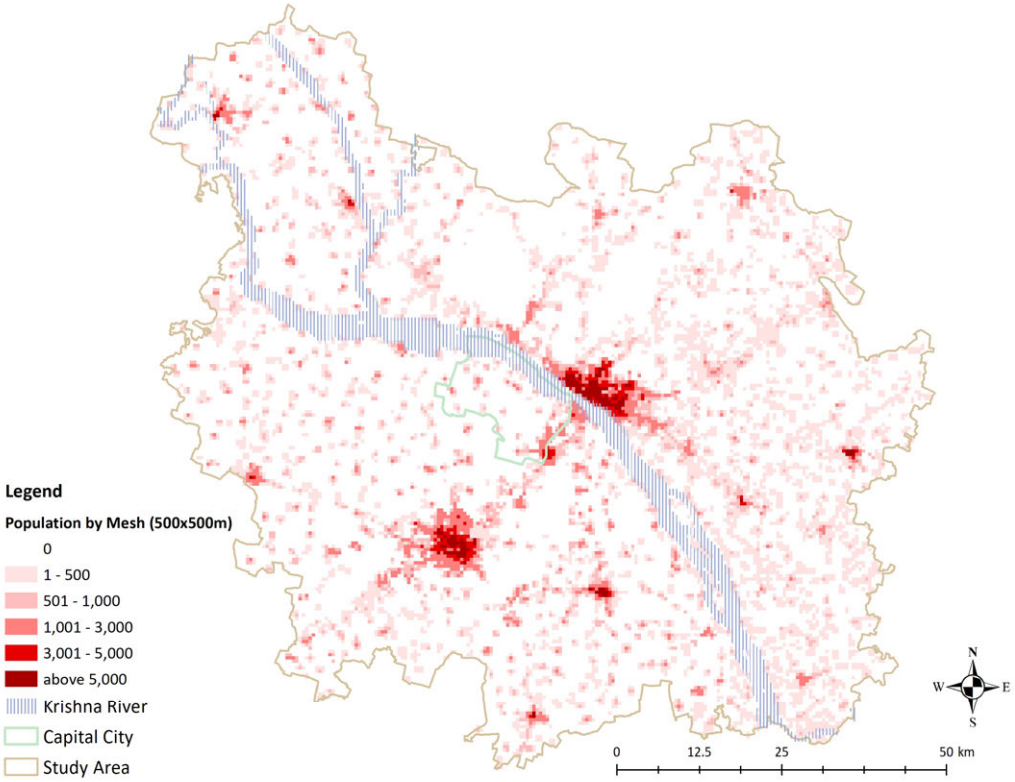
In 2011, 2.64m APCR residents lived in urban areas and 3.23m in rural areas. The 12 ULBs comprise 45% of the population classified as urban, distributed in 5.2% of the region's total area. APCR is predominantly urbanized compared to AP State (33%) and India (31%).

Recent urbanization trends show increasing concentration in Vijayawada and Guntur ULBs and NH16 in Tadepalle, where growth rates from 1981 to 2011 (2.69% p.a.) were similar to Vijayawada (2.72% p.a.).

Table 2.13 Population growth trends in four major ULBs

Municipality	Population (000)		Annual average growth rate (%)	
	1961	2011	1961-2011	1981-2011
Vijayawada	234.4	1,034.4	3.01%	2.72%
Mangalagiri	22.2	73.6	2.43%	1.57%
Tadepalle	17.6	54.4	2.86%	2.69%
Guntur	187.1	770.0	2.87%	2.09%

Source: 2011 Census



Source: JICA Study Team

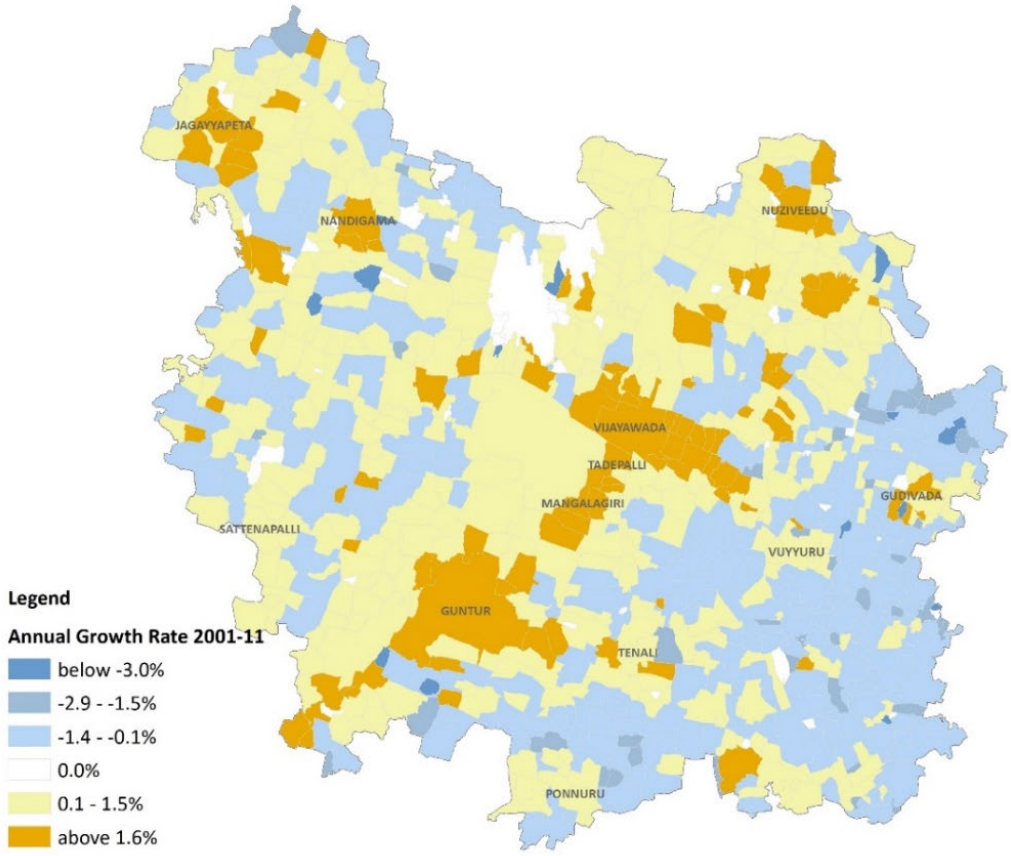
Figure 2.9 APCR population distribution, 2017

Despite the VGMT urban core, population decline was evident, especially in eastern areas. From 1981 to 2011, growth in Tenali was 1.09% p.a. and Ponnuru 0.61% p.a., compared with 1961 to 2011 growth of 1.5% and 2.31% respectively. This decline stemmed from a shift in employment out of agriculture.

Table 2.14 APCR ULBs: Census population 1961- 2011

Municipality	1961	2011	1961-2011	1981-2011
Gudivada	44.8	118.2	2.20%	1.42%
Nuziveedu	19.0	58.6	2.57%	2.25%
Jaggayyapeta	13.9	53.5	3.14%	2.66%
Sattenapalle	17.5	56.3	2.70%	2.01%
Ponnuru	22.9	59.9	2.31%	0.61%
Nandigama (1)	23.2	44.4	N/A	2.42%
Vuyyuru (1)	23.4	46.6	N/A	2.66%
Tenali	78.5	164.9	1.50%	1.09%

Source:
(1) Nagar Panchayat Data for 1981-2011 (1961-2011 not available)
- 2011 Census
- Interim Draft DMP, Aug. 2017
- Census Handbook, CMDA Website, and in force ZDP Reports



Source: JICA Study Team 2018 based on Census data 2001 and 2011; Statistical Abstract AP State, 2015

Figure 2.10 Population growth rate by village, 2001-2011

2.2 2050 Socio-economic framework for CTTS

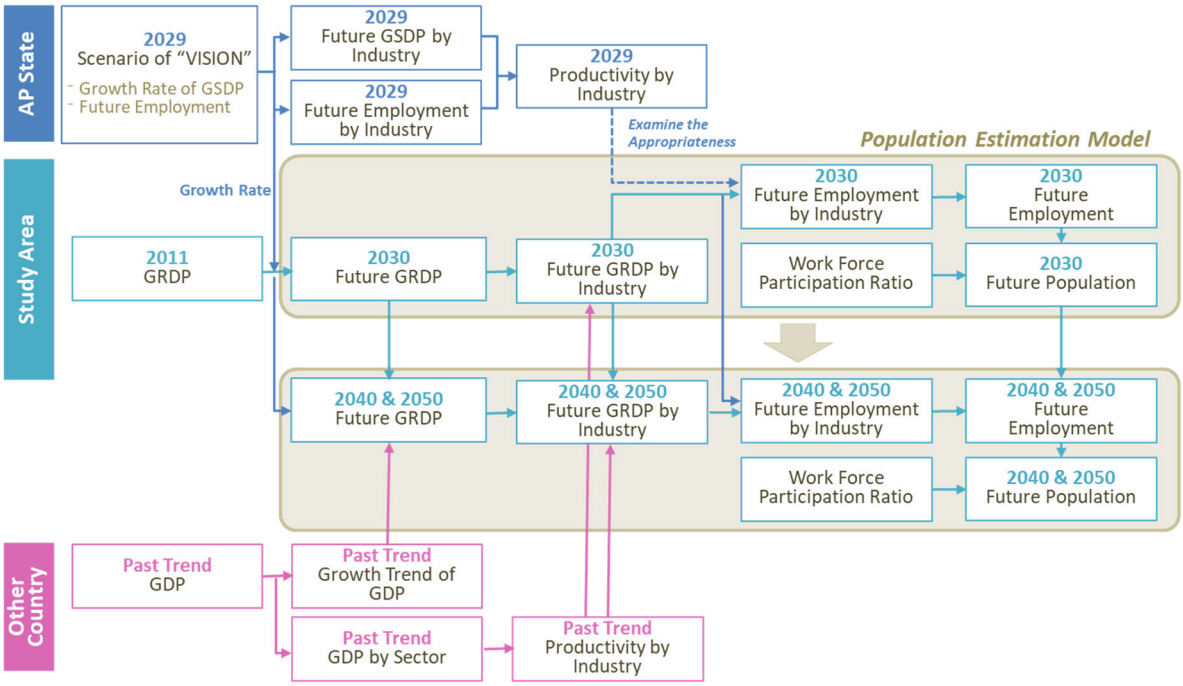
2.2.1 Forecasts of future growth in APCR

The socio-economic framework for APCR CTTS is based on the assumptions and estimates informed by AP State Government's 'Sunrise Andhra Pradesh Vision 2029, prepared in 2016. Vision 2029 targeted the future statewide economy and population parameters for 2029, which would need to be achieved to help remold Andhra Pradesh as "A Happy and Globally Competitive Society." To achieve the vision, 12 goals and 115 targets were set along with the UN's Sustainable Development Goals 2030 (SDGs 2030).[2]

The future APCR regional population was also considered in the DPP and draft CMP/DMP. Although the calculation methodology of DPP was not informed to the JICA study team[3], it was understood that DMP and CMP employed an induced growth model based on case studies of other cities in India. For Capital City, forecasts for population growth and expected industrial development were also included in the Socio-economic Master Plan (SEMP) and the later Happy City Blueprint (Amaravati MP).

Due to the different economic bases of the future Capital City and the rest of the region, a different approach to population estimation was followed based on the future economic growth considering Vision 2029 and the Amaravati MP. Since traffic demand, including passenger and cargo, depends on economic activity, population estimates based on economic growth are considered appropriate for APCR CTTS.

Accordingly, Gross Regional Domestic Product (GRDP), productivity (GRDP per employee by industrial sector), and workforce participation ratios (WFPR) are used to derive 2050 employment opportunities (the number of workers) to produce the expected GRDP and associated population in APCR (refer to Figure 2.11).



Source: JICA Study Team

Figure 2.11 Population Forecast Method

[2] SDGs 2030 set by the United Nation in 2015
[3] As of July 2018

The population forecast method consists of the following steps: 1) set a future target of GRDP for the study area: APCR, 2) calculate required employment levels to achieve the target GRDP, and then 3) calculate the total APCR population based on the required employment (workforce) and workforce participation ratio (WFPR).

(1) Future GRDP in AP State

To achieve the Vision 2029 goals and targets, AP State's Gross State Domestic Product (GSDP) aims to achieve double-digit growth rates between 10.0-12.1 % p.a. over the next 15 years with an average of 11.1% pa. Therefore, as shown in Table 2.15, the six scenarios for the AP state were referred to establish an economic growth scenario of APCR.

Table 2.15 Six Scenarios of VISION 2029

Scenario	GSDP by sector				Productivity (ICOR)
	Primary	Secondary	Tertiary	Overall	
Scenario 1	8.6 %	11.6 %	10.0 %	**10.1 %**	BAU
Scenario 2	8.6 %	11.1 %	10.2 %	**10.0 %**	BAU+1%/year
Scenario 3	9.5 %	13.0 %	10.8 %	**11.1 %**	BAU
Scenario 4	9.5 %	12.5 %	11.1 %	**11.0 %**	BAU+1%/year
Scenario 5	10.4 %	14.2 %	11.8 %	**12.1 %**	BAU
Scenario 6	10.3 %	13.6 %	12.1 %	**12.0 %**	BAU+1%/year

Productivity (ICOR): For each of the six growth scenarios, the necessary scale of capital investment is tested using Incremental Capital Output Ratio (ICOR) to achieve the target of each scenario. The Incremental Capital-Output Ratio (ICOR) is the ratio of investment to growth equal to the reciprocal of the marginal product of capital. The higher the ICOR, the lower capital productivity or the marginal efficiency of capital. Based on the business as usual productivity (BAU), an annual productivity increase of 1% is tested.

Source: Sunrise Andhra Pradesh Vision 2029, Draft for Review and Discussion June 2016

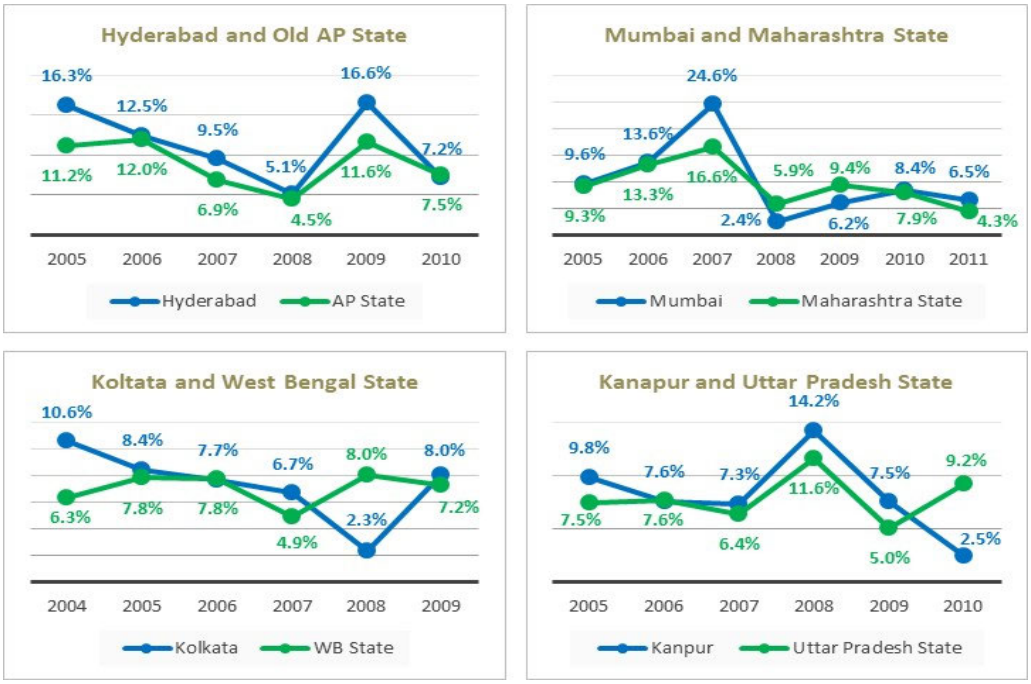
(2) Future GRDP in APCR

Figure 2.12, the growth rates of a state and its capital city in India, indicates that the growth rates of the APCR, as the capital city, will be higher at about 1% than the average of the AP State.

Vision 2029 informs that the average growth rate of the AP State is 11.1% during the planning horizon (until 2029). As the study area (APCR) includes the new state capital city Amaravati, various new functions and services are expected to be concentrated in Amaravati Capital City and its surrounding areas, such as state administration, education, health, commercial, services, and tourism. This accumulation of new functions is expected to contribute to added economic growth, as experienced in other capital regions in India.

Therefore, as the capital region of the AP State, APCR can grow at 12.1% p.a. (11.1+1.0%) until 2030, which is considered a moderate growth scenario (or a likely growth scenario). As part of the planning exercises, three additional scenarios are considered, namely Business as Usual (Case 0), Low growth (Case 1:11.1%), and High growth (Case 3: 13.1%). The growth rate of the Business as Usual Case is 8.1% p.a. which is the same as the average growth rate of India in the past.

- Business as Usual Case (Case 0): 8.1% p.a. (average growth rate of India 2011-2016)
- Low Growth (Case 1): 11.1% p.a. (expected average future growth in AP state)
- Moderate Growth (Case 2): 12.1% p.a. (Case 1 + 1% higher case)
- High Growth (Case 3): 13.1% p.a. (Case 1 + 2% higher case).



Source: JICA Study Team 2018 based on Statistics and Program Implementation, Government of West Bengal and data processed by Planning Commission, 2017

Figure 2.12 Indian states and capital cities: GSDP average growth rates

Further breakdown of growth rates by industrial sectors is considered for each growth scenario (until 2030).

It is thought that the growth rate of the primary sector is relatively low in comparison with other sectors (secondary and tertiary sectors). Accordingly, 8.6% is used for all cases, of which the rate is the same as the lowest growth scenario informed by Vision 2029.

The growth rate of the secondary sector in APCR is thought to be lower than the average growth rate of the secondary sector in the AP State because other areas, such as the VCI Corridor, grow faster. Therefore, the growth rate of the secondary sector is set at 10.7%, lower than the AP State average at 2%. The growth rate of the tertiary sector is adjusted (flexible) to meet the target growth of APCR. Accordingly, it ranges from 12.3% to 15.4%.

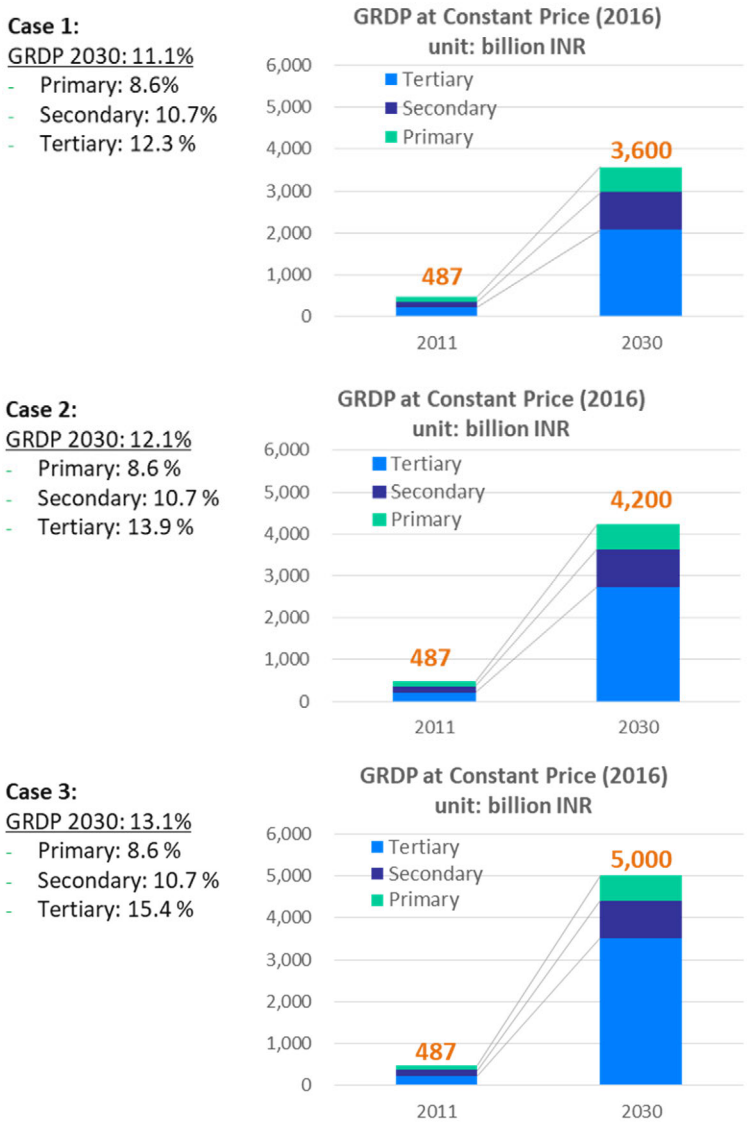
GRDP growth rates by the industrial sector in APCR until 2030

For each of the growth scenarios until 2030 (Case 1~3), growth rates of GRDP by the industrial sector are considered as follows:

Primary sector: 8.6% p.a.
Considering the expected structural changes in APCR, including the capital city of Amaravati, a lower growth rate in the primary sector is expected. Therefore, the lowest GRDP growth rate (8.6%) assumed in the VISON 2029 has been used.

Secondary Sector: 10.7%
A growth rate of being lower at 2% than the average growth rate of the secondary sector (12.7%) in VISION 2029 has been used. Therefore, it is considered that the secondary sector development concentrates on the VCI Corridor, while there will be less development in APCR comparatively.

Tertiary Sector:
To achieve the target GRDP, the growth rate in the tertiary sector is adjusted. For Case 1: 12.3%, Case 2: 13.9% and Case 3:15.4%.



Source: JICA Study Team

Figure 2.13 GRDP in APCR (2030) – 3 Cases

GRDP growth rate after 2030

Although Vision 2029 anticipates continued double-digit economic growth in the state, from past experiences in other countries, it is considered unrealistic for such growth rates to be sustained over longer time horizons (e.g., more than 15 years).

Several Asian countries experienced sharp economic growth after World War II ("East Asian Miracle[4]"). Japan, for example, experienced double-digit growth intermittently for more than ten years after the postwar recovery (11.1% p.a. for 13 years from 1960 to 1973), while other countries also enjoyed rapid growth from seven to ten years (see Table 2.16). It is also commonly observed that GDP growth rates became lower after achieving a certain value (scale) of GDP.

[4] According to "The East Asian Miracle, Economic Growth and Public Policy (World Bank' 1993)" the East Asian Miracle was spurred by sound development policies including the provision of an essential framework for private investment, increasing integrity of banking systems and financial saving, and improved educational systems.

Table 2.16 Asian countries: past trends of high GDP growth

Country	GDP growth rate (% p.a.)	Period
India	11.3	3 years (2014-2016)
Japan	11.1	13 years (1960-1973)
South Korea	10.1	10 years (1987-1996)
Thailand	9.7	10 years (1987-1996)
Malaysia	10.6	7 years (1989-1996)

Source: World Bank Development Indicators, 2018

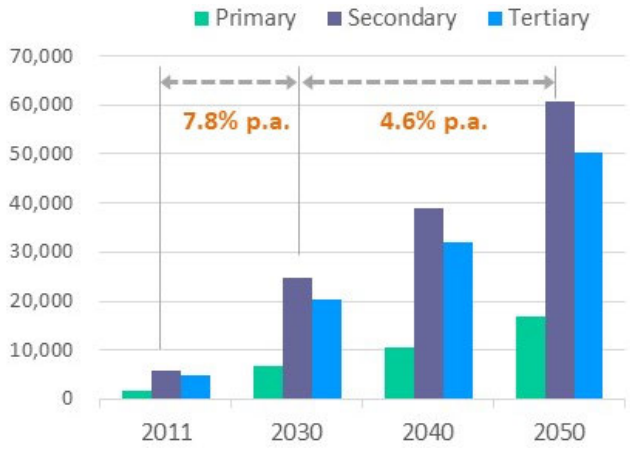
While it is reasonable to anticipate that the capital region's development will catalyze higher economic growth across APCR, the effect is likely to level off over time as Amaravati nears full build-out. The international benchmark study suggests that the GRDP growth rate can be lowered from the initial high levels (double-digit growth) to a lower rate. Considering the scale of the economy of AP State, the experience of South Korea can be referred to set a future GDP growth rate in AP State after 2030. In South Korea, for 20 years after GDP reached 670.8 billion USD (slightly higher than the expected GDP of AP State in 2030), the growth rate was 6.2 % p.a., excluding the crisis impacted years. Therefore, a 6.2% p.a. rate is used as the GRDP growth rate of APCR after 2030 for the APCR CTTS.

The growth rate of each sector until 2030, for example, in Case 2, is 8.6% for the primary sector, 10.7% for the secondary, and 13.9% for the tertiary sector, respectively. These growth rates are proportionally decreased towards 2050 under the Case 2 growth scenario. The same adjustment method is used for the other two cases (Cases 1 and 3).

Future productivity and employment

Productivity (GRDP per worker by industrial sector) is a dominant factor in estimating future employment and population. Vision 2029 data (for the state as a whole) targets 14.6% p.a. growth in the primary sector, 4.0% p.a. in the secondary sector, and 7.8% p.a. tertiary sector up to 2029 in terms of the productivity. However, for the longer term, towards 2050, such growth rates seem unrealistic, particularly in the primary and tertiary sectors, even when potentials for added value from capital city service industries such as IT, financial services, and R&D are taken into account.

Generally, primary sector productivity is expected to improve through automation and advanced technologies. However, this improvement tends to slow down after widespread adoption of mechanized farming practices and higher added value on agricultural products achieved through exporting. This is expected to stabilize beyond 2030, similar to GDP growth.



Unit: USD at 2017 constant prices

Source: JICA Study Team 2018

Figure 2.14 Future productivity (GRDP per worker) in APCR

Table 2.17 Future productivity by sector 2011-2050 in APCR

Unit: GRDP per worker at 2017 constant prices

Sector	unit	2011	2030	2040	2050
Primary	USD	1,632	6,800	10,700	16,700
	INR	106,096	442,000	693,100	1,086,700
Secondary	USD	5,942	24,800	38,800	60,900
	INR	386,350	1,609,700	2,523, 800	3,957,100
Tertiary	USD	4,911	20,700	32,100	50,300
	INR	319,305	1,330,300	2,085,800	3,270,400

Source: JICA Study Team 2018

Besides, anticipated industrial sector growth in APCR seems to be relatively low, considering that the AP State has enormous potential for industrial development in other areas. They include benefits from their strategic locations within the emerging East Coast Economic Corridor growth and planned Machilipatnam container port

The JICA study team studied experiences in other Asian nations' productivity (GDP per worker) to set the APCR's future productivity until 2030 and beyond. Referring to Thailand and South Korea, likely productivity improvement ratios in APCR are set at 7.8% for the period from 2011 to 2030 and 4.6% from 2031 to 2050 (see Figure 2.14. Based on this approach, future employment by sector has been estimated.

Accordingly, in the base-case scenario (Case 0), employment (worker) grows slowly to reach 3.24 million by 2050, while other scenarios range between 4.33 to 5.80 million. While the primary sector still dominates employment in the base case, the tertiary sector is the main economic contributor in all other scenarios (Case 1~3).

Table 2.18 Future employment by sector 2011-2050 in APCR

Scenario	2011	2030	2035	2040	2050
Case 0					
Total	**2,343,243**	**2,672,000**	**2,807,500**	**2,943,000**	**3,241,000**
Primary	1,237,762	1,487,000	1,562,500	1,638,000	1,804,000
Secondary	350,042	421,000	442,000	463,000	510,000
Tertiary	755,439	764,000	803,000	842,000	927,000
Case 1					
Total	**2,343,243**	**3,646,000**	**3,813,000**	**3,980,000**	**4,335,000**
Primary	1,237,762	1,424,000	1,334,500	1,245,000	987,000
Secondary	350,042	479,000	493,500	508,000	538,000
Tertiary	755,439	1,743,000	1,985,000	2,227,000	2,810,000
Case 2					
Total	**2,343,243**	**4,138,000**	**4,466,000**	**4,794,000**	**5,285,000**
Primary	1,237,762	1,424,000	1,334,500	1,245,000	987,000
Secondary	350,042	610,000	628,000	646,000	684,000
Tertiary	755,439	2,104,000	2,503,500	2,903,000	3,614,000
Case 3					
Total	**2,343,243**	**4,719,000**	**4,976,500**	**5,234,000**	**5,800,000**
Primary	1,237,762	1,424,000	1,334,500	1,245,000	987,000
Secondary	350,042	749,000	771,000	793,000	839,000
Tertiary	755,439	2,546,000	2,871,000	3,196,000	3,974,000

Source: Data in 2011 is based on Census 2011. Others are prepared by JICA Study Team 2018

(3) APCR Future population

The long-term future population in the study area (APCR) has been derived from forecasts of future employment and workforce participation ratio (WFPR)[5] as discussed above; the WFPR has been taken as 40.9%, according to the APCRDA Draft Perspective Plan (DPP-2015). The resulting forecasts show a total population range from 7.9 million to 14.2 million by 2050.

Table 2.19 Future population 2011-2050 in APCR

Scenario	2011	2030	2035	2050	Annual growth rate		
					2011-30	2030-50	2011-50
Case 0	5,873,588	6,526,000	6,856,500	7,915,000	0.56%	0.97%	0.77%
Case 1	5,873,588	8,907,000	9,313,000	10,586,000	2.22%	0.87%	1.52%.
Case 2	5,873,588	10,108,000	10,908,500	12,909,000	2.90%	1.23%	2.04%
Case 3	5,873,588	11,526,000	12,154,000	14,167,000	3.61%	1.04%	2.28%

Source: Data for 2011 is based on the 2011 Census. Others are prepared by JICA Study Team 2018

APCRDA Detailed City Masterplan informs 3.9 million as the Amaravati Capital City's population in 2050. Therefore, this population has been considered the fixed population for planning this CTTS[6].

Based on the total APCR population and the fixed population composition of Amaravati Capital City (3.9m[7] in 2050), the population outside the capital city is estimated to assist the generation of CTTS alternative transport/land-use scenarios.

Table 2.20 Future population in Amaravati Capital City and rest of region, 2011-2050

Scenario	Year	Population			Rest of region	
		Total	Amaravati Capital City	Rest of the region (outside ACC)	Growth Rate 2011-50 p.a.	Pop. growth 2011-50
Case 0	2011	5,873,588	97,960	5,775,628		
	2050	7,915,000	3,900,000	4,415,000	-0.93%	-1,760,629
Case 1	2011	5,873,588	97,960	5,775,628		
	2050	10,586,000	3,900,000	7,086,000	0.38%	910,372
Case 2	2011	5,873,588	97,960	5,775,628		
	2050	12,909,000	3,900,000	9,409,000	1.15%	3,233,372
Case 3	2011	5,873,588	97,960	5,775,628		
	2050	14,167,000	3,900,000	10,667,000	1.49%	4,491,372

Source: 2011 data based on census. Others are prepared by JICA Study Team 2018

Case 0 anticipates significant depopulation outside the capital city (around 1.7 million by 2050), while Case 1 indicates only a slight increase. Neither forecast is deemed realistic since the most recent APCR growth trend was 1.16% p.a. between 2001 and 2011, i.e., pre-capital city designation. Moreover, as Amaravati MP anticipates a "queen bee effect," the new capital city is expected to induce migration from inside and outside APCR by introducing new value-added industries, hi-tech services, and state government services.

[5] WFPR is calculated as "number of employed" divided by "total population"
[6] Amaravati Capital City forecast as of May 2018
[7] Data as of May 2018

Table 2.21 Future Population 2011-2050 in APCR

APCR Forecast	Population (000)				Pop. growth (CAGR)	
	2011	2017	2035	2050	2011-2035 (%)	2011-2050 (%)
Draft Perspective Plan (1)	5,873.6		11,250.0	13,800.0	2.74	2.21
DMP (2)	5,873.6	6,879.8	12,290.9	15,253.9	3.12	2.73
CTTS (3)	5,873.6	6,322.3	10,908.5	12,909.0	2.61	2.04
AP State (4)	49,577.1	55,500			0.80	

(1) DPP APCRDA Surbana 2015
(2) Draft DMP APCRDA 2018
(3) CTTS JST 2 018
(4) UN (2017)

Source: Census of India 2011, Interim Draft DMP, Aug. 2017, APCRDA, CTTS JST May 2018

According to recent United Nations data, India's future population will grow at 0.75% p.a. from 2010 to 2050[8]. From this perspective, as APCR 2050 Case 2 (12.91m) shows a growth rate closer to the national outlook, it is appropriate to use it as the fundamental data for traffic forecasts in CTTS. Therefore Case 2 is adopted as the population framework for this study.

2.2.2 ULB population growth

The 12 ULBs vary significantly in terms of population, area, urban form, topography, economy, income levels, and growth constraints. APCR's two largest ULBs in Vijayawada (estimated population over 1.7m in 2017) and Guntur (0.94m) is forecast to reach 2.21m and 1.54m, respectively; by 2050, Amaravati Capital City will be built between them. The other major ULBs adjacent to the new capital city, Tadepalle, and Mangalagiri, will likewise experience rapid growth. CTTS forecasts that by 2050 the total population of these four ULBs will reach 3.94 m, up from 2.80 m in 2017 – an increase of 40.7%.

Table 2.22 APCR ULBs : Population forecasts 2011-2050 (1)

ULB	Population (000)		Population (000)		Pop. growth CAGR
	1961	2011	2017	2050	2017-50 (%)
Vijayawada	234.4	1034.3	1,209.5	1,231.8	0.06%
Mangalagiri	22.2	73.6	67.2	69.3	0.10%
Tadepalle	17.6 (a)	54.4	58.6	77.5	0.85%
Guntur	187.1	769.9	940.4	1,202.6	0.75%
Amaravati Capital City (ACC)	-	98.0	125.8	3,885	10.95%
Total metropolitan ULBs + ACC	461.3	2,030.2	3,327.9	8,742.6	2.97%

Data Source: Census of India 2011; Interim Draft DMP, Aug 2017
(a) 1971, Census Handbook, CMDA Website & In force ZDP Reports, JST 2017-50 TAZ-based Forecasts, 2017

Table 2.23 APCR ULBs: Population forecasts 2011-2050 (2)

ULB	Population (000)		Population (000)		Pop. growth CAGR 2017-50 (%)
	1961	2011	2017	2050	
Gudivada	44.8	118.2	117.2	150.9	0.77%
Nuziveedu	19	58.6	63	111.8	1.75%
Jaggayyapeta	13.9	53.5	61.8	75.7	0.62%

[8] Data refers to UN, Dept. of Economic & Social Affairs, Population Division (2017), World Population Prospects

ULB	Population (000)		Population (000)		Pop. growth CAGR 2017-50 (%)
	1961	2011	2017	2050	
Sattenapalli	17.5	56.3	59.2	86.7	1.16%
Ponnuru	22.9	59.9	60.2	86.7	1.11%
Nandigama (1)	23.2	44.4	48.1	97.1	2.15%
Vuyyuru (1)	23.4	46.5	37.7	60.2	1.43%
Tenali	78.5	164.9	171.9	175.4	0.06%

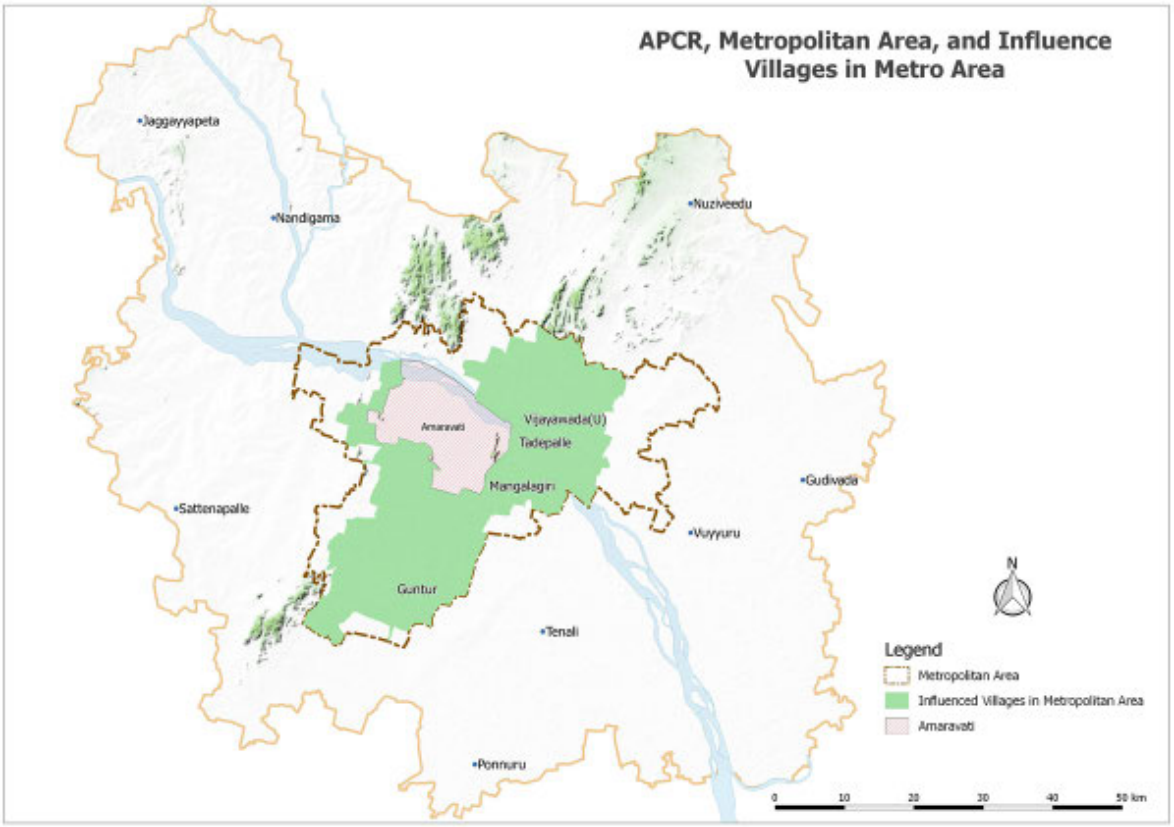
(1) Nagar Panchayat date for 1981-2011

Source: Census of India 2011; Census Handbook, CMDA Website, In force ZDP Reports, Interim Draft DMP, Aug 2017

2.3 Key planning tool for APCR: the "Urbanization Simulation Model"

2.3.1 Planning for APCR

Within the APCR study area, the CTTS identified a core metropolitan area including Vijayawada, Guntur, Tadepalle, Mangalagiri, Amaravati Capital City, and the area between the capital city and Guntur (see Figure 2.15). As this area will be the focus of future growth and infrastructure investment, a sophisticated approach was required to chart the likely course of development and determine appropriate policy interventions and infrastructure needs. To provide for this, the JICA Study Team has custom-built a state-of-the-art tool: the Urbanization Simulation Model, as explained below.



Source: JICA Study Team

Figure 2.15 APCR metropolitan area and influenced villages in the metropolitan area

The APCR Urbanization Simulation Model uses Geographic Information System (GIS) software to correlate and map a wide variety of physical, demographic, and economic data on the region as it exists today. Various growth scenarios can then be simulated with this meticulously inter-related data as a base. For example, add 10,000 jobs in one location, 10,000 residents in another area, plus new transport networks, and the model can simulate the likely effect in great detail.

In building the model, the first step was to divide the 8,603 km^2 APCR into 35,379 rectangular "mesh units" of 500mx500m (0.25km^2). Next, a wealth of detail on each of these units was added: data on physical conditions, land use, population, employment and income, economic activity, transport infrastructure, traffic, etc.

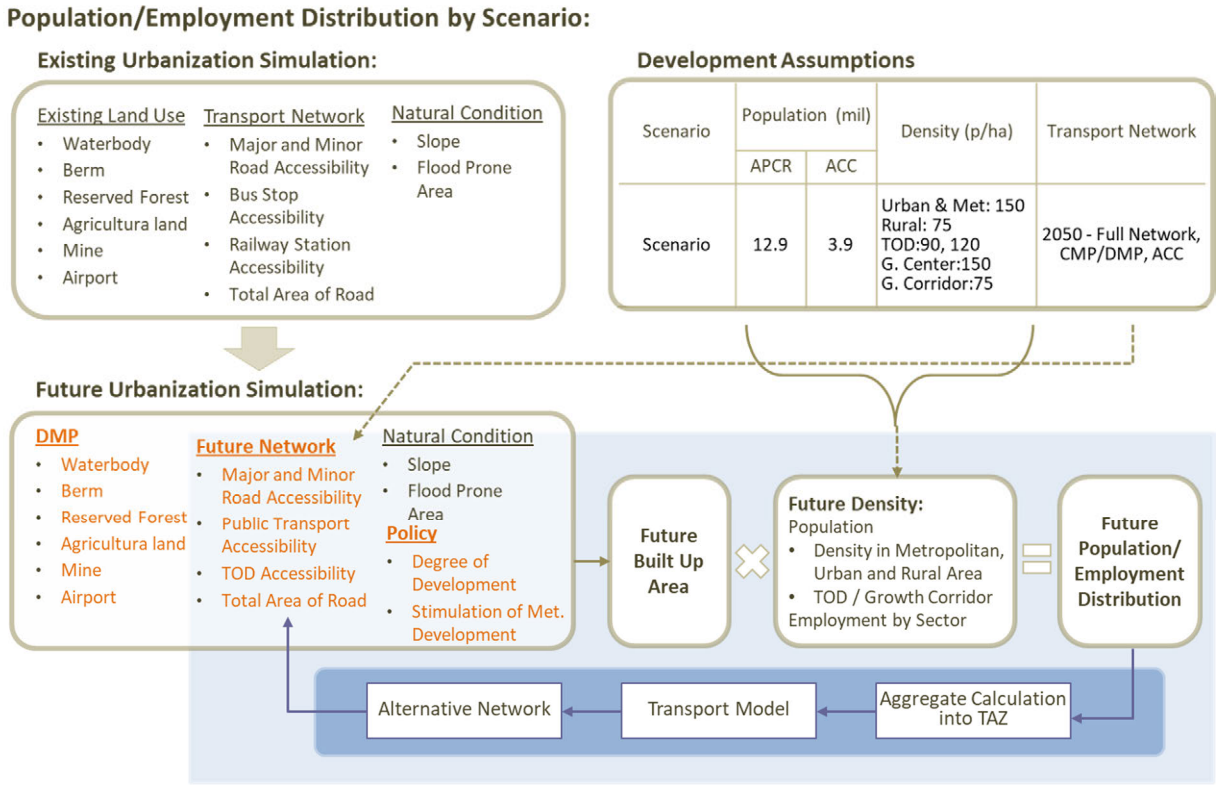
Once all the data are in place, the combined mesh units generate an accurate picture of the region as it exists – and its accuracy can be gauged in various ways, for example, by comparing traffic flows estimated by the model with real-world observations.

From this baseline model of existing conditions, growth scenarios and the effects of new infrastructure can then be simulated, as will be shown throughout this report.

This Urbanization Simulation Model should be understood as a key legacy of this CTTS process. APCR has a tool like this to support its future planning. If the model and its underlying databases are carefully maintained and updated, this will remain a critical tool. However, organic growth may unfold, and whatever policy interventions are made in the future.

2.3.2 Methodology of future population and employment distribution

Population and employment opportunities in each future scenario were prepared using the urbanization simulation model and the following workflow shown in Figure 2.16. For a detailed explanation of the urbanization simulation model, please refer to Chapter 5, Technical Note No. 1 Socio-economic development framework.



Source: JICA Study Team

Figure 2.16 Workflow of future population/employment distribution

2.3.3 Population & employment opportunity distribution

To predict anticipated changes in land use and other conditions as future growth occurs, the data from the draft DMP, the transport network, and other sources were correlated with each 500m x 500m unit in the mesh model. Then, the density defined in each scenario was computed for each mesh unit population and employment opportunities. Finally, values for population and employment opportunity by sector from each mesh unit were accumulated by transport analysis zone (TAZ) and exported to the transport model. In this way, highly detailed forecasts were developed.

CTTS sets the four future development scenarios to examine the possible alternatives and then select the most appropriate spatial distribution scenario using the transport simulation exercise. These four scenarios are the followings:

Scenario A) Do-nothing case: Amaravati is fully developed (a given condition in the CTTS brief). However, no new transport proposals are implemented: the capital city scenario assumes the 2018 transport system as the base network.

Table 2.24 Summary of Scenario A (2050)

Type	Study Area		
	Total	Capital City	Other Area
Population	12,909,000	3,885,000	9,024,000
Employment Opportunity	5,285,000	2,413,000	2,872,000
Primary Sector	987,000	0	987,000
Secondary Sector	684,000	227,000	457,000
Tertiary Sector	3,614,000	2,186,000	1,428,000

Source: JICA Study Team 2018

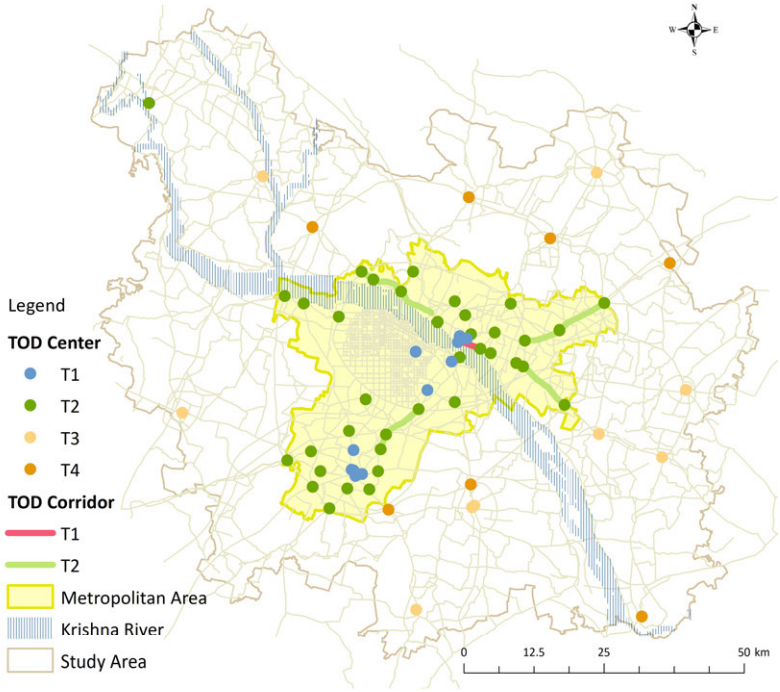
Scenario B) Dispersed growth: Envisages growth (6.2 m. by 2050) distributed around both strategic corridors (ORR/IRR and NH/SH) plus strategic urban nodes (APCRDA proposal). Balance of 2050 population (2.8 m.) dispersed proportionally to existing ULBs across the region.

Table 2.25 Summary of Scenario B (2050)

Type	Study Area			
	Total	Capital City	Growth Center/Corridor	Other Area
Population	12,909,000	3,885,000	6,253,000	2,771,000
Employment Opportunity	5,285,000	2,413,000	508,000	2,364,000
Primary Sector	987,000	0	57,000	930,000
Secondary Sector	684,000	227,000	229,000	228,000
Tertiary Sector	3,614,000	2,186,000	222,000	1,206,000

Source: JICA Study Team 2018

Scenario C) Concentrated growth: Scenario C proposes “compact development” as the global trend. In order to avoid urban sprawl, a metropolitan area was established to concentrate the population in the central area. The proposed metropolitan area includes Amaravati Capital City, Vijayawada ULB, Guntur ULB, Tadepali ULB, Mangaragili ULB, and surrounding villages. This area is considered an “urban area” whose population density is set at 150 persons/ha. Scenario C also offers TOD centers and corridors to encourage mixed-land use with workplaces and residents closer. The following figure shows the locations of TOD, and the table indicates the impact area and each density. Besides, the concept of TOD should be used as an urbanized area and excludes any agricultural activities within it.



Source: JICA Study Team

Figure 2.17 Proposed TOD Centers, TOD Corridors, and Metropolitan Area

Table 2.26 Definition of TOD used in Urbanization Simulation Model in Scenario C

Type of TOD	Impact Area Radius (m)	Population Density (P./ha)	Secondary Sector Employment Density (p./ha)	Tertiary Sector Employment Density (p./ha)
T1	800	90	n.a.	344
T2	800	120	30	234
T3	500	90	15	340
T4	500	120	30	234
T1 Corridor	800	90	n.a.	344
T2 Corridor	800	120	30	234

Source: JICA Study Team 2018

Table 2.27 Summary of Scenario C (2050)

Type	Study Area			
	Total	Capital City	TOD Center/Corridor	Other Area
Population	12,909,000	3,885,000	2,506,000	6,518,000
Employment Opportunity	5,285,000	2,413,000	890,000	1,982,000
Primary Sector	987,000	0	0	987,000
Secondary Sector	684,000	227,000	51,000	406,000
Tertiary Sector	3,614,000	2,186,000	839,000	589,000

Source: JICA Study Team 2018

Scenario F) Combination of scenarios B and C: Combine dispersed and concentrated growth scenarios. The population is distributed along strategic corridors such as ORR, IRR, NH, SH, and strategic urban nodes (APCRDA proposal). TOD nodes and corridors are also factored in. The entire build-out case of the road and transit network is included: ORR, IRR, western bypass, Metro and BRT corridors, etc.

Table 2.28 Summary of Scenario F (2050)

Type	Study Area				
	Total	Metropolitan Area			Outside Met. Area
		ACC	Other Area	Total	
Population	12,909,000	3,885,000	4,856,000	8,741,000	4,168,000
Employment Opportunity	5,285,000	2,413,000	1,590,000	4,003,000	1,282,000
Primary Sector	987,000	0	127,000	127,000	860,000
Secondary Sector	684,000	227,000	333,000	560,000	124,000
Tertiary Sector	3,614,000	2,186,000	1,130,000	3,316,000	298,000

Note: "ACC" means Amaravati Capital City, and "Met." Means Metropolitan

Source: JICA Study Team 2018

A summary of the alternative spatial population distribution scenarios tested with the transport model is given in Table 2.29 and Figure 2.16. The associated employment opportunities distributions (Scenario F) are shown in Source: JICA Study Team

Figure 2.19~Figure 2.21. Further details and results from the transport model can be found in the Technical Notes.

Table 2.29 Summary of Future Development Scenarios in 2050

Scenario Title	Population (million)				Growth Centers			Population density (person/ha)			Transport Network
	APCR *	Metropolitan		Out-side	TOD	along IRR	along ORR	Urban	rural	TOD	
		ACC **	Out-side ACC								
Scenario A Do Nothing	12.9	3.9	4.7	4.3	×	×	×	Exist	exist	×	Existing network
Scenario B Equitable Growth	12.9	3.9	3.9	5.1	×	○	○	150	75	×	2050 - full network - CMP/DMP--In Population estimation, the metro is not included
Scenario C Concentrated Growth	12.9	3.9	4.9	4.1	○	×	×	150	75	90 to 120	2050 - full network - CMP/DMP
Scenario F Mixed Policy B and C	12.9	3.9	4.1	4.9	○	○ ***	○ ***	150	75	90 to 120	2050 - full network - CMP/DMP

Note: *Population of APCR is referred to as "Case 2 Scenario" of the Global Framework.
**Planned population of Amaravati Capital City as of March 2018
*** 40% of the development is taken

Source: JICA Study Team 2020

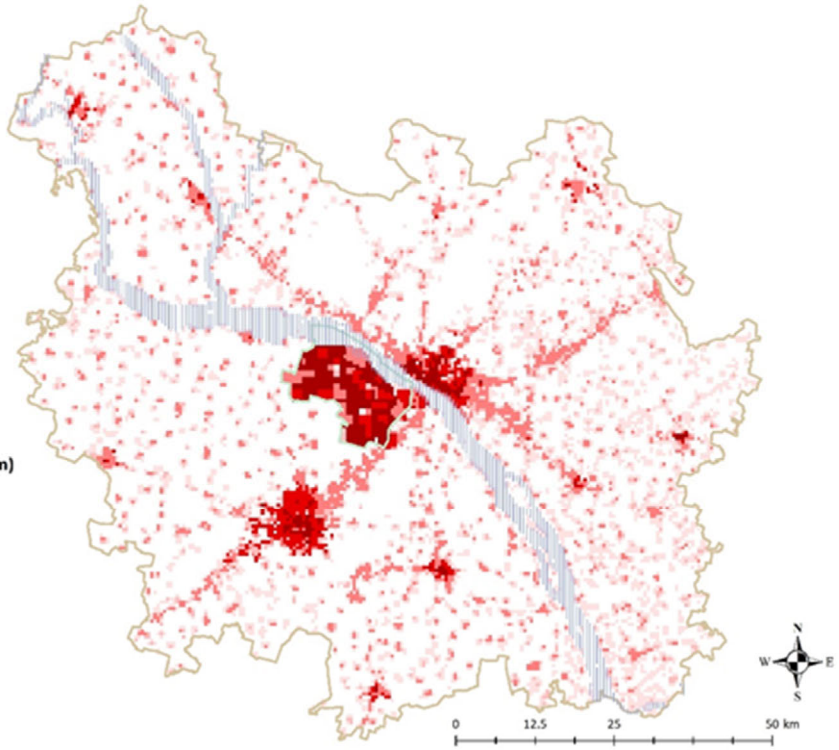
Scenario A

Study Area: 12,909,000 (Case2)
Capital City: 3,884,976

Network:
Network in 2017

Node:
Nothing

Density:
- Urban Area 150per./ha
- Rural Area 75per./ha



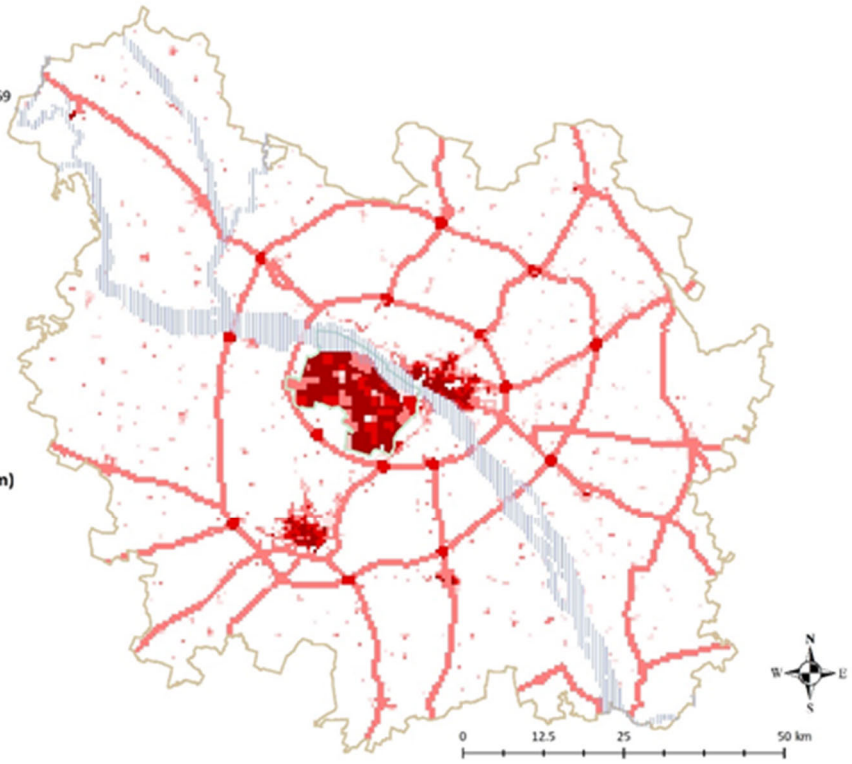
Scenario B

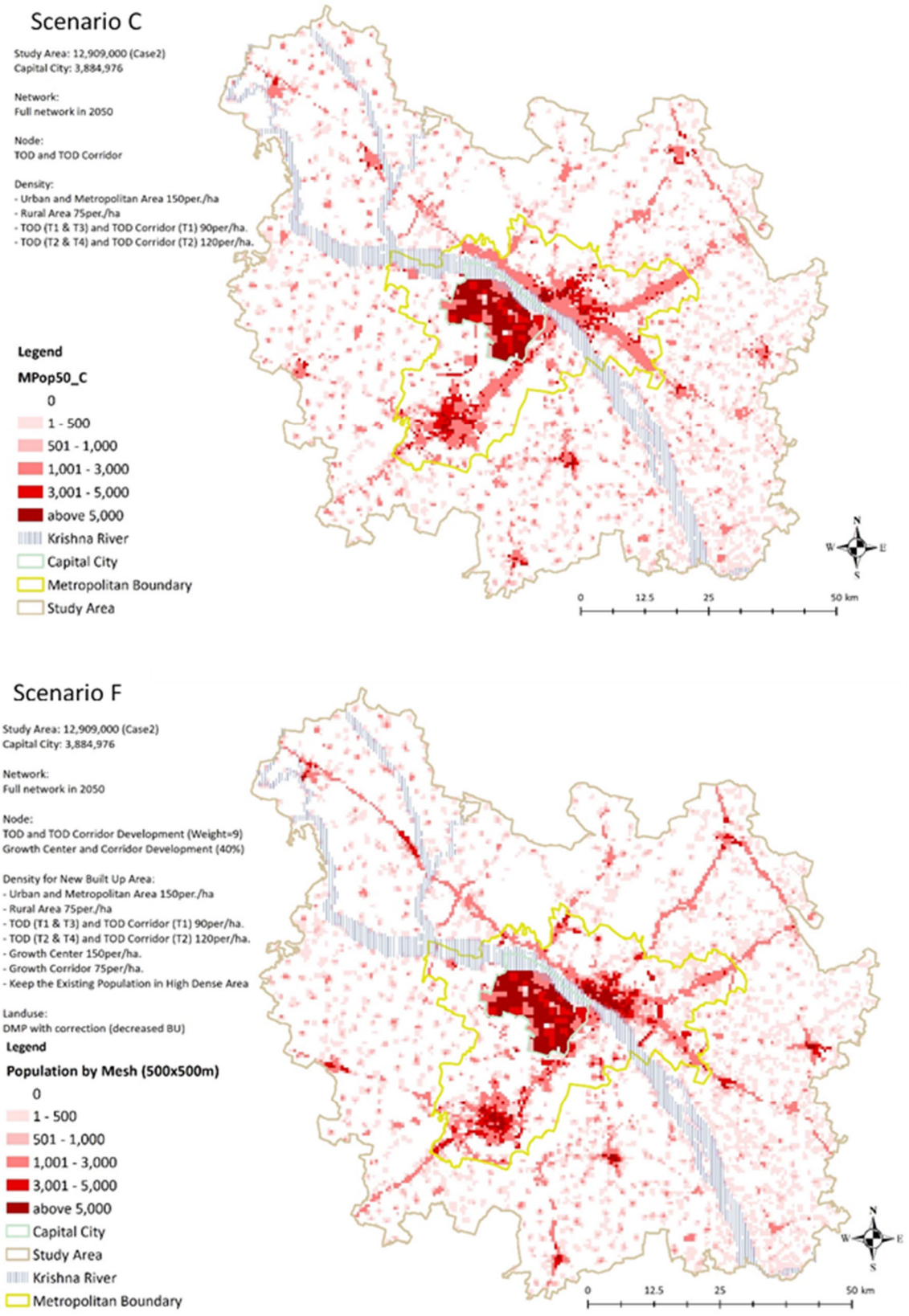
Study Area: 12,909,000 (Case2)
Capital City: 3,884,976
Growth Center and Corridor: 6,252,469

Network:
Network in 2050

Node:
Growth Center
Growth Corridor

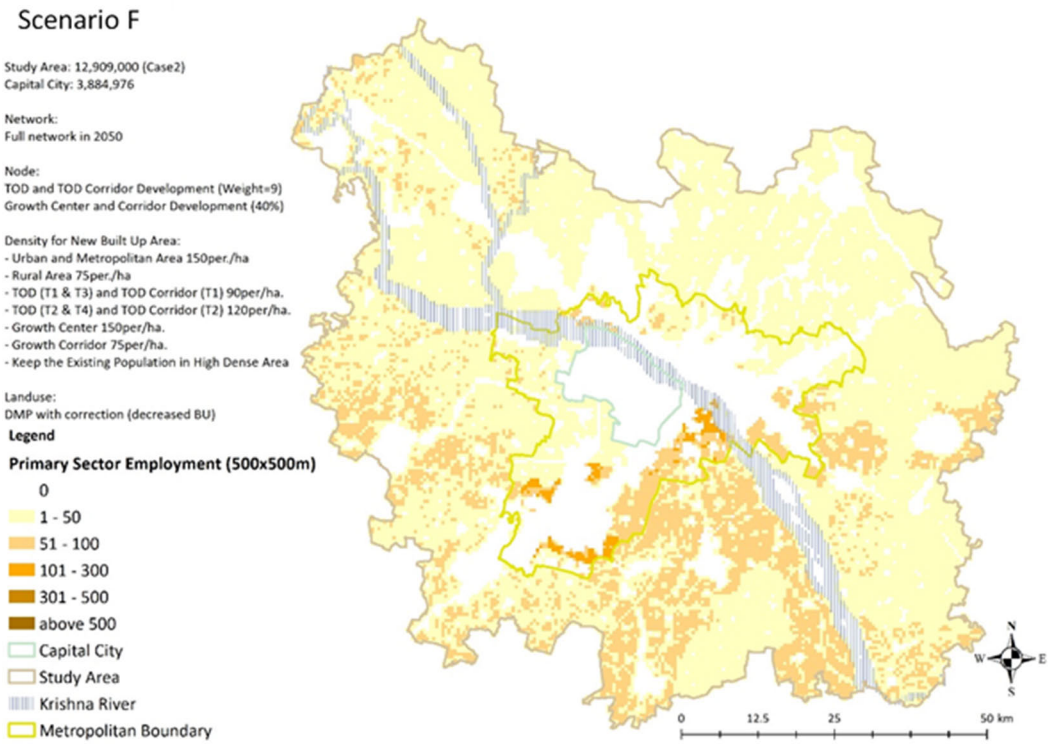
Density:
- Urban Area 150per./ha
- Rural Area 75per./ha
- Growth Center 150per./ha
- Growth Corridor 75per./ha





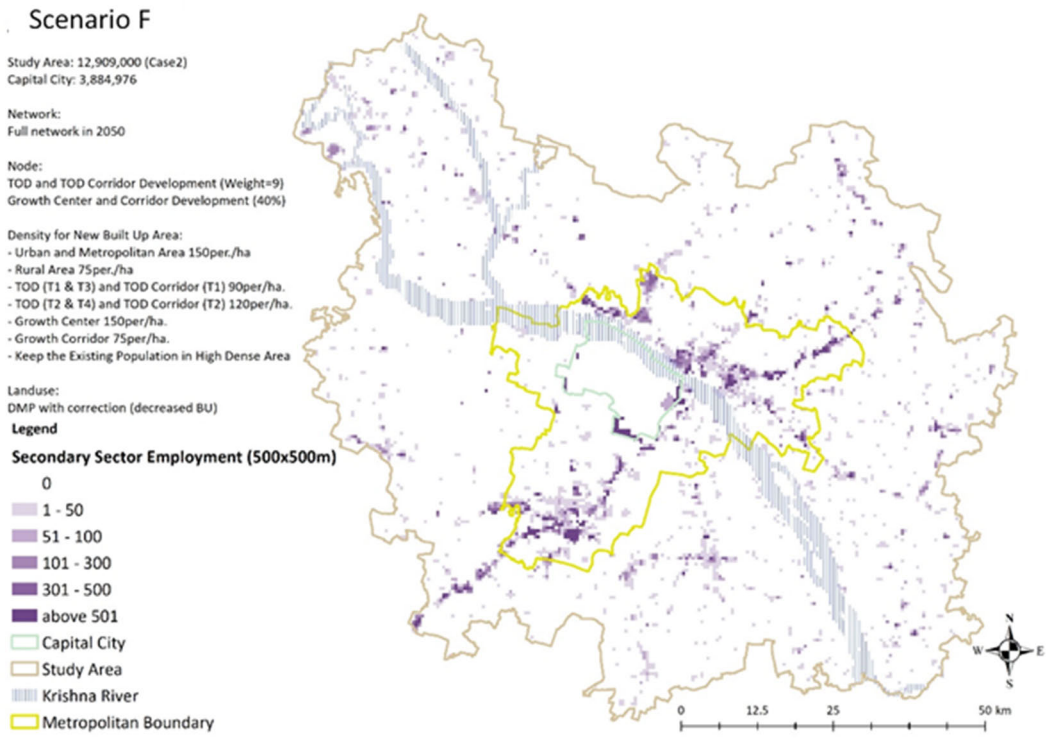
Source: JICA Study Team

Figure 2.18 Alternative population spatial distribution scenarios in 2050



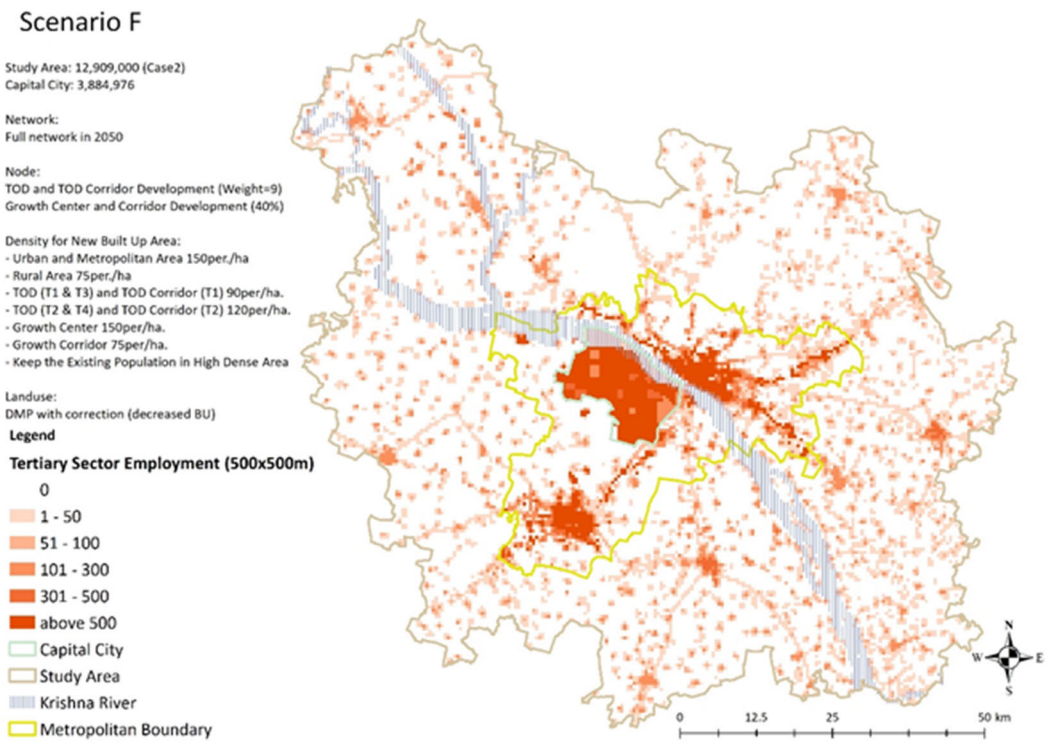
Source: JICA Study Team

Figure 2.19 Primary-sector employment distribution (Scenario F)



Source: JICA Study Team

Figure 2.20 Secondary-sector employment distribution (Scenario F)



Source: JICA Study Team

Figure 2.21 Tertiary-sector employment distribution (Scenario F)

A four-step transport model (APCR strategic transport model) was used to assess alternative interactions between land use and transport and policy assumptions. The model factors-in population growth trends and forecasts for the ULBs and Amaravati; the vitality of existing commercial areas; proposed urban growth nodes and activity hubs; the transport vision and objectives; and transport-related economic data (household income and expenditure patterns etc.).

2.3.4 Scenarios for Amaravati Capital City in 2030

Reflecting recent changes in AP state policy for the capital region, special attention was given to forecasts of the socio-economic framework in 2030. Three scenarios (A, B, and C) were prepared to test the impacts of developing Amaravati Capital City. The process of population and employment forecasts for 2030 is explained below.

1. Amaravati Capital City is subdivided into 13 LPS (land pooling system) zones for infrastructure development. Development priority was considered based on the proposed development activities in each LPS zone. Accordingly, detailed designs for infrastructure and consequent activities for each priority zone have been initiated.

2. Based on the above, it is assumed that the six priority LPS zones (1,2,3,6,7 & 10) will be developed by 2030.

3. The remaining LPS zones (4, 5, 8, 9, 11, 12, and 12A, along with start-up areas Phase 1, Phase 2, Phase 3, and river portion), for which no detailed designs have been yet prepared, may be developed at a later stage.

4. Population estimates in priority LPS zones (1,2,3,6,7 & 10) are set following the Case 2 socio-economic framework.

5. Options (for test cases) were prepared: Case A, B, and C responding to 50%, 75%, and 100% development cases.

6. Populations in the remaining capital city zones are estimated by applying a growth factor of 1.3% CAGR, 1.5% CAGR, and 1.7% CAGR for the respective case to 2017 population.

7. Some zones outside Amaravati Capital City but within the metropolitan area are likely to experience growth due to Amaravati's development. These zones are termed "Metropolitan Impact Areas." Population in these zones has been increased by a factor, as shown in Table 2.30.

8. The factor for TAZ in the "Metropolitan Impact Areas" is added to the growth factor obtained from 2017 to 2030 (Socio-economic framework Case 2)

9. Employment by sector is distributed proportionally to each TAZ based on its population.

Table 2.30 APCR: 2030 future population framework for Amaravati Capital City

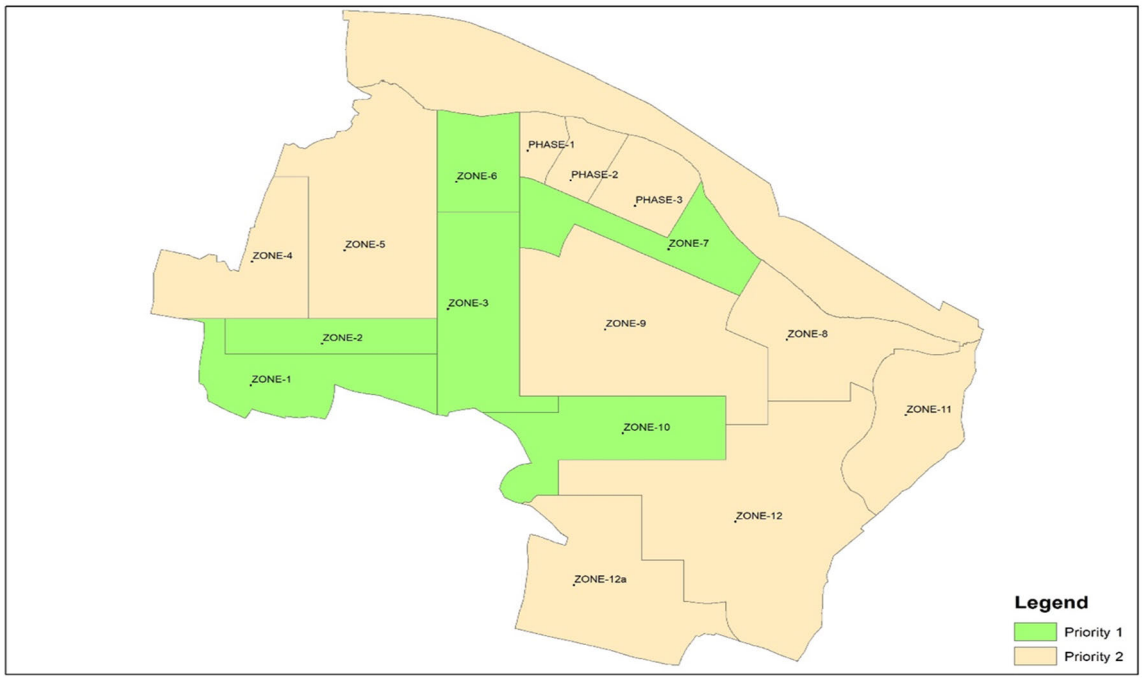
LPS zones	A	B	C
1, 2, 3, 6, 7 & 10	50% of the base case	75% of the base case	100% of the base case
4, 5, 8, 9, 11, 12, 12A, etc.	Existing population (2017) + 1.3% CAGR	Existing population (2017) + 1.5% CAGR	Existing population (2017) + 1.7% CAGR
Metropolitan Impact Areas	+2.5% p.a.	+2.25% p.a.	+2% p.a.

Source: JICA Study Team

Table 2.31 Base case - as per Case 2 socio-economic data in 2030 (,000)

	APCR	Amaravati	Metropolitan	Rest of region
Population	10,108	3,042.0	6,845.6	3,262.4
Employment	4,138	1,474.9	2,616.3	1,521.7
Primary	1,424	-	183.8	1,240.2
Secondary	610	202.3	499.9	110.1
Tertiary	2,104	1,272.6	1,932.6	171.4

Source: JICA Study Team



Source: APCRDA

Figure 2.22 LPS zones in Amaravati Capital City

A summary of three options, A, B, and C, is shown in the following tables. Based on advice from TAC, Option C was used to test the network for 2030.

Table 2.25 APCR - 2030 (,000)

	A	B	C
Population	8,748.6	8,867.3	8,989.6
Employment	3,222.7	3,299.5	3,377.3
Primary	1,492.9	1,488.8	1,485.0
Secondary	497.2	495.2	493.5
Tertiary	1,232,7	1,315.5	1,398.8

Source: JICA Study Team

Table 2.25 Amaravati Capital City - 2030 (,000)

Description	A	B	C
Population	611.1	851.5	1,091.9
Employment	266.6	376.6	486.7
Primary	27.0	27.7	28.4
Secondary	20.1	26.1	32.0
Tertiary	219.4	322.9	426.3

Source: JICA Study Team

Table 2.25 Metropolitan area - 2030 (,000)

Description	A	B	C
Population	5,486.1	5,604.9	5,727.2
Employment	1,701.0	1,777.8	1,855.5
Primary	2,52.7	248.6	244.7
Secondary	387.1	385.1	383.4
Tertiary	1,061.2	1,144.0	1,227.4

Source: JICA Study Team

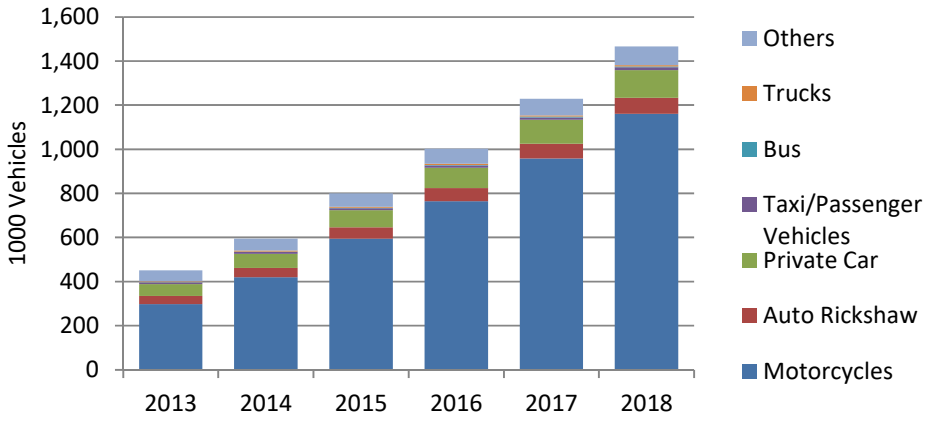
Chapter 3 Regional transport systems

3.1 Growth in vehicle registration

Rapid economic growth and liberalization of transport policies have led to steep increases in road traffic in APCR, resulting in worsening congestion, pollution, and deterioration of existing infrastructure.

Motorcycles predominate among APCR's registered motorized vehicles, with a 74% share in 2018. Transport Department vehicle registration data from 2004 to 2015 show compound growth of 14% for cars, 12.8% for two-wheelers, 11.2% for buses, and 15.2% for all types of trucks. After the State's bifurcation, growth continued apace from March 2014 to March 2015: 11.9% for cars, 13.2% for two-wheelers and trucks 7.3%.

The number of registered motor vehicles in Krishna and Guntur districts has increased from 0.5 million in 2013 to 1.6 million vehicles in 2018. The average annual growth over this period was about 26%.



Note: This includes scrapped vehicles that have not been officially deregistered.
Source: Transportation Department, AP State

Figure 3.1 Registered vehicles in Krishna and Guntur Districts

As shown in Table 3.1 (below), the home interview survey (HIS) conducted for the CMP/DMP project, reported the estimated average number of trips per vehicle per day by vehicle type in APCR.

Table 3.1 Number of trips by vehicle category in APCR, average 2016

Vehicle type	No. of registered vehicles, (1000)	Estimated trips/day, (1000 person-trips/day)	Occupancy ratio (person/vehicle)	No. of trips per vehicle/day
Motorcycles	764	1,847	1.64	1.47
Auto-rickshaw	60	1,184	5.03	3.89
Private car	92	86	2.77	0.34
Taxi/passenger vehicles	10	11	4.28	0.25
Bus	3	1,141	32	12.33

Source: CMP/DMP study and Transportation Department, AP State

Source: JICA Study Team

Figure 3.2 Traffic in Vijayawada

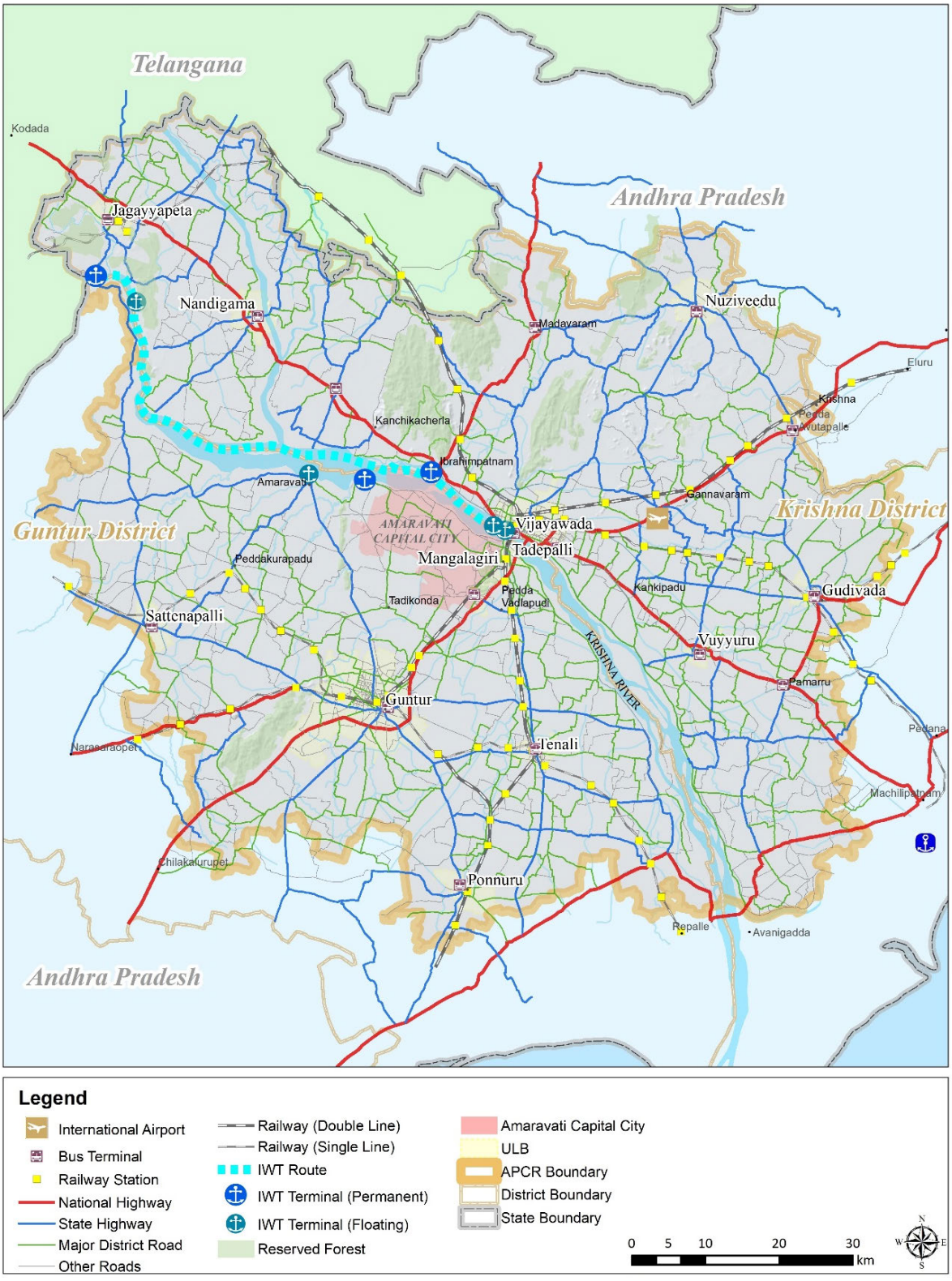
3.2 Highways

AP's road networks are vital to support the State's future economic growth and productivity. Two major national highways NH16 (Chennai–APCR–Visakhapatnam–Kolkata) and NH65 (Hyderabad–APCR–Machilipatnam port) intersect at Vijayawada. Responsibility for highways and road transport in AP is shared among several agencies.

The National Highways Authority of India (NHAI) is responsible for upgrading and maintaining national highways in AP via its Project Implementation Unit (PIU) and the national highway wing of RBD. NHAI oversees projects under the National Highway Development Program (NHDP), upgrading 1,691 km of AP's 4,913 km network. NHAI is currently upgrading 172 km of its network to 4 or 6 lanes with an investment of Rs.31,170 million. PIU and RBD are responsible for the remaining 3,222 km of national highway in AP.

Meanwhile, the Ministry of Road Transport and Highways (MoRTH) is currently upgrading 800 km of national highways in AP with a budget of Rs.42,600 million.

To establish a road grid hierarchy, AP State has designated high traffic volume arteries as elements of the Core Road Network (CRN) – which comprises high-volume state highways (85%) and Major District Roads (15%). This CRN is the responsibility of the Andhra Pradesh Road Development Corp. (APRDC). Since it was established in 1997, APRDC has streamlined decision-making and increased autonomy in project execution. The Roads and Building Department (RBD) is responsible for non-CRN state roads.



Source: JICA Study Team

Figure 3.3 Regional transport network

APRDC is also responsible for implementing state highway and public-private partnership (PPP) projects, including two recently completed: (i) Narkedpally–Addanki and Hyderabad–Karimnagar–Ramagundaram (44km), and (ii) a 4.1 km bridge across the Godavari plus a 10.4 km approach road. Two further PPP projects are under preparation, upgrading: (i) 372 km of state highway, and (ii) 1,778 km of other roads.

State highways link larger towns and cities in Guntur District, but the network is less extensive in Krishna District. Major District Roads meanwhile link smaller villages in APCR. Public Works Department (PWD) roads and Panchayat roads play a vital role in developing the hinterland at the local level.

Available data indicate that relative to the statewide strategic road system (i.e., National Highways, State Highways, and Major District Roads = 44,969 km), APCR share (4,260 km) is 9.5%, even though its population share is 11.8%. This results in a below-average strategic road density (AP State 0.91km/000 population v. APCR 0.73km/000 population).

Table 3.2 AP State and APCR: strategic road density (km)

Road type		AP State	APCR	
a)	National Highway	4,423	584	13.20%
b)	State Highway	12,235	1,383	11.30%
c)	Major District Road	28,311	2,293	8.10%
d)	Subtotal (a + b + c)	44,969	4,260	9.47%
e)	Population 2011 (000)	49,387	5,874	11.89%
d) / e)	Strategic road density (km/population)	0.91	0.73	

Source: State R&B Department, Vijayawada, 2018; Draft Master Plan, APCRDA, 2016

Table 3.3 APCR strategic road network

Road no.	Strategic network hierarchy	Length (km)
National Highways		
NH16 (5)	Chennai to Cuttack (Odisha) via Chilakaluripeta, Hanuman Jn.	122.69
NH65 (9)	Pune to Machilipatnam via Nandigama, Vuyyuru and Pamarru	152.10
NH30 (221)	Ibrahimpatnam to Jagdalpur via Kondapalli, Mylavaram	41.18
NH165 (214)	Pamarru – Kathipudi via Gudivada	22.70
NH216 (214A)	Ongole – Narsapur (Digamarru) via Mopidevi, Challapalle	60.51
NH544D	Perecherla – Kurnool road via Narasaraopet and Venukonda	22.57
State Highways		
SH21	Guntur – Narketpalli road via Sattenapalli	44.87
SH316	Mangalagiri – Chandolu road via Duggirala, Tenali	24.46
SH28	Pedana – Visannapeta road via Gudlavelluru, Gudivada and Nuziveedu	61.34
SH328	Pamarru – Challapalle road Via Movva	27.05
SH40	Guntur – Bapatla road via Narakoduru, Chebrolu, Ponnuru and Mulukoduru	36.59
SH238	Gannavaram – Nuziveedu via Agiripalle, Ravicharla	36.09
SH236	Vijayawada – Nuzuveedu road via Agiripalle	42.54
SH243	Gudivada – Kankipadu road via Ventrapragada	24.51
SH249	Guntur - Naguluppalapadu via Prathipadu, Pedanandipadu, Inkollu	20.29
SH288	Guntur-Amaravati	33.20
SH34	Sattenapalli -Krosuru-Achampet - Madipadu	51.07
SH209	Amaravati-Pedakurapadu – Sattenapalli Road	5.18

Road no.	Strategic network hierarchy	Length (km)
SH322	Sattenapalli-Narasaraopeta road via Muppala	1.07
SH222	Nandigama-Madhira road via Koduru	15.01
SH207	Mylavaram-Nuziveedu road	23.33
SH32	Vijayawada-Vissanapeta via Kothuru Tadepalle, Gannavaram, Keerthirayanaguem	29.19
SH265	Tenali Road-Vellaturu Via -Vemuru, Kolluru and Donepudi	25.46
SH280	Tellaprolu-Thotlavalluru Via Unguturu, Nandamuri and Vuyyuru	36.61
SH306	Kesarapalle - Kankipadu Via Uppaluru	10.28
SH233	Gannavaram – Gudivada Road Via Unguturu	20.71
SH298	Gannavaram - Maanikonda Via Tarigoppula	14.50
Major District Roads		
MDR33	Undavalli-Amaravati road	17.90
MDR149	Kesara-Madhira road via Illuru	16.09
MDR45	Veeravalli to Vattigudipadu Via Mallavalli	15.20
MDR196	Kaza – Uppalapadu via Namburu settlement	10.60
MDR129	Madduru – Uppaluru Via Gosala	10.30
MDR47	Guntur – Nidammaru Via Kantheru	19.90
MDR143	Namburu - Duggirala	12.30

Source: JICA Study Team

Table 3.4 River bridges in APCR

Name	Structure	Owner	Operator	Length	Opening Year
Prakasam Barrage	Barrage	AP	AP	1.23 km	1957
Kanaka Durga Varadhi (NH16)	Beam	NHAI	NHAI	2.60 km	2012 (part of NH16 widening project)

Source: JICA Study Team

Source: JICA Study Team

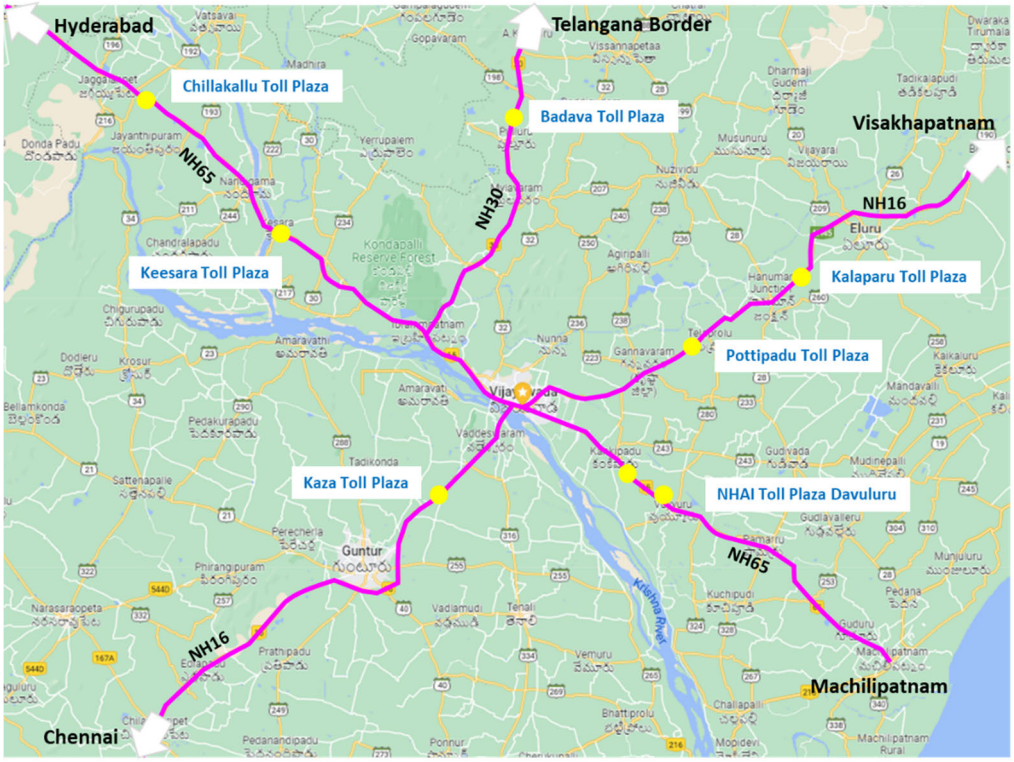
Figure 3.4 Prakasam Barrage

NHAI maintains national highways via a BOT scheme. There are five toll gates in APCR.

Table 3.5 Toll gates in APCR

Tollgate	Section	Traffic volume (PCU/day)	Operator	Toll fee (Car, single journey)
Chillakallu	50.8 km NH65 (9) Hyderabad-Vijayawada	25,454 (16, Apr. 2017)	BOT (GMR Hyderabad-Vijayawada Expressway Pvt. Ltd)	80 Rp.
Keesara	48.0 km NH9 Nandigama-Vijayawada	19,747 (31, Mar. 2016)	BOT (Swarna Tollway Pvt. Ltd.)	50 Rp.
Kaza	82.5 km NH16 (5) Vijayawada-Chilakaluripet	64,279 (8, Apr. 2017)	BOT (Vijayawada Tollway Pvt. Ltd.)	85 Rp.
Pottipadu	39.1 km NH16 (5) Gundugolanu-Vijayawada	33,312 (31, Mar. 2016)	BOT (Ms Eagle Infra India Ltd.)	30 Rp.
Bodava	36.9 km NH221 Ibrahimpatnam to AP Telangana Border	N/A	BOT (Sh. V. Vidya Sagar Reddy)	25 Rp.

Notes: N/A = not available.
Source: NHAI Toll Information System

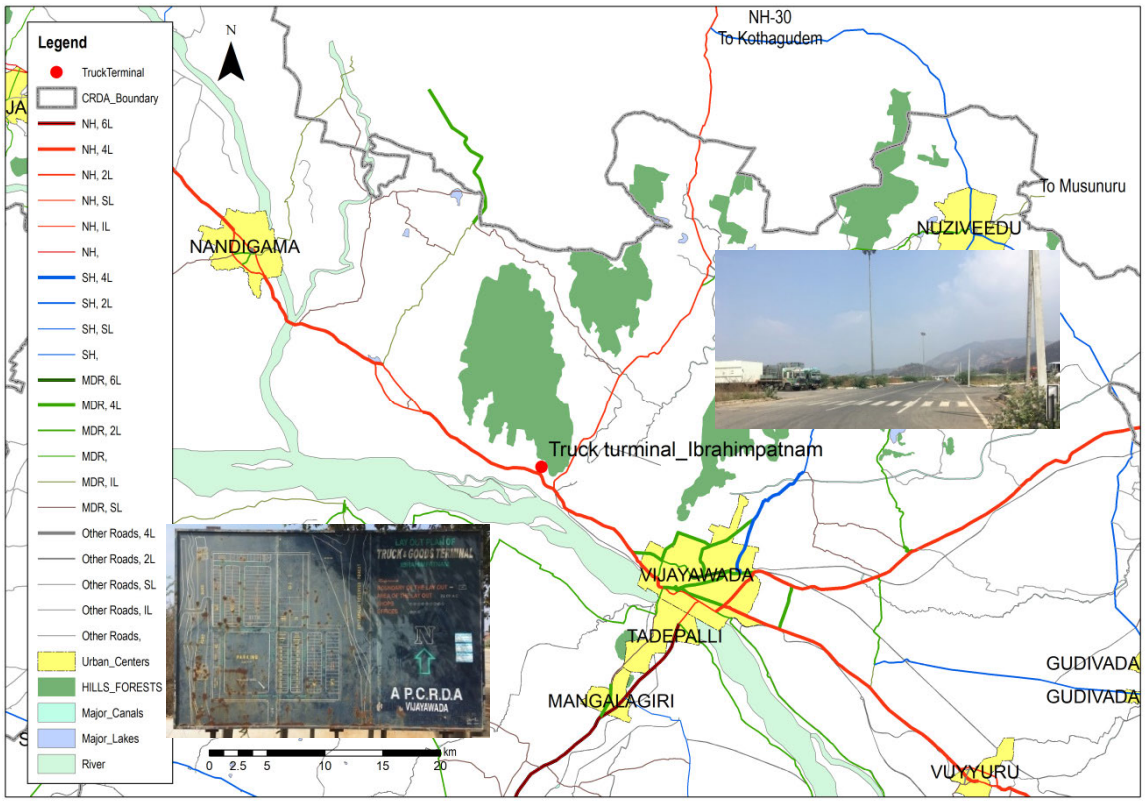


Source: JICA Study Team

Figure 3.5 Toll Plaza Locations in APCR

3.3 Truck terminal

There is only one public truck terminal in APCR – Ibarahimpatnam Truck Terminal – located between Vijayawada and Nandigama near the junction of NH65 and NH30. According to interviews with truck drivers at Ibrahimpatnam, conducted by CTTS, few drivers use the terminal because of its high parking charges and inconvenient location away from the city center.



Source: JICA Study Team

Figure 3.6 Location and layout of Ibrahimpatnam Truck Terminal

3.4 Bus and IPT (Para-transit)

Especially in a dispersed urban region like APCR, efficient and affordable bus services are vital to enabling sustainable mobility and employment opportunities. As such, promoting efficient public transport should be a key policy priority.

Bus services can be broadly categorized into three types: urban/suburban, rural, and long-distance/regional. Considering the CRDA jurisdiction and the dispersal of the population in the 12 ULBs around the capital city, public transport operations can be summed up in two categories:

- CRDA services: Urban/suburban (10-15 km) & Rural/mofussil (15-25 km)
- Regional services: long-distance intercity, interstate, and wider region (25-100 km+)

Source: JICA Study Team

Figure 3.7 APSRTC Buses

As a rule, private bus operators (contract and tourist) services are not allowed to compete with APSRTC. However, some operators do compete with APSRTC for passengers.

Table 3.6 Categories of bus operations

S/No.	Category of operation	Class of service/product	Average passenger trip length (m)
a)	Urban & suburban operations	1. City ordinary 2. Metro express	10 to 15 km
b)	Rural/mofussil operations	Palle Velugu/Telugu Velugu	15 to 25 km
c)	Long-distance/Regional operations (Intercity & Interstate)	1. Express 2. Super Luxury 3. Ultra Deluxe 4. Garuda/GarudaPlus 5. Amaravati/Indra 6. Vennela/Vennela Plus	Above100 km

Source: APSRTC MIS office of Regional Manager, 2017

3.4.1 Bus network and services

An efficient public transport network is essential in ensuring a sustainable financial strategy for bus operation by improving efficiency, building market share, and improving passenger revenues.

A well-integrated and connected network as a 'travel product' encourages people to use public transport, while reducing traffic congestion and improving quality of life via reduced air and noise pollution and commuting stress. Priority service networks offer significant benefits to commuters through reduced travel times. As bus systems commonly operate under budget constraints, investment in efficient infrastructure typically yields benefits in terms of financial viability.

In November 2017, the Andhra Pradesh State Road Transport Corporation (APSRTC) had 17 bus depots in APCR with 1,641 buses. Guntur District had six bus depots with 522 buses, while Krishna District had 11 depots with 1,119 buses.

Operations are broadly divided into three groups:

- Vijayawada city (5 depots with 503 buses)
- Mofussil services incl. long-distance premium buses from Vijayawada (2 depots with 275 buses)
- District ULB services (4 depots with 341 buses)

(1) Vijayawada - Pandit Nehru Bus Station (PNBS)

Pandit Nehru Bus Station (PNBS) in central Vijayawada, owned and operated by APSRTC, is one of the largest bus stations in AP: 28 acres with 62 platforms and two terminal buildings. Terminals include various services, including cinema, kiosks, food shops, etc.

From PNBS, APSRTC provides direct services to destinations across AP plus other states such as Telangana, Tamil Nadu, Karnataka, Odisha, and Chattisgarh. APCR city buses also operate from PNBS.

APSRTC bus services include Amaravati, Ultra Deluxe, Telugu Velugu, Express, Garuda, Garuda Plus, Indra, Super Luxury and Vennela bus fleets with Palle Velugu, Express, Deluxe, Super Luxury, Rajadhani A/C, Garuda, Garuda Plus buses.

Within Vijayawada, APSTRC operates 417 bus routes, carrying 70,000 passengers/day. These include 117 city routes carrying about 30,000 passengers/day, with each bus carrying around 1,000 passengers/day. Twenty or more routes from villages to PNBS also serve stops on main city arterials like MG Road and Bandar Road.

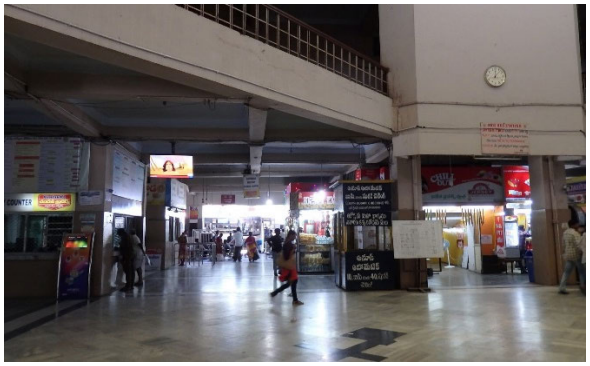
Source: JICA Study Team

Figure 3.8 Vijayawada PNBS bus station

(2) Guntur - NTR Bus Station

Guntur NTR bus station, the second-largest in AP, also owned and operated by APSRTC, includes two bus depots and two terminals: Arrival (12 platforms) and Departure (36 platforms). The terminals have a wide range of services, such as hotels, canteens, net cafes, parcel offices, and other shops.

APSRTC operates both city and district services and interstate routes to Karnataka, Tamil Nadu, and Telangana. Feeder services (city buses, private services, auto-rickshaws) offer convenient connections to Guntur and the surrounding area. A new city bus stand and depot are planned nearby.

Source: JICA Study Team

Figure 3.9 Guntur APSRTC Bus Terminal

Point-to-point versus network services: One current shortcoming of APSTRC services within Vijayawada is that most routes are 'point-to-point' to the main terminal, with few transfer options short of the terminal. There appears to be little planning effort to make such transfers convenient.

Figure 3.11 shows the present inner-city routes in Vijayawada, where each line represents a different bus route. The dense arrangement of different routes on a single line can be observed.

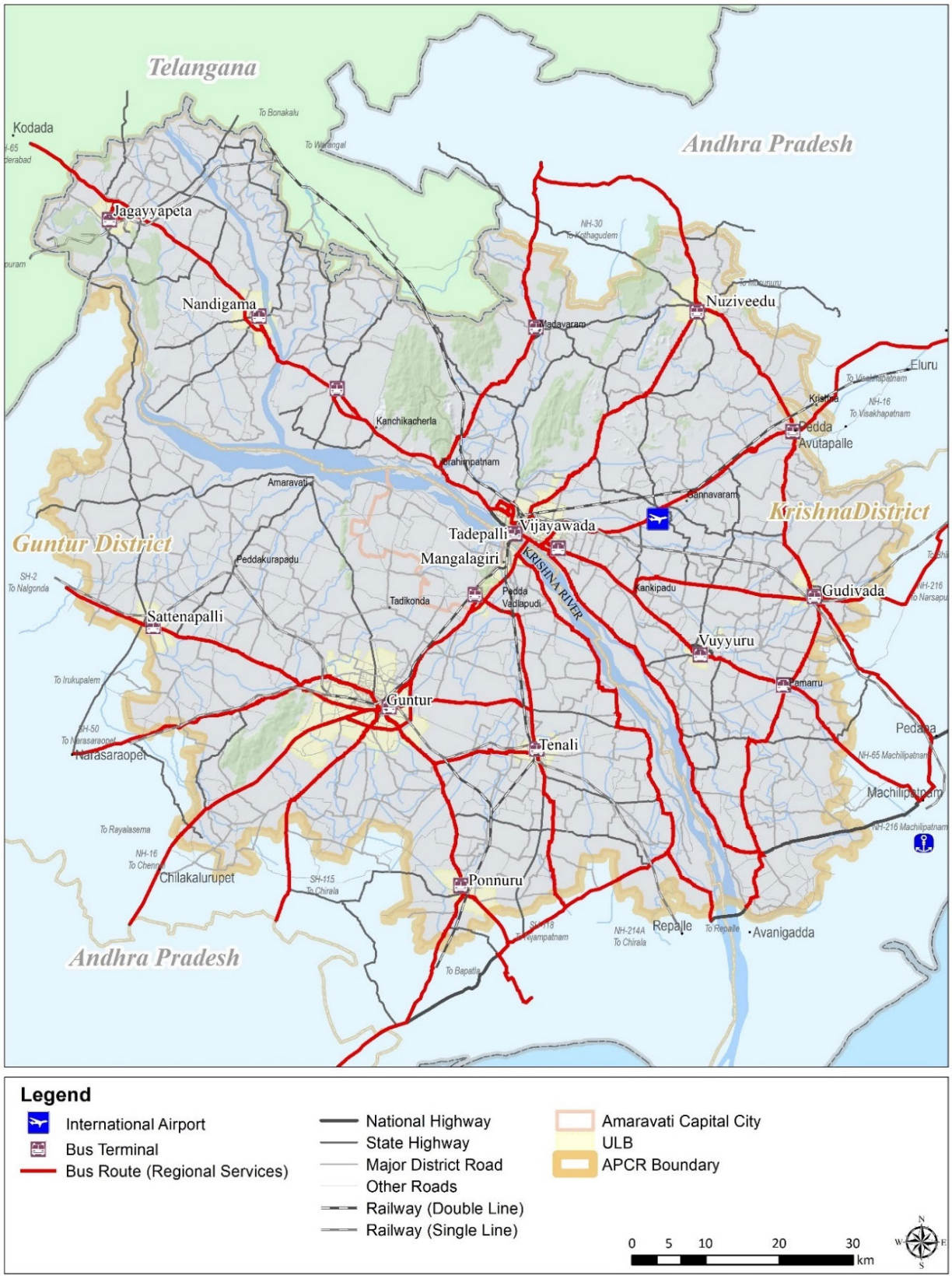
While the advantage of such a design is that passengers have an uninterrupted journey, the disadvantages of point-to-point services are:

- Route alignment or destinations may not align with traveler's requirements forcing a difficult-to-navigate transfer.
- With long routes, there is often a mismatch between passenger demand in outlying areas versus service needs in populated sections of the route. Consequently, resources cannot be optimized.
- Buses on multiple routes often converge randomly, resulting in wasteful duplication.
- Having many routes operating without a planned schedule results in bus congestion at various places including the terminus.

Despite a large number of routes, there is very little network connectivity available to passengers.

The adage that "a collection of single routes does not make a network" holds, as network characteristics of access, connectivity, and integration deliver a surplus of benefits that single routes cannot offer. Efficient networks can provide a 'social surplus' – benefits to the community that exceeds the cost of providing them.

The key feature of an efficient network is its connectivity – the ability to access a wide choice of destinations conveniently. In this way, the network can offer convenience competitive with private travel modes. To function effectively, a one-ticket operation is required (where the passenger pays for distance or holds a universal bus pass) plus seamless connections: convenient, safe, and with minimal impact on total travel time (i.e., frequent service to reduce waiting time).



Source: JICA Study Team

Figure 3.10 Existing bus route network and terminals (regional services)

Source: JICA Study Team

Figure 3.11 Existing bus route network (city bus services)

3.4.2 Para-transit/IPT services

A range of small private-sector IPT (para-transit) vehicles (licensed by the APRTA) provides two types of passenger transport services:

- Contract carriage services from railway stations, bus stations, hospitals, etc.: In this capacity, the vehicles provide flexible, demand-based services with fares subject to negotiation.
- Shared auto-rickshaws (3 wheelers carrying 6-8 passengers) and shared taxis (4-wheelers carrying 10-12 passengers: operating fixed routes (often competing for passengers on major bus routes) and designated stops, but also making random stops as requested by users.

Auto-rickshaws are the prime movers of Vijayawada residents, with some 14,000 vehicles providing around 70% of public transport travel capacity. Auto-rickshaws seating capacity (14,000 auto-rickshaws x seating capacity) exceeds that of buses: 71% of seating capacity is provided by auto-rickshaws and 29% by buses.

Auto-rickshaws registered in Vijayawada City can operate in Vijayawada but not other areas. The quality of their services depends largely on the drivers – and there are few institutional mechanisms to monitor and improve the quality of their services.

Source: JICA Study Team

Figure 3.12 Auto-rickshaws in Vijayawada

Shared auto-rickshaws in Vijayawada serve the following major routes:

- Kaleswara Rao Market to Kandrika
- Skew Bridge/Varadhi to Benz Circle
- Challapalli Bungalow to Moghal Rajapuram
- Eluru Loculu to Ajit Singh Nagar
- Kaleswara Rao Market to Bhavani Puram
- Prabhas College to One Town Tunnel
- Benz Circle to Ramavarappadu.

There are about 50 auto-rickshaw stands along these major routes. In general, service levels are poor in terms of convenience, safety, and security. Although fare structures are similar to APSRTC bus services, interview surveys done for CTTS found that auto-rickshaws are preferred over buses due to overall lower travel costs.

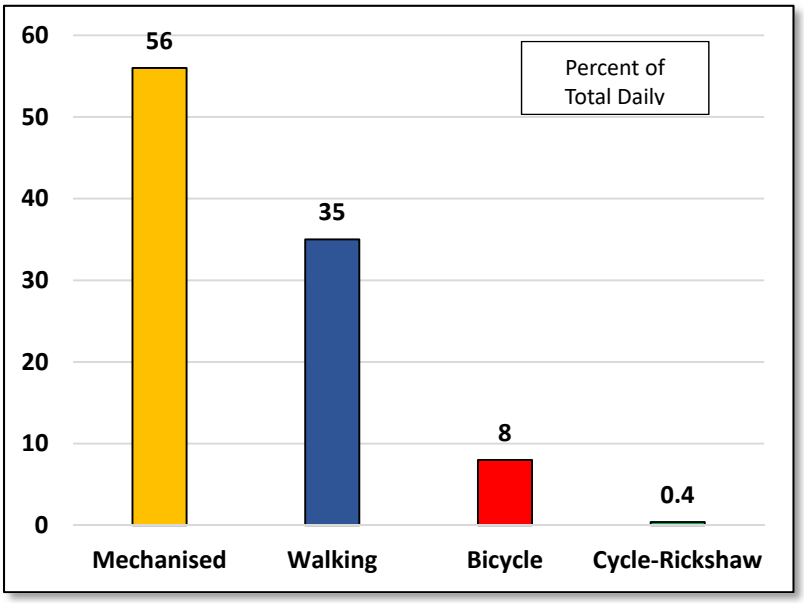
3.5 Non-motorized transport

Although cycling is an essential transport mode in APCR, accounting for nearly 8% of all household trips in 2017, this is below many other large Indian cities (typically 10-20% modal share) and declining, especially in larger cities such as Vijayawada. Reasons for this decline are unclear but may stem from (1) growing motorcycle ownership; (2) increasing road danger from motor vehicles.

The bicycle's benefits are evident in terms of speed, low cost/affordability, space efficiency, physical exercise, and sustainability. In line with national policy to promote cycling throughout India, substantial efforts are needed in APCR to reverse the decline and increase cycling's modal share of urban transport.

3.5.1 Bicycle modal share in APCR

According to the 2017 CTTS base data,[1] nearly 8% of all household trips in APCR were made by bicycle, and a further 35% were made on foot. Cycle-rickshaw trips were negligible – only 0.4% of total trips.

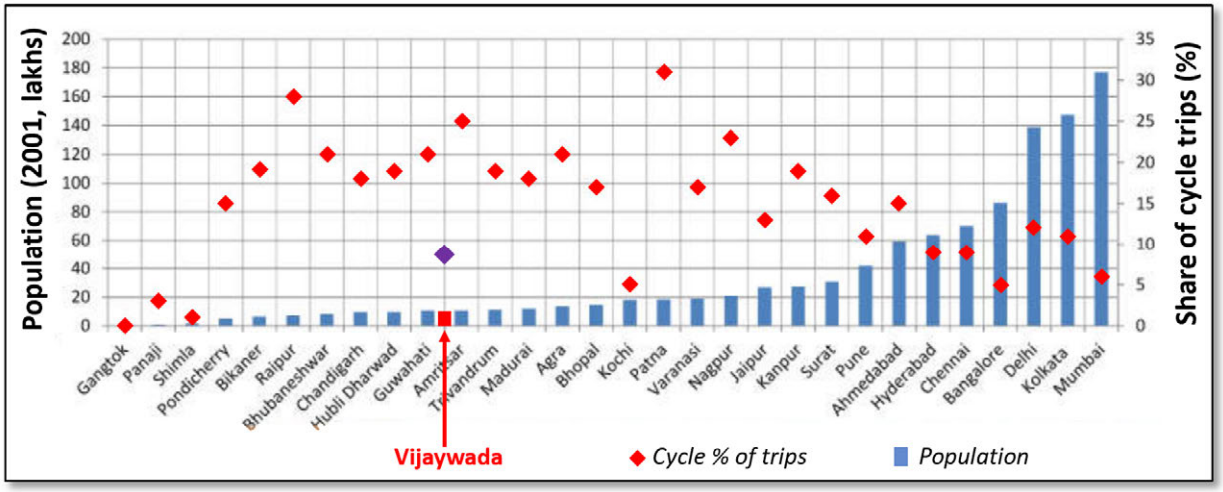


Source: Household Interview Survey, 2014/15, prepared for APCR Concept Master Plan and Detailed Master Plan. Data was updated to the 2017 CTTS base year and figures are in percent.

Figure 3.13 Modal share of daily trips made by APCR households, 2017

Compared with other cities, the modal share of cycling in APCR (8%) and Vijayawada (8%) is low. Generally, in Indian cities with 0.5 to 2. Cycling's modal share was 10-20% in the late 2000s.[2]

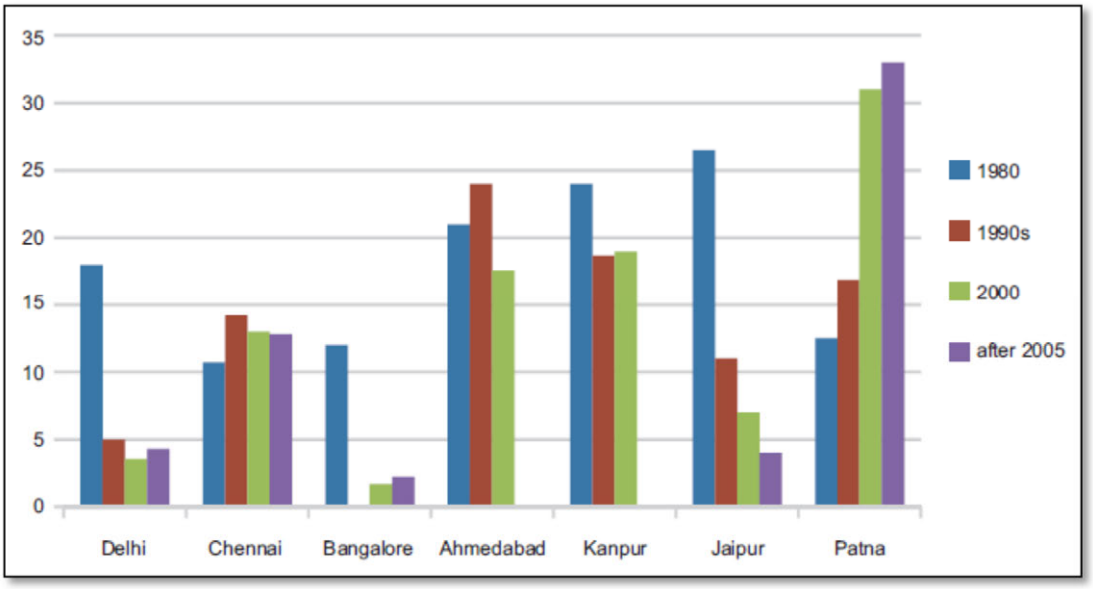
[1] 2017 CTTS base data is derived from 2014 household survey for Concept Master Plan and Detailed Master Plan
[2] National Transport Policy Development Committee, 2013, Vol. 5: Urban Transport, Table 5.4



Source: Premjeet Das Gupta and Kshama Puntambekar, Bhopal School of Planning and Architecture, 'Bicycle Use in Indian Cities', Conference Paper, 2016 (using statistics obtained from MoUD, 2008)

Figure 3.14 Cycling modal share in Vijayawada versus other Indian cities

The bicycle's modal share in Vijayawada is decreasing, in common with many other cities in India.

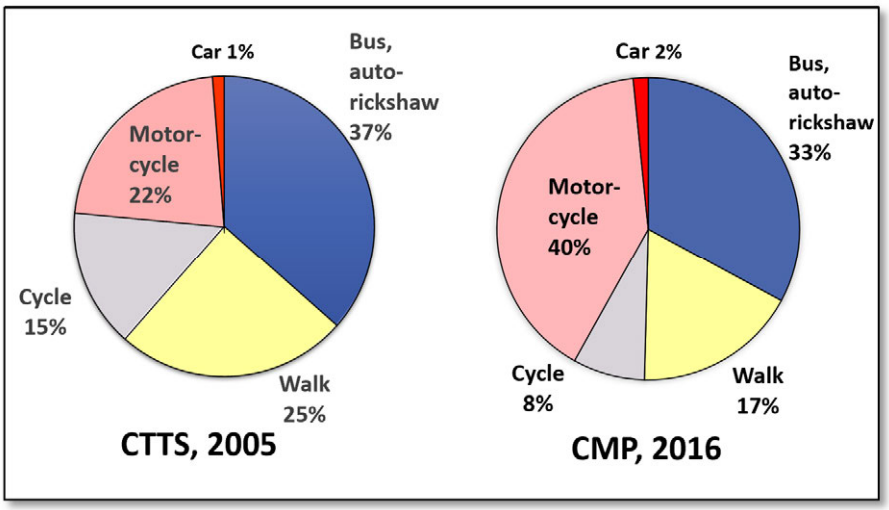


Source: Tiwari and Jain, 2013, 'NMT Infrastructure in India: Investment, Policy, and Design', Figure 2, TRIPP Accident Research Centre, IIT, Delhi, funded by UNEP and German GiZ

Figure 3.15 Trends in modal share of bicycles in selected Indian cities since the 1980s

In Vijayawada, the decline is illustrated by data collected in 2005 and 2016. The 2005 Comprehensive Traffic and Transportation Study[3] found that bicycles accounted for about 15% of total trips in the city, whereas 11 years later, the Comprehensive Mobility Plan[4] found a modal share of only 8%. Even allowing for sampling differences and random variation, results suggest that cycling's share in Vijayawada has declined significantly. Meanwhile, the share of motorcycles and cars almost doubled during this period.

[3] 2006 Comprehensive Traffic and Transportation Study for Vijayawada City
[4] 2017, Comprehensive Mobility Plan for Vijayawada, Final Report



Sources: 2006 CTTS for Vijayawada City, and 2017 Comprehensive Mobility Plan for Vijayawada, Final Report

Figure 3.16 Comparisons of modal shares in Vijayawada in 2005 and 2016

3.5.2 Cycling levels in various APCR towns

Usually, cycling is more common in larger towns, and less common in smaller towns where distances are shorter and walking is easier, but also lower in the largest cities where distances are longer, and motorized transport predominates. In practice, the CTTS 2017 base data (derived from the 2014/15 household survey for the CMP and DMP) is not very clear-cut. While all APCR towns and cities have a high modal share of combined walking and cycling (varying from 25-61%), there is no clear pattern relating to town size.

Another data source is the traffic counts for the CMP/DMP in 2014 and the CTTS in 2017/18. As these focus on main roads where motorized traffic predominates, they tend to understate cycling (as cycling is more dispersed). Nonetheless, traffic counts show high cycling levels in all the smaller ULBs (5-17% of total vehicles), with bicycles the second-most common mode after motorcycles or third after auto-rickshaws.

3.5.3 Who cycles, and why?

Bicycle ownership: The 2015 Comprehensive Mobility Plan survey found that 27% of Vijayawada households owned a bicycle[5], lower than the all-India average of 40% and also lower than most medium and large Indian cities, where typically have 35-65% of all households own a bicycle.[6]

Cyclists' income level: 2017 CTTS baseline data showed that people from all income groups in APCR use bicycles and that cycling levels are similar among different income groups. This contrasts with walking trips, which are less frequent among upper-income groups, while motorized trips are correspondingly higher.

[5] 2017 CMP, op cit, Table 4-18
[6] 2013, Geetam Tiwari and Deepthi Jain, NMT Infrastructure in India: Investment, Policy and Design, UNEP, page 6

Table 3.7 Modal shares in APCR according to income levels

No.	Income group (Rp/month)	Mechanized (%)	Walk (%)	Rickshaw (%)	Bicycle (%)	Total trips (number)
1	< 10,000	51	41	0.4	7	831,428
2	10,000 – 20,000	58	33	0.3	9	542,706
3	> 20.000	70	24	0.3	6	292,350

Source: 2017 CTTS base year household survey data, based on updated Household Interview Survey in 2014/15 for APCR Concept Master Plan and Detailed Master Plan. Figures are in percent.

Bicycle trip purpose: Studies in other Indian cities have found that work and education are the main cycling trip purposes, accounting for around 70-80% of all cycle trips.[7] One key role of cycling in APCR, and globally, is as a feeder mode to public transport. In Gudivada, commuters park about 150 bicycles each day at the railway station, while about 100 bicycles are parked at the bus terminal (Photos 1 and 2).

150 bicycles parked daily at Gudivada railway station – mostly commuters to Vijayawada

100 bicycles park daily at two cycle/motorcycle parks at the main Gudivada bus terminal

Source: JICA Study Team

Figure 3.17 Bicycle Parking in APCR (1)

Gender: Across India, few females use bicycles: one study found that only 4% of commuter cyclists are female[8]. But female cycling appears to be higher than the national average in APCR. For example, at some schools in Gudivada 40% of children cycling to school are female[9] (Photos 3 and 4). And the 2006 Vijayawada CTTS study found that 27% of all cyclists were female.[10]

[7] 2016, Premjeet Das Gupta and Kshama Puntambekar, 'Bicycle Use in Indian Cities', Conference Paper, 2016, page 8.
[8] 2017, ITDP, Women and Transport in Indian Cities: A Policy Brief, page 13
[9] 2019, Gudivada Urban Transport Plan, Section 5.4.3
[10] 2006, Vijayawada CTTS, op cit, Table 5.7

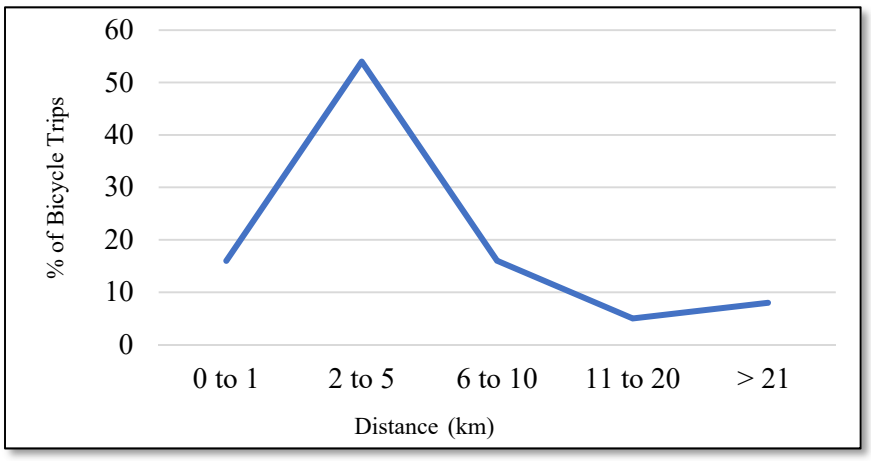
Cycling to School in Gudivada – Nearly 40% of 105 children at Gudivada AGK Municipal High School cycle to school, and nearly half are female.

255 bicycles parked at Gowtham Concept School, Gudivada's largest school. About 40% are ladies' bikes.

Source: JICA Study Team

Figure 3.18 Bicycle Parking in APCR (2)

Average bicycle trip distance: India's 2011 Census reported that 70% of urban bicycle trips were under 5 km and 13% were more than 10 km – both figures in line with data from other countries. As most areas of Vijayawada and Tadepalle are within 5 km of central Vijayawada, there appears to be good scope for developing a strategic cycle network in the Amaravati/Vijayawada/Guntur metropolitan area.



Source: Premjeet Das Gupta and Kshama Puntambekar, op cit, Figure 2, based on 2011 Census

Figure 3.19 Bicycle trip distances in urban India by 'Other Workers' census category

3.5.4 Cycle-rickshaws in APCR

Vijayawada used to have over 30,000 cycle rickshaws, and in the 1960s and 1970s, it was something of a 'status symbol' to travel in one. However, competition from auto-rickshaws and other modes has displaced them. At one time, about 50 workshops produced cycle rickshaws for Vijayawada and surrounding towns, but today only half-a-dozen remain, and their business is limited.[11] Vijayawada's passenger rickshaws are now mostly in poor condition (Photo 6), and rickshaw-pullers complain they cannot increase fares due to low demand, in contrast with auto-rickshaws.[12]

Source: JICA Study Team

Figure 3.20 Vijayawada's cycle-rickshaw fleet has significantly contracted in recent years.

In smaller APCR towns, cycle-rickshaws are still quite common, in 2017 accounting for about 4% of total main road traffic in Ponnuru and Vuyyuru, and 1.5-2% in Tenali, Gudivada, and Sattenapalli. Passenger cycle-rickshaws still perform a useful role in some situations, for example, taxi trips over short distances; people with children or luggage and those less able to walk; low cost, personalized transport when other public transport may not be available, etc.

However, pedaled tricycles still have a future in APCR. Goods tricycles (flat-top cycle-rickshaws – Photo 7) are a low-cost means of transport well-suited for distributing small quantities of goods, especially in congested areas with narrow streets. They are also widely used by small traders as mobile vending stalls.

In the U.S., UK, and other countries, pedicabs have made a comeback. The Asian Development Bank is actively promoting electrically-assisted pedicabs as a feeder mode to BRT services, and technical improvements to the pedicab (with gears and electrical assistance) make this an efficient, quiet, and environmentally-friendly mode of public transport in urban areas.

[11] The Hindu, 9th May 2016, 'No more pedalling: autos are here to stay', by J.R. Shridharan
[12] Op cit

Source: JICA Study Team

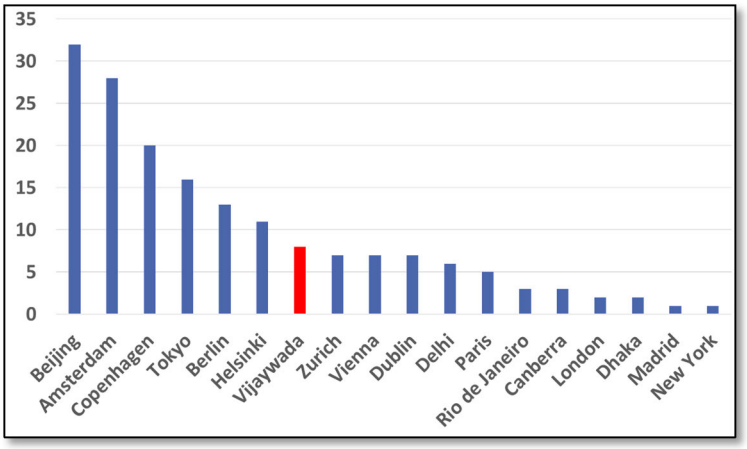
Figure 3.21 Vijayawada Old Town – goods tricycles are widely used throughout APCR

3.5.5 Challenges for NMT in APCR

Despite the many advantages and benefits of cycling, the trend of decline in APCR seems to be challenging to reverse. Key obstacles to maintaining or increasing cycling's share include:

- Road danger: The growth of motorized traffic makes the roads less safe and unattractive for cyclists, especially for children and inexperienced cyclists, etc.
- Attractiveness of private motor transport (motorcycles and cars): In the absence of good public transport, users have little option but to acquire private motorized transport for longer-distance daily trips. Once acquired, these motorized modes will be used, and there is less incentive to use other modes such as cycling and walking
- Status: Cycling still has a 'poor man's image in India (unlike most western countries), which can be a strong deterrent to using a bicycle.

Cycling is making a comeback in developed counties, especially in busy central areas of big cities. In Europe, cycling steadily declined from a peak in the 1940s as motorization took over. Cycling was largely confined to those who could not afford motor vehicles. However, since the 1970s, there has been a substantial change in some European countries, especially the Netherlands and Denmark, but also Germany, Sweden, and some other countries. These countries have seen significant investment in cycling facilities and a significant shift back to using bicycles.



Source: Compiled from various sources by the Author

Figure 3.22 Modal share of cycling in various capitals and major cities, 2015

In Vijayawada, while cycling's 8% modal share is higher than many major global cities, reversing the trend of decline will be a significant challenge. Still, there is excellent scope for APCR to aim at higher levels of cycling.

3.6 Traffic control and management

3.6.1 National-level policies

(1) National Urban Transport Policy, 2014

The National Urban Transport Policy (NUTP), the first edition published by India's Ministry of Urban Development in 2006, lays out fundamental policies for urban transport policy. It was updated in 2014 based on the 12th Five Year Plan (April 2012 to March 2017), taking into account the needs and characteristics of each city. In traffic management, it introduced Intelligent Transport Systems (ITS), Traffic Demand Management (TDM), and various measures to improve traffic safety.

(2) Jawaharlal Nehru National Urban Renewal Mission (JnNURM)

The objective of JnNURM is to accelerate city development across the country, focusing on efficiency improvements in urban infrastructure, service delivery mechanisms, community participation, and accountability of Urban Local Bodies (ULBs) and other parastatal agencies. The Mission was launched in 2005 initially for seven years up to 2012, then extended for two more years to complete ongoing initiatives.

The second phase, JnNURM-II, focused on roads, transport development, and ITS. Buses procured under JnNURM-II are equipped with ITS equipment such as CCTV cameras, LED signage, audio-visual passenger information, GPS, smart-card ticketing, etc.

(3) ITS policy under the 12th Five Year Plan (FY2012-FY2017)

The Government of India set up the Planning Commission to promote economic development via efficient utilization of the nation's resources. A Planning Commission working group made urban transport recommendations, including ITS for the 12th Five Year Plan (FY2012-2017), highlighting the importance of ITS in the transport sector:

- Utilizing real-time traffic information and traffic data collection systems to support traffic management and transport planning
- Introducing new vehicle technology to reduce pollution
- Introducing electronic road pricing, congestion-based road pricing, and toll collection by ITS
- Integrating multi-modal transport assisted by ITS

(4) Smart Cities Mission, India 2015

The Smart Cities Mission, targeting 100 cities, was launched by the Modi government in 2015. It aims to achieve environmentally friendly communities with good governance by efficiently managing social infrastructure, sustainable economic development, and improving life quality. Its "Smart City Guidelines" focus on several sectors – energy, water, transport, and public services – utilizing IT in each sector. Figure 3.23 (below) lays out the concept.

The 100 selected cities are prioritized in several groups. Twenty cities were selected as first-round priorities, and others in a second group. Amaravati Capital City was selected for the third round.

The Smart Cities Mission has been allocated a budget of INR 10,000 million for FY2017-2022. This budget is shared 50/50 by the central government and each state government.

Source: Smart City Mission Statement and Guidelines, 2015 by MoRTH

Figure 3.23 Smart City Mission concept

(5) National Digital Communications Policy, 2018

India's Ministry of Communications, Department of Telecommunications, formulated the National Digital Communications Policy in 2018. The key objective is to provide broadband for all by 2022, creating 4m new jobs and boosting GDP in the digital communication sector. The policy also promotes the adoption of new digital technologies – 5G, IoT, big data, sensors, AI, etc. – plus the establishment of a National Digital Grid with common service ducts and utility corridors in all new cities and highways.

(6) National Optical Fibre Network (NOFN) Program

The Ministry of Communications plans to connect all villages across India with optical fiber cable (OFC) under the National Optical Fibre Network (NOFN) program. Bharat Broadband Network Ltd. (BBNL) is a Special Purpose Vehicle set up by the government for this purpose. OFC connectivity has been achieved in all state capitals, district headquarters, and up to the Tehsil/block level. By 2019 the program aims to connect all villages in India, and by 2023 to achieve universal 5G coverage.

(7) ITS Policy for National Highways

ETC using RFID: The Ministry of Road Transport & Highways (MoRTH) directed NHAI/IHMCL to introduce Electronic Toll Collection (ETC) based on Radio Frequency Identification (RFID) technology at toll plazas on National Highways. In 2017 MoRTH directed vehicle manufacturers to embed RFID tags on all new vehicles manufactured from December 2017. This system automates tolling so vehicles can pass without stopping. So far, 180 toll plazas on National Highways have been equipped with the system.

Advanced Traffic Management System (ATMS): NHAI mandated the introduction of ATMS on National Highways where traffic volume exceeds 40,000 PCUs/day to ensure smooth traffic flow and road safety. It provides real-time information to road users, emergency assistance, alerts for abnormal road and weather conditions, etc. A typical ATMS comprises the following components:

- Video surveillance
- Video incident detection
- Vehicle speed detection
- Emergency roadside telephones
- Variable message signs
- Meteorological measurement
- Weigh-in-motion
- Automatic traffic counter cum classifier (ATCC)
- Mobile radio communication
- Communication network
- ATMS Control Center

(8) Indian Regional Navigation Satellite System (IRNSS)

The Indian Regional Navigation Satellite System (IRNSS) was developed by the Indian Space Research Organization (ISRO) as an alternative to U.S. GPS technology. It will cover the entire country with seven satellites that are already in orbit. ISRO is currently testing IRNSS, which will offer two types of service, one for all users and a more precise version for authorized users. The system is expected to provide positional accuracy of better than 20 meters. Potential applications include:

- Vehicle tracking and fleet management
- Terrestrial, aerial, and marine navigation
- Disaster management
- New applications for mobile phones, etc.

(9) Standardization of vehicle number plates

To standardize vehicle number plates nationwide, India's Ministry of Road Transport & Highways (MORTH), began introducing High-Security Registration Plates (HSRP) in 2005. Eventually, all vehicle licensing information will be digitized and stored in a national repository. HSRP is now mandatory for all vehicles manufactured from April 2019, and the scheme is gradually being implemented across India. Benefits include:

- All vehicle data will become available to authorities, supporting traffic enforcement, road safety, and tracing vehicles involved in crimes
- Plates will be machine-readable

(10) Vehicle registration database

MoRTH is gradually establishing a nationwide vehicle registration database that will allow quick searches for any registered vehicle. But there are many hurdles still to overcome, particularly with second-hand vehicles whose sale is not reported correctly to the RTO. Several related measures are required to resolve this issue: encouraging compliance, improving current taxation systems, vehicle inspection regulations, penalties related to drivers' licenses, etc.

(11) National Common Mobility Card

The Ministry of Housing & Urban Affairs is introducing a National Common Mobility Card (NCMC) for cashless public transport fare payments and retail shopping to enable seamless transfers between public transport modes. The National Payments Corp. of India (NPCI) is developing the required specifications, based on its experience developing the RuPay contactless card, now used in several cities. However, as e-payment technology advances quickly, the planned technology may be superseded by other alternatives.

(12) National Electric Mobility Mission Plan (NEMMP) 2020

India's Ministry of Heavy Industries and Public Enterprises launched the National Electric Mobility Mission Plan (NEMMP) 2020 in January 2013 to promote environment-friendly electric mobility solutions. This was followed by Faster Adoption and Manufacturing of Hybrid & Electric Vehicles (FAME India) in 2015.

The scheme is focused on technology development, demand creation, pilot projects, and the development of charging infrastructure. It targets 6-7 million hybrid and electric vehicle sales by 2020, resulting in 2.2-2.5 million tonnes of fuel savings. It will be implemented in phases over six years up to 2020, with a budget of INR 7,950 million. Amaravati Capital City, Vijayawada, and Visakhapatnam are all included in Phase 1 of the scheme.

(13) Autonomous vehicles

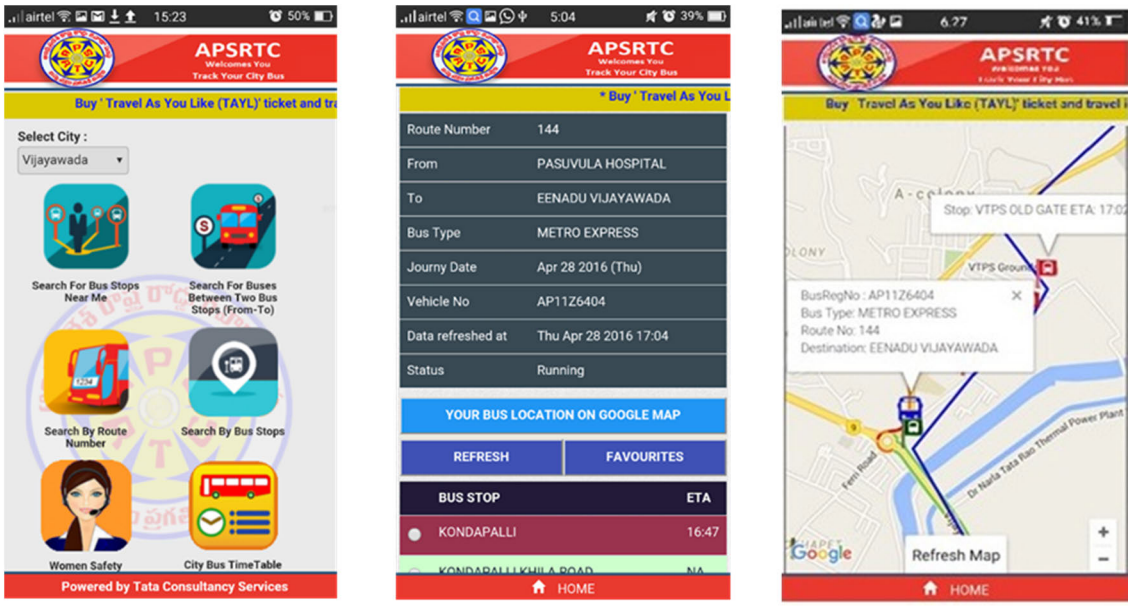
The Government of India does not yet have clear policies for autonomous vehicles, but several Indian automakers are conducting R&D under Indian conditions.

3.6.2 Existing ITS and related facilities in APCR

(1) APSRTC bus systems

APSRTC has installed an IT management system for its fleet that tracks bus locations and provides information to passengers via LED displays in terminals, bus shelters, and stops. Information includes scheduled and expected arrival times, route numbers, operating bus numbers, etc. Major components of the system include a vehicle tracking system (VTS), passenger information system (PIS), data center, and command control center (CCC).

GPS tracking devices are installed on all APSRTC buses, with route information programmed into each tracking device. Current bus locations are transmitted in real-time to the control center where an application server calculates arrival times. This information is then sent via the GPRS communication network to LED displays at 68 key city bus shelters, terminals, and stops in Vijayawada. This information is also available via a mobile phone application. The figures below show how this works.



Source: apsrtc.gov.in

Figure 3.24 APSRTC bus information mobile phone application

Source: JICA Study Team

Figure 3.25 APSRTC passenger information system

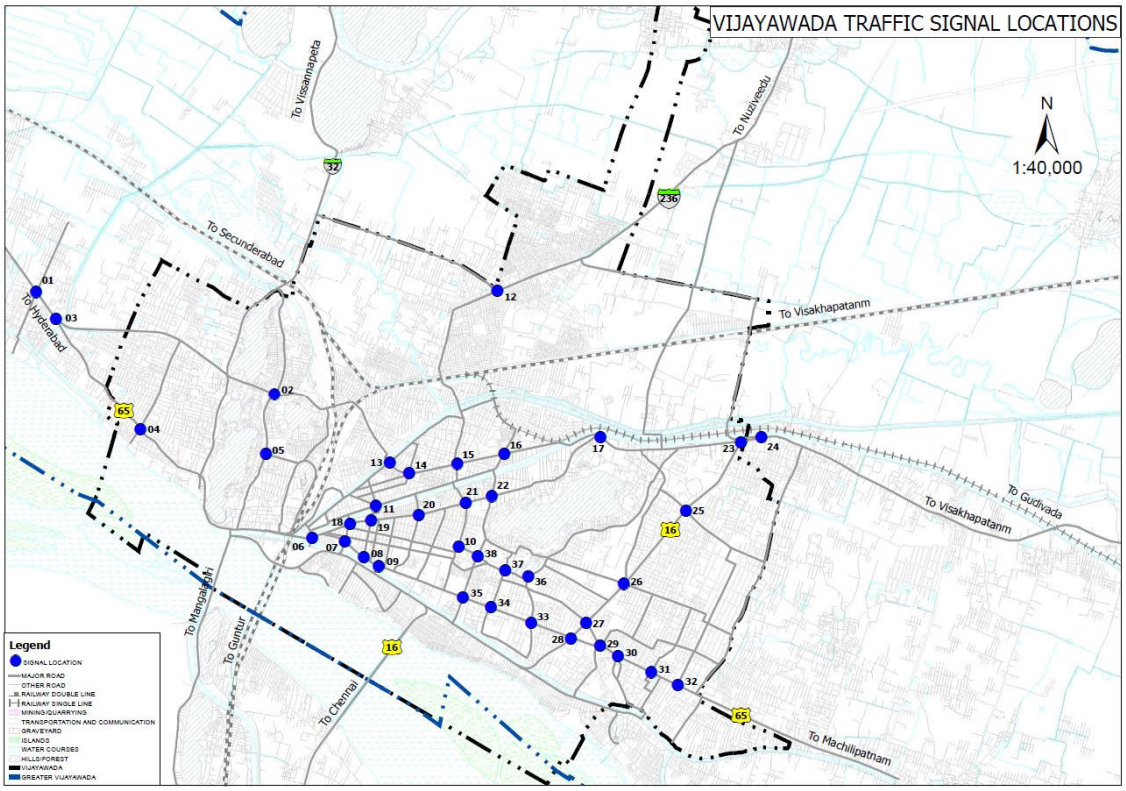
(2) Police traffic management system

1) Traffic management system in Vijayawada

Vijayawada Municipal Corp. and Vijayawada Traffic Police introduced a traffic management system that supports traffic management and enforcement in the city. Operated by the Traffic Police, its components include a traffic management center (TMC), traffic signals, CCTV, red-light violation and speed violation detection systems, and E-Challan generation of traffic tickets. Signals were installed at major 38 junctions along with 1,300 CCTV cameras. The photos below show roadside equipment and the TMC.

Source: JICA Study Team

Figure 3.26 Roadside equipment and TMC in Vijayawada



Source: JICA Study Team

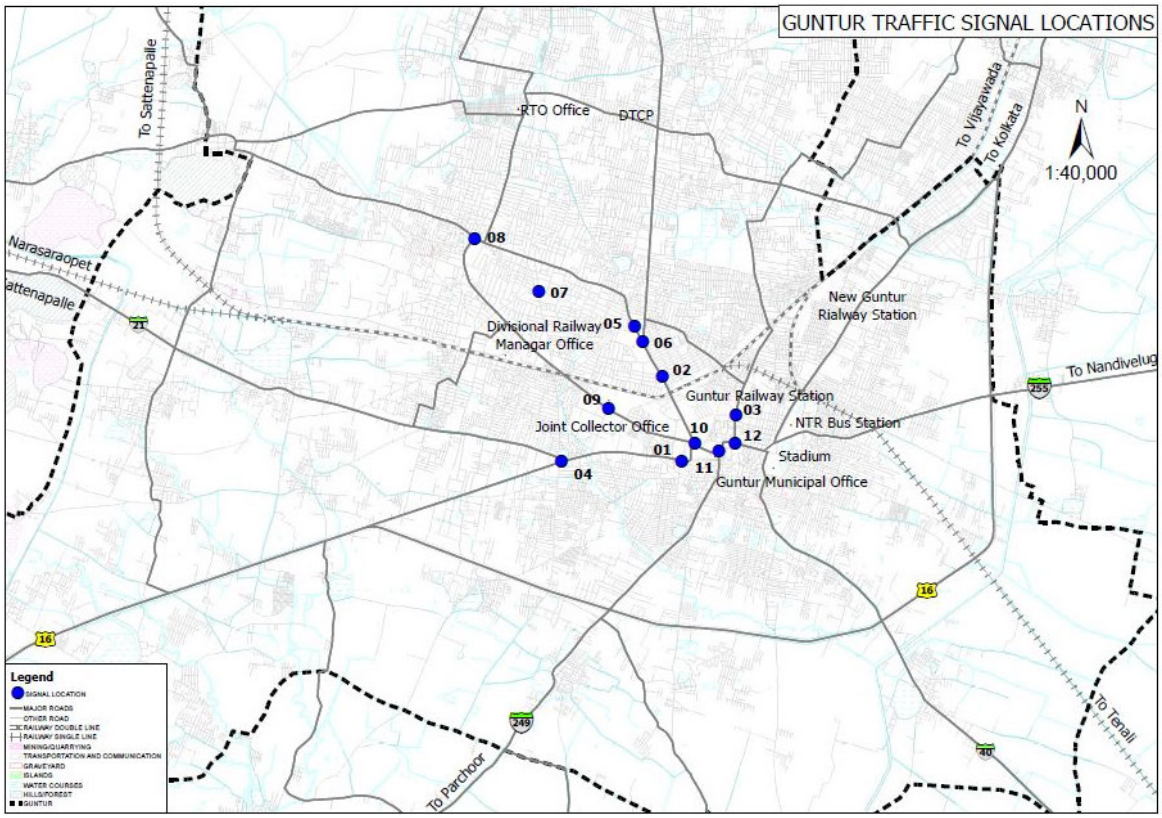
Figure 3.27 Existing traffic signal locations in Vijayawada

2) Traffic management system in Guntur

Guntur Municipal Corp. (GMC) and Guntur Traffic Police introduced a traffic management system that includes a traffic monitoring room, signals at 12 junctions, CCTV at 36 junctions, and an E-Challan system to generate traffic tickets, and a public address system at key junctions. The photos below show roadside equipment in Guntur, and the following figure shows traffic signal locations.

Source: JICA Study Team

Figure 3.28 Roadside equipment in Guntur



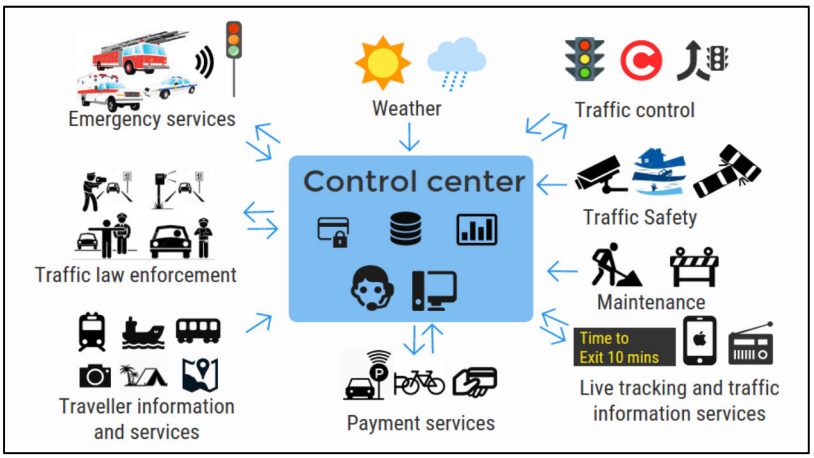
Source: JICA Study Team

Figure 3.29 Existing traffic signal locations in Guntur

3) ITS master plan for Amaravati Capital City

In line with ambitions to make Amaravati a world-class capital, AP plans to develop state-of-the-art ITS infrastructure in the city via the ITS Master Plan. This includes guidelines for ITS, functional specifications and communication standards for devices, high-level deployment plan, phasing plan, and cost estimates.

The ITS control center (shown in the figure below) will monitor and manage all systems proposed for the new capital.



Source: Smart Integrated Infrastructure Master Plan for Amaravati Capital City

Figure 3.30 Concept of Amaravati ITS Control Center

Table 3.8 Amaravati proposed ITS infrastructure

ITS	ITS Components
Real-time data collection system	Traffic detection system
	Air quality and weather monitoring system
Video surveillance system	Closed Circuit Television (CCTV) cameras
	Automated incident detection cameras
	Automated number-plate recognition cameras
Traffic management system	Traffic signals
	Pedestrian crossing system
	Lane and speed control signs
	Ramp metering
	Electronic road pricing
Enforcement system	Red-light violation detection system
	Bus-lane violation detection system
	Speed violation detection system
	Over-height vehicle detection system
	Weigh-in-motion system
Real-time information dissemination system	Variable message sign (VMS)
	Public address system
	Advisory radio
	Websites and mobile applications
Parking management system	Vehicle sensors
	Small variable message sign (VMS)
Transit management system	Passenger information systems
	On-bus facilities for BRT
	Automated fare-collection systems
	Automated cycle-sharing system
Payment system	National common mobility card
	Unified payment interface and EMV cards
ITS Control Center	Video display wall
	Workstations for operators
	Servers with application software
	Transport data center
	Access controlled security system

Source: Compiled by JICA Study Team from Amaravati ITS Master Plan

3.6.3 Challenges for traffic control and management

Issues in traffic control/management are summarized in line with national ITS development policy from four aspects: 1) Big Data, 2) Traffic management & safety, 3) Convenience & comfort, 4) Transport productivity.

(1) Issues in traffic control and management

Big Data

- Lack of organized means to gather and analyze traffic/transport data in an integrated manner.

- Limited capability to analyze and use traffic/transport data for planning, evaluation, etc.
- Limited big data sources: GPS installed on APSRTC buses, smartphones, etc., but no common mobility electronic payment system.
- Lack of proper road inventory data.
- Lack of system to gather, analyze and integrate available data and disseminate information to users.
- Limited use of GPS data – only for bus management and bus users' information.
- Vijayawada and Guntur traffic control centers are not equipped with the capability to use big data.

Traffic management and safety

- Inter-agency coordination: Traffic police are responsible for the operation of roadside facilities, while municipalities are responsible for installation/maintenance – which is often inadequate.
- Limited capacity of municipal staff in traffic management facility design, procurement, and maintenance: heavy dependency on contractors.
- Limited traffic police knowledge of traffic management, i.e., traffic control, signal operation, intersection improvement, etc.
- Ineffective traffic management: U-turn points, limited number, and improper operation/maintenance of traffic signals.
- Inadequate traffic management budget for traffic police.
- Inadequate application of guidelines for traffic management and traffic regulations.
- Limited capacity of Vijayawada/Guntur traffic control centers: collecting/analyzing traffic data and accident causes.
- Inadequate means to provide dynamic/real-time road information to control traffic.
- Vehicle number plates are not standardized.
- Vehicle registration database needs a periodic update.
- Mixed traffic (vehicles of varying dimensions/speeds) makes traffic management difficult.
- Insufficient inspection and control of overloaded vehicles.
- Lack of wayside amenities such as retail outlets (petrol pumps), toilets, food courts, and parking along inter-city roads (national and state highways).
- Poorly designed urban road infrastructure: poorly structured intersections, insufficient road space for pedestrians, NMT, etc.
- Poor visibility: trees and statues obstruct drivers' visibility, road signs are too small, and traffic signals are improperly located.
- Weak public awareness and compliance with traffic rules.
- Road capacity reduced by encroachments.
- Lack of sufficient legal parking and rampant illegal parking.
- Two major roads in the planning stage (Inner and Outer Rings) is opportunity to introduce ITS.
- Substandard telecom and electric power supply hinder the stable operation of traffic control facilities.

User convenience and comfort

- Lack of useful traffic information for pre-trip planning.
- Need for common mobility electronic payment (smart card)
- Encroachment on roads by hawkers and illegal parking creates danger for drivers and pedestrians

- Limited number of legal parking spaces and lack of parking guidance system.
- Inconvenient intermodal connectivity – e.g., between rail stations and bus stops
- Obsolete, unattractive public buses.

Transport productivity

- Heavy road congestion due to insufficient passenger rail system.
- Poor connectivity between commercial hubs by bus.
- Krishna River bridge bottlenecks.
- Limited route choices for long-distance vehicle travelers
- Frequent heavy vehicle breakdowns due to obsolete vehicles, lack of maintenance, etc.

(2) Possible policy directions

Based on the observations above, some possible policy directions to improve traffic control and management.

- **Better information**
  - Provide better information for pre-trip planning (selection of route, transport mode with travel time, and fare information) plus in-trip decision-making backed by real-time data covering the entire capital region.
  - Using a travel smart card, collect user's movement data.
  - Make commercial vehicle movement data available.
  - Better disaster information warnings: storm, flood, terrorism, etc.
  - Better real-time regional road traffic info: congestion, road closure, accident, etc.
  - Make park-and-ride information more available.
- **Data utilization**
  - Establish a single organization to gather and manage traffic and transport data.
  - Use quantitative data on road/traffic and transport/weather for better planning and evaluation.
  - Boost logistic efficiency by utilizing freight movement information.
- **Traffic demand management**
  - Manage through traffic, especially heavy vehicles, using planned ring roads via TDM techniques such as dynamic road pricing and provision of traffic information.
- **Advanced traffic signal control**
  - Install an advanced traffic control system covering the metro area, plus physical intersection improvements.
- **Park-and-ride**
  - Develop park-and-ride facilities along with a smart card to promote public transport use.
- **Promote NMT**
  - Introduce shared bicycles with smart card payment, management system, and availability info.

- **Protect vulnerable road users**
    - Ensure the safety of vulnerable road users by adopting ITS measures including pedestrian warning/detection using roadside-vehicle communication, etc.
- **Traffic Police enforcement**
    - Increase traffic violation enforcement capacity and efficiency via ITS measures including monitoring and detection system.
- **Heavy vehicle control**
    - Increase regulatory measures to control vehicle over-loading
- **Highway control**
    - Use an advanced traffic management system to boost safety, punctuality, driving comfort, and convenience
- **Highway safety measures**
    - Create more wayside amenities on intercity highways to enhance long-distance driving safety.
- **Long-distance smooth travel**
    - Develop an adequate high-standard road network for convenient long-distance travel.

3.7 Railways and rail transport services

3.7.1 Overview

Several agencies play key roles in passenger-rail developments in AP. Foremost is Indian Railways, whose South Central Railways (SCR) zone operates around 3,700 km of track in the state.

Andhra Pradesh Rail Infrastructure Development Corporation Ltd. (APRIDCL) is a Special Purpose Vehicle (SPV) under a joint-venture agreement between the national and state railway ministries. Through this, India's Railway Ministry is actively involved in planning, development financing, and implementation of railway projects in AP.

Amaravati Metro Rail Corp. Ltd. (AMRCL) is another SPV that acts as a nodal agency for passenger rail projects initiated by the state government. It is currently commissioning studies on a possible Vijayawada Metro (LRT) and Visakhapatnam Metro as well as a High-Speed Circular Rail (HSCR) line to improve transit connectivity in APCR. As well, AMRCL oversees related developments to enhance transit.

The Rail Land Development Authority (RLDA) is a subsidiary of Indian Railways with a mandate to generate non-fare box revenue through commercial development of vacant land/air space – notably mixed-use commercial/residential complexes, redeveloping railway staff housing areas and stations.

Source: JICA Study Team

Figure 3.31 South Central Railways (SCR)

3.7.2 Rail network

APCR is well-connected to the national network with 385 km of lines, including 175 km of double track and 210 km of single track, plus industrial branches. Two national main lines – Howrah-Chennai & Delhi-Chennai – intersect at Vijayawada Junction Station, through which 400 trains and 1.4 million passengers pass each day. Guntur and Tenali are also important terminals, while stations at Ponnuru, Sattenapalli, Gudivada, Gannavaram, Jaggayyapeta, Kondapalle, Tadepalle and Mangalagiri serve regional centers.

Figure 3.32 below shows the existing Indian Railways network in APCR with double- and single-track lines.

Source: JICA Study Team

Figure 3.32 Existing Rail Network

3.7.3 Railway stations

APCR has 60 railway stations, including two major terminals. The most important are:

Vijayawada Junction (station code: BZA)

Second-busiest rail junction in India, where Howrah-Chennai and New Delhi-Chennai main lines intersect.

More than 400 trains per day, including Super-fast, Express, Mails, and local passenger trains

Average daily passengers: 107,178 (2016/17 fiscal year); Platforms:10; Area: 69,613 m^2

A1 Model station: under IR station redevelopment program.

Guntur (station code: GNT)

Major junction in Guntur Division.

Average daily passengers: 21,935 (2016/17 fiscal year); Platforms:7; Area: 43,146 m^2

Served by 100 trains daily

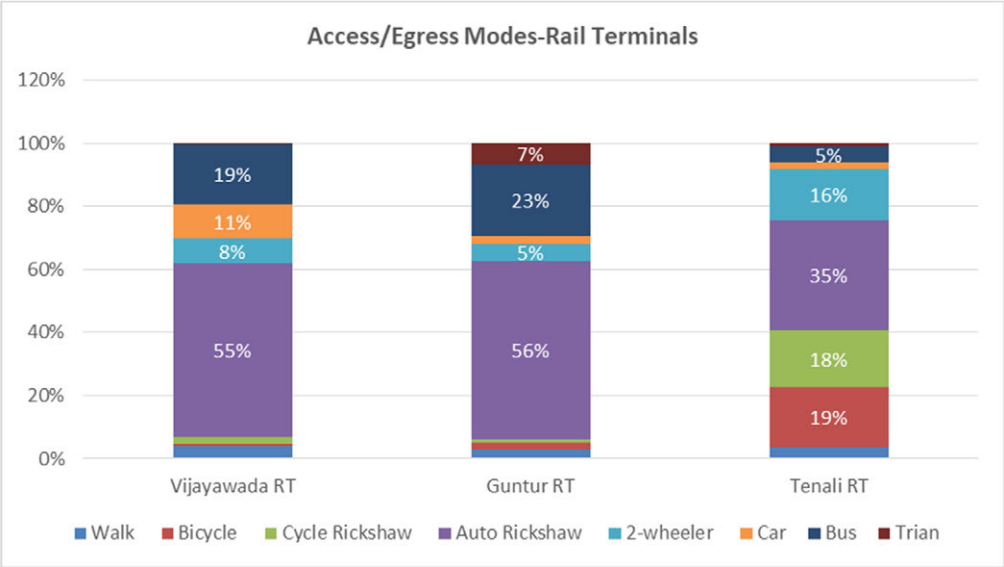
Being upgraded under the IR station redevelopment program

Tenali (station code: TEL)

- Major junction on Howrah-Chennai line
- Average daily passengers: 28,688 (2016/17 fiscal year); Platforms: 5; Area: 38,417 m^2
- Served by 125 trains daily

Source: JICA Study Team

Figure 3.33 Major Rail Terminals in APCR



Source: CTTS terminal survey, JICA Study Team

Figure 3.34 Modal share of access and egress at railway stations

As the figure above shows, auto-rickshaws are the predominant feeder mode for passengers departing and arriving at APCR's main rail terminals.

3.7.4 Passenger rail services in APCR

Indian Railways prioritizes nationwide freight over passenger services and intercity passenger services over urban commuter services. Consequently, APSRTC's city bus services are not well-coordinated with IR rail services. Plus, several ULBs such as Vuyyuru, Nandigama, and Jaggayyapeta have neither railway stations nor reliable feeder services to railway stations.

One obstacle to providing reliable urban commuter rail services is rail traffic congestion at APCR's major rail junctions (Krishna Canal and Vijayawada). Once the proposed Dedicated Freight Corridors and a new bypass line connecting Visakhapatnam and Hyderabad are completed, this should ease congestion at the junctions. If frequent, reliable commuter rail services can be provided on existing IR lines, this would make a significant contribution to public transport in APCR. Currently, as shown below, service is very sparse.

Table 3.9 Existing commuter rail services

S. No	Origin	Destination	No. of services	Frequency	Type of train
1	Vijayawada	Guntur	4	Daily	DEMU/MEMU
2	Vijayawada	Tenali	3	Daily	DEMU/MEMU
3	Guntur	Vijayawada	4	Daily	DEMU/MEMU
4	Guntur	Tenali	3	Daily	DEMU/MEMU
5	Tenali	Vijayawada	2	Daily	DEMU/MEMU
6	Tenali	Guntur	2	Daily	DEMU/MEMU

Note: DEMU- Diesel Electric Multiple Unit, MEMU - Mainline Electric Multiple Unit
Source: Indian Railways Timetable, SCR, 2017

Table 3.10 ULB connectivity with transport systems

No	ULB	NH	SH	Railway	Intercity bus	Remarks
1	Vijayawada	Yes	Yes	Yes	Yes	- Partial BRT network exists but is not in use. Study in progress for METRO/LRT/BRTS
2	Guntur	Yes	Yes	Yes	Yes	
3	Tenali	No	Yes	Yes	Yes	
4	Mangalagiri	Yes	Yes	Yes	Yes	
5	Tadepalle	Yes	No	Yes	Yes	Railway Station: Krishna Canal Junction
6	Gudivada	Yes	Yes	Yes	Yes	
7	Nuziveedu	No	Yes	Yes	Yes	
8	Sattenapalli	No	Yes	Yes	Yes	
9	Ponnuru	No	Yes	Yes	Yes	Railway Station: Nidubrolu
10	Vuyyuru	Yes	No	No	Yes	
11	Nandigama	Yes	Yes	No	Yes	
12	Jaggayyapeta	Yes	Yes	No	Yes	

Note: NH – National Highway, SH – State Highway
Source: JICA Study Team

3.7.5 Rail freight in APCR

Indian Railways prioritizes freight over passengers because freight generates 70% of its income versus 30% from passenger services (refer to Table 3.11).

Table 3.11 Cargo loaded in India (2016-17)

No	Commodity	Tonnes originating (million)[1]		Net tonne-km in APCR (million)		Earnings (in INR crores)[2]	
		2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
1	Coal	551.83	532.83	2,80,700	2,49,615	49,349.65	45,228.57
2	Raw material for steel plants except iron ore	20.3	22.8	11,655.0	12,461.0	2,004.8	2,061.8
3	Pig Iron & finished steel	44.8	52.4	40,443.0	44,027.0	7,182.3	7,672.3
4	Iron ore	116.9	137.6	32,420.0	39,743.0	6,896.3	8,175.9
5	Cement	105.4	103.3	55,959.0	54,600.0	8,851.5	8,629.9
6	Food grains	45.7	44.9	60,126.0	57,809.0	7,754.3	7,505.8
7	Fertilizers	52.2	48.3	43,700.0	39,217.0	6,553.4	5,561.2
8	Mineral oil (POL)	43.2	42.4	29,326.0	28,518.0	5,927.0	5,686.3
9	Container services	45.8	47.4	45,430.0	44,294.0	4,843.7	4,716.4
10	Balance other goods	75.3	74.4	54,722.0	49,891.0	7,577.7	6,789.8
11	TOTAL	1,101.5	1,106.2	373,781.0	370,560.0	106,940.6	102,027.8

1 Excludes loading on Konkan Railway
2 Excludes 'other goods earnings' such as wharfage, demurrage, etc.
Source: Ministry of Railways, 2017

Apart from national freight through traffic, within APCR the major freight origins/destinations include the thermal power plant at Ibrahimpatnam (Dr. Narla Tata Rao Thermal Power Plant), which is linked by the rail to Singareni Collieries Company Limited for the supply of Coal. The coal for the first stage is transported from about 250 km. The second, third, and fourth stages of the plant are connected by rail to the Talcher Coal Fields in Orissa to meet the required power generation. This field in Orissa is located

at about 950 km from the power plant. Besides, there are three major Indian Railways cargo terminals in APCR, at Vijayawada, Guntur, and Tenali. In total, these three terminals handle about 57,900 tonnes of cargo per year.

Vijayawada (station code: BZA)

Second-busiest railway junction in India, the intersection of Howrah-Chennai and Delhi-Chennai main lines

Freight services: 150 trains daily, 46,444.1 MT of cargo handled annually

Guntur (station code: GNT)

Major railway station (junction) in Guntur Division.

Handles 7,000.0 MT of cargo annually, generating an average annual income of Rs.20.736 m.

Tenali (station code: TEL)

Major junction on Howrah-Chennai line

Handles 4,474.7 MT of cargo annually, generating an average annual income of Rs.7.049 m.

Source: JICA Study Team

Table 3.12 Major rail freight logistics terminals

Sl. No	Name	Type	ULB Location
1	Vijayawada Junction Station	Passenger & freight terminal	Vijayawada
2	Guntur Railway Station	Passenger & freight terminal	Guntur
3	Rail wagon workshop, Guntupalli	Wagon workshop/Repairs	Vijayawada (Guntupalli)
4	Nuziveedu Railway Station	Passenger & freight terminal	Nuziveedu (nr. Hanuman Jn.)
5	Tenali Junction	Passenger & freight terminal	Tenali
6	Nidubrolu Railway Station	Passenger terminal	Nidubrolu (Ponnuru)
7	Mangalagiri Railway Station	Passenger terminal	Mangalagiri
8	Tadepalle Railway Station	Passenger & freight terminal	Tadepalle
9	Gudivada railway station	Passenger & freight terminal	Gudivada
10	Jaggayyapeta	Freight line/sidings	Jaggayyapeta

Source: Indian Railways, 2018

3.7.6 National railway development policy

(1) Indian Railways Vision 2020

Initiated by the Ministry of Railways in 2009, the program has four strategic goals:

- Inclusive development, geographic and social;
- Strengthening national integration;
- Large-scale generation of productive employment; and
- Environmental sustainability

The targets and measures to achieve these goals are:

1. **Leapfrogging to a higher growth trajectory**
    - Indian Railways must achieve annual growth of 10% over the next 10 years by developing a sharper commercial focus with a strong social commitment.
2. **Network expansion**
    - Add 25,000 km of new lines by 2020, including 11,985 km of lines already funded by the government plus a significant increase in Public-Private Partnerships (PPPs).
3. **Capacity creation**
    - Double-track (or more) over 30,000 route km. Of this, over 6,000 km would be four-track lines with segregated passenger and freight services (Delhi-Kolkata, Delhi-Mumbai, Kolkata-Mumbai, and Delhi- Chennai) plus Dedicated Freight Corridors.
    - Increase maximum speed of passenger trains from 110-130 km/h to 160-200 km/h; and freight trains from 60-70 km/h to 100+ km/h.
    - Complete gauge-conversion program and electrify 33,0000 route km (additional electrification of 14,000 km)
4. **Train safety mission: zero accident tolerance**

    Make rail operations accident-free (no derailments, collisions, or fires) using advanced technologies in all spheres: track, rolling stock, and signaling.

5. Reduce railways' carbon footprint

Several measures include: a) introducing suburban trains, b) projects under Clean Development Mechanism (CDM), c) introducing light-weight stainless-steel coaches with more carrying capacity, d) increasing production of high-horsepower, fuel-efficient diesel locomotives, and e) energy audits to boost station energy efficiency, f) shift to renewable energy, g) landscaping along tracks.

6. Need for bold, innovative measures

To achieve the ambitious goals in IR Vision 2020, IR plans various aggressive, innovative measures: a) high-speed passenger trains in segregated corridors, b) ticket purchase in no more than five minutes, c) double-decker coaches and longer trains on popular inter-city routes, d) partnerships with state/city authorities to augment infrastructure and manage suburban services under a single umbrella, e) separate Indian Railways Metro Development Authority.

High-speed rail: Raise the speed of regular passenger trains to 160-200 km/h on segregated routes and build at least four high-speed rail lines with services at 250-300 kph. Six corridors have been identified:

- Delhi-Chandigarh-Amristar
- Pune-Mumbai-Ahmedabad
- Hyderabad-Vijayawada-Chennai
- Howrah-Haldia
- Chennai-Bangalore-Coimbatore-Ernakulam
- Delhi-Agra-Lucknow-Varanasi-Patna

Freight services: Reverse market-share loss to trucks, boosting share from 35% to at least 50% by 2020. Strategic measures to achieve this target include developing Dedicated Freight Corridors (DFCs). IR intends to use land bank assets in setting up multi-modal logistics parks and industrial hubs along DFCs, including:

- Eastern DFC (Ludhiana-Dankumi)
- Western DFC (Mumbai-Delhi)
- North-South (Delhi-Chennai)
- East-West (Howrah-Mumbai)
- Southern (Chennai-Goa)
- East-coast (Kharagpur-Vijayawada)

Mobilizing alternate revenue sources: IR aims to boost revenues by focusing on four major areas:

- Parcel services
- Advertising
- Commercial use of railway land
- Telecom and IT using 64,000 km rail right-of-way

Technological excellence: Advances in rolling stock, track, signaling, diagnostic tools, anti-collision devices, level-crossing protection, train speeds, ticketing, satellite-based train-tracking system (real-time train location information), maintenance equipment, and waste management.

Organizational reforms for greater effectiveness and better governance: Rather than privatization, the goal is to enhance the efficacy and accountability via reforms at all levels.

Enhancing human capital: 1.4 million people work for IR. The Vision aims to train, motivate and equip all railway staff to reach the target.

7. **Investment for growth**

The IR Vision projected that 64% of the Rs. 1.4 million crore investment needed to realize the plan would be required between 2010 and 2020. This was to be financed through increased surpluses and via PPP. For the remaining 36%, it was proposed to establish an Accelerated Rail Development Fund (ARDF).

(2) National Railway Plan 2030

In December 2016, IR launched the National Rail Plan 2030 (NRP2030). Although Vision 2020 had not been completed, the new plan came in response to concerns that it had been sidetracked by pressures from various stakeholders and was not progressing in an integrated manner. To return to a more holistic approach, National Rail Plan 2030 aims beyond existing corridors to the identification and development of new corridors and connections.

NRP2030 Mission

IR's updated vision is to be a key driver of India's growth and development via safe, financially viable, environment-friendly services and care for customers and employees with a focus on eight key areas;

- Provide safe travel by achieving "Near Zero Fatality" performance.
- Upgrade infrastructure: add 1.5% to India's GDP with infrastructure to support 40% modal freight share.
- Preferred freight carrier: develop integrated business solutions to capture new traffic.
- Passenger experience: provide climate-controlled service to long-distance passengers in all segments.
- Value engineering to ensure transparency, cost-effectiveness, and expeditious decision-making.
- Cultural reform to foster teamwork, innovation, accountability, and proactive initiative-taking.
- Increase customer satisfaction by leveraging the latest technology, training methods, and infrastructure upgrades in stations and trains.
- Promote sustainability and environmental friendliness.

Upgrading infrastructure, the new plan focuses on the five themes:

- Increase throughput on existing network
- Build terminal infrastructure
- Innovative fund-raising and sourcing
- Accelerate infrastructure buildout
- Deliver high-speed network

Major plans include:

- Draw up plans for Trans-Asian Rail Network
- Meet strategic requirements along international borders
- Connectivity to ports – incorporating network planned in Sagarmala Project
- Upgrading 3rd & 4th Lines to DFC standards
- Integrated planning of HSR network including Chennai-Nagpur Line via Vijayawada

- Six DFCs, including North-South Corridor (2,328 km) and East Coast Corridor (1,115 km) passing through APCR

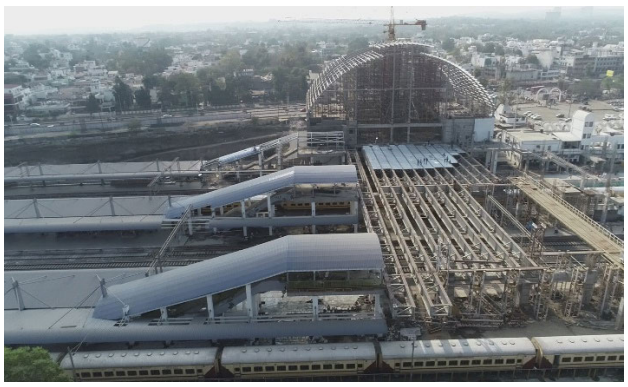
(3) Station redevelopment program

IR's Station Redevelopment program, one of India's largest infrastructure initiatives, is being implemented by Indian Railways Stations Development Corp. Ltd. (IRSDC) and the Rail Land Development Authority (RLDA) under the Ministry of Railways. IRSDC's main objectives are:

- To develop/redevelop existing/new railway stations with enhanced passenger amenities and upgrading of station buildings, platform surfaces, circulating areas, etc.
- Develop railway/government real estate with new commercial facilities.
- Planning, design, development, construction, improvement, commissioning, operation, maintenance, and financing of projects and various services including marketing, revenue collection, etc.
- Develop stations via Build-Operate-Transfer (BOT), Build-Own-Operate-Transfer (BOOT), Build-Lease-Transfer (BLT), etc.

The program is planned for 400 stations in multiple phases across 100 cities with approximately 2,700 acres of land available for commercial development. Redevelopments may be carried out under PPP schemes. The first set of 23 stations with 140 acres of available land is now available for bidding, including Vijayawada Junction with 8 acres of land available for commercial development.

As of April 2020, two projects are ongoing: Habibganj and Gandhinagar Gujarat stations. A further 13 stations are in the planning phase: Anand Vihar, Bijwasan, Chandigarh, Shivaji Nagar, Surat, Baiyyappanahalli, Nagpur, Gwalior, Amritsar, Gandhinagar Jaipur, Sabarmati, Kanpur, and Thakurli.




Source: IRSDC website

Figure 3.35 Habibganj station (left) and Gandhinagar Gujarat (right)

(4) IR's policy on suburban rail systems

The Ministry of Railways has been asked by state governments to introduce suburban rail services to meet growing urban transport demand, currently served only by buses. In response, MR established guidelines in 2017 for suburban railway system development on IR's suburban rail lines.

The main objective is to eliminate conflicts between suburban rail services and long-distance intercity passenger and freight transport. It mandates:

- IR to launch a major program to develop integrated suburban services
- IR to collaborate with state governments in developing suburban systems

- State governments to conduct feasibility studies to be submitted to IR for approval
- Feasibility study cost is to be borne by state governments and project costs to be on equity share between IR and state governments
- Projects should be integrated with the rail network without reducing freight and long-distance passenger capacity. As such, it may be preferable for states to opt for Metro options under the Metro act.
- Projects should commence only after 70% of the land required is provided by the state government
- Special Purpose Vehicles (SPVs) should be formed for rail system execution, operation, and maintenance.

(5) Metro Rail Policy, 2017

The Ministry of Housing and Urban Affairs (MOHUA) announced the Metro Rail Policy in 2017 to tackle issues caused by rapid urbanization, growing mobility needs, increasing travel costs and distances caused by sprawl, and worsening accidents. One particular focus was mobility for lower-income people.

Vision:

- To recognize that as people occupy center-stage in our cities, all plans should be for their common benefit and well-being.
- To make our cities the most livable in the world and enable them to become the "engines of economic growth" that power India's development in the 21st century.
- To allow our cities to evolve into an urban form that is best suited for the unique geography of their locations and best placed to support the main social and economic activities of each city.

The policy objective is to ensure safe, affordable, quick, comfortable, reliable, and sustainable mobility for the growing number of residents to jobs, education, recreation, etc. To achieve these objectives, the following approaches were proposed:

- Integrating land-use and transport planning
- Equitable allocation of road space
- Priority for public transport
- Quality and pricing of public transport
- Public transport technologies
- Integrated public transport systems
- Financing
- Role of para-transit
- Priority to non-motorized transport
- Parking
- Freight traffic
- Legal and administrative issues
- Capacity building
- Use of cleaner technologies
- Innovative financing mechanisms using land as a resource
- Participation of the private sector

The Metro Rail Policy lays out three important conditions for delivering metro rail systems. First, state governments should be responsible for project implementation. Second, metro rail projects should be

based on comprehensive mobility plans (CMPs). Third, it called for the formation of a Unified Metropolitan Transport Authority (UMTA) to ensure an integrated approach in the planning and management of urban transport.

The basic financing principle laid out in the policy is that the government provides the infrastructure while users pay for the rolling stock and operation costs.

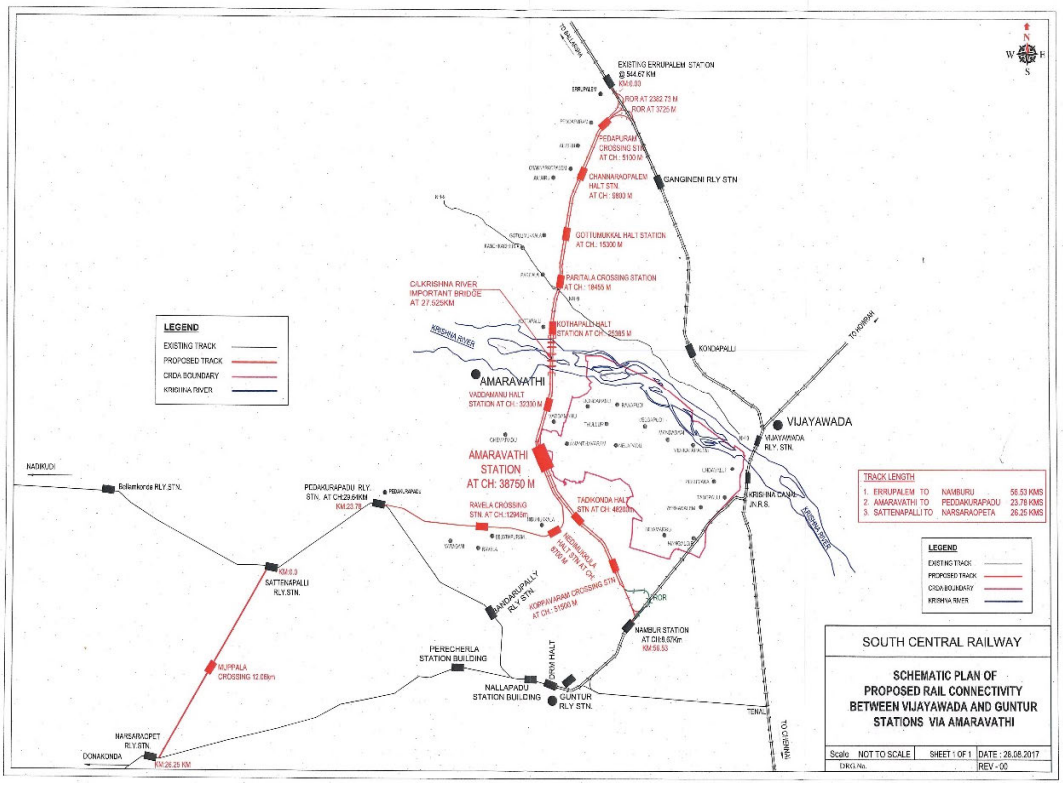
To oversee the financing of Metro systems, the government encouraged the formation of Special Purpose Vehicles (SPVs).

3.7.7 Railway infrastructure plans and proposals

(1) IR's Amaravati Rail Link

South Central Railway submitted a Detailed Project Report (DPR) to the railway board for approval of the Amaravati Rail Link in September 2018. The budget has not yet been approved. The proposed link would connect Amaravati Capital City to other cities in the APCR via three lines:

- Nambur-Amaravati-Errupalem (56.8 km), electrified double-track line with 9 stations: Peddapuram, Paritala, Amaravati, Koppuravuru, Channaraopalem, Gottumukkala, Kothapalli, Vaddamanu, Tadikonda.
- Sattenapalli-Narasaraopeta (25 km), non-electrified single track with one station at Chagantivaripalem.
- Amaravati-Peddakurapadu (24.5 km); non-electrified single-track line with stations at Ravela and Nidumukkola.



Source: South Central Railway

Figure 3.36 Proposed Amaravati Rail Link

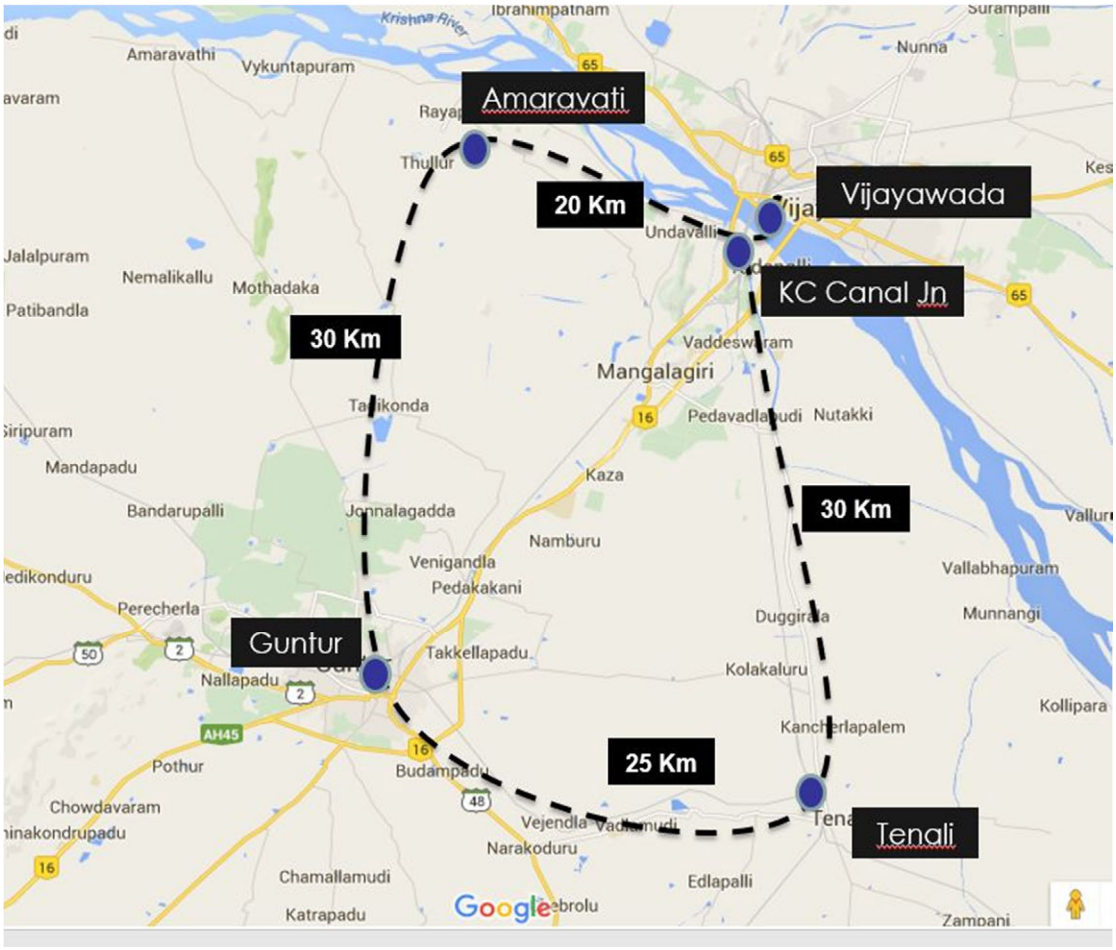
The Nambur-Amaravati-Errupalem line, through the west side of the capital and featuring a world-class station at Amaravati, would connect to existing rail lines. Hyderabad-Vijayawada-Chennai trains would shift to Hyderabad-Amaravati-Chennai with this new line, thus relieving congestion at Vijayawada Junction.

(2) High-Speed Circular Rail (HSCR)

In line with IR's new suburban rail policies, APCRDA proposed a further105 km line to link four major regional cities – Amaravati, Vijayawada, Guntur, and Tenali – dubbed High-Speed Circular Rail (HSCR).

A DPR for the project proposes alignment running: Vijayawada-Krishna Canal Junction-Tenali-Guntur-Amaravati-Vijayawada.

However, this proposal is not included in the CTTS2050, while, radial commuter rail networks are proposed, as explained in a later section.



Source: JICA Study Team

Figure 3.37 HSCR conceptual alignment

(3) Dedicated Freight Corridors

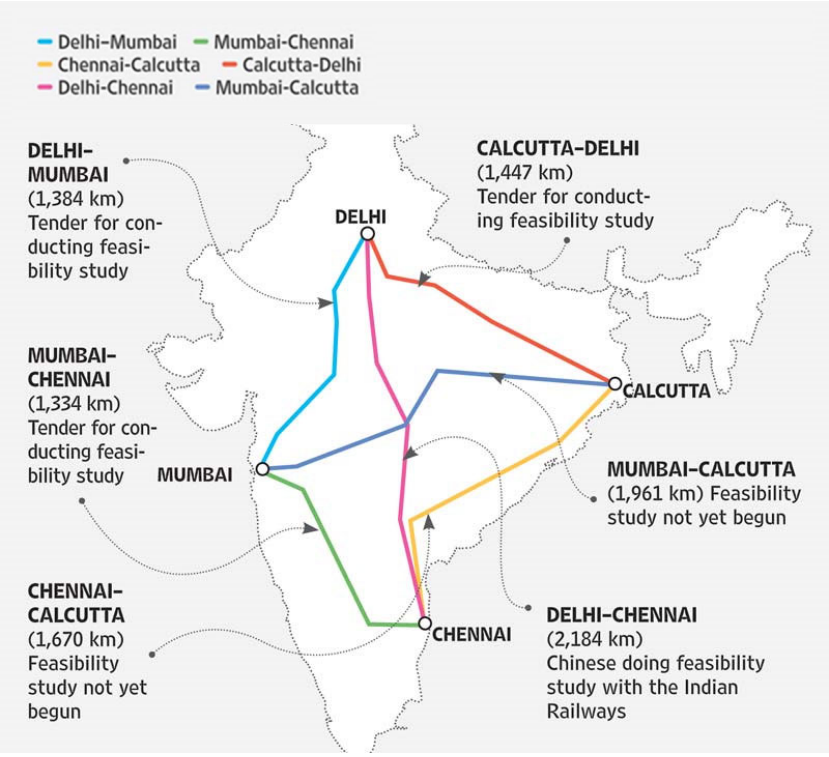
IR is now developing dedicated freight corridors (DFCs) across India. Vijayawada is a major junction connecting two corridors: North-South (Delhi-Chennai) and East Coast (Kharagpur-Vijayawada). To link these two corridors without adding to congestion on existing lines, proposed DFC lines in APCR follow alignments shown in Figure 3.38.

Source: Alternatives for Proposed Dedicated Freight Corridor Alignment within APCR, RITES Ltd., 2019

Figure 3.38 DFC network in India

(4) High-Speed Rail

In 2012 India's Ministry of Railways formed the High-Speed Rail Corp. of India Ltd. (HSRC) to develop a national high-speed rail project. The first project, a 508 km line from Ahmedabad to Mumbai, is now under construction. Five more corridors have been proposed to connect major cities across India. The Delhi-Chennai HSR line will pass through Amaravati, where a world-class HSR station is proposed.



Source: UITP

Figure 3.39 HSR Network in India

(5) Vijayawada Metro

Vijayawada Metro was initially proposed in 2015 as a tunneled, heavy-rail system with Delhi Metro Rail Corp. as the implementing agency. It was later canceled due to high cost and anticipated low ridership. In 2017, the AP government opted for a Light Rail Transit (LRT) system. Feasibility studies were done and a DPR was submitted to Amaravati Metro Rail Corporation (AMRLC) in 2019.

The proposed system comprises two LRT lines totaling 66.2 km with 51 stations in Vijayawada, Guntur, and Amaravati Capital City.

It should be noted that this proposal was reviewed and modified based on the CTTS strategic transport model.

Phase 1A Route (Line 2)

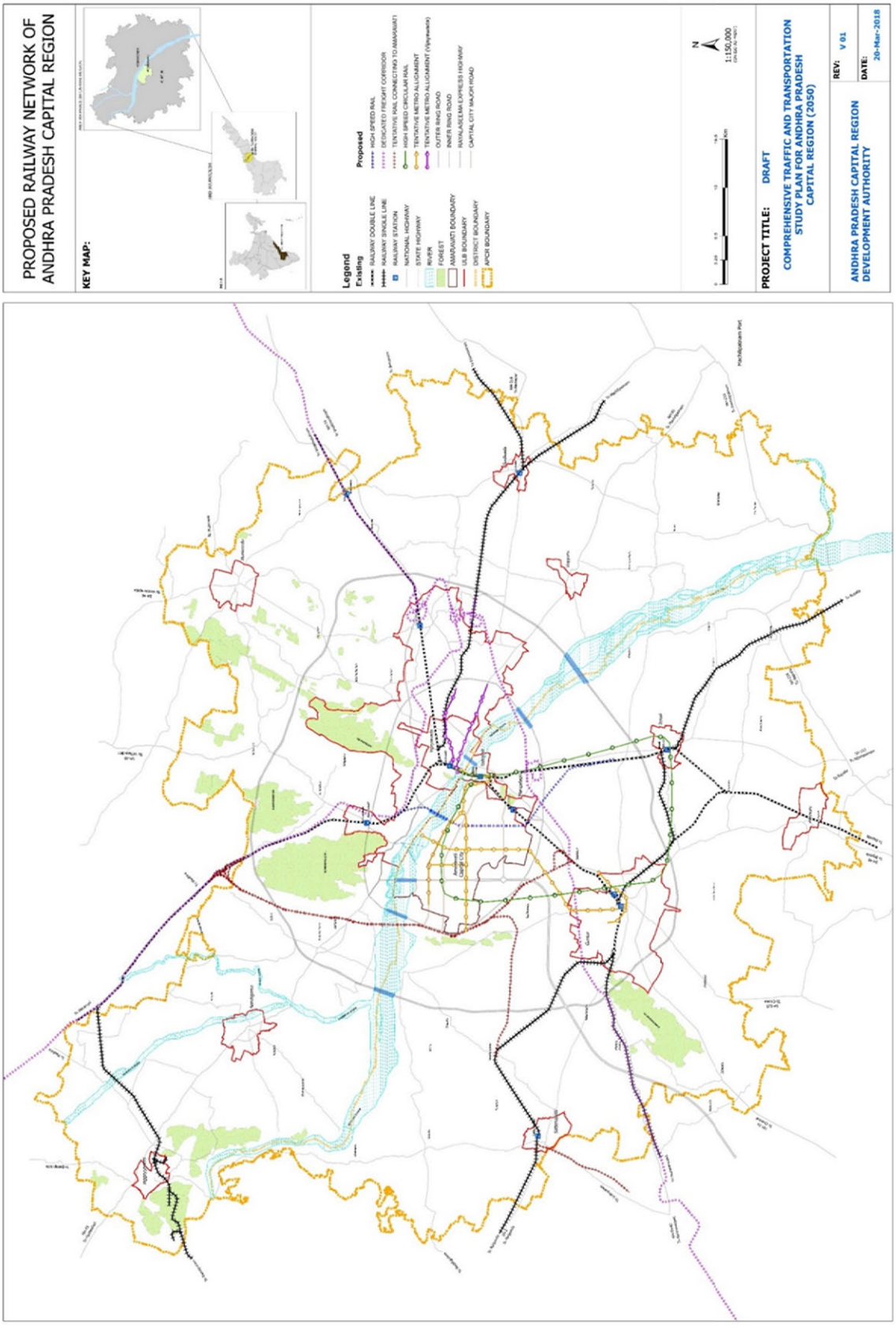
- Route: Pandit Nehru Bus Station (PNBS) to Vijayawada Airport (25.9 km)
- Type: Elevated (23 km) & underground (2.9 km)
- 22 stations: PNBS, Railway Station South, Railway Station East, Besant Road, Sri Sathya Sai Mandir, SRR Government College, City Cancer Hospital, Gunadala, Ramavarappadu Ring, Prasadampadu, Ramakrishna Weigh Bridge, Enikepadu, Nidamanuru. (Additional station names to be added later)

Phase 1B Route (Line 1)

- Route: PNBS to Penamaluru (12.76 km)
- Type: Elevated
- 12 stations: PNBS, Museum, IG Stadium, DV Manor, Benz Circle, Auto Nagar Gate, Ravindra Bharati School, Gayatri Jr. College, Law College, Tadigadapa, Poranki, Penamaluru.

Phase 2 Route (Line 2)

- Route: PNBS to Amaravati Reservoir (27.8 km)
- Type: Elevated (4.7 km) & Underground (23.1 km)
- 18 stations (18): The list of stations has yet to be announced, but the line would connect Krishna Canal Junction, Undavalli, Uddandrayuni Palem, and terminate at Amaravati Reservoir



Source: JICA Study Team

Figure 3.40 Metropolitan transport plans

3.8 Airports and aviation

3.8.1 Overview

Vijayawada Airport (IATA: VGA), located at Gannavaram, is operated by the Airports Authority of India (AAI). Built as a military airfield in WW II, it was later converted to civil use. In 2011, the runway was extended to 2,286 m, bringing it up to the IATA Code-C standard sufficient for operating Airbus 320 and Boeing 737 aircraft. Passenger services currently operate to Delhi, Mumbai, Hyderabad, Bangalore, Chennai, Cuddapah, Tirupati, and Visakhapatnam.

Source: JICA Study Team

Figure 3.41 Vijayawada Int'l Airport

The runway is now being extended to 3,360 m, bringing it up to Code-E, long enough for Boeing 777 and 747 aircraft. Due to rapid air traffic growth, AAI is fast-tracking airport renovations and expansion to serve APCR. A new integrated terminal (33,000 m^2) will be completed by 2022.

In 2018, commercial flight activity jumped by 50%, increasing from 16 to 24 non-stop daily flights. Air India and its partner airlines, Air India-Express and Alliance Air, account for 44% of total VGA seat capacity and serve all but one of Vijayawada's nonstop destinations. Air India-Express recently introduced three weekly flights with 186-seat Boeing 737-800 aircraft to Mumbai and announced plans to link this flight to Dubai. This could be Vijayawada's first direct international link.

Source: JICA Study Team

Figure 3.42 VGA nonstop destinations (July 2018)

In June 2018, a new VGA air cargo facility opened near the "old passenger terminal," a building set up to serve international passenger flights until the new integrated terminal is completed in 2022. AAI has appointed Shreepa Logistics, an international customs clearing, and freight forwarding agency to manage cargo operations. With the launching of improved VGA air cargo services, freight activity is expected to increase rapidly to 22 tonnes/day, or 8,000 tonnes/year. Longer-term as flights are added and more shippers establish operations at VGA, cargo volumes are expected to increase to around 50,000 tonnes/year. Development plans include a special economic zone (SEZ) on the VGA eastern boundary, adjacent to a rail cargo terminal on Indian Railways' proposed Dedicated Freight Corridor. Eventually, a new 7,500 m^2 air cargo terminal is planned for the second phase (2025-35).

3.8.2 Increasing domestic and international air services

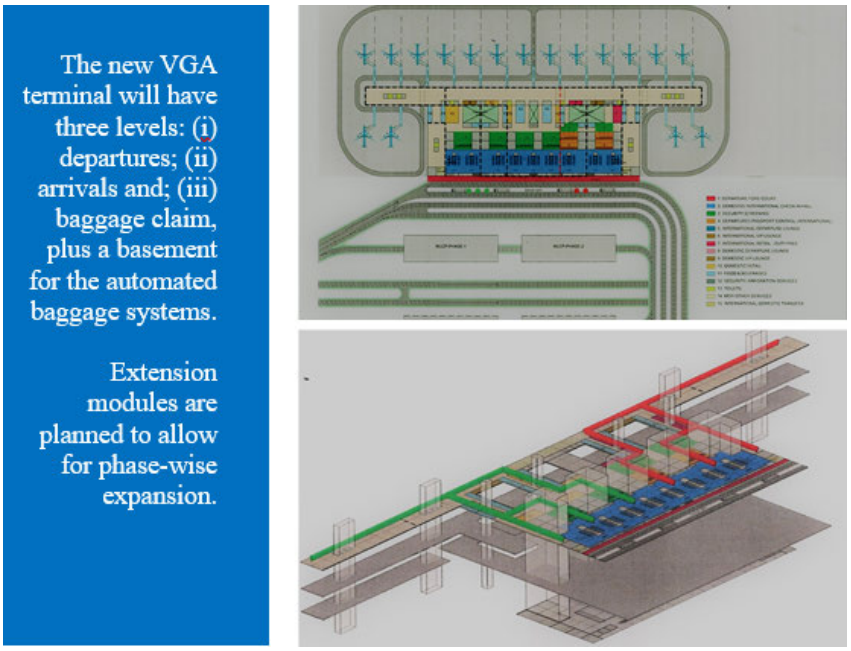
Air traffic growth in AP and the new international status of VGA, granted in August 2017, are of vital importance to the development of APCR. The current interim international and domestic terminals will remain in use until early 2022 when a new 30,360 m^2 integrated domestic and international passenger terminal comes online.

The AAI Master Plan Detailed Project Report (DPR) for VGA addresses short- and long-term requirements for infrastructure expansion through four phases with a total investment of INR 3,007 crore (about USD 445 million):

- **Phase 1:** 2015-2025 (3.1 million annual passengers design capacity)
- **Phase 2:** 2035 (9.2 million annual passengers design capacity)
- **Phase 3:** 2042 (13.4 million annual passengers design capacity)
- **Phase 4:** 2050 (17.4 million annual passengers design capacity)

AAI assumes a high-case traffic forecast in calculating that the ultimate design capacity of VGA will be reached by 2050. So VGA will be developed to handle roughly the passenger traffic volume of Hyderabad airport in 2017. Among other features, VGA improvements will include:

- 24-hour integrated domestic and international passenger terminal operations
- Boarding bridges, multi-level car park, spaces for commercial hotel development
- 4,430 m runway (CODE F compliance), parallel taxiway, fuel farm.



Source: VGA Airport

Figure 3.43 New VGA domestic and international passenger terminal (2022)

To improve VGA airport accessibility, AMRC is considering extending its proposed LRT system underground to the airport.

New airports are now commonly located 30-50 km beyond city centers for several reasons, starting with the availability of sufficiently large greenfield sites. New airports can also serve as natural catalysts to stimulate development in adjacent areas. As VGA is located only 20 km east of Vijayawada, with Amaravati and Guntur just beyond, it is relatively well-situated. Absent any unforeseen issues with land acquisition, the airport's planned expansion should meet the expected air travel needs of the region well into the future.

As VGA traffic grows in the coming years, the AP government might ask AAI to invite a strategic joint-venture partner to participate in airport operations and maintenance to ensure high standards of service.

Ahmedabad and Jaipur airports have taken this approach, which have both experienced exceptionally high traffic growth.

Building an "Amaravati Greenfield Airport" is another approach that has been discussed as a long-term option, and land has been reserved under the Capital City area plans. However, central government policy guidelines state that "a greenfield airport cannot be constructed within 150 km of an existing civilian airport until the DGCA decides to evaluate the impact on the existing airport." Considering AAI's substantial capital investment plans at the existing VGA, it seems unlikely that a case could be made to replace the current airport unless it becomes too constrained to meet APCR air travel needs and a greenfield initiative is deemed economically viable.

3.8.3 Policy direction and challenges

The Directorate General of Civil Aviation (DGCA) is an autonomous organization within the Ministry of Civil Aviation that oversees the licensing and certification of all aerodromes in India, plus other regulatory and air safety areas. The DGCA administers India's aviation policy concerning international air sector traffic rights within its mandate. And since 2014, a freeze has been imposed on international landing rights to Indian airports for all foreign carriers.

Airports newly designated as international since 2014, e.g. VGA, can therefore not seek services by foreign airlines and must rely on Indian air carriers for international flights, except where bilateral agreements permit. DGCA's rationale for this policy is to strengthen India's international hub airports with Indian carriers and not allow foreign airlines to draw traffic away to their hubs.

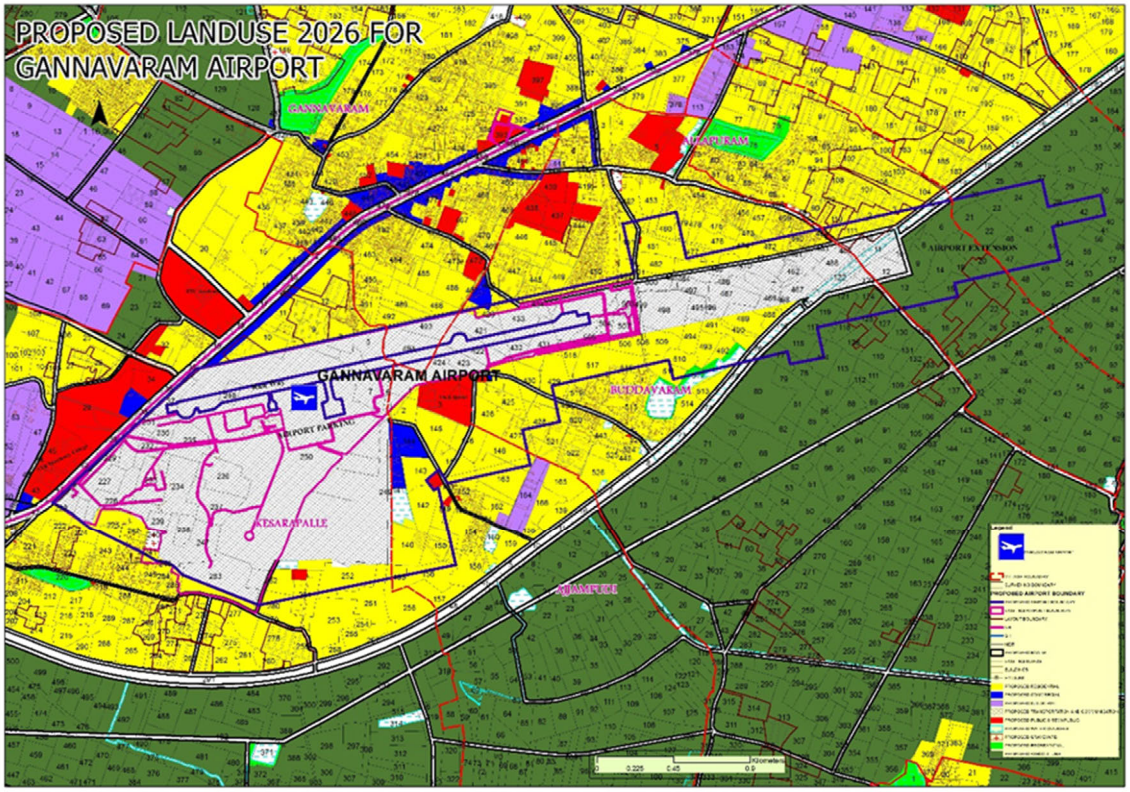
In the case of Vijayawada, except for the agreement with UAE that is now fully subscribed, India's international air service bilateral agreements should not be a hindrance for any Indian air carrier who wishes to introduce new international flights here. As the VGA airport operator, AAI is responsible for approaching Indian air carriers to launch new international and domestic flights.

While introducing new services to Dubai is problematic due to bilateral restrictions, AAI market research indicates top potential VGA international destinations include Singapore (Singapore Airlines Star Alliance hub) and Bangkok (Thai Star Alliance hub). Air India is also a Star Alliance member, it could provide useful links to both these hubs. Other potential international destinations include Kuala Lumpur and Colombo plus Middle East hubs such as Oman and Qatar. Air India, Air India Express, Jet Airways, Indigo, SpiceJet, AirAsia India, GoAir, and Vistara are all candidates Indian airlines for new international services from VGA.

- As VGA passenger demand will likely not exceed 17-18 million passengers by 2050, a greenfield airport is not justified until after 2050
- AAI plans to upgrade VGA in four phases up to 2050, spending INR 30.07 billion for a design capacity of 17-18 million passengers
- Air India Express VGA-BOM flights linked to Dubai, as well as the likelihood of a DGCA tender for subsidized VGA service to Dubai and Singapore, may further kick-start international traffic from/to VGA.
- To support rapid development throughout AP State thru 2025, the pace of development of the Capital City and its impact on VGA traffic growth should be reviewed, and the option of AAI inviting a strategic joint-venture partner for VGA should be considered, or the prospects for a greenfield airport later on.

Source: VGA Airport

Figure 3.44 VGA airport additional land for expansion (698 acres)



Source: VGA Airport

Figure 3.45 VGA airport proposed land use, 2026 (Phase 1 development)

3.9 Inland water transport

3.9.1 Overview

Inland water transport is a low-cost, environmentally friendly transport mode and a viable alternative to road or rail for bulk cargoes. Ministry of Shipping data pegs inland waterways as the cheapest mode in India, pegging the cost of moving cargo by barge at Rs. 1.06 per tonne-km versus Rs.1.41 by rail and Rs.2.58[13].

Table 3.13 Cargo transport costs by mode

Mode	Pretax freight (Rs. per tonne-km)	Post-service tax freight (Rs. per tonne-km)
Rail	1.36	1.41
Truck	2.50	2.58
Inland water transport	1.06	1.06

Source: Ministry of Shipping (March 2017)

Historically, APCR has an extensive inland water transport (IWT) network, which has mostly fallen into disuse. But plans are now afoot to redevelop National Waterway 4 in three phases. Other proposals involve the Vykuntapuram barrage, canal beautification in Vijayawada, a Green Walk project, new reservoirs in the capital city, and the development of Machilipatnam port.

Future proposals may also include navigational development of the Bandar and Nizampatnam canals to connect with the planned Machilipatnam and Nizampatnam ports, which could facilitate the import/export of bulk goods. This could include multimodal terminals at Gannavaram, Amaravati, and Harischandrapuram. Water taxis have also been proposed between Amaravati and Vijayawada.

However, the reality is that funding for the inland water sector is very limited. But recent proposals have aimed to increase funding, for example by encouraging the private sector to invest and promoting tourism activities.

As APCR's inland water transport sector is at an initial stage of redevelopment much remains to be done, including:

- To provide facilities for the safe movement of goods more cost-effectively
- Ensuring that all channels have adequate depths of at least 2.5m year-round
- Inter-agency cooperation to secure terminals with adequate road and rail connectivity

3.9.2 History

A canal network built during colonial times was actively used until 1975. Key arteries included the Kakinada, Eluru, Commamur, and Buckingham canals as well as the Krishna and Godavari rivers.

In 1987-89, IWT techno-economic feasibility studies were carried out for the Godavari and Krishna rivers. Although cargo potential was deemed to be inadequate, the studies also found that cargo potential was more promising if these arteries were linked with existing irrigation-cum-navigation canals connecting Chennai and Kakinada.

Subsequently, AP's Irrigation & Command Area Development (CAD) Dept. asked the Inland Waterways Authority of India (IWAI) to explore IWT development potential using the integrated waterway system of AP and Tamil Nadu. IWAI responded with a study done during 1993-95.

[13] Ministry of Shipping http://pib.nic.in/newsite/PrintRelease.aspx?relid=159571

3.9.3 Existing inland waterways

Inland Waterways Authority of India (IWAI) is the statutory body responsible for constructing, maintaining, and operating the waterway network under the Ministry of Shipping. The Government has formulated an IWT policy to accelerate development and encourage private-sector participation.

AP State, interested in developing IWT, proposed to the Ministry of Shipping the Sagarmala Project, a port-centered scheme that includes IWT as a key component. In response, IWAI and AP State formed a special purpose vehicle to construct National Waterway 4.

Currently, there is not much water transport activity in APCR beyond river tourist boats. However, many cement industries are centered around the limestone deposits in the northwest of APCR, and water transport could prove effective in moving their bulk cargoes – particularly for the construction of the Amaravati capital city. But this would require upgrading channels on the Krishna River, where depths have decreased due to water storage and diversion upstream. Consequently, most of the water behind Prakasam Barrage now comes from the Godavari River via the Polavaram Canal.

(1) Krishna River

The 83 km navigable stretch of the Krishna River in APCR runs from Muktyala down to Prakasam Barrage. There are no bridges along this stretch. Water depths are currently sufficient for IWT up to 20 km upstream from Prakasam Barrage and 20 km downstream from Muktyala.

Source: JICA Study Team

Figure 3.46 Krishna River (upstream from Prakasam Barrage)

(2) Eluru Canal

Eluru Canal runs between the Krishna East main canal in Vijayawada and Eluru where it connects with the Polavaram Canal to the Godavari River. About 45 km of its length is in APCR, with 25 bridge crossings, mostly in Vijayawada. Water from the Eluru canal is used for irrigation. Its source is water stored behind the Prakasam Barrage.

(3) Commumur Canal

The Commumur Canal (50 km in APCR) runs from the Sitanagaram lock on the Krishna West main canal to Pedaganjam lock where it joins Buckingham Canal. There are a total of 16 bridges and two old navigation locks on the canal. Its source is water stored behind the Prakasam Barrage.

Source: JICA Study Team

Figure 3.47 Jagarlamudi and Duggirala Navigational locks on Commumur Canal

3.9.4 Tourist boats on the Krishna River

On average, each weekend day 1,300 to 1,600 tourists take boat trips across the Krishna River between Vijayawada/Punnami Ghat and Bhavani Island.

Source: JICA Study Team

Figure 3.48 Passenger boats on the Krishna River

3.9.5 Ports and shipping

Ocean transport is a highly efficient mode for bulk commodities and containerized goods. AP State with a 1,000 km coastline, and 3,000 km straight-line sailing to Singapore, a maritime gateway to East Asia, is well-positioned to participate in the Asia-Pacific economy. Visakhapatnam, AP's largest city, is one of India's 12 major ports.

Although APCR does not extend to the coast, its proximity to the Bay of Bengal gives the region a "ringside seat" on the ASEAN and East Asian economies. There is potential to expand several small nearby ports including Machilipatnam, 20 km from APCR's southeast boundary.

A greenfield deep-water port is being developed at Machilipatnam. Environmental clearance was obtained in 2009 for a Phase-1 development of four ocean berths with a 685 ha port area. Further expansion proposals now call for 15 berths.

Machilipatnam is expected to attract several port-based industries including oil refining, power plants, and SEZs. Some cargo currently transported by road through Vijayawada north to Kolkata and Vizag

port and south to Chennai will be diverted to Machilipatnam, thus easing congestion and bridge crossing bottlenecks on NH16.

Source: JICA Study Team

Figure 3.49 Existing inland waterway network

3.10 Traffic surveys

3.10.1 Overview

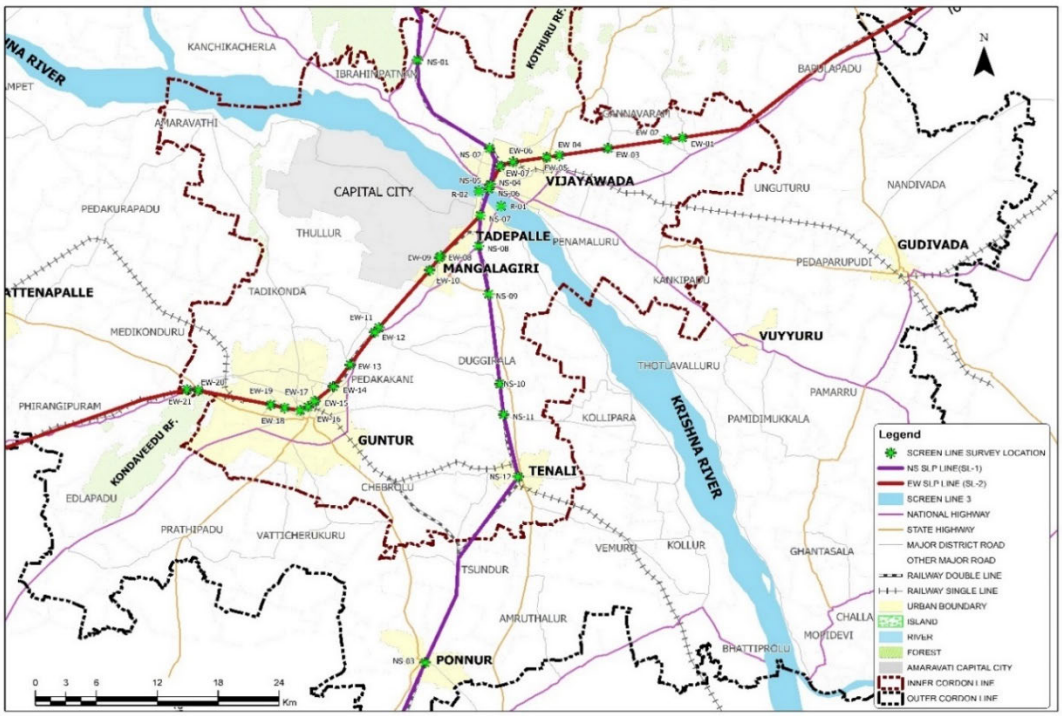
The bedrock on which this CTTS has been built is very detailed observation and measurement of APCR's existing traffic and travel characteristics – starting with extensive traffic surveys. This baseline data not only provides a clear understanding of existing traffic and transport conditions, identifying problems and constraints. It is the foundation on which travel demand forecasts can be modeled under various scenarios.

A series of traffic and transportation surveys were conducted as part of the study to assess passenger and goods movement patterns, travel characteristics, pedestrian and parking facilities, and available infrastructure facilities within the study area. The data collection activity included classified traffic volume counts (screen line, mid-block, and cordon), origin-destination surveys, road inventory surveys, speed and delay surveys, public and intermediate public transport (IPT) operator and user surveys, parking surveys, pedestrian facility surveys, and terminal surveys. In addition, significant data from secondary sources about demographic socio-economic characteristics, public transport systems, etc. were also collected.

3.10.2 Screen line traffic count

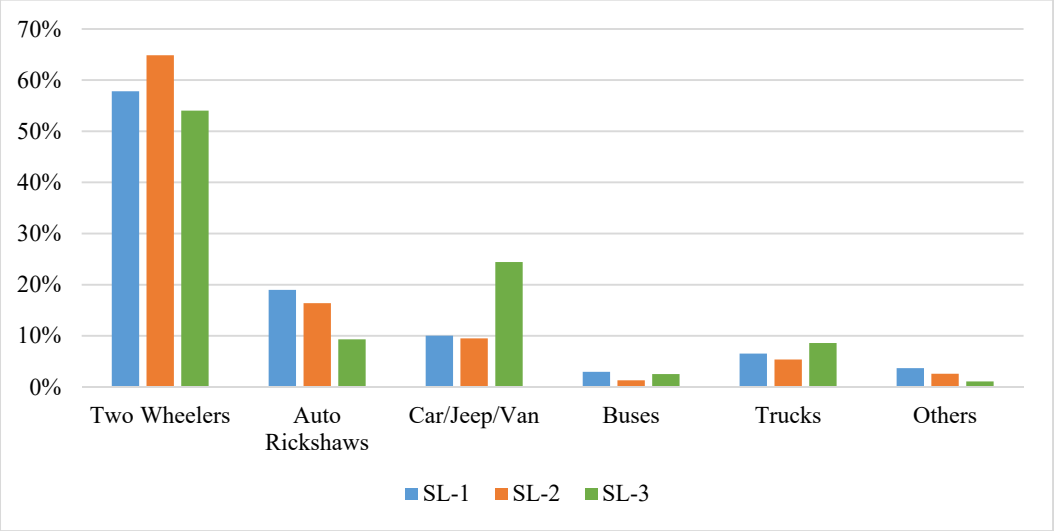
A comparison of average traffic composition among the screen lines shows (Figure 3.51) that more or less each screen line has a similar modal share. Figure 3.50 presents the traffic composition among the three-screen lines. The share of two-wheelers crossing the Screen Line-2 is greater compared with other screen lines. However, when the overall composition of traffic volumes for all screen lines is put together, two-wheelers account for 59%, cars 15%, and auto-rickshaws 15%.

Hourly traffic flows expressed as % of average daily traffic (ADT) in passenger car units (PCUs), on a normal working day at all the screen lines are shown in Figure 3.52.



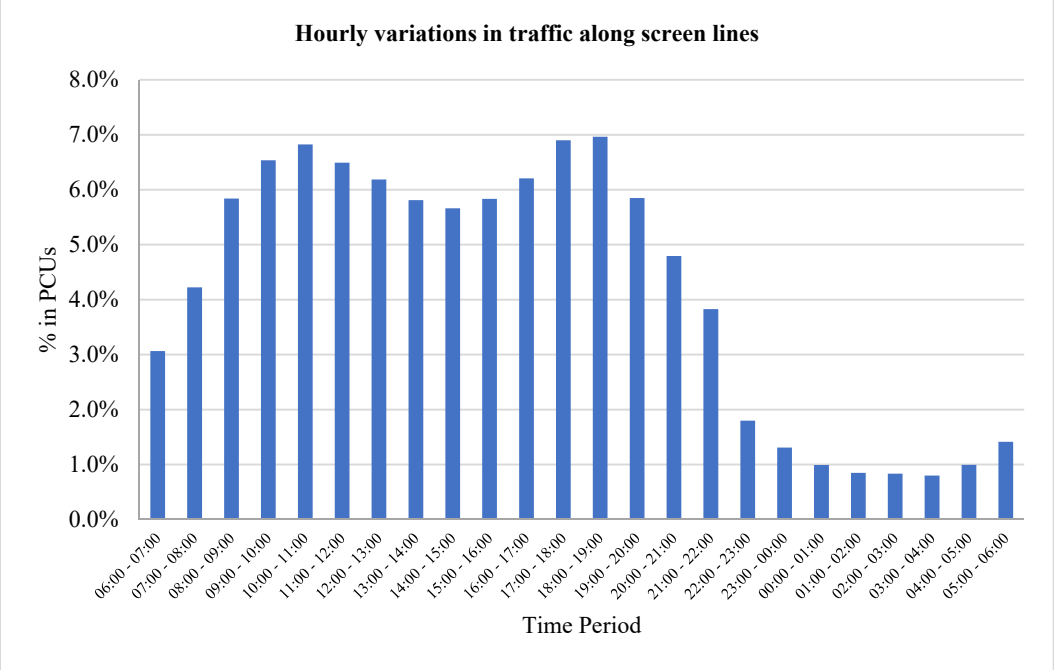
Source: JICA Study Team

Figure 3.50 Screen lines in the study area



Source: JICA Study Team

Figure 3.51 Overall traffic composition for screen lines



Source: JICA Study Team

Figure 3.52 APCR: Overall hourly variation in traffic crossing screen lines

No distinct sharp peaks are observed in the study area. Rather traffic is distributed over three to four hours both in the morning peak period and in the evening period. Looking at the distribution of hourly share, 09:00-12:00 hrs. can be considered as morning peak period and 17:00-19:00 hrs. as the evening peak period. It can also be seen that in both the peak periods, the peak ratio is about 7% of daily traffic.

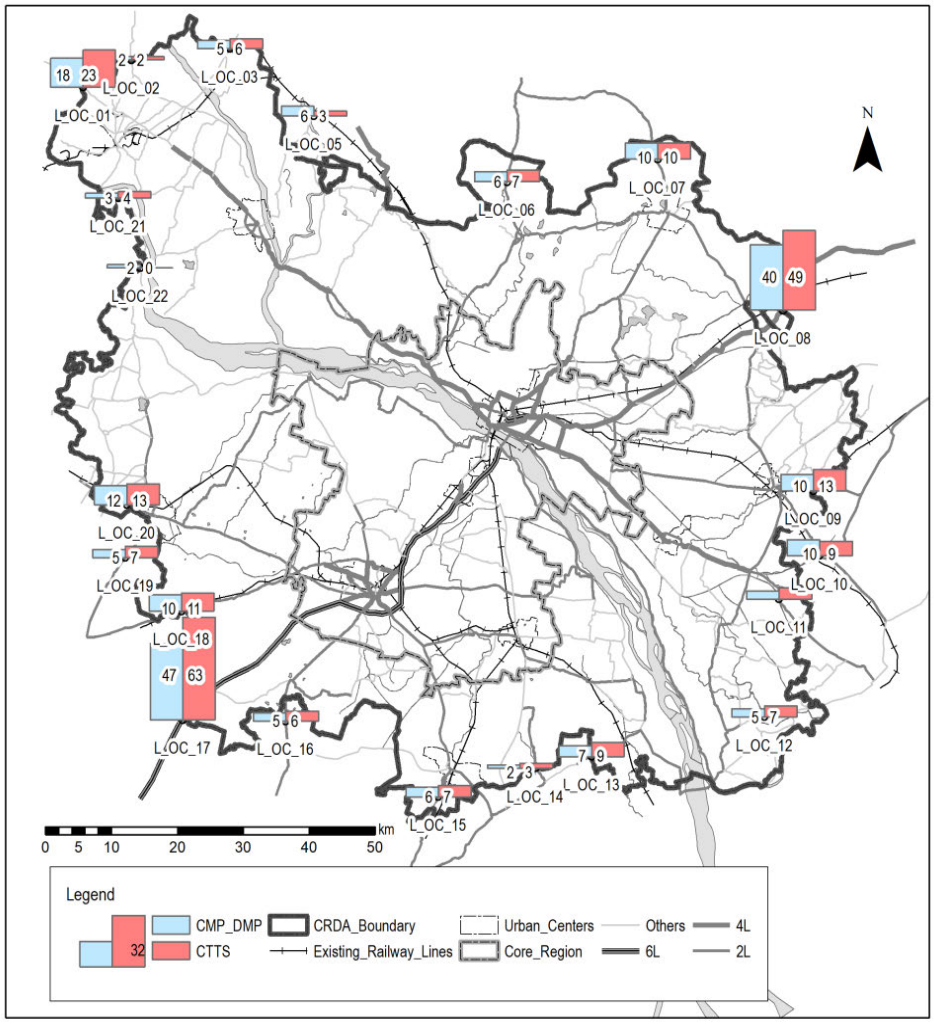
3.10.3 Cordon line traffic count

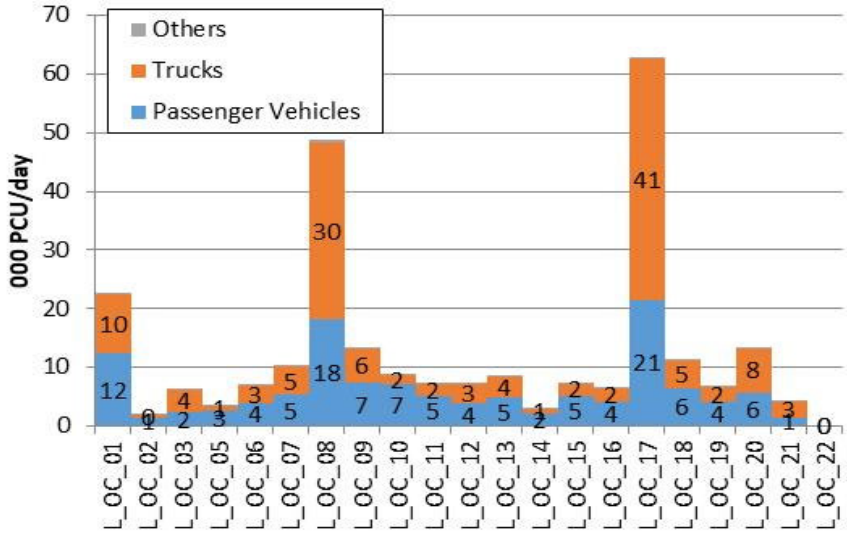
(1) Outer cordon line

To capture the vehicular traffic movement crossing the APCR boundary, outer cordon line traffic count survey and OD interview surveys were conducted in 2017.

The survey result informs the through-traffic of high traffic volume, of which 60 to 70% are heavy vehicles (trucks), along the national highway 16 (NH16) (refer to OC08 and OC17).

Since NH16 runs through the downtown area of Vijayawada, serious traffic congestion is observed at the intersections in Vijayawada downtown area. This indicates that if such through-traffics are diverted to outside the downtown area by providing alternative routes such as the Inner Ring Road and the Outer Ring Road (by-pass), the congestion problem in the Vijayawada downtown can be mitigated.





Source: CMP/DMP (2014/2016) & CTTS (2017)

Figure 3.53 Traffic survey findings (1) outer cordon

The total number of observed vehicles crossing the APCR boundary is 257,000 PCUs/day. Through-traffic volume is about 17% of the total cordon line traffic volume. It should be noted that 36,000 PCUs/day, that is 27 % of total observed trucks crossing the outer cordon, are through-traffic.

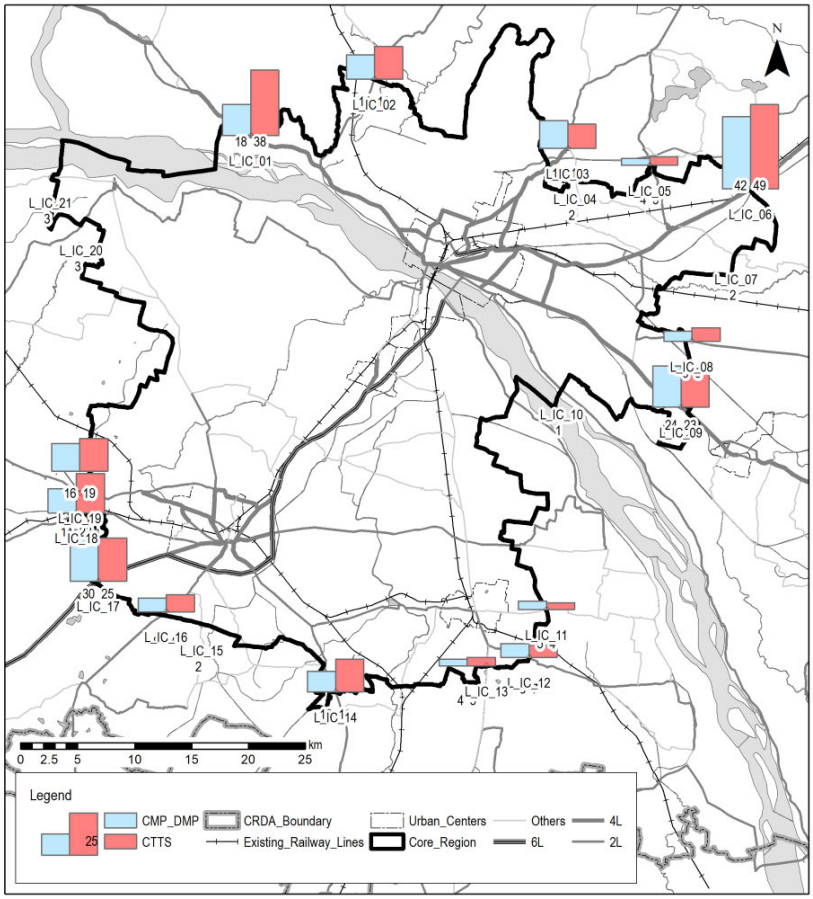
Table 3.14 Summary of Outer Cordon Line Traffic Count

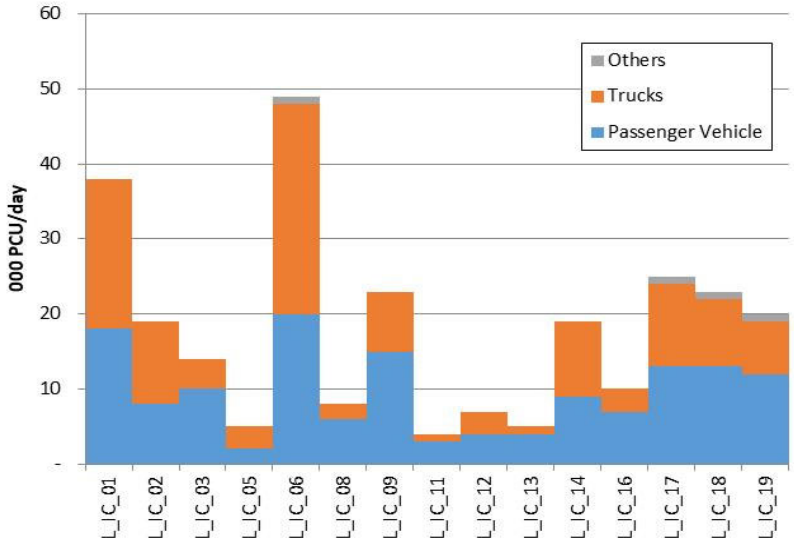
Vehicle Category	Traffic Volume (1,000 PCUs/day)			Share	
	External-Internal	External-External	Total	External-Internal	External-External
Passenger	119	8	126	94%	6%
Truck	95	36	130	73%	27%
Total	**213**	**43**	**257**	**83%**	**17%**

Source: JICA Study Team

(2) Inner cordon line

To capture the traffic movement patterns and volumes crossing the core area of APCR, that is VGTM, inner cordon line surveys were conducted in 2017. The inner cordon line survey also informs of heavy traffic along NH16 and its higher rate of heavy vehicles.

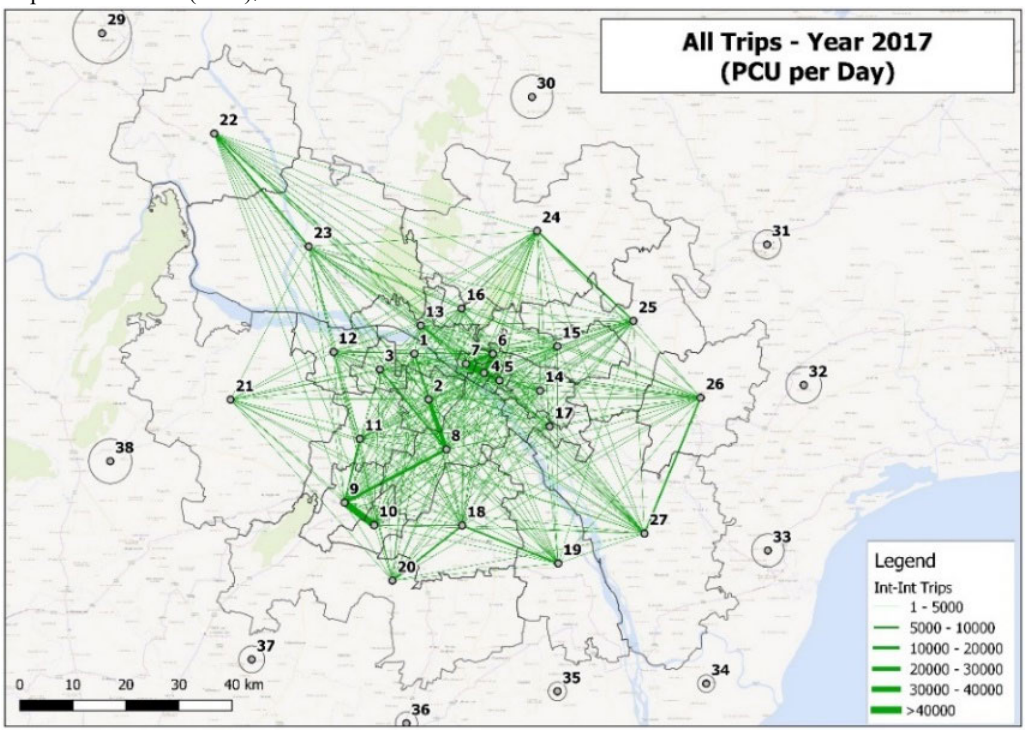




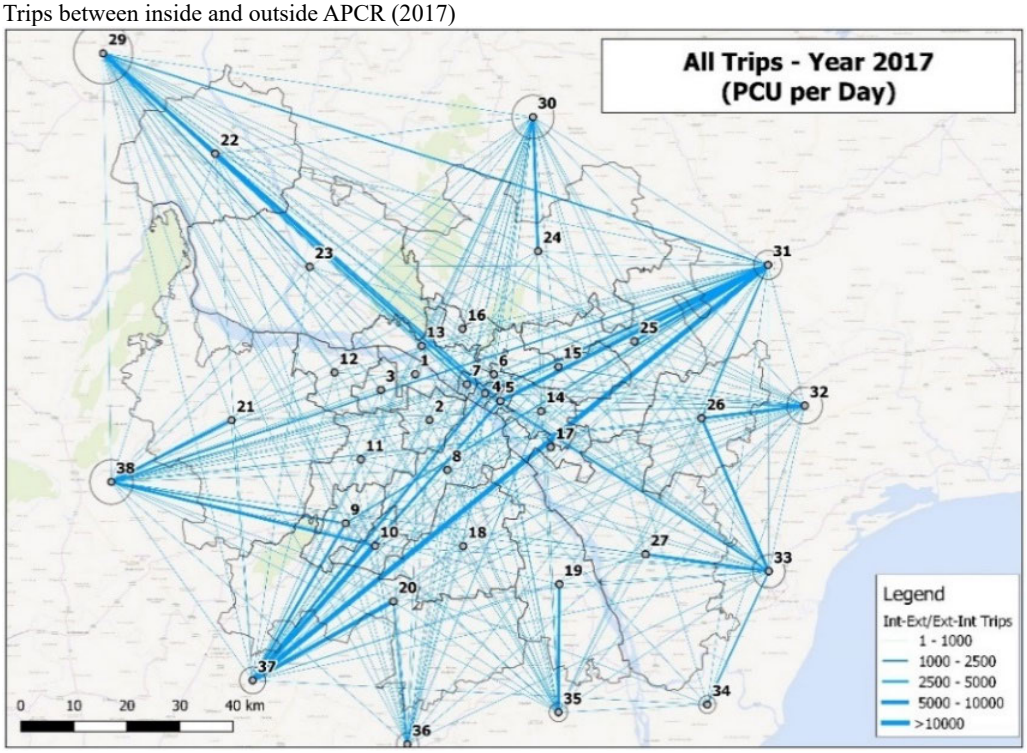
Source: CMP/DMP (2014/2016) & CTTS (2017)

Figure 3.54 Traffic survey findings (2) inner cordon

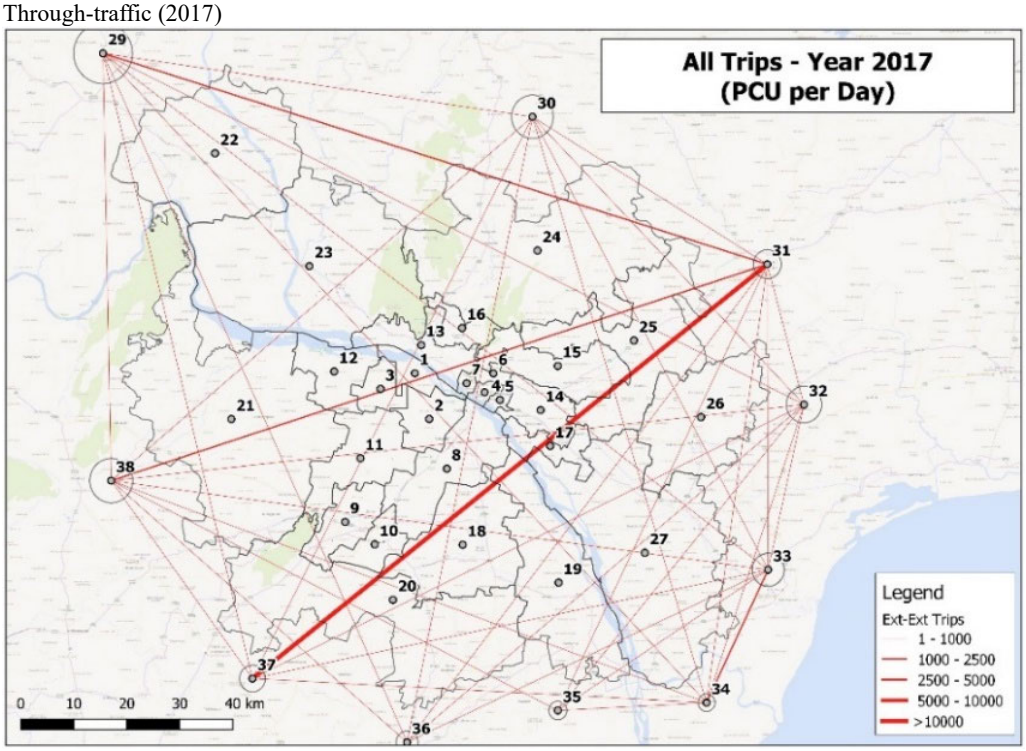
Trips inside APCR (2017))



Trips between inside and outside APCR (2017)



Through-traffic (2017)



Note: PCUs including Car, Two Wheeler, Auto Rickshaw, and Bus

Source JICA Study for CTTS

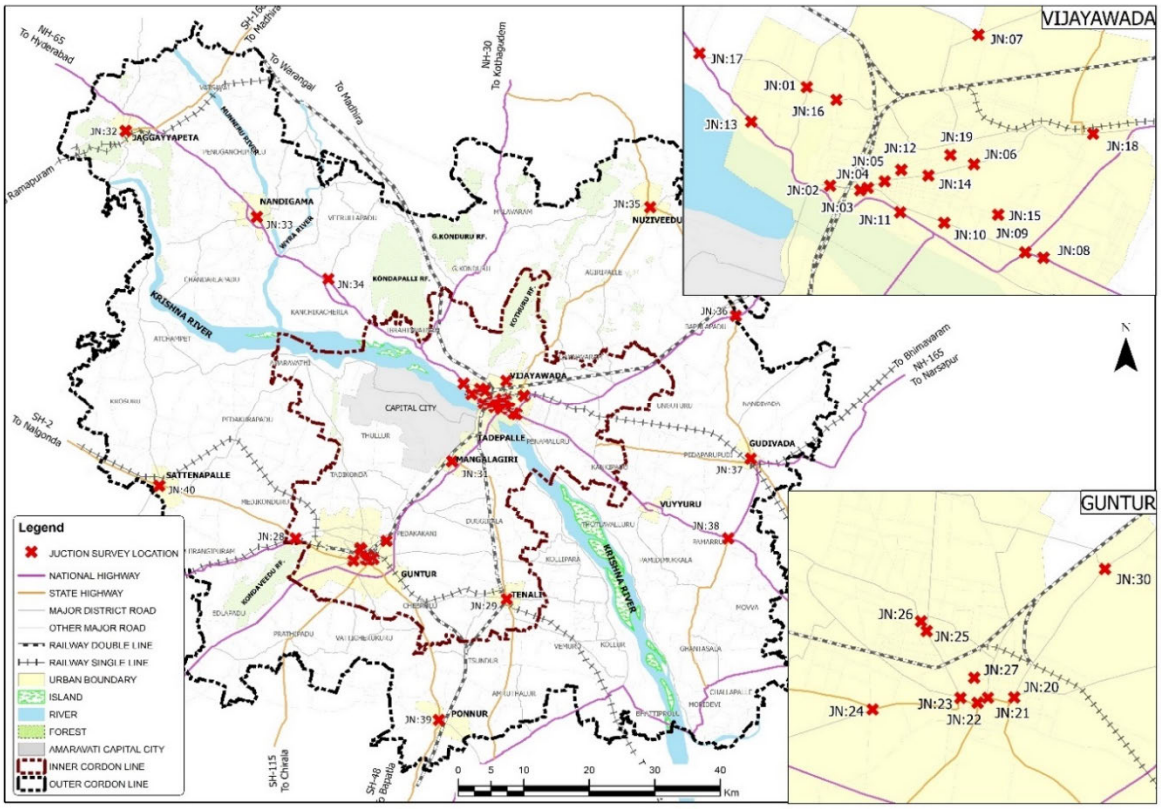
Figure 3.55 Desiered Line (2017)

3.10.4 Traffic volumes at major intersections and mid-block

Classified traffic volume counts and turning movement surveys were conducted at 40 strategic intersections during morning and evening peak periods for a duration of 12 to 16 hours each on normal working days.

The intersections were identified based on the importance of the junctions in the region's overall transportation network. The purpose of the turning movement volume count survey was to provide data to facilitate validation of the Household Interview Survey (HIS) and other field survey estimates of travel demand.

The survey formats contain information relating to the location identification, flow direction, date and time of the survey, and provision for recording the class of vehicles. The format included passengers and goods, and motorized and non-motorized modes.



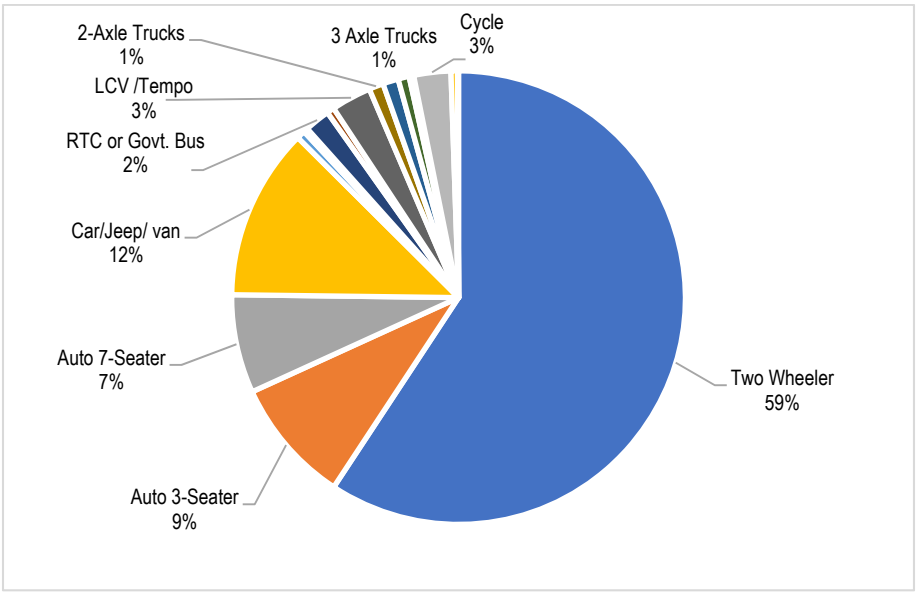
Source: JICA Study Team

Figure 3.56 Traffic survey locations

Maximum traffic was observed at Junction:08, i.e. NTR Circle with 171,648 vehicles/day (122,549 PCUs/day). Peak hour traffic at this junction was 10,236 PCUs. Minimum traffic was observed at Junction:17, i.e. Gollapudi Junction with 21,408 vehicles/day (16,470 PCUs/day). Peak hour traffic at this junction was 1,602 PCUs.

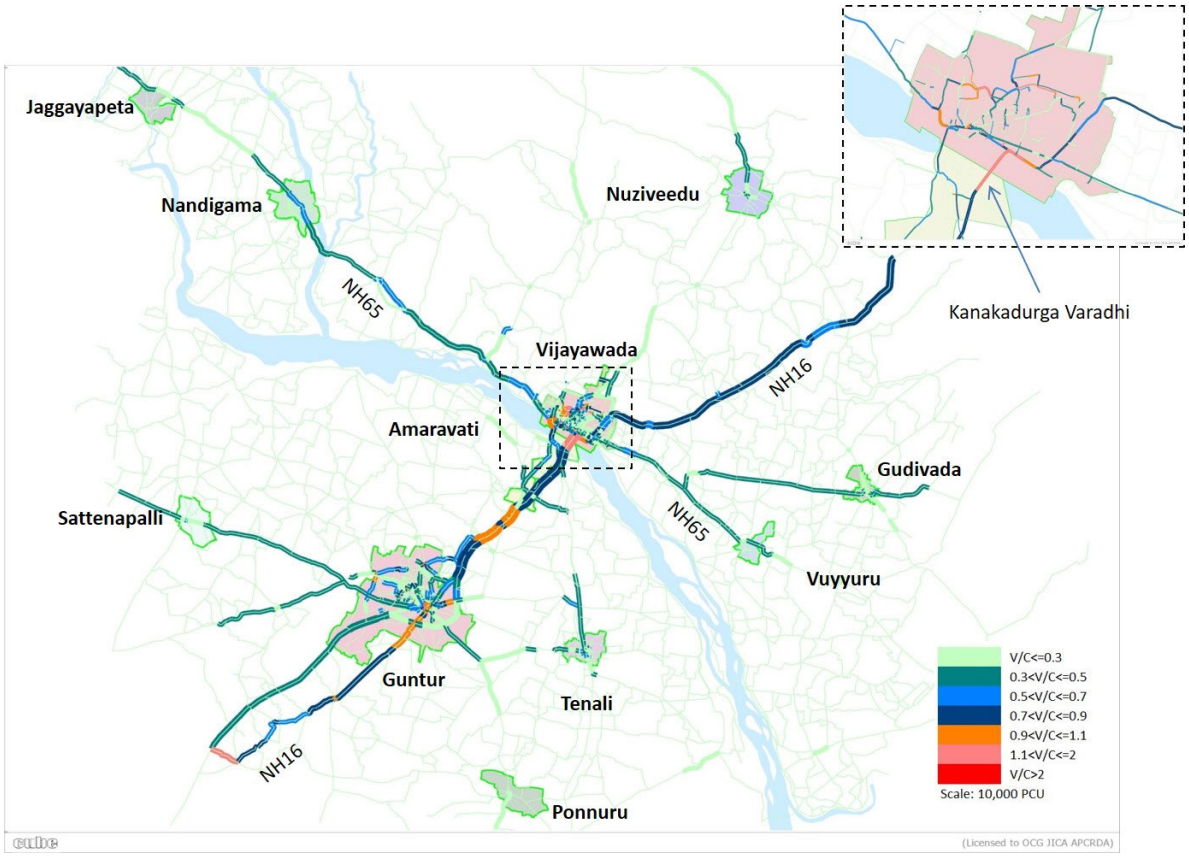
Maximum traffic at mid-block locations was observed at MB:14, i.e. MG Road near Fortune Murali with 110,288 vehicles/day (81,751 PCUs/day). Minimum traffic was observed at MB:55S1, i.e. Guntur Bypass Service Road-Right with 2,986 vehicles/day (3,630 PCUs/day).

The following figure presents the traffic composition of the mid-block locations. The overall composition of traffic volumes for all mid-block locations combined, two-wheelers account for 59%, cars 12%, and auto-rickshaws 16%.



Source: JICA Study Team

Figure 3.57 Overall traffic composition (in vehicles) at mid-block locations



Source: JICA Study Team

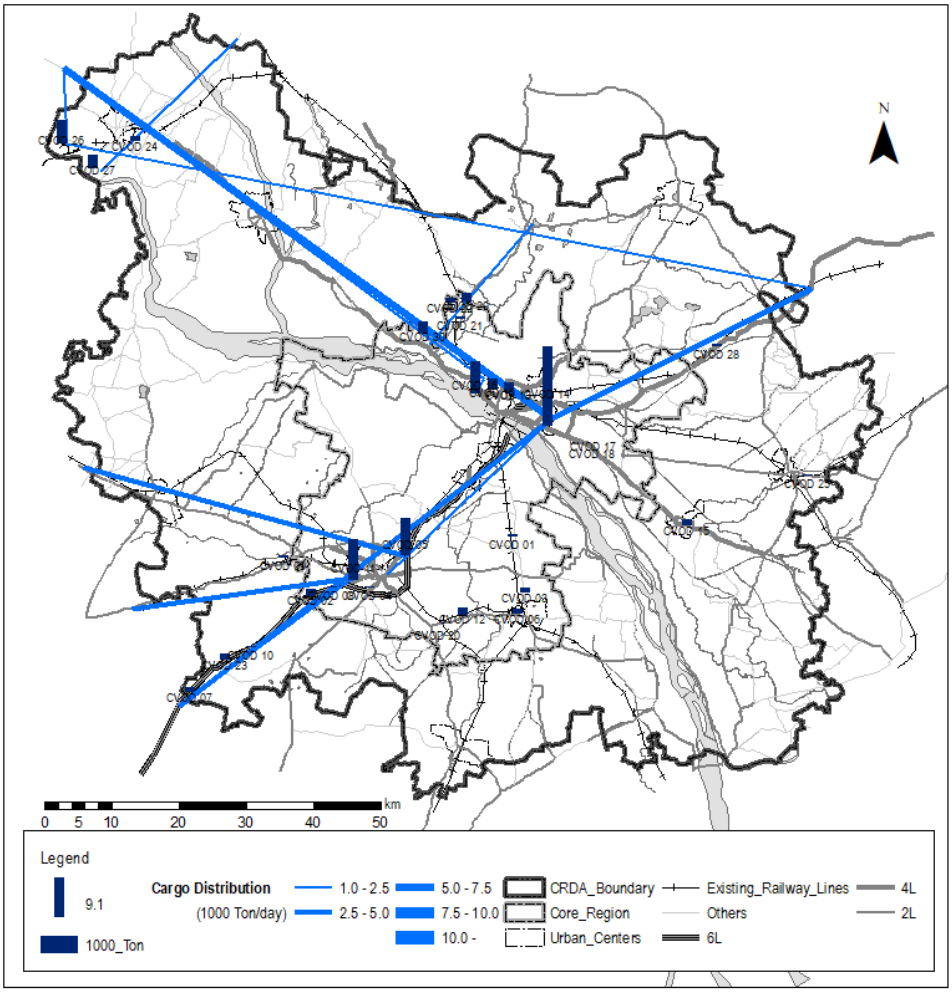
Figure 3.58 Traffic assignment on major highways in 2017

3.10.5 Road transport logistics

To raise the efficiency of logistics systems in APCR, more coordination is required. Road cargoes in APCR are mainly agricultural products, construction materials, household goods, foodstuffs, and minerals, with transport activities concentrated mainly at Auto Nagars, goods terminals, wholesale markets, vegetable markets, warehouses, go-downs, and major industrial sites.

Every day more than 150 trucks from logistics companies arrive at Vijayawada's Auto Nagar – primarily from Navata Transport, VRL, and SRMT. Many firms use Vijayawada as a hub since it has good road connectivity to Hyderabad, Chennai, Bangalore, Kolkata, Visakhapatnam, etc.

Auto Nagar Vijayawada, one of the major sources of traffic congestion in the city, is now close to residential areas due to rapid urban sprawl. To solve this problem authorities are now considering relocating the Auto Nagar alternative to a site closer to major industries and the major National Highways.



Source: JICA Study Team

Figure 3.59 Cargo terminal survey

Given their location on the Visakhapatnam-Chennai Industrial Corridor, Vijayawada and Guntur are focal points of intercity goods movement. Both the highway junction of NH16 and NH65 and the rail junction make APCR a compelling hub for logistics facilities incorporating distribution and storage functions.

Source: JICA Study Team

Figure 3.60 Major road-based logistics/transport companies

CTTS Commercial OD surveys and focal point surveys have identified the flow of truck movements at major truck generating industries. Most truck terminal activities are concentrated on two major highway corridors:

- Along NH65 Hyderabad-Vijayawada-Machilipatnam
- Along NH16 Vizag/Kolkata-Vijayawada-Chennai.

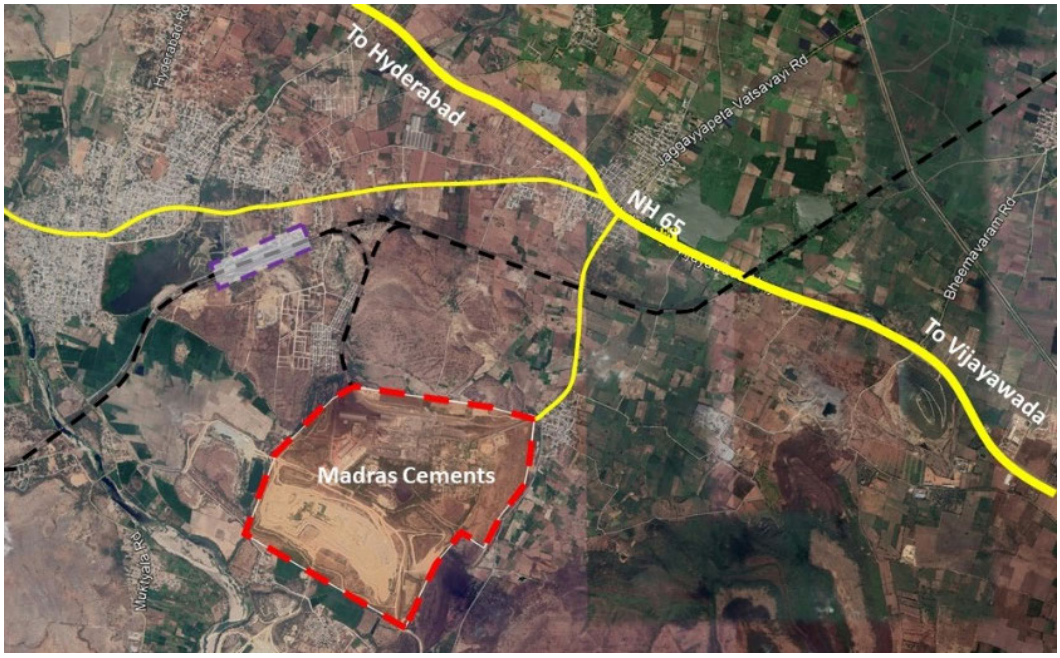
Source: Aarevee Associates

Figure 3.61 Major road corridors generating truck movement

(1) Corridor 1: Along NH65 Hyderabad-Vijayawada-Machilipatnam

In the northwest of this corridor, the Jaggayyapeta area generates almost 290 daily truck movements, mainly related to cement manufacturing. Sources include K.C.P Cement, Ramco Cement, etc. Limestone is also shipped by truck to steel plants in AP (Visakhapatnam Steel and others).

In the center of the corridor, Kondapalli Fly Ash Pond generates around 300 truck movements daily (i.e. in and out) distributing fly ash byproduct from the nearby thermal power station all statewide.



Source: JICA Study Team

Figure 3.62 Jaggayyapeta: Madras Cement and limestone quarry

Source: JICA Study Team

Figure 3.63 Kondapalli fly ash pond

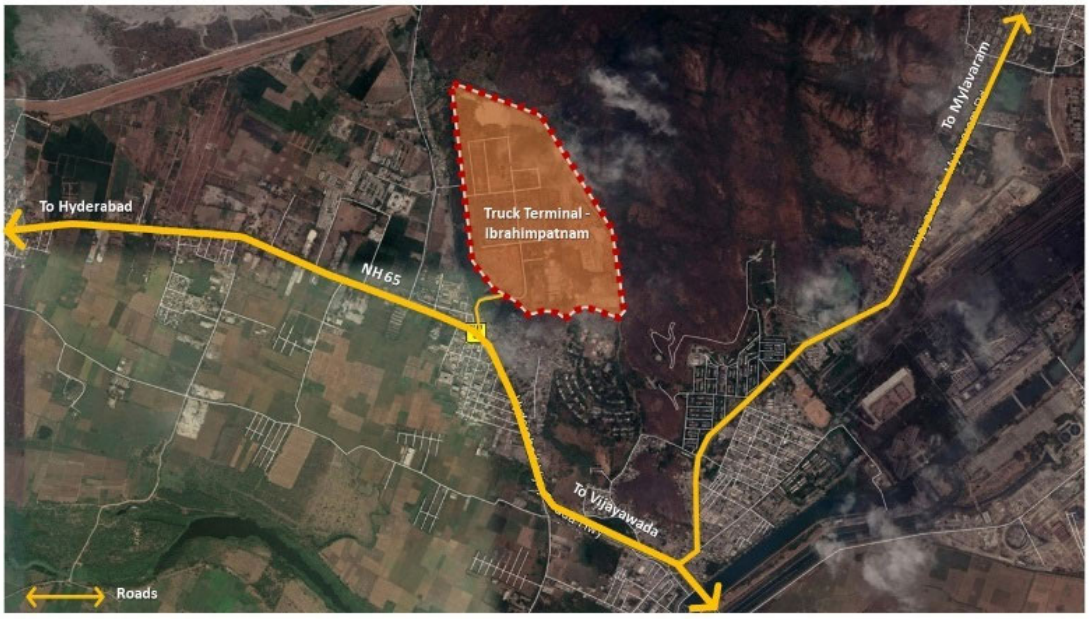
Also in this area, Ibrahimpatnam Industrial Zone generates about 1,100 truck movements per day. Major industries include:

- Hindustan Petroleum Corp. (Bottling plant) - 250 trucks/day
- Bharat Petroleum Corp. (Petrol plant) - 250 trucks/day
- Iron Merchant Yard - 150 trucks/day
- Indian Oil Corp. (Petrol Plant) - 100 trucks/day
- NCL Industries (Nagarjuna Corp. Ltd.) - 100 trucks/ day

(2) Ibrahimpatnam Truck Terminal, Vijayawada

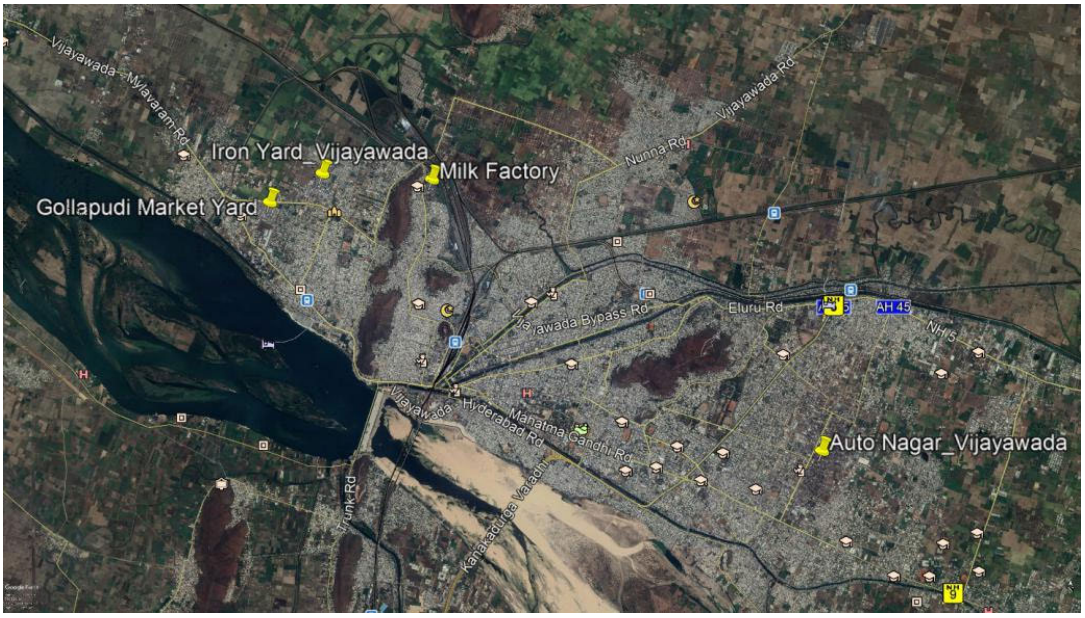
Ibrahimpatnam Truck Terminal was built a decade ago on 75 acres with 532 shops, 120 offices, 91 warehouses, and 24-row warehouses. Its original intended purpose was to serve as a holding area for trucks prohibited from entering the city during peak times to ease traffic congestion.

However, as no regulations were put in place to restrict truck movement into the city, the terminal is now hardly used except for equipment storage by the nearby thermal power plant (which generates few truck movements). Many trucks arriving from the Hyderabad direction now unload instead at Bhavanipuram on the inner ring, which is creating a growing traffic problem.



Source: JICA Study Team

Figure 3.64 Ibrahimpatnam Truck Terminal



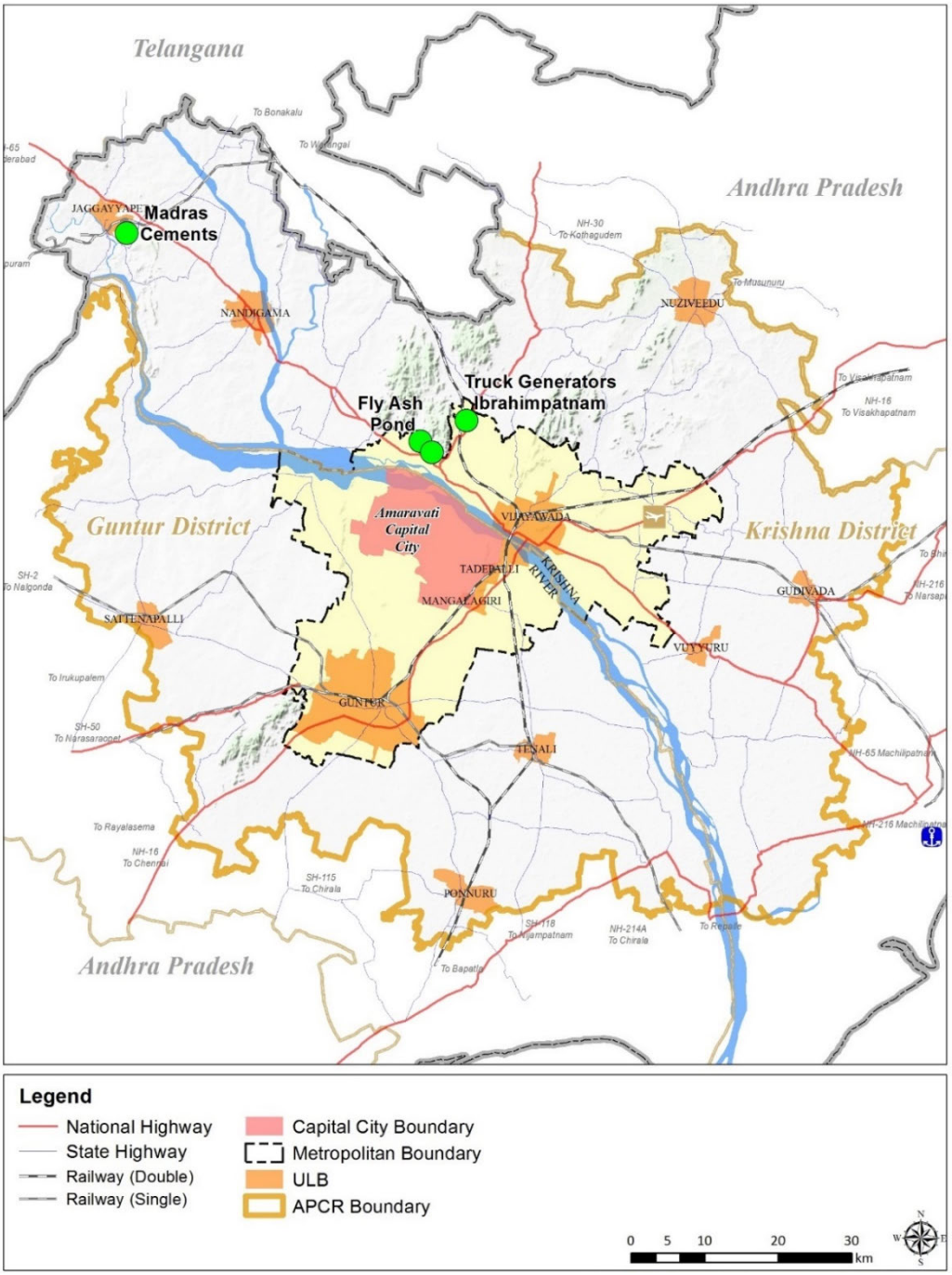
Source: JICA Study Team

Figure 3.65 Major truck-traffic generators in Vijayawada

In the southeast of the corridor, Vuyyuru KCP Sugar Pvt. Ltd is the major generator of truck traffic, but only during the November to April harvest season when each day 200 trucks, 300 tractors and 200 bullock carts haul cane from surrounding villages to the sugar factory.

Other major truck-traffic generators include:

- Gollapudi wholesale market yard – approximately 280 trucks/day
- Vijaya milk factory – 80 trucks/day
- Vijayawada Auto Nagar – approximately 1,000 trucks/day.



Source: JICA Study Team

Figure 3.66 Major truck-traffic generators along Corridor 1

(3) Corridor 2: Along NH16 & 216

In the Guntur to Timmapuram section of this corridor, Tirumala and Cottons Agro products, NSL Textiles, and Sakku Spinning Mills in Konduru Padu are the industries all generating more than 100 trucks per day. Guntur Auto Nagar, on the city's outskirts adjacent to NH16, has 270 acres and parking for 3,000 trucks. Some 1,500 trucks come to Auto Nagar daily.

Along Guntur Highway, Mirchi Cold Storage, K. Ramohanrao & Co. Storage, Hindustan Uniliver, and Balarama Krishna Spinning Mill all generate more than 150 truck movements per day.

Source: JICA Study Team

Figure 3.67 Corridor 2: Along NH16 & 216

3.11 Environmental issues

3.11.1 Environmental baseline review

Baseline data were compiled to establish the environmental and socio-economic profile of the study area. Findings from the environmental baseline include (1) strategic environmental assets, (2) strategic environment constraints, and (3) pollution levels. Findings from the socio-economic baseline include (4) accessibility by area and (5) accessibility by income.

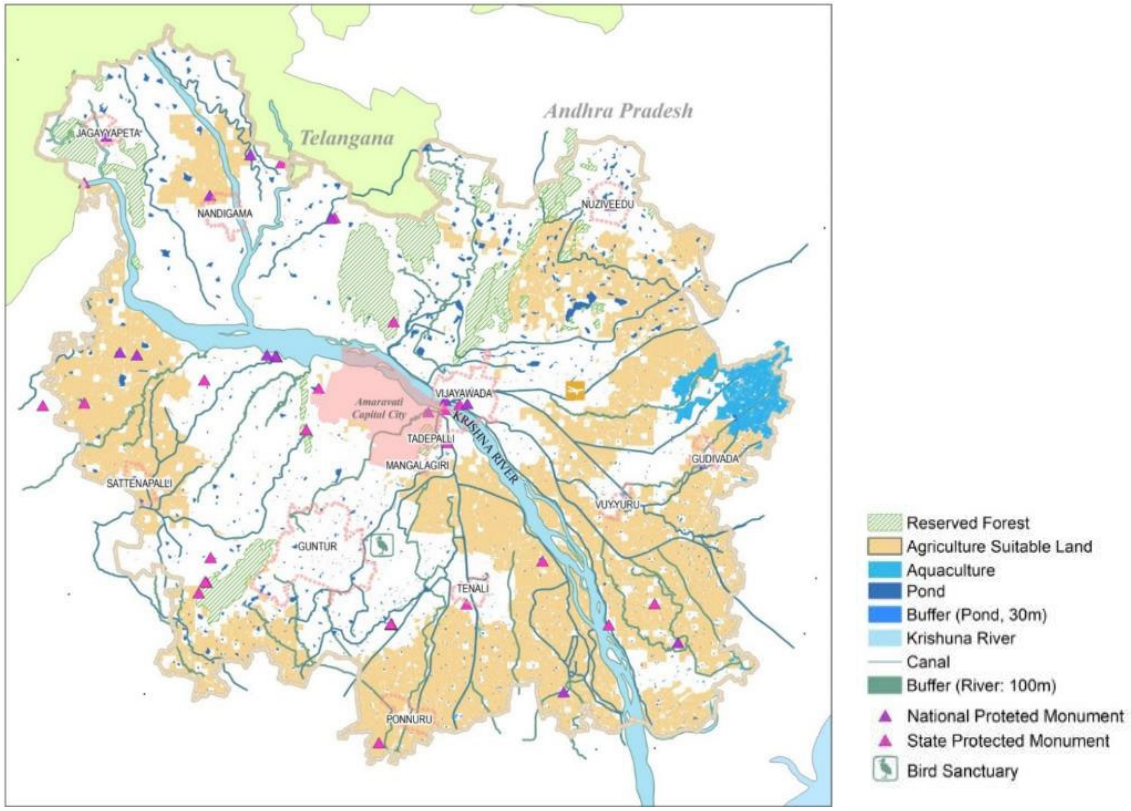
(1) Strategic environmental assets

Strategic environmental assets in APCR include reserved forest, river and water bodies, and a bird sanctuary as well as manmade assets such as monuments and agricultural land. As shown in Figure 3.68, the northern area has reserved forests while the eastern part is rich in agricultural land.

Table 3.15 Summary of strategic environmental assets – natural and manmade

Planning designation	Findings	Importance
Environmental assets		
Reserved forest (RF)	North of Vijayawada, West of Guntur, Jaggayyapeta	State
River and water bodies	Krishna River	Regional
Bird sanctuary (IBA)	Uppalapadu (0.2 km^2) at10 km East of Guntur	Birdlife Int'l (NGO)
Manmade assets		
Monuments	Around 50 sites in APCR	National & State
Productive agricultural land	East of Vijayawada-Guntur corridor	State

Source: JICA Study Team



Source: JICA Study Team

Figure 3.68 Strategic environmental assets – built and manmade

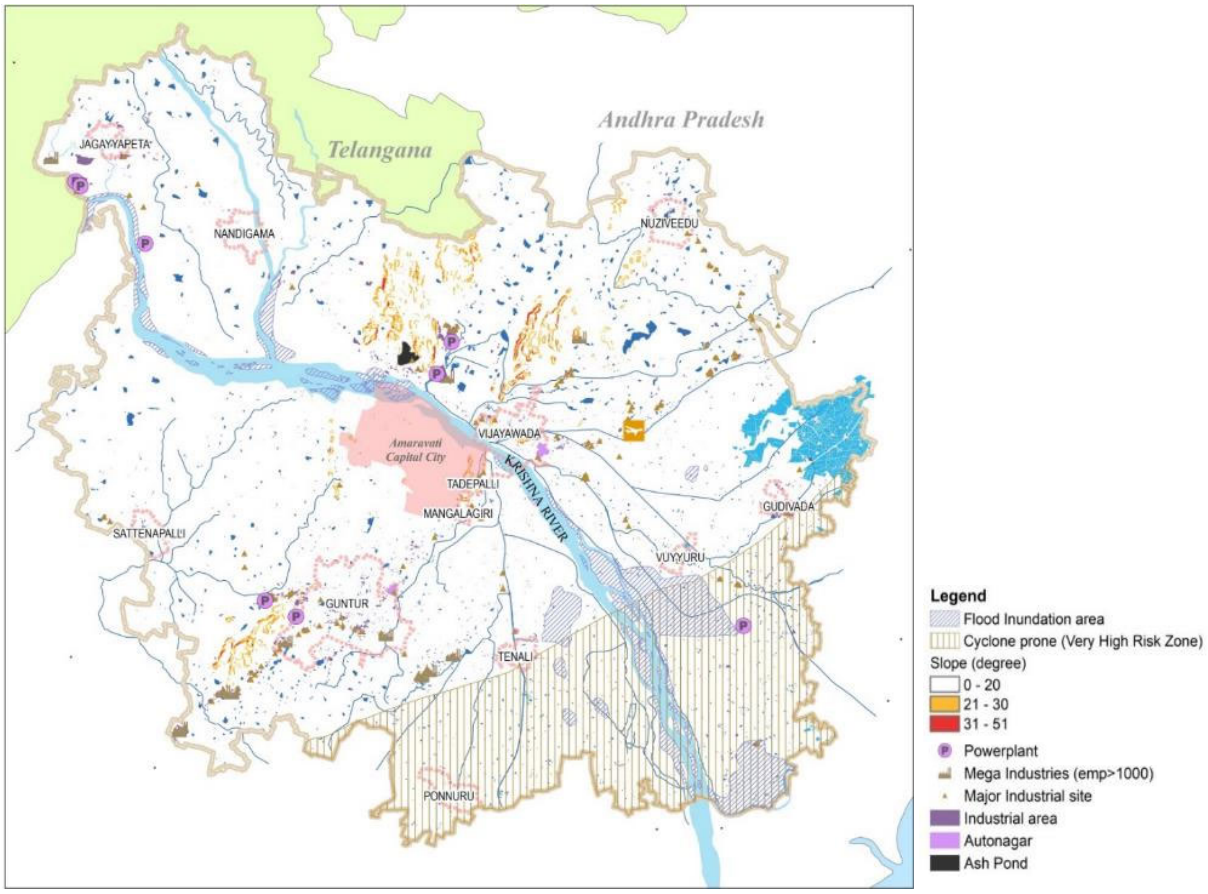
(2) Strategic environmental constraints

"Environmental constraints" refers to areas requiring special care in developing transport infrastructure and expanding urban development. Categories include flood- and cyclone-prone areas, steep-slope areas, and major industrial areas. As shown in Table 3.16 and Figure 3.69, the southeast part of APCR is vulnerable to natural disasters including cyclones and river flood risks.

Table 3.16 Strategic environmental constraints

Analysis component	Findings
Natural disaster	
Flood risk area*1	Along Krishna River, especially in the southeast part of APCR
Cyclone area*2	Southeast part of APCR
Steep slope	North of Vijayawada, West of Guntur
Residential issues	
Major industrial area	Northeast and southwest ends of NH16
Power plant	Northwest Vijayawada, Guntur, Jaggayyapeta
Ash pond	Kandapalle

Source: JICA Study Team



Source: JICA Study Team

Figure 3.69 Strategic environmental constraints

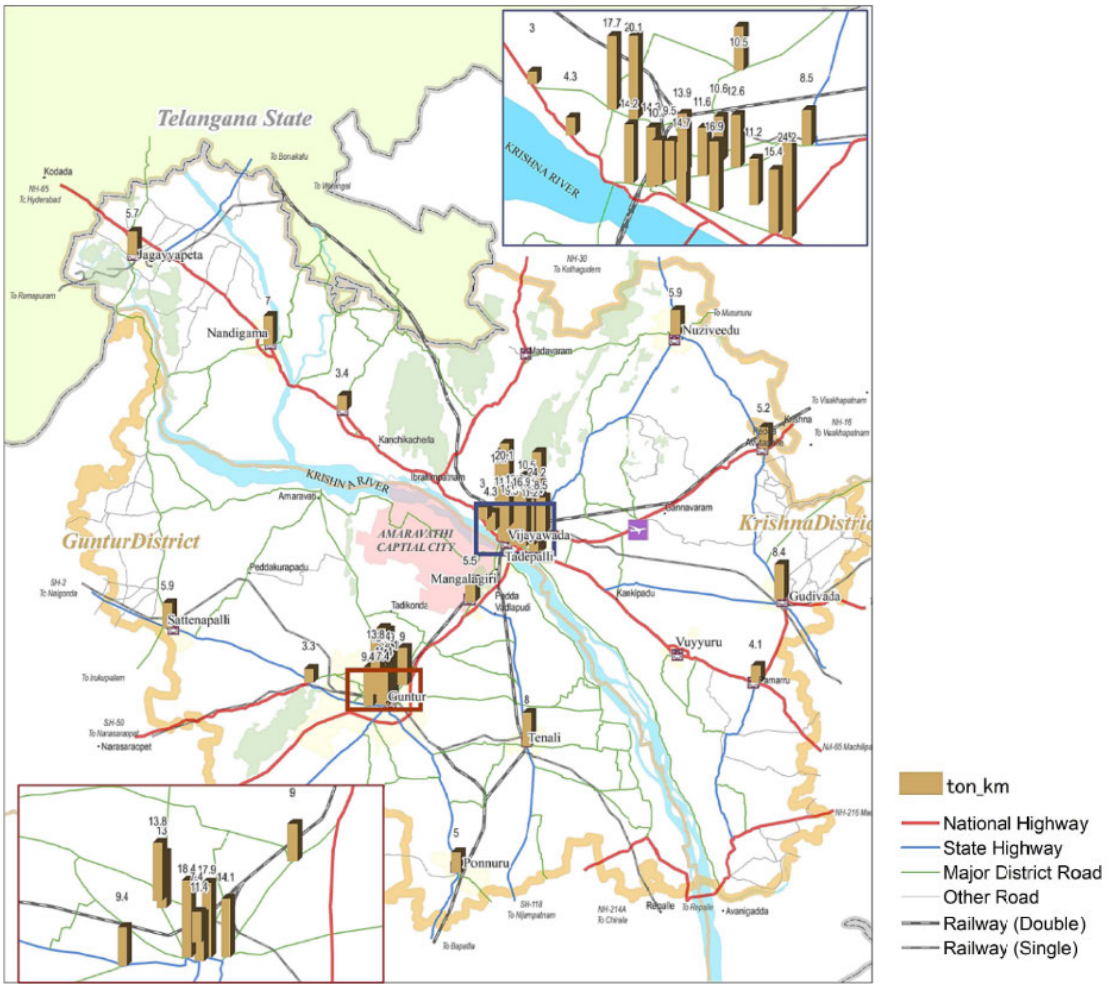
(3) Pollution levels

Existing pollution levels are mapped out based on the traffic survey conducted in the CMP/DMP 2016. Higher emission levels were found in Vijayawada and Guntur, indicating traffic volume and truck movement in and around the area. Both cities are on the list of polluted cities “non-attainment cities (NACs)” issued by the Central Pollution Control Board (CPCB) and the target of “Clean Air Action Plans” of Andhra Pradesh.

Table 3.17 Summary of pollution levels

Analysis component	Findings
Noise	Exceeding national standards in Vijayawada, Mangalagiri, Tenali, Vuyyuru, Nandigama, Gudivada
Air pollution	PM_{10} exceeding the national standard in Vijayawada
CO_2 emissions	High in Vijayawada and Guntur
Water quality	Mostly within the national standard (except for BOD)

Source: JICA Study Team



Source: JICA Study Team

Figure 3.70 Pollution levels

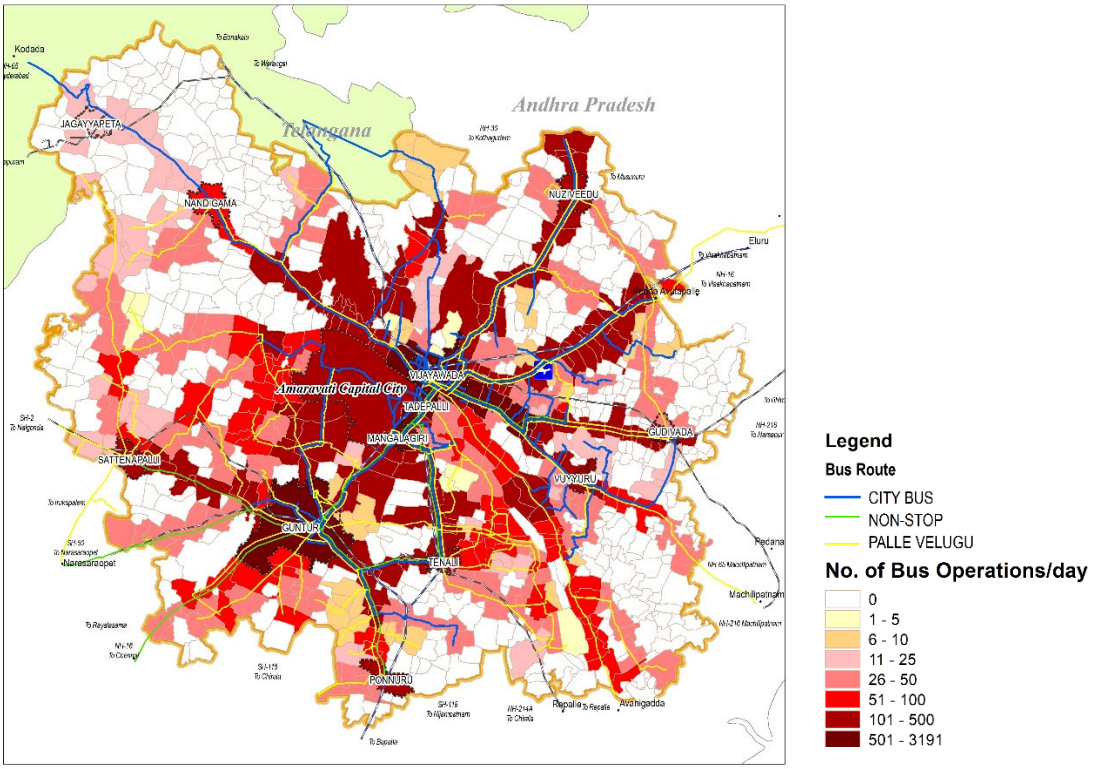
(4) Accessibility by area

Table 3.18 shows current accessibility by area in APCR and Figure 3.71 shows public transport service coverage. Employment opportunities, higher education, and government services are concentrated in Vijayawada, Guntur, and Tenali. Local bus services are concentrated in the central area and along roads connecting outer ULBs, except for Jaggayyapeta where only regional buses are available. Considering that most travel in the region is on foot, NMT, inter-city public transport links, and the NMT environment within the cities should be improved.

Table 3.18 Summary of accessibility by area in APCR

Analysis component	Findings
Government services	Vijayawada, Guntur, Tenali (General and District hospitals)
Job opportunities	Vijayawada, Guntur: few industrial areas

*HIS from CMP/DMP



Source: JICA Study Team

Figure 3.71 Bus transport service coverage

(5) Accessibility by income

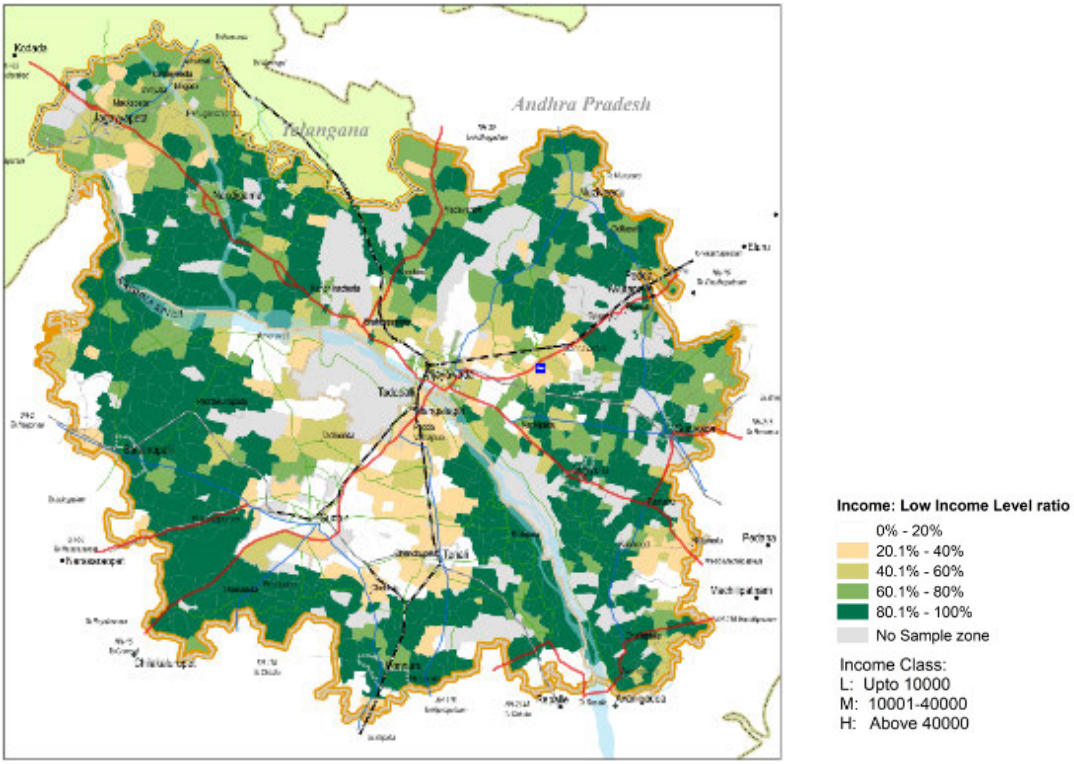
Large portions of APCR's low-income residents (less than Rs.10,000/household/month) are concentrated in peripheral areas. Since motorcycle ownership starts to increase as household income exceeds Rs.10,000/month and car ownership begins above 40,000/month (as shown in Figure 3.73), NMT and public transport are the primary modes for the majority of APCR's population.

Table 3.19 Summary of accessibility by income in APCR

Analysis component	Findings
Modal share*	Walking 36%, Bus & NMT 39%, Car 1%, 2-wheelers 24%
Low-income groups*	Walking 40%, trip length: 90% travel less than 1 km
Disabled groups	Public transport (bus) is not user friendly
NMT	Lack of footpath (parking, encroachment), no dedicated cycle lane

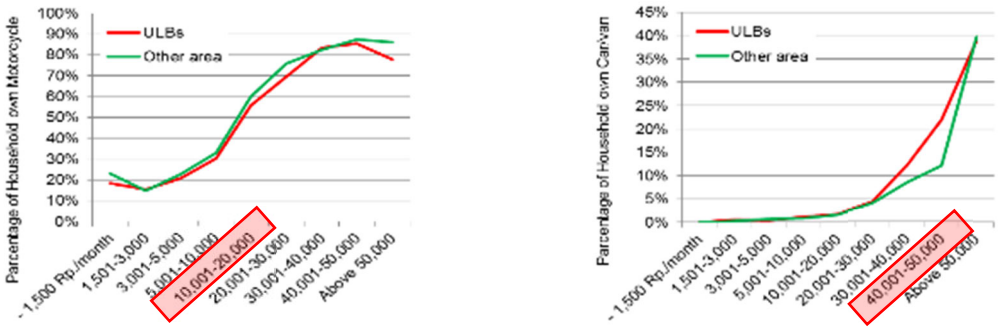
* HIS from draft CMP/DMP

Source: JICA Study Team



Source: JICA Study Team

Figure 3.72 Distribution of income groups



Source: HIS from draft CMP/DMP

Figure 3.73 Vehicle ownership by income group

3.11.2 Current environmental issues in the transport sector

(1) Road transport impacts on the environment

Improving transport connectivity can improve people's economic and social welfare via reduced travel times, lower costs, and increased access to markets, jobs, and education/health services. As roads are the dominant transport mode in APCR this usually means that more vehicles and better roads improve people's lives. At the same time, road transport also has significant negative effects on human life and the environment – from accident deaths to diminished health from air and noise pollution to global climate change. Other impacts include:

- Extraction of materials for infrastructure construction

- Emission of carbon dioxide and other greenhouse gases (GHGs)
- Motors vehicle wastes e.g. tires and fluids
- Wildlife habitat fragmentation
- Pollution and disruption of water systems

The environmental impacts of road transport span all facets from construction through daily operation – with the largest impacts generated by daily operations. However, efforts to curb impacts mostly focus on remedies before vehicles take to the road, e.g. improving vehicle technology and fuel quality.

(2) Vehicle pollution control

Trends and projections show that policies to reduce GHGs emissions have been more than offset by increased traffic volumes. The Central Pollution Control Board (CPCB) and AP Pollution Control Board (APPCB)[14] recommend that reducing emissions to reasonable levels can only be achieved by measures to address transport demand.

To reduce vehicle pollution, AP State now imposes an annual "green" tax of Rs.200 on all transport vehicles older than five years. For two-wheelers older than 15 years, the green tax is Rs.250 for five years; and for other vehicles, Rs.500 for five years. The Transport Department carries out random pollution control checks; vehicles not up to standard are subject to penalties.

(3) Road safety

AP ranks third in India for the highest number of road accidents, half of which occur on the 10,500 km national and state highway network. In 2009, AP had 24,730 accidents with 8,140 (32.9%) involving fatalities. By 2014, although the total had dropped to 23,512, fatalities increased to 33.4% with 47% of all accidents involving 2-wheelers or 3-wheelers.

To address road safety issues, AP State has formulated a road safety policy and established a Road Safety Council. The target is to reduce accidents by 30% over the next three years.

(4) Improving the urban environment for pedestrians, cyclists, and NMT

It is not easy to be a pedestrian in APCR, especially for the disabled. Footways are scarce, poorly maintained, and encroached by obstacles including utility poles, open drains, hawkers, and illegally parked vehicles. The good news is that the pedestrian environment can be vastly improved at a relatively low cost through the application of appropriate design standards, including shade trees, improved signage, signals, and crossing markers. The same applies to bicycles: cycle paths are cheap and easy to build.

Improving the environment for pedestrians and cyclists may be the quickest, easiest and cheapest means to achieving a dramatic improvement in life quality for communities across APCR: fewer accidents, less demand for motorized transport, health benefits from increased physical activity, and a more appealing look to urban spaces. This should be a high priority for each ULB.

At the same time, efforts are needed to make auto-rickshaws – a key mode in all communities –more friendly to users and the environment.

[14] AP Pollution Control Board (APPCB) was established in 1976 to lead the development and implementation of policies and strategies related to environmental management and climate change mitigation and adaptation.

(5) Impacts of road transport on inclusive and green growth

Inclusive growth calls for equitable allocation of resources to create opportunities for the whole community. An inclusive growth strategy should also enhance prosperity by expanding economic activities beyond the barriers of age, gender, identity, and geography. Investments in infrastructure including transport are critical enablers of required transformations such as private-sector development, job creation, and improved competitiveness.

Prioritizing inclusive growth also serves to unlock the potential of the private sector and promote effective community participation in infrastructure development. Green growth leads to the protection of communities from the social and environmental impacts of development, improved water, energy, and food security, and sustainable use of local natural resources.

The vision of the Transport Policy (TP) is to ensure the provision of modern and cost-effective infrastructure and services with due regard to safety and environmental concerns. In addition, the TP envisions that transport infrastructure should be developed sustainably to reduce transport constraints, promote sustainable economic growth and contribute to poverty reduction. TP strategies consistent with inclusive growth include:

- Encouraging the private sector to play a greater role in the development of infrastructure and provision of transport services
- Involving and supporting local communities in maintaining rural access transport.

(6) Impacts of road transport on sustainable development and equity

Transport strategy aims to harness a broad range of policy tools to achieve sustainable development and shift to more environmentally-friendly transport modes, especially for long-distance travel, in urban areas and on congested corridors. At the same time, each transport mode should be optimized to become more environmentally friendly, safe, and energy-efficient. Finally, multi-modality, or the efficient usage of different transport modes in combination, is critical to optimal and sustainable resource utilization. These measures offer the best way to achieve a high level of mobility and environmental protection.

Policies required to achieve these aims include:

- Enhance the use of enviro-friendly modes such as NMT
- Pricing measures to promote the use of public transport
- Improve transport efficiency: new tech and cleaner fuels to minimize environmental impacts
- Manage travel demand through better land-use and transport planning.

3.12 Key strategic transport issues

3.12.1 Fragmentation of transport and land-use planning

Regional economic transformation, employment creation, and export growth will require an inclusive regulatory and policy framework, implemented by institutions capable of providing quality transport services in collaboration with partners and civil society.

Currently, with many different AP State and national agencies having various responsibilities for transport and land-use planning, progress in these policy areas suffers from a lack of coordination among them. This has several effects:

- Transport networks are among the most permanent elements of cities, changing relatively slowly over time. Together with buildings and land uses, they shape the future form of cities. However,

in India, there is a disconnect between transport and land use. Planning and regulation of land use is a statutory function while transportation planning is not statutory.

- Several key national agencies – including the Town & Country Planning Organization (TCPO), Central Public Works Dept. (CPWD), Central Pollution Control Board (CPCB), Indian Roads Congress (IRC), and Institute of Urban Transport – play important roles in urban and regional transport planning under national jurisdiction, with no accountability to state governments.
- Many key pieces of legislation with important implications for urban transport are administered by Delhi – e.g. Motor Vehicle Act, Metro Construction Act, Jawaharlal Nehru National Urban Renewal Mission, Viability Gap Funding Urban Infrastructure Development Scheme for Small & Medium Towns, etc.
- Fragmented responsibilities between APCRDA and ULBs for project planning and building permit approvals have led to peri-urban sprawl with isolated developments and apartment blocks. Dispersing population densities frustrate efficient land-use planning and vastly complicates the provision of municipal services including public transport.
- Declining public transport share is exacerbated by ad hoc enforcement of planning regulations, especially in development-pressure areas near Vijayawada and between Amaravati and Guntur.

The MoUD/MoHUA Town and Country Planning Organization (TCPO) is advocating a shift away from separate land-use and transport planning approaches to close coordination between the two functions. State-level Transport Action Plans and programs are to be integrated with development plans to bridge the planning of transport projects with statutory land-use planning[15].

Other key institutional issues include:

- The specification of a regional road hierarchy to help underpin efficient land use and transport planning, and prioritize highway improvements, (incl. upgrading and new missing links) to alleviate strategic bottlenecks in light of predicted future traffic growth and composition.
- The introduction, monitoring, and periodic updating of comprehensive regional transport and traffic database to assess and manage road assets, e.g. data management systems like GIS
- Enhancement of knowledge transfer programs and use of private-sector expertise in road development and maintenance, including shared experience in promoting private-sector finance, PPP, etc. to enable road sector development
- Improved efficiency and increased staff capacity in road sector institutions, including training programs to upgrade skills and adoption of international best practices in highway and street design standards i.e., in relation to periodic updates of IRC codes.

3.12.2 National policy favors public transport as APCR modal share declines

Despite national transport policy that now favors a fundamental shift to public transport in response to rapid urban growth, in APCR the modal share of public transport is steadily declining.

APSRTC buses now provide the region's main public transportation. Its remit is to focus on urban and suburban bus operations to improve market share from para-transit, leaving long-distance and inter-state services largely in the hands of the unregulated private sector.

[15] Ministry of Urban Development, Town and Country Planning Organisation, Urban and Regional Development Plans, Formulation and Implementation (URDPFI) Guidelines, Volume 1, January 2015

Although private operators provide a major share of long-distance services, they lack terminals and depots, authorized bus stops, and other customer facilities. As this sector is fragmented, there is no accurate data on passenger numbers carried or service quality. More data and studies on the private-sector bus market are needed to better understand the issues.

Furthermore, as Indian Railways is focused on freight and long-distance passenger services, APCR lacks adequate suburban/regional services despite having an extensive rail network. Consequently, and due to bottlenecks from Vijayawada Junction through the Krishna River rail bridge, alternative transit options including BRT, LRT, and MRT/Metro are being considered to meet the demands of APCR's rapidly-growing cities.

3.12.3 Obstacles to connectivity between Amaravati and the wider region

Providing APCR with a sustainable and inclusive future transport network will require a much higher level of public transport service region-wide. And new transport initiatives will need to be carefully integrated with existing road and rail networks.

To this end, rationalization and prioritization of the many major transport projects proposed since APCRDA was set up in 2014 are urgently required. Many of these proposals address specific modal demand-side problems such as bridge or station capacity constraints, rather than wider regional needs resulting from the growth dynamics created by plans for the new capital city.

Prioritization is important because the two key development areas (Capital City and the metropolitan ULBs) are to a large extent evolving independently: the Capital City is being planned as a world-class compact city with a high level of public transit networks including BRT, Metro, E-buses and water taxis, while the development of highways and public transport services in the existing ULBs and surrounding rural areas is following a more incremental and problem-based approach.

The extent to which the Capital City's proposed public transport service standards and norms can be replicated throughout APCR (including minimum travel demand requirements for first/last mile connectivity), to create a seamless, equitable, and inclusive public transport network will be a significant challenge. Transport model analyses of existing and predicted future strategic transport and traffic conditions will assist in this process.

With the 2014 enactment of the APCRDA Act, the region's land-use planning functions were absorbed by CRDA while a Unified Transport Authority (APCRUTA) was created soon after to ensure effective implementation and coordination of various traffic and transportation measures being planned or undertaken by APCRDA and other government bodies in APCR. As such, it is incumbent on APCRDA to ensure land-use and transport planning are done in harmony. APCRDA must take the lead in integrating regional transport planning with land-use planning.

3.12.4 Capacity constraints to Amaravati-Vijayawada connectivity

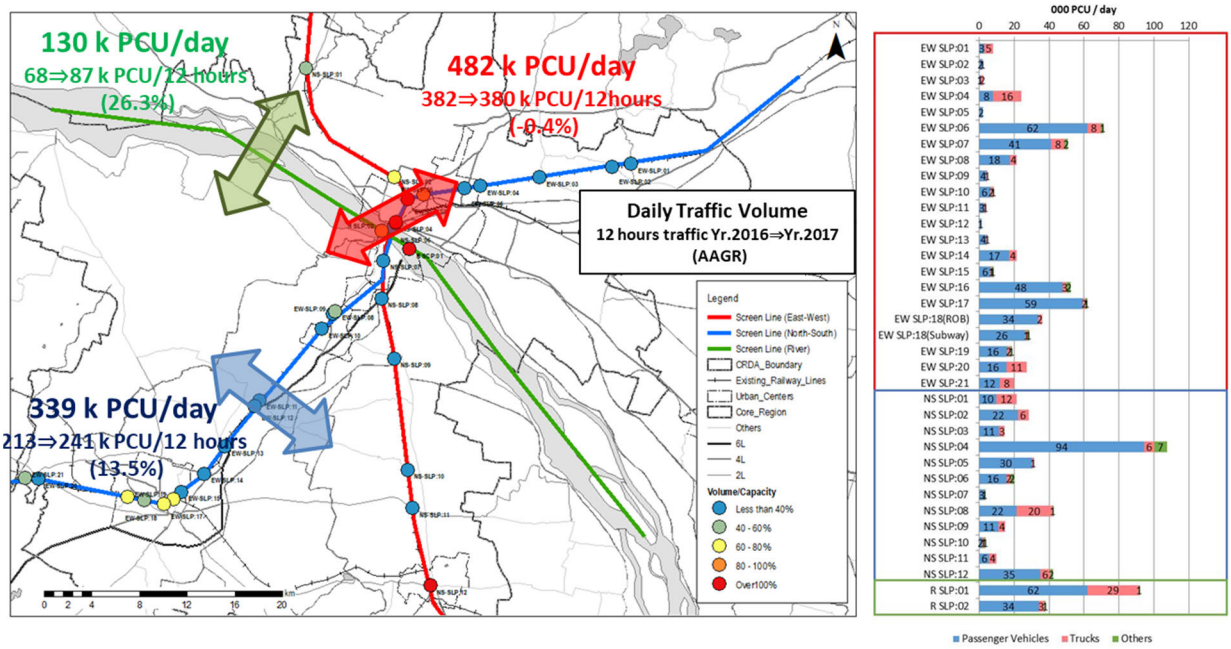
A more specific and urgent challenge is the barrier imposed by the Krishna River on the efficient road and rail connectivity between Vijayawada and the Capital City: currently limited to two road bridges (Prakasam Barrage and NH16) plus twin rail crossings for lines to/from Chennai.

The two-lane Prakasam Barrage bridge is weight-restricted to light-vehicle use only (no trucks nor buses) due to its age and condition, while the NH16 crossing is a 4-lane road on a 6-lane structure. The result is extremely heavy congestion.

As capital city construction increases, truck traffic on the Varadhi bridge will greatly amplify congestion. Plus, rail passenger and freight capacity from Vijayawada Junction through the river crossing is already overloaded.

Severe traffic congestion imposes serious negative social, economic, and environmental impacts: lost productivity as people sit in traffic jams, higher freight costs increased fuel use and emissions from idling vehicles – and more. Following are some key data points related to the river barrier:

- Total traffic flow crossing the outer cordon/APCR boundary (257,000 PCU/day) is growing at 7.4% per annum (AAGR)
- In total traffic flow, modal shares are passenger vehicles 79% and trucks 19%.
- Of truck traffic, 27% (36,000 PCU) is through traffic (i.e. origin and destination are outside APCR)
- Traffic volume crossing Krishna River exceeds road capacity (V/C=108% (130,000/120,000 PCU/day))



Source: CMP/DMP (2016) / CTTS (2017)

Figure 3.74 Key findings from screen line traffic surveys

Regional traffic

- 257,000 PCU/day crossed outer cordon (APCR boundary): AAGR 7.4%
- 36,000 PCU trucks (27% of all trucks) passed through APCR
- NH16 is a major freight artery to Vizag and Chennai. (22,000 PCU trucks passing through)
- Vijayawada & Guntur Auto Nagars and AMC Guntur are major cargo generators
- Modal share based on HIS in CMP/DMP is: NMT: 43.5%; Motorcycles: 24.3%; Auto: 15.6%; Public transportation 15.3%

Metropolitan area

- The NH16 Varadhi bridge over the Krishna River is operating over capacity (V/C=108%)
- The highest trips are observed on NH16 between Vijayawada-Mangalagiri (126,000 trips/day)
- NH16, NH65, and roads around Vijayawada Station over rail corridors are congested.

To support the successful socio-economic growth of the new capital city, it will be essential to upgrade existing highway and public transport networks with rail transit and upgraded roads between existing ULBs, key employment hubs, and the airport.

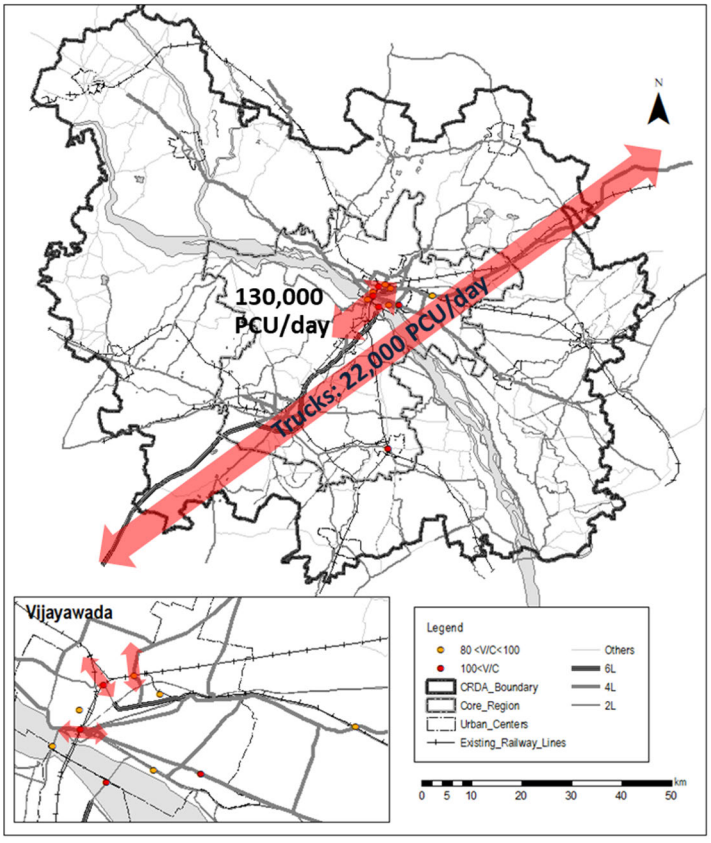
Trends indicate that by 2050 there will be demand for additional highway and transit services as well as road and rail crossings over the Krishna:

- To improve public transport connectivity between Vijayawada, Amaravati, and Guntur
- To relieve capacity constraints for long-distance truck traffic on NH16 and rail passenger and freight traffic through Vijayawada Junction and Krishna Canal Junction.

The proposed Dedicated Freight Corridor (DFC) bypassing Vijayawada and Krishna Canal could free up some capacity for urban commuter rail services between Guntur, Tenali, and Vijayawada.

3.12.5 Bridge capacity

In addition to rail crossings, two road bridges connect Vijayawada with the south bank of the Krishna River: one old 2-lane crossing from which buses and trucks are prohibited, and a modern 4-lane NH16 bridge. Current sanctioned bridge proposals would add four roads, one rail, and one LRT bridge. Along a 23 km stretch of the river, this would provide six roads and three rail/LRT bridges. By comparison, London and Tokyo each have 13 road bridges over the same distance (excluding rail-only bridges/tunnels).



- Traffic is growing by 7% per annum
- Bridge capacity is already saturated
- Within 10 years flows may double

Additional crossing capacity is urgently required!

Year	Volume (PCU/day)	Capacity (PCU/day)	Required additional no. of lanes
2017	130,000	120,000	1
2020	150,000	120,000	2
2030	245,000	120,000	7

* Tentatively assuming AAGR of 5%
* Note: Due to weight/load restrictions, heavy trucks and buses are not permitted to use Prakasam Barrage Bridge over Krishna

Source: JICA Study Team

Figure 3.75 Key findings and implications from traffic surveys

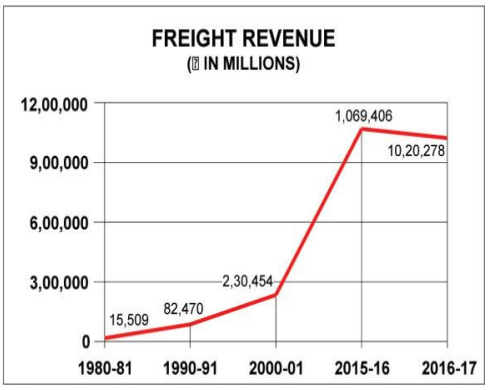
3.12.6 Making public transport financially sustainable

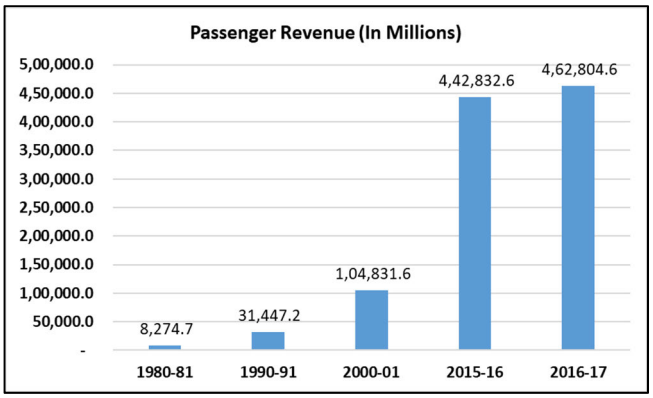
To be financially sustainable, public transport must offer users a network of services that takes them efficiently and comfortably wherever they need to go. This "network effect" is critical to attracting new users, building market share, and increasing revenues. When done effectively, this can reduce traffic

congestion and improve quality of life by reducing air and noise pollution. To achieve this, APCR needs to make many improvements, starting with existing bus services.

APSTRC buses now mainly operate 'point to point', with few transfer options short of the main terminals. Transfers en route tend to be difficult given little effort to make them convenient. Consequently, few routes are profitable. Not that public bus services can realistically aim for all routes to be profitable, or even the overall operation. In most countries, public transport is subsidized. In this country, Indian Railways subsidizes 43% of the cost of passenger operations, partially compensating for this with freight revenue.

It is a question of balance: attracting sufficient fare revenue to minimize the need for public subsidies – validated by healthy market share and good customer satisfaction numbers. Generating non-fare revenues via commercial facilities at terminals can also boost financial results.





Source: JICA Study Team

Figure 3.76 Indian Railways revenue - freight and passengers

At the same time, APSTRC faces a challenge in the growth of private vehicles. In AP State, private ownership of motorcycles and cars is growing by 9-12% annually. And as ridership falls APSTRC has shrunk its bus fleet – down 19% in 2016. Growing traffic congestion is also negatively affecting bus operating costs and making bus travel less convenient.

Again, however, the main issue is not simply profitability. Rather, it is providing a sufficiently convenient and competitive service to divert private vehicle traffic to transit to reduce congestion and negative environmental effects service and provide inclusive mobility for all citizens.

Table 3.20 AP State: composition of vehicle fleet 2014-16 (consolidated for 13 districts)

S/No.	Category	2014	2015	2016
1	APSTRC buses	2%	6%	-19%
2	Private buses	-2%	11%	80%
3	3-wheel goods carriage	13%	13%	12%
4	Trucks	8%	9%	9%
5	Maxi-cabs	15%	7%	6%
6	Other cabs	6%	5%	5%
7	Auto-rickshaws	12%	12%	11%
8	Contract carriages	7%	9%	5%
12	Motorcycles	10%	12%	10%
13	Motor cars	11%	11%	9%

Source: JICA Study Team

In public transport network planning, the optimization of direct travel options vs. trunk/feeder design to improve resource efficiency is an ever-present dilemma. As users dislike having to transfer, reducing the need for them is always an important goal. Still, adverse user reactions to bus transfers can be mitigated by:

- Single-ticket operation (no cost penalty for transfer)
- Improved physical facilities to make transfers less inconvenient
- Creating positive benefits such as transfers to a priority bus service, or offering a wider range of destination options at the transfer point.

3.12.7 Para-transit/intermediate public transport (IPT) improvements

While APSTRC buses can be considered the backbone of public transport in APCR, private sector-operated para-transit/auto rickshaws carry by far the majority of passengers in the major cities and towns. Auto-rickshaws are the prime movers of passenger services but they are not very productive due to their limited radius of operations and traffic density, making only about 10 trips per shift (around 150 passengers per shift).
Quality of services relies largely on the drivers and there is little if any institutional mechanism to monitor or improve quality – safety and security are perennial concerns. Auto-rickshaws are only allowed to operate in the particular jurisdiction where they are registered, and numbers in each jurisdiction are limited. They operate from informal auto stands that lack facilities.
Para-transit fulfills needs that neither public transport nor personalized transport vehicles can meet: mainly 'last-mile' trips, e.g. to railway stations or bus stands.
However, when public transport quality deteriorates, paratransit/IPT tends to be the substitute mode, which is evident in APCR. Unofficial estimates suggest IPT carries more passengers in Guntur and Vijayawada than APSRTC. And as the aging fleet of APSRTC buses struggles to compete with IPT in urban areas this mode becomes more dominant; while in rural areas local demand is mostly met by auto-rickshaws.
Going forward, the best course would be for auto-rickshaws to become more enviro-friendly and a more sophisticated transportation mode. How to achieve this needs to be considered further.
While IPT/para-transit plays an important role as feeder services, excessive numbers of small vehicles on major road arterials cause congestion. So they should not be considered a long-term substitute for higher-capacity, more efficient buses or rail. As IPT/para-transit is a fragmented industry, there is no reliable data on passenger volumes or service quality, so there is a need to study the sector in more detail. In the meantime, policy should seek to normalize the role of IPT/para-transit within a comprehensive, integrated public transport network.

3.12.8 APCR's logistical advantages and disadvantages

Within India, APCR occupies a strong position as a logistical hub as the junction point between two main National Highways and two key Indian Railways freight lines. And its advantages will grow with the expansion of VGA airport's cargo capability and, especially, the construction of two IR Dedicated Freight Corridors (DFCs) paralleling the existing rail lines that meet in APCR.

The DFCs will accommodate longer, heavier trains operating at speeds up to 100 km/h and, critically, double-stack container trains. In North America, the introduction of fast, 125-wagon double-stack container trains (capable of carrying 500 40-foot containers) radically changed logistical economics, giving U.S. and Canadian railways an edge on trucks for journeys over 1,000 km. In India, the DFC network can be expected to give IR a similar advantage, allowing it to regain market share lost to trucks. That advantage is likely to benefit APCR, located as it is relatively distant from the main Delhi-Mumbai corridor. So in the future APCR will be logistically well-placed in the national economy.

In the global economy though, APCR is at a disadvantage relative to neighboring Bay of Bengal cities like Chennai and Vishakapatnam in that it lacks a major ocean port – and specifically a container port. For global manufacturers seeking low-cost production sites, proximity to a major container port is an almost overwhelming consideration. Chennai's container and RO/RO (roll-on/roll-off) port facilities were pivotal to its ability to attract major plant investments by several global automakers, including Ford, Nissan/Renault, FCA, Hyundai, Daimler, and BMW.

If APCR did have a major container port, it would be well-placed to connect with the economies of ASEAN and East Asia – 3,000 km or 80-hours sailing in a straight line to Singapore. While efforts are underway to build new port facilities at Machilipatnam, adjacent to APCR, as this is not a natural deep-water port it may be difficult to accommodate large container vessels. As current port plans mainly revolve around bulk cargoes, Machilipatnam's competitive strength could be boosted by links to an improved inland waterway system allowing bulk commodities to be cheaply shipped to/from sites in the hinterland. Although National Waterway 4 has been identified for development there are obstacles to overcome, including low bridges and seasonally low water levels.

3.12.9 Enforcing traffic/transport regulations

As mentioned earlier, AP ranks third in India for the highest number of road accidents, half of which occur on the 10,500 km national and state highway network. In 2009, AP had 24,730 accidents with 8,140 (32.9%) involving fatalities. By 2014, although the total had dropped to 23,512, fatalities increased to 33.4% with 47% of all accidents involving 2-wheelers or 3-wheelers. To address road safety issues, AP State has formulated a road safety policy and established a Road Safety Council. The target is to reduce accidents by 30% over the next three years.

Overloading of trucks is also a growing nationwide problem as the number of multi-axle trailers is increasing along with the economic incentive to overload. In response, five weigh-stations are proposed at the state borders, with the first three at Puroshothapuram (Srikakulam District), Bheemunivaripalem (Nellore District), and Naraharipet (Chittoor District). These are to be operated under a PPP scheme.

3.12.10 Intelligent Transport Systems (ITS) for better traffic management

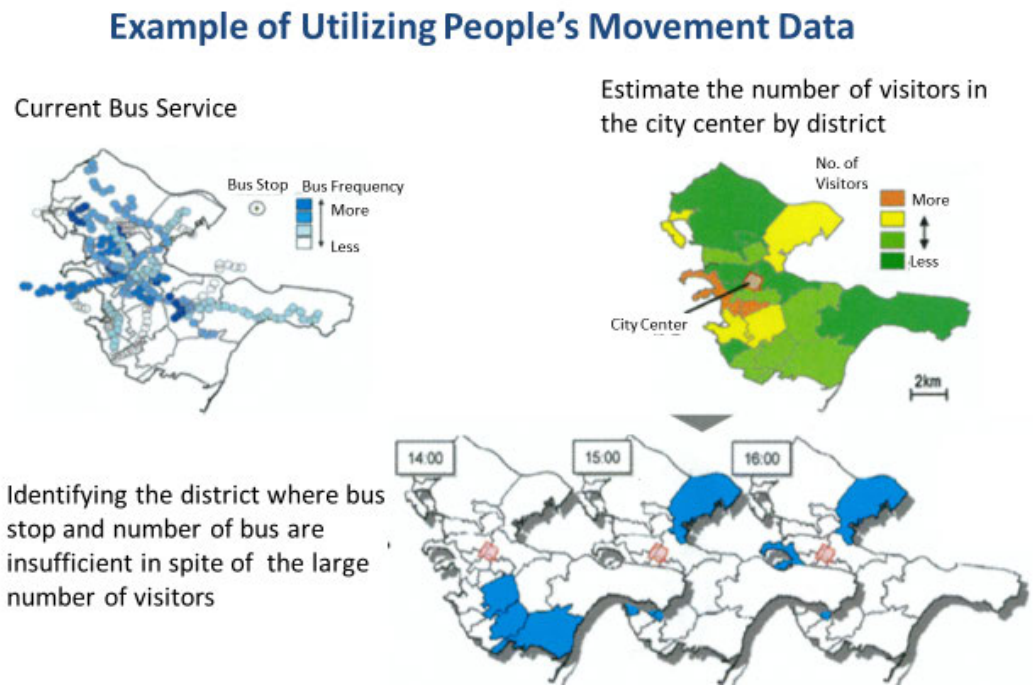
ITS is a catch-all term for IT-based measures to monitor, synchronize and regulate traffic flows – at the most basic level controlling traffic signals to ensure traffic flows smoothly. At a higher level, ITS monitors and records traffic flows over time to create databases that support machine learning to analyze traffic problems and devise solutions. Currently, APCR has no effective capability to do any of this. But according to JST observations, Vijayawada and Guntur both urgently require modern ITS-based traffic management systems.

Source: JICA Study Team

Figure 3.77 Video incident detection system

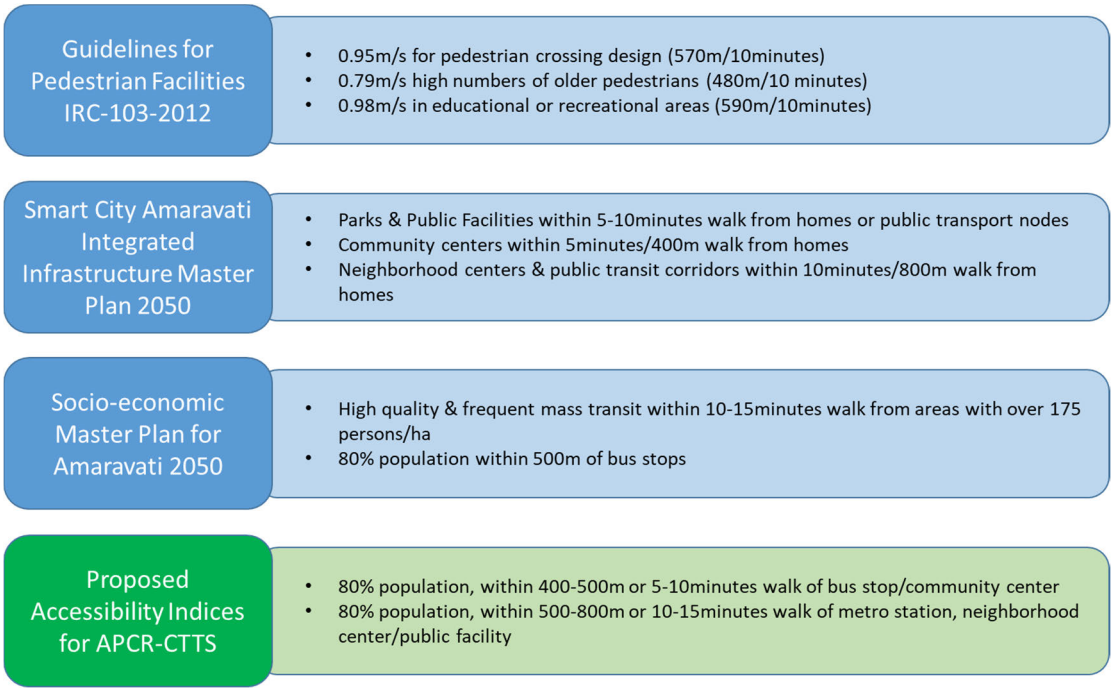
The first step is to make the best use of existing transport assets, for example supporting existing traffic signals with basic ITS capability. Longer-term, APCR should work towards the establishment of an area-wide traffic information and control center (TIC) focused initially on the most congested parts of Vijayawada and Guntur before gradually expanding to cover all 12 ULBs. This should be coordinated with the state-of-the-art ITS plan for Amaravati.

To plan and implement ITS infrastructure, APCR will need an organizational structure under which AP State, APCRUTA, APCRDA, Traffic Police, etc. can effectively collaborate.



Source: JICA Study Team

Figure 3.78 Examples of ITS data usage



Source: JICA Study Team

Figure 3.79 Accessibility policy criteria, design standards & monitoring indicators

3.12.11 Reorienting ULB urban transport planning

As APCR's 12 ULBs vary greatly in terms of population, area, topography, urban form and constraints, economic activities, and income levels, the design of future transport systems must reflect their specific features. Further, as transport planning is intrinsically linked to land-use planning, future transport networks and land use need to be synchronized to serve the entire population equitably and inclusively.

Vijayawada and Guntur have serious and unique traffic problems that must be addressed in a timely and holistic manner. These problems are often compounded by constraints that limit alternatives such as bypass alignment options for highways and railways. For example, the area north of Vijayawada railway station/PNBS is dissected by railway corridors, power lines, and steep slopes. Meanwhile, Gudivada, Ponnuru, and Sattenapalli suffer heavy congestion due to inadequate road width. The guiding principles for ULB transport plans should be:

1. Planning a future transport system that complements and supports the CMP/DMP and ensures that each ULB has the best possible transport system for its future population.
2. Coordinate activities of government agencies with transport responsibilities in the ULB area, and also private-sector activities, so that efforts are well-integrated.
3. Assist all levels of government in identifying, mobilizing, and prioritizing necessary resources to implement transport proposals at the ULB level.
4. Complement strategic transport planning at the APCR level, so major transport developments and funding programs are properly integrated at the local level. Also, to provide local inputs to inform and influence strategic plans.
5. Ensure that ULB transport plans are broadly supported by the local population and stakeholders.

ULB urban transport plans are primarily coordinating mechanisms to help various stakeholders organize and coordinate efforts in the transport sector. While plans will be formally approved by APCRDA, implementation will be primarily by agencies at the local level, especially municipalities and other

government agencies with transport responsibilities (such as Traffic Police, Roads & Buildings Department, APSRTC, Indian Railways, and others).

Where problem- or site-specific solutions to alleviate traffic congestion are put forward, these can sometimes exacerbate other area problems. For example, one of the most critical highway junctions in the region is Benz Circle in central Vijayawada where NH16, NH65, and Bandar Road (MG Road) intersect with high volumes of trucks through traffic throughout the day. To tackle this problem, a new NH16 grade separation is under construction. But this solution will likely increase traffic volumes with knock-on effects on the capacity of the NH16 bridge over the Krishna River. As such, the urban transport environment along NH16 and NH65 in central Vijayawada may not be better than before.

In public transport, the lack of integration between bus and rail services remains a key challenge region-wide. Some ULBs do not have bus links to local railway stations, while others (Vuyyuru, Nandigama, and Nuziveedu) have no rail connectivity at all. These challenges need to be addressed.

In developing future transport plans, attention needs to be paid to channeling or structuring future urban growth around a pre-planned public transport network, to support the provision of efficient, comfortable, and convenient public transport, IPT, and NMT travel modes. Regional and Urban Transport Plans (UTPs) should therefore enable each ULB to pursue an urban form that best suits its location, its economic activities, and the aspirations and travel requirements of its residents.

Table 3.21 ULB strategic connectivity

S. no	ULB	National highway	State highway	Railway	Bus (intracity)	Rapid transit	Remarks
1	Vijayawada	Yes	Yes	Yes	Yes	No	- Partial BRT network exists but is not in use - Metro/LRT/BRTS study in progress
2	Guntur	Yes	Yes	Yes	Yes	No	- Intra-city buses are privately operated buses
3	Tenali	No	Yes	Yes	No	No	
4	Mangalagiri	Yes	Yes	Yes	No	No	
5	Tadepalle	Yes	No	Yes	No	No	Railway Station: Krishna Canal Junction
6	Gudivada	Yes	Yes	Yes	No	No	
7	Nuziveedu	No	Yes	Yes	No	No	
8	Sattenapalli	No	Yes	Yes	No	No	
9	Ponnuru	No	Yes	Yes	No	No	
10	Vuyyuru	Yes	No	No	No	No	
11	Nandigama	Yes	Yes	No	No	No	
12	Jaggayyapeta	Yes	Yes	No	No	No	

Source: JICA Study Team

Chapter 4 The emerging land-use planning framework

4.1 Introduction

The National Urban Transport Policy (NUTP 2014) now requires an integrated, holistic approach to planning transport and land use. The aim is to develop both systems in concert to serve each region's population; prioritize public transport connectivity, and minimize the need for private motorized travel.

Guided by this, the Scope of Work for APCR-CTTS identified the importance of harmonizing the CTTS with the following land-use plans: i) the Draft Perspective Plan (DPP) 2050 for APCR; ii) the Capital Region Plan & Report and (Capital) City Master Plan (CMP), and iii) the APCR Interim Draft Concept Master Plan/Detailed Master Plan (CMP/DMP).

4.1.1 Previous land-use plans – VGTM UDA Master Plan and ZDPs

Before the above land-use plans were drafted in 1988, the Vijayawada, Guntur, Tenali & Mangalagiri (VGTM) Urban Development Authority (UDA) prepared a Master Plan for the area including the four larger municipalities plus 147 surrounding villages (total area of 1,665 km^2) in the Krishna and Guntur districts. Its stated objective was to plan for the healthy development of the region.

The Master Plan, with a 15-year time horizon (i.e., to 2001), analyzed the existing situation (demographic, physical, social, cultural, spatial, transport, etc.), and highlighted various issues like housing shortages, growth of slums, deficiencies in physical and social infrastructure, traffic and transportation, migration, pollution, etc. The plan put forward broad proposals and solutions with respect to land-use allocations, zoning regulations, traffic, and transportation needs, identifying and developing satellite towns, conservation of water bodies and agricultural lands, etc.

In 2004, 39 more villages in Krishna and Guntur districts (total area, 288.98 km^2) were added to the UDA area, bringing it to 1,954.6 km^2. VGTM UDA also drafted more detailed Zonal Development Plans (ZDPs) for 27 planning zones and a Master Plan for the newly added area. These ZDPs were prepared in two phases and approved in 2006 and 2008, with horizon periods of 2021 and 2031. They remain in force as regulatory land-use plans through their horizon dates.

In 2014, following state bifurcation, the Government announced the new state capital, Amaravati, and established the Capital Region Development Authority (APCRDA). As this new body superseded VGTM, it proceeded to prepare new regulatory regional and urban land-use plans.

4.1.2 APCR Draft Perspective Plan - 2050

The "Draft Perspective Plan - 2050 for Andhra Pradesh Capital Region" (DPP 2015) and the complementary "Capital Region Plan and Report" (2015) are long-term strategic plans that set out goals, policies, strategies, and programs for socio-economic development in line with government policies. The DPP/Region Plan includes proposals for land use, infrastructure, transportation, and socio-economic development up to 2050, with proposed revisions every ten years. The plan also details the planning direction and strategies for APCR with a stated vision to create a "People's Capital of Andhra Pradesh."

The DPP proposed a planning framework based on a 2035 forecast of 11.25 million population and 3.36 million employment, rising to 13.8 million population and 5.65 million employment in 2050. Population projections were based on eight planning areas (or zones) across APCR: the Central Planning Area, including Vijayawada and Mangalagiri, was forecast with the highest (gross) population density, exceeding 5,000 per km^2. Each planning area was centered on a key town/city designated as a "regional center" with employment generation clusters. These regional centers were connected to the Capital City via seven development/economic growth corridors.

Table 4.1 APCR: DPP population forecast, 2011-2050

Target year	Present (2015)	2035	2050	Beyond 2050
Population (million)	6.05	11.25	13.80	20
Average annual growth rate (%)	—	3.15	2.38	—

Source: Draft Perspective Plan - 2050, APCRDA, 2015. Growth rates are calculated by JST.

Regional centers: Seven existing urban centers within a 30-55 km radius of the Capital City were designated as "regional centers," each surrounded by wider planning areas. These regional centers were seen as a way to decentralize the functions and services of the Capital City, helping to alleviate congestion and bring employment closer to peoples' homes.

Better regional connectivity: Expressways, ring roads, and transport corridors were proposed to provide faster connections within APCR. Major projects proposed include:

- Outer Ring Road
- Inland waterway
- Suburban rail
- Dedicated Freight Corridor (DFC)
- High-Speed Rail

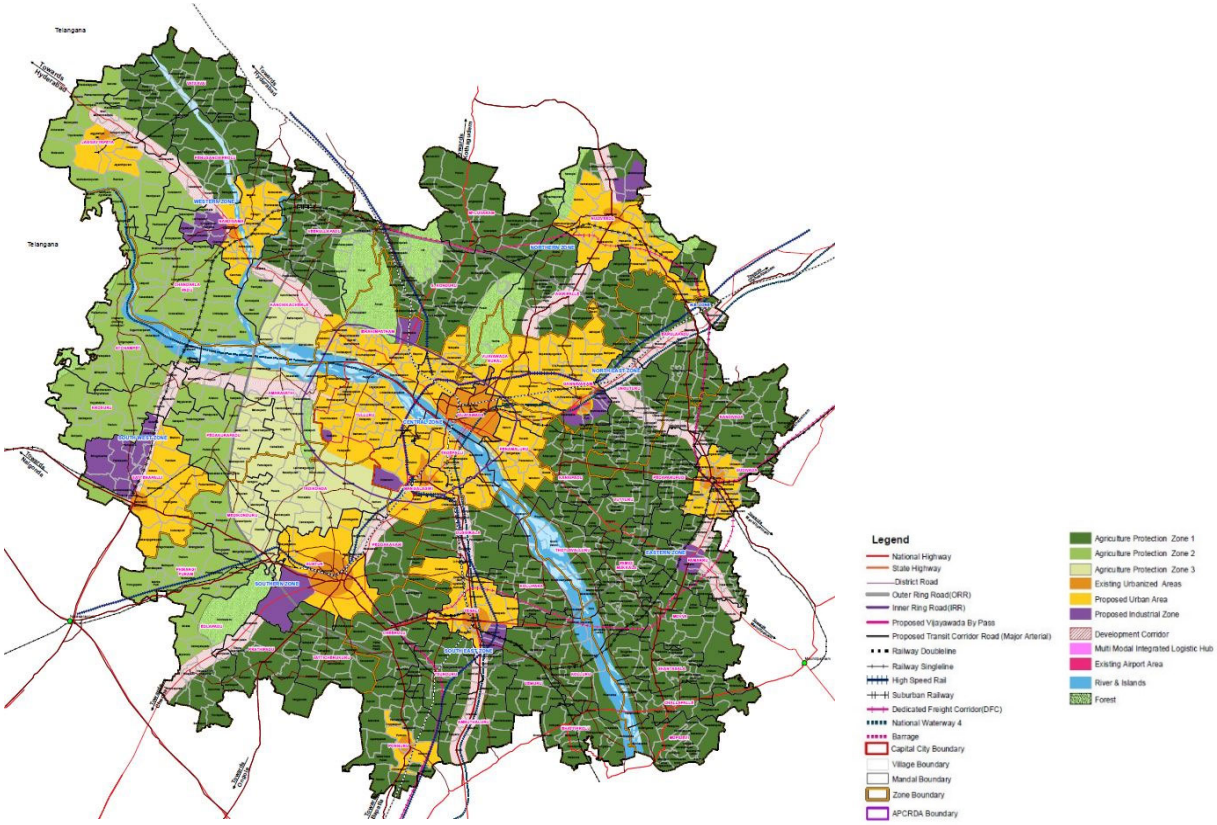
Development corridors: Seven development corridors (aka economic growth corridors) were proposed to connect the Capital City with the regional centers. These were meant to create opportunities for linear developments with "Special Use Developments" such as clean industries, infrastructure projects, and logistics-based activities.

Protected agricultural zones: Key farming areas were earmarked for protection from development to curb urban sprawl and protect prime agricultural lands.

Industrial development: Based on perceived locational advantages, various nodes were identified as promising sites for various industrial sectors.

To achieve the Capital Region vision, the DPP set medium- and long-term goals for six critical development sectors: 1) Jobs & houses for all; 2) World-class infrastructure; 3) Quality living; 4) Identity & heritage; 5) Efficient resource management, and 6) Clean & green.

The DPP also laid out a set of "Draft Policy Guidelines" to guide future development in specific land-use zones. These guidelines were to apply to the entire region under the 2014 APCRDA Act.



Source: JICA Study Team

Figure 4.1 APCR: Draft Perspective Plan (DPP) 2050

4.1.3 Conceptual Master Plan & Detailed Master Plans (CMP/DMP) for APCR – 2035

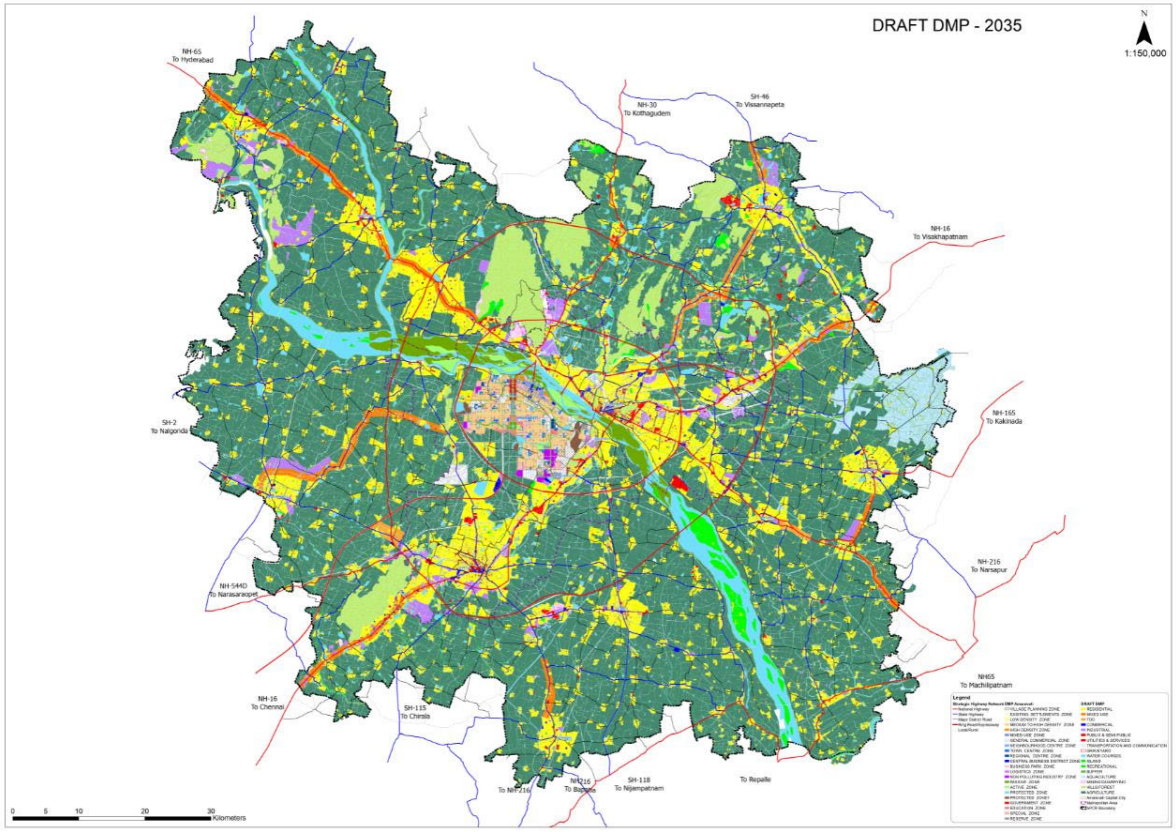
Following the DPP and draft Regional Plan, a more detailed (Interim Draft) Concept Master Plan (CMP-2017) and Detailed Master Plan (DMP-2017) were produced for areas surrounding the Capital with a planning horizon of 2035.

A City Master Plan and Report for the Capital City were prepared at the same time (see below). The CMP/DMP area comprised a Core Region, an Extended Region, and a Peripheral Extended Region with a combined 2011 population of 5.87 million.

The draft CMP/DMP strategies and broad proposals for the development of the region are:

- Planning strategy focused on polycentric rather than typical monocentric development with the region divided into eight planning areas, each with a major urban center spatially well-located, resulting in overall regional development without any disparity
- Develop growth centers and sub-centers outside Vijayawada and Amaravati to reduce congestion and rapid urbanization in the core area and enable overall dispersed development
- Provide sufficient job/housing opportunities across the identified growth centers to ensure desired spatial growth

- Promote diverse economic opportunities and industrial clusters across the growth centers to generate employment opportunities and enhance the economic balance of the region
- Propose development/economic corridors along major highways where the potential for economic growth is high and without any adverse effects
- Strengthen existing road network and major transportation corridors, e.g., ORR, IRR, Rail network, etc., to facilitate development across the region
- Strengthen links and network connectivity between lower-order and higher-order settlements to sustain each other
- Promote compact, high-density development in identified urban centers
- Promote transit-oriented development across the region
- Conserve prime agricultural land for food production; build on the region's agro-based economy
- Preserve natural features (hills, forests, water bodies, etc.) but permit some uses that do not adversely affect the environment
- Strategically allocate various land uses to achieve sustainable development.



Source: APCRDA

Figure 4.2 APCR Draft DMP, 2035

4.2 Master Plans for Amaravati Capital City

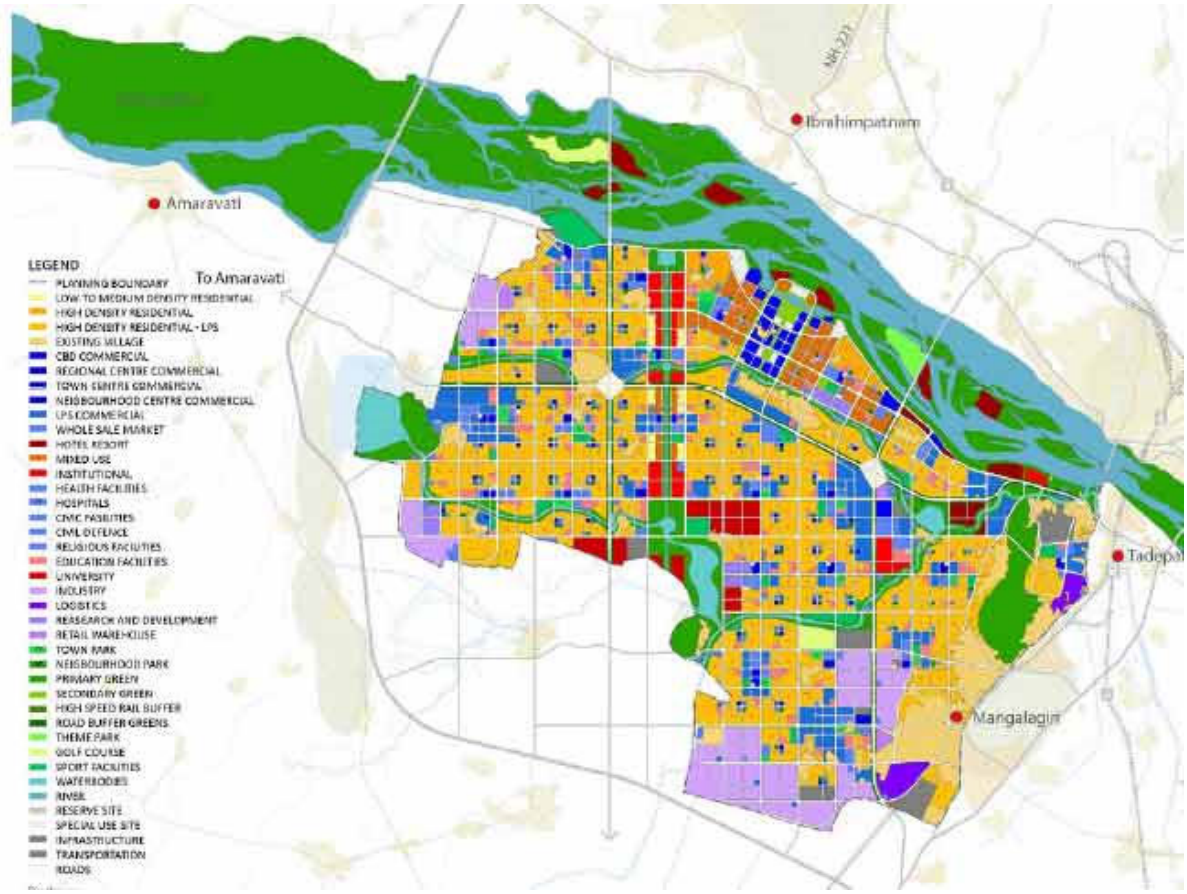
4.2.1 Conceptual Master Plan and Detailed Master Plan for Amaravati

The new city of Amaravati, envisaged in the CMP as a capital of international stature, is being constructed on 217 km^2 of predominantly flat, open land. The site on the western bank of the River Krishna, opposite the commercial and trading hub of Vijayawada (2011 pop. 1.03 million), is located at the center of the eastern coastal belt with good accessibility to rail, highways, airport, and inland waterways networks. In February 2016, the Detailed Master Plan for Amaravati (DMP) was formally approved and notified by the state government as a statutory document.

Table 4.2 Amaravati Capital City: Population forecast, 2011-2050

Target year	Present (2011)	10 Years (2025)	10-20 Years (2035)	20-35 Years (2050)
Population (million)	0.1	0.80	1.71	3.88
Annual average growth rate (%)	—	7.73	6.13	7.10

Source: Detailed Master Plan, APCRDA、Population in 2050 was later modified. Annual growth rate calculated by JST.



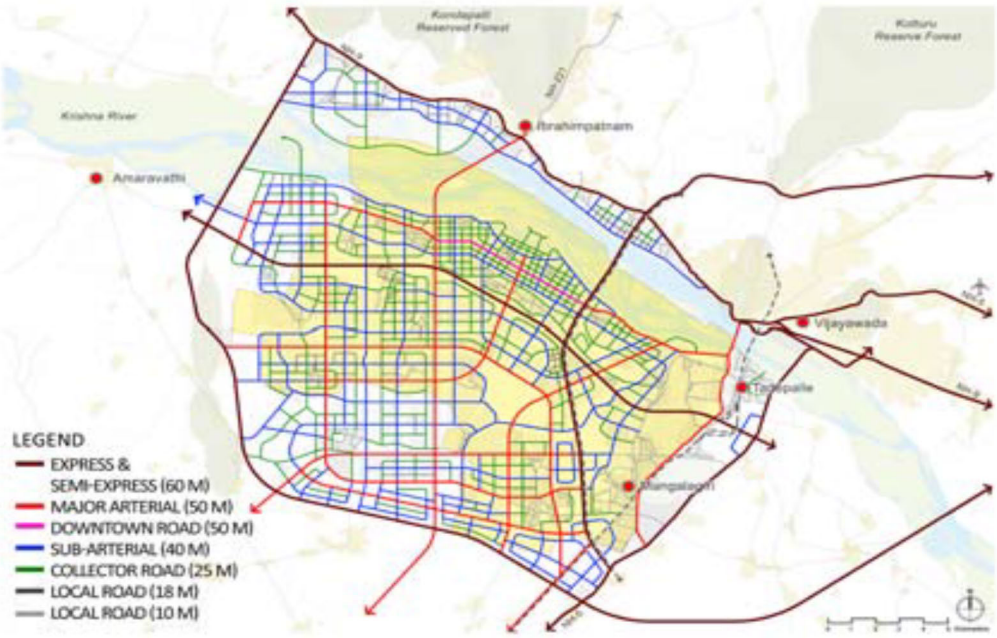
Source: Amaravati Capital City: Detailed City Master Plan

Figure 4.3 Amaravati Capital City: Detailed City Master Plan

The Amaravati plan envisages residents enjoying world-class infrastructure, a pleasant residential environment, efficient transportation, high-quality education, medical care, and entertainment. The comprehensive development concept also proposes affordable rental housing with access to education

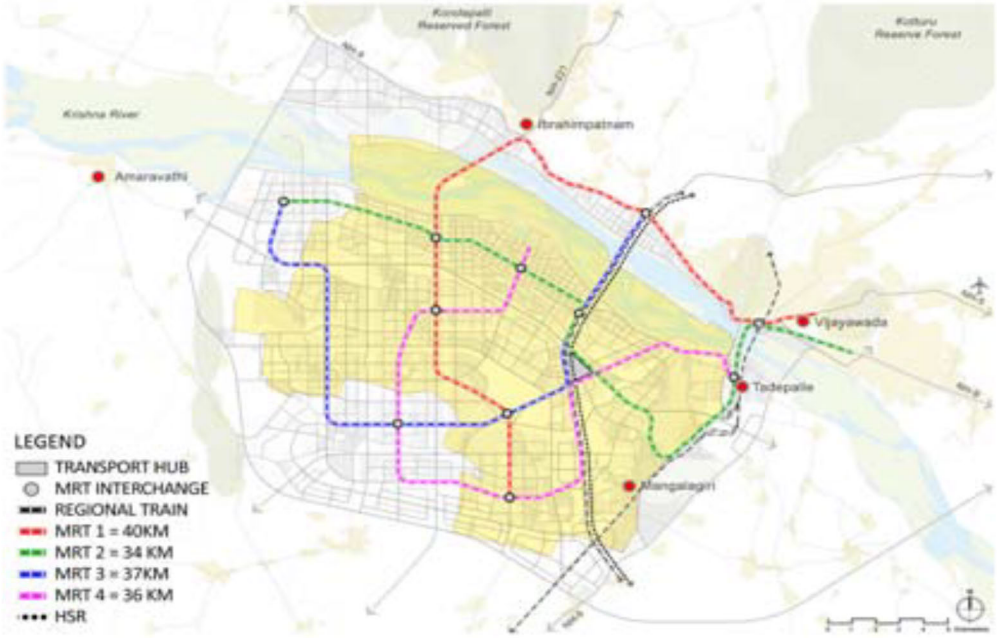
and medical treatment to create an ideal village ambiance, all in a walkable and bicycle-friendly street environment.

Amaravati's proposed highway network includes express and semi-express roads (RoW 60m), major arterials (RoW 50m), downtown roads (RoW 50m), sub-arterials (RoW 40m), collectors (RoW 25m), and local roads (RoW 10-18m). Its public transport network is to include four MRT routes covering almost the entire city.



Source: Detailed Master Plan, APCRDA

Figure 4.4 Amaravati: road network plan



Source: Detailed Master Plan, APCRDA

Figure 4.5 Amaravati: MRT plan

4.2.2 Smart City Integrated Infrastructure Master Plan

Plans for Amaravati propose a sophisticated urban transportation system featuring an integrated, hierarchical public transportation system and arterial road network, backed by IT-based Intelligent Transport Systems (ITS), including advanced traffic information provision, area-wide traffic management, and traffic crime prevention. Plus, mobility will be enhanced via IT-based vehicle movement and parking monitoring, including signal control and parking guidance.

The Smart City Integrated Infrastructure Master Plan (SCIIMP-2017) includes proposals for an Inner Ring Road, Western Bypass, Iconic Bridge, bus/BRT, Indian Railways Amaravati rail link (passing the western edge of Amaravati with a new world-class station), High-Speed Rail line (Chennai-Hyderabad) through the city, plus a city Metro or other form of higher-order MRT transit, possibly with connectivity to/from Vijayawada.

Road networks are planned in a grid system to facilitate the development of hierarchical public transportation systems and services. Amaravati will be divided into two-km^2 grid blocks by arterial roads (60m RoW), one-km^2 blocks by sub-arterial roads (50m RoW), and 25m RoW collectors. Typical cross-section designs for each road type have been prepared and assessed from the aspect of non-motorized transport (NMT), rapid transit systems, and transit-oriented development (TOD).

Based on the NUTP guidelines, the modal share for public transport is targeted at 50%. Land use and facility placement will be planned so that 80% of residents can access public transport within five minutes. Public transportation is a priority, with Bus Rapid Transit (BRT) proposed in the short term and Mass Rapid Transit (MRT) in the long term.

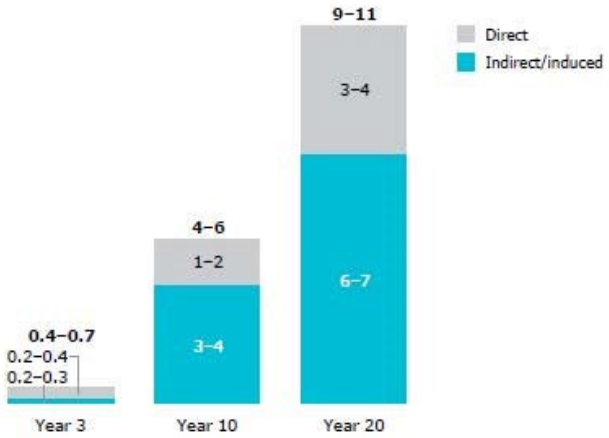
The plan states that an effective traffic and transportation system will act as a catalyst for socio-economic growth, cultural vibrancy, social equality, and prosperity of the city and its hinterland. The vision aims to provide seamless, safe, and convenient universal access to conveyance and movement through sustainable public transport and NMT systems with a high preference for smart and green transport modes in sync with the objectives of the NUTP.

APCRDA has proposed that development within the Capital Region will progress at three spatial levels: the Capital City Seed Area (16.9 km^2); the Capital City itself (217 km^2) with government facilities, commercial facilities, housing, and educational facilities, etc.; and the broader Capital Region (8,603 km^2) incorporating the surrounding mainly rural area. Phased construction is assumed to start in the Seed Area with urban transportation systems integrated with the urban development program.

Amaravati's population is expected to grow rapidly from 100,000 to 1.71 million by 2035, then up to 3.88 million by 2050. In the Capital Region as a whole, the population is expected to grow from 5.88 million to 10.91 million by 2035 and 12.91 million by 2050.

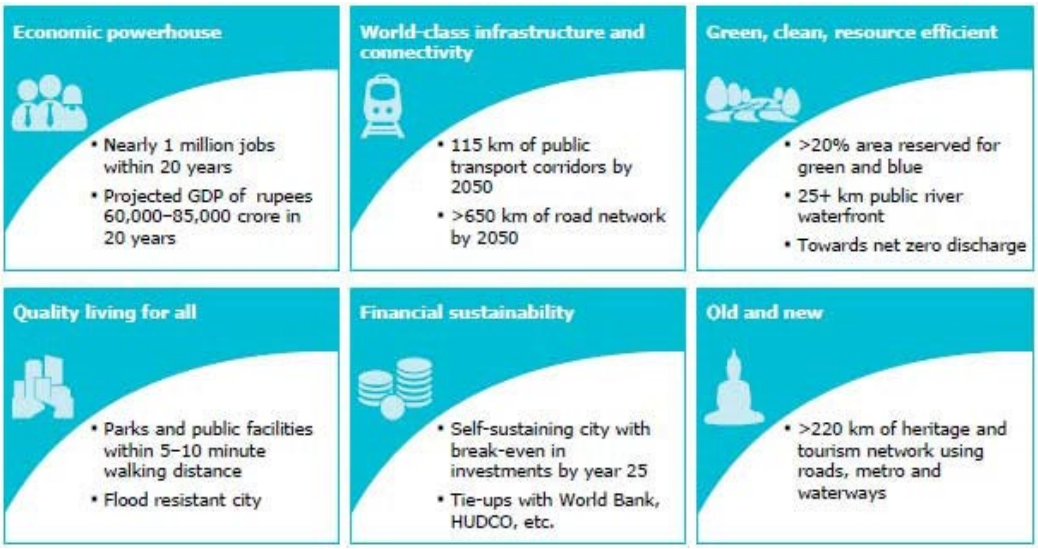
Socio-economic Master Plan for Amaravati Capital City (SEMP): In 2016, APCRDA released the Socio-economic Master Plan (SEMP) for Amaravati. In 2018 this was updated with "Happy City Blueprint for Amaravati." These plans aim to define the new city's livability and attractiveness for residents and businesses. Principle themes include: 1) an economic powerhouse; 2) world-class infrastructure and connectivity; 3) green, clean, resource-efficient; 4) quality living for all; 5) financial sustainability; and 6) synthesis of old and new.

The SEMP projected that in 10 years (around 2025), new direct employment would reach 300,000-550,000 and new indirect employment 105,000-195,000 – for a total range of 400,000-750,000 new jobs in Amaravati. By 2035 total employment is projected to reach 1 million.



Source: Socio-economic Master Plan, APCRDA, 2016 (unit: 100,000 persons)

Figure 4.6 Amaravati: employment generation, 2016-2035



Source: Socio-economic Master Plan for Amaravati Capital City, APCRDA, Sep. 2016

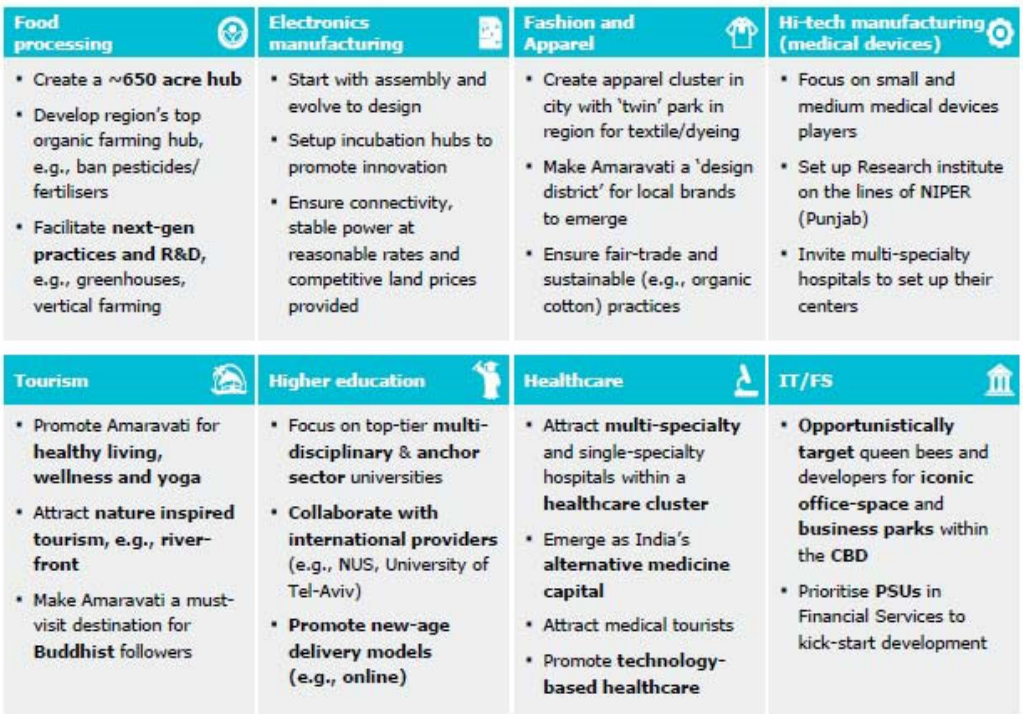
Figure 4.7 Amaravati: SEMP vision

The plan proposed nine priority economic activities suited for Amaravati in two categories:

Manufacturing: Food processing, electronics manufacturing, fashion & apparel, hi-tech

Service sector: tourism, higher education, healthcare, high-end services (IT, R&D, etc.), government administration

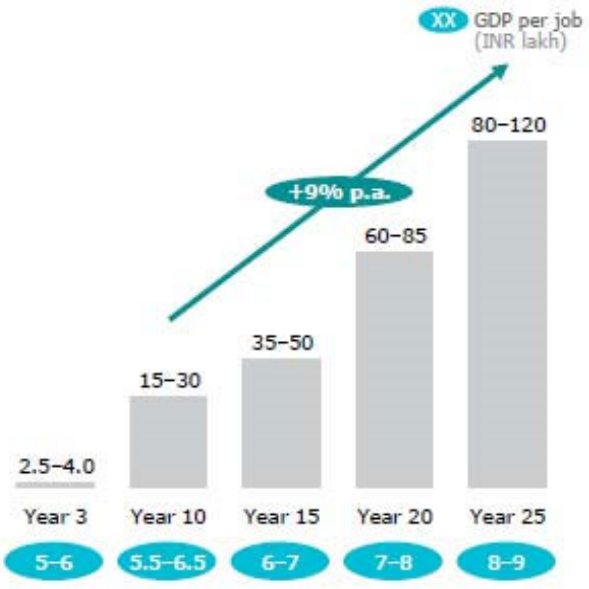
For these sectors (excluding government), the SEMP lays out the following strategies for industrial development:



Source: Socio-economic Master Plan, APCRDA, Sep 2016

Figure 4.8 Amaravati: economic development strategy

The plan projected Amaravati's GRDP would grow at an annual rate of about 9% over 25 years (to about 2040) and that GDP in this target year would be Rs. 800,000 -1,200,000.



Source: Socio-economic Master Plan, APCRDA, 2016

Figure 4.9 Amaravati: projected GRDP, 2016-2040

Chapter 5 Transport vision, guiding principles & strategic objectives

5.1 National Urban Transport Policy

Guided by the principles laid out in the National Urban Transport Policy (NUTP-2014), the CTTS has aimed primarily at maximizing benefits for the community rather than simply planning a more efficient transport system. Fundamental principles in the NUTP include:

- To provide seamless intermodal transfer and single travel experience to commuters by connecting various transportation modes, including non-motorized transport, in a safe, comfortable, secure, and timely manner.
- To evolve an integrated transportation system that contributes to the city's productivity and improves the quality of life with minimal environmental impact.
- To achieve a sustainable transport system in the city that achieves and balances social, economic, and environmental objectives.

The MoHUA's Toolkit for Comprehensive Mobility Plans (CMP-2014) and its URDPFI Guidelines (URDPFI- 2015) also identify other critical transport policy goals:

- Effective integration of urban transport plans into urban (development) plans, focusing on the equitable allocation of road space for people rather than cars and mobility for all socio-economic groups and genders to support balanced and equitable spatial and economic development in the region.
- Expansion and improvement of public transportation services, including IPT and NMT modes, better traffic safety, and enhanced urban environments for pedestrians and cyclists, in synchronization with TOD, affordable housing, and municipal services.
- Collaboration on mechanisms for the planning and management of transport systems, including the introduction of area-based ITS for traffic management and innovative mechanisms for financial procurement.
- Optimization of regional multimodal mobility, including cargo/freight transport, to effect modal shifts where viable alternatives exist (e.g., from road to rail and water transport) while ensuring local air-quality norms and other social and environmental aspects are not compromised.
- Upgrading institutions, regulations, capacity building, and knowledge management necessary for sustainable urban transportation.

5.2 Vision for CTTS and expected outcomes

Although these National Policy vision statements focus on urban transport studies and solutions, the same principles can be applied to regional transport plans. As such, the Scope of Work for APCR-CTTS highlights the need for the Transport Vision to contribute to:

- Enhancing the position and role of APCR in the East Coast Economic Corridor
- Strengthening the competitiveness of special products export business
- Improving intermodal connectivity
- Improving the capacity of transportation companies in APCR
- Safeguarding corridors and sites for future provision and enhancement of strategic transport infrastructure and utilities.

The MoHUA's CMP-2014 also identifies several long-term outcomes that can flow from the successful implementation of a well-done transport study:

- Improvement in mobility for all socio-economic groups and genders
- Improvement in safety and security for pedestrians/NMT, and liveability in the city
- Increase in sustainable transport modal share and decrease in private motor-vehicle use
- Improvement in the air quality of Sustainable Urban Transport Scenarios compared with Business As Usual (BAU) scenarios
- Achievement of desirable indicators and benchmarks
- Better integration with Master Plans.

The CTTS Transport Vision and Guidelines have also focused on specific objectives driven by APCR's travel patterns and needs. These objectives have reflected the vision set and been aimed to reflect input from elected representatives of both APCR and the ULBs. Policies that set targets aim to ensure these are aligned with objectives. They should also provide benchmarks for measuring achievement, where data and resources for measurement and monitoring are available.

The vision and strategic objectives have also been used to guide the formulation and testing of the demographic, land use, and transport scenarios through the four-step transport modeling process and in carrying out the Strategic Environmental Assessment (SEA) to arrive at the Regional Transport Strategy and Metropolitan Region Transport Plan.

In accord with NUTP guidance and the Scope of Work for this study, a Draft Transport Vision has guided the preparation and assessment of APCR-CTTS:

The DRAFT CTTS Transport Vision

"A Comprehensive Smart Transport Master Plan for safe, secure, sustainable & seamless connectivity that secures the APCR's drive to become a 21st Century engine of economic growth"

5.3 APCR-CTTS guiding principles, strategic objectives, and policies

To achieve this vision while addressing the key transport-sector issues identified above, a set of guiding principles, strategic objectives, and transport policies were synthesized to frame the Capital Region's Transport Strategy.

Guiding principles for APCR regional transport framework

1: Enable economic growth & resilience
2: Sustain inclusive & equitable growth
3: Promote people-centered mobility
4: Foster innovation in transport technology
5: Improve the quality of life & environmental values
6: Encourage engagement & ownership

5.3.1 Guiding Principle 1: Enable economic growth & resilience

Objective 1: To create an effective regional transportation system connecting existing and new urban centers and clusters of economic activity to support resilient regional growth and sustain the long-term future of APCR.

Policy 1-1: Enhance passenger and freight transport connectivity within APCR and with other regions to sustain long-term growth, economic diversification, and regional competitiveness.

Policy 1-2: Provide state-of-the-art public transport connectivity, including consideration of a demand-based LRT/Metro system, to promote sustainable travel and help reduce dependency on private vehicle commuting.

Policy 1-3: Prioritize short-term investments which enhance existing transport network capacity, facilities, and services to achieve a better return on assets while holistically assessing long-term needs for new capital-intensive projects.

5.3.2 Guiding Principle 2: Sustain inclusive and equitable growth

Objective 2: To enable effective public transport connections between existing urban centers and new growth locations to sustain inclusive/equitable access to affordable housing, social infrastructure, and municipal services.

Policy 2-1: Prioritize access to affordable public transport (including NMT & IPT), cycling, and pedestrian facilities (for all classes, genders, and income groups) to promote balanced equitable development.

Policy 2-2: Provide a range of affordable, efficient public transport and NMT facilities/services to sustain the development of mixed-use, mixed density communities, including affordable housing and transit-oriented development.

Policy 2-3: Promote more equitable allocation of space within road rights-of-way to enable NMT and other sustainable transport modes to help reduce carbon footprints.

5.3.3 Guiding Principle 3: Promote people-centered mobility

Objective 3: Promote better use of existing infrastructure (i.e., better public transport, pedestrian/ NMT facilities) towards better mobility and integration of land use and transportation – which is key to building smart cities.

Policy 3-1: Promote integrated transport, land-use, and economic planning to support quality, compact, livable, and walkable communities and help reduce urban sprawl.

Policy 3-2: Ensure safe, convenient, and affordable passenger interchange facilities (incl. IPT & NMT) are provided at the major bus, rail, and transit hubs to improve mobility for all.

Policy 3-3: Provide high-quality, safe, and comfortably walkable streets with green canopy coverage in new developments (including TOD schemes) to encourage pedestrians and cyclists.

5.3.4 Guiding Principle 4: Foster innovation in transport technology

Objective 4: To sustain long-term regional growth through innovation in transport technology to reinforce and enhance connectivity between socially, economically, or functionally inter-dependent settlements.

Policy 4-1: Ensure long-term transport plans/programs provide sufficient flexibility to respond to future changes in transport systems and services as a result of technological innovation.

Policy 4-2: Enable integration and enhancement of Intelligent Transport Systems (ITS) throughout APCR to improve coordination/management of traffic and transport networks and services.

Policy 4-3: Support transport technology innovations for a cross-section of income groups to improve information quality in selecting safe, efficient, and affordable transport choices.

5.3.5 Guiding Principle 5: Improve the quality of life and environmental values

Objective 5: To improve quality of life and environmental well-being through comprehensive transport plans that holistically integrate urban nodes with semi-urban and rural areas, based on understanding the characteristics of each area, including flows of people, goods, knowledge, and financial resources.

Policy 5-1: Ensure major new transport investments recognize/emphasize the unique traditional cultural and heritage contexts in which they are being implemented to contribute to national integration and social justice.

Policy 5-2: Prioritize the use of public transport, NMT, and innovative, energy-efficient transport modes to minimize adverse social, cultural, and environmental impacts to improve quality of life in accord with the National Transport Vision and UN Sustainable Development Goals (SDGs).

Policy 5-3: Promote schemes that minimize impacts on environmental assets, including forests, water bodies, public open spaces, city parks, and heritage trees, to help reduce GHG emissions and contribute to a healthier living environment.

5.3.6 Guiding Principle 6: Encourage engagement and ownership

Objective 6: To support government focus on accelerating agricultural growth and farmers' welfare while making efforts to transform AP into a knowledge-based economy and sustaining Amaravati’s growth through inclusive development.

Policy 6-1: Strengthen the roles, responsibilities, and resources of APCRDA & APCRUTA, including the use of ITS and other technological innovations to improve regional transport planning.

Policy 6-2: Ensure the CTTS is harmonized with broader national and regional strategies for transport land use.

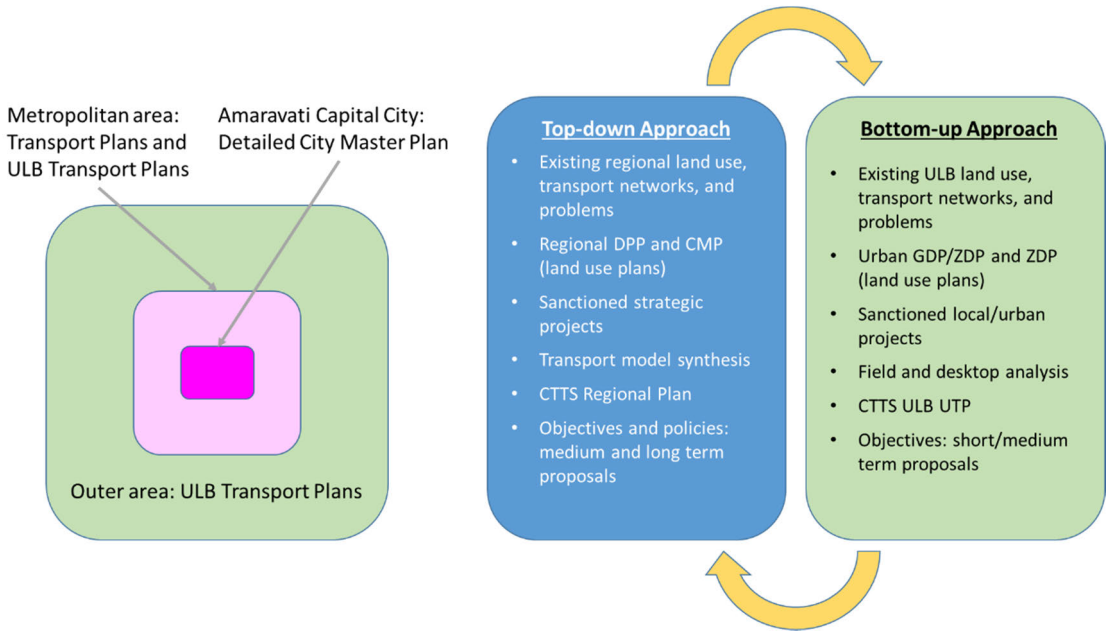
Policy 6-3: Improve information management and knowledge transfer between APCRDA, the ULBs, and other public- and private-sector stakeholders.

Chapter 6 Regional transport strategy

6.1 Approach to strategy formulation

6.1.1 Top-down versus bottom-up approach

Plans for a sustainable, equitable regional transport strategy should be anchored in a robust 2050 strategic transport network. The initial 2050 strategic transport plan was generated based on a top-down/bottom-up approach considering several inter-dependent components (see Figures 6.1 and 6.2).



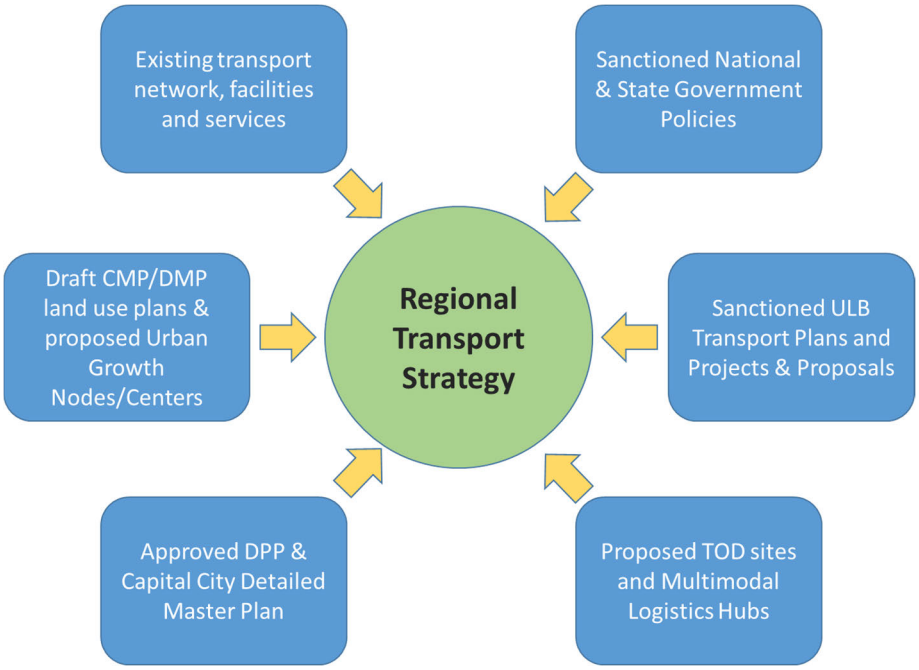
Source: JICA Study Team

Figure 6.1 Strategy formulation approach

Key components in the strategy include ongoing, sanctioned/committed strategic transport projects with a high probability of implementation (i.e., funding in place and/or construction program identified) and plans by national and state government ministries, departments, and agencies. These include:

- Current/future transport needs of the Vijayawada-Tadepalli-Mangalagiri-Guntur metropolitan area
- Future influence of the proposed Capital City and its state-wide government functions
- AP's economic growth trajectory and its implications for APCR

- Current/anticipated capacity constraints and bottlenecks in national highway and rail systems (passenger and freight) passing through the region
- Other transport enhancement proposals, including airports, ports, and inland waterways
- Capital City Master Plan (Feb.2016) land-use mix, density, and transport network parameters (assumed as 'fixed' parameters or inputs in CTTS)
- Draft APCR CMP/DMP land-use parameters for APCR outside the Capital City, including proposed urban growth centers (assumed as 'tentative' parameters subject to possible modification)
- Major TOD opportunity sites identified by CTTS – anchoring future mixed-use urban growth nodes within the integrated 2050 Regional Transport Strategy
- Multi-modal logistics facilities (existing and CTTS-proposed), including truck terminals, industrial estates, and retail/wholesale markets, are located mainly along strategic transportation corridors and intersection nodes (existing and proposed).



Source: JICA Study Team

Figure 6.2 Key components of the regional transport plan

6.1.2 Integrating transport and land-use plans

The National Urban Transport Policy (NUTP-2014) asserts the fundamental principle that transport and land-use planning must be closely integrated. Accordingly, the CTTS has been guided by future land-use patterns proposed in the DPP and CMP/DMP Master Plans, aiming (as the NUTP asserts) ***"to serve the region's population, prioritize public transport connectivity and minimize personal motorized travel needs."***

6.2 Regional transport strategy

6.2.1 Planning concepts

To amplify Amaravati's compact city development principles across APCR will require a regional strategy that provides a smooth, seamless, and efficient regional transport network integrating various modes via an appropriate institutional framework. To this end, the NUTP offers the following guidance:

1. **Regional planning:** To ensure sustainable development, regional planning needs to be extended to all contiguous urban areas that are socially, economically, or functionally interdependent.
2. **Regional plans:** Comprehensive plans for integrating urban nodes with semi-urban and rural areas. Plans should be based on understanding regional characteristics such as the flow of people, goods, knowledge, and money.
3. **Comprehensive mobility plans:** Road network comprehensive mobility plans (e.g. CTTS) can be more efficiently executed on a regional basis rather than limited to the jurisdictions of statutory authorities administering their respective lands.

6.2.2 Urbanization and transport synergy

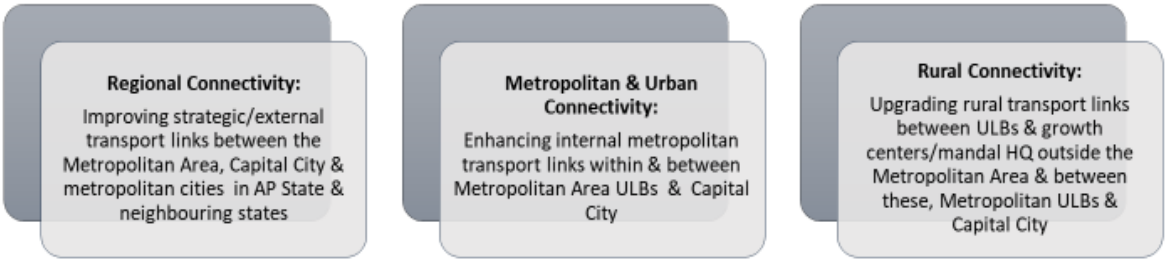
Synergizing urbanization and economic development at new locations (e.g., Amaravati) require both long-term and short-term strategies (ADB: Vizag-Chennai Industrial Corridor VCIC-2016).

1. It is important to create an effective regional transportation system connecting existing and new urban centers with existing and new clusters of economic activity.
2. New urban development at or near new economic centers, including affordable housing, social infrastructure, and municipal services.
3. Hierarchically structured public transport networks at regional and local levels.

6.3 Principles of regional connectivity

Identifying a hierarchy of urban centers across a region allows a clear understanding of the spatial and functional inter-relationships among them. The key is to determine whether current government and private-sector facilities and services are evenly distributed as per their spatial and functional importance so that equitable and sustainable access for people from all regional settlements can be provided.

To ensure proper balance, it is essential to efficiently link urban centers and sub-centers with a range of affordable/sustainable transport choices – especially public transport – along with commercial and industrial facilities such as multi-modal logistics hubs. These transport enhancements must be backed by consistent enforcement of planning regulations to contain urban sprawl.



Source: JICA Study Team

Figure 6.3 Connectivity principles

6.3.1 Improving regional connectivity

Improving regional connectivity includes:

1. Upgrading national-level passenger and freight transportation corridors linking the APCR region to the rest of AP and India.
2. Rectifying critical bottlenecks (bridges, intersections, stations) on these corridors
3. Identifying and strengthening sub-standard or missing links between strategic networks and throughout APCR – particularly between existing and proposed strategic nodal centers and activity hubs (major TOD nodes and multi-modal logistics hubs).

While many strategic improvement proposals for APCR are local components of national programs, APCRDA can use CTTS findings to optimize benefits from proposed national schemes, for example, by identifying the potential for new or upgraded links between national highways and the state road network; or by coordinating future strategic growth centers and logistics hubs.

6.3.2 Enhancing metropolitan and urban connectivity

To enhance intra-regional and inter-urban connectivity, improved metropolitan links and public transport should be a priority:

1. within the Metropolitan Urban Area and between the metropolitan ULBs
2. between the metropolitan area ULBs and the Capital City
3. between Metropolitan Area ULBs and the hinterland.

Proposals typically include projects to improve capacity, speeds, and safety on main ULB roads where congestion and bottleneck delays are becoming critical. Proposals also include improving or providing upgraded links to existing and proposed activity hubs, TOD/nodal centers, and logistics hubs where anticipated traffic volume increases. Private-sector-led projects can also be considered (e.g., PPP schemes) for projects such as nodal center/TOD/logistics hub improvements.

6.3.3 Upgrading rural connectivity

Strengthening rural connectivity requires improvements to:

1. Bus/rail passenger services between nearby rural ULBs and other activity centers outside the metropolitan area
2. Public transport services between rural ULBs and Metropolitan ULBs, especially for home-based work and education trips
3. Road links catering to trucks between agro-industrial logistics hubs and produce-export gateways and the strategic road and rail networks
4. Bus/NMT services linking rural ULBs and catchment areas for local commuting, shopping, and school trips

Projects could be state or ULB-sponsored but should involve intensive local consultation and participation in planning and implementation. Where deprived rural areas are identified (e.g., insufficient access to medical care or education), providing low-cost or subsidized public transport should be considered.

6.4 Enabling compact smart city development

A clean slate is generally required to build a compact smart city: either a central area available for redevelopment (e.g., extra rail yards) or a Greenfield site on the outskirts. Otherwise, land assembly is generally complex in large cities due to high prices and small, fragmented lots. Sites on the outskirts can meanwhile contribute to urban sprawl. So, in general, the best alternatives are either carefully planned developments in suburban areas or intensification or redevelopment of existing central areas. However, with Amaravati, APCR is fortunate to have a clean slate midway between its two most significant urban centers.

Source: Smart City Mission, India

Figure 6.4 Smart City Mission

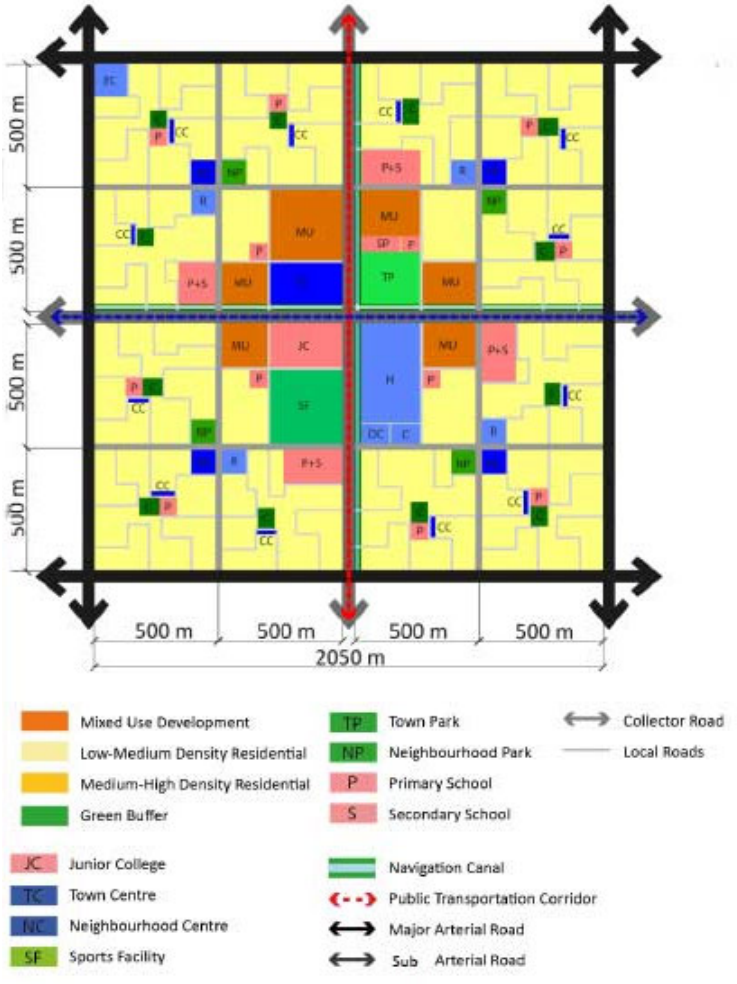
6.4.1 Smart city principles and accessibility

The fundamental principles in Smart and Compact city design revolve around providing medium-to-high-density developments with mixed uses and enhanced quality of life with accessibility for all. Sustainability is a crucial feature with high-quality environments for pedestrians and cyclists and excellent public transport.

In inner-city areas, the focus is often on redeveloping built-up areas around transit hubs and railway stations, replacing dilapidated buildings, widening narrow congested streets, and providing more public

open spaces. The opportunity for this typically arises when a new rapid transit station makes land in the vicinity more valuable – transit-oriented development or TOD.

To create an environment favorable to walking, cycling, and public transport, the aim is typically to locate housing, shopping, and employment within convenient walking distance of a Metro station (e.g., 500-800m or 10-15 minutes) in the main built-up areas and 1-1.5 km or 30 minutes in lower-density areas.



Source: APCRDA, amended by JICA Study Team

Figure 6.5 Compact city development concept (e.g. 500-meter radius for 80% of population)

6.4.2 Amaravati Smart City proposal

With Amaravati, APCR's Smart City development plans call for a three-tier, three-phase rollout:

Phase 1 - from commencement:

- Greenfield site: Amaravati Capital City 'World Class' standards & norms

Phase 2 – over the next 5 - 10+ years:

- Redevelopment of existing areas (e.g., creating TOD-based suburban activity centers around existing bus stations): Metropolitan ULBs, selected larger Outer Area ULBs

Phase 3 – over the next 5-15+ years:

- Retrofitting built-up areas (e.g., in/around existing city center transport hubs to introduce smart city applications and link with Amaravati ITS systems): Metropolitan ULBs

6.5 Urban growth centers and TOD

Seamless integration is particularly important given potential disparities in service levels between existing urban transport systems in and around Vijayawada, Guntur, Tadepalli, and Mangalagiri (identified in the CMP/DMP) and plans for Amaravati that aim to provide a high level of public transport services.

Beyond the 13 existing growth centers (12 ULBs plus Amaravati), the DMP proposes 12 new centers for development by 2035. These future growth centers will require new or upgraded strategic links to the Metropolitan Area and adjacent ULBs over three phases of the Plan period:

Phase I (2021) – Ibrahimpatnam, Bapulapadu, and Kanchikacherla

Phase II (2031) – Gannavaram, Kankipadu, Pamarru, Edlapadu, Challapalle and Phirangipuram

Phase III (2035) – Atchampeta, Bhattiprolu, and Mylavaram.

Table 6.1 APCR: Proposed CMP/DMP growth centers

S. No.	Growth Centre	Corridor	Administrative Status	Key Sector
1	Ibrahimpatnam	NH 65, NH 30	Mandal HQ	Industrial Service town - Power sector
2	Gannavaram	NH 16	Mandal HQ	IT Hub & Service Centre
3	Bapulapadu	NH 16	Mandal HQ	Hanuman Junction - Agri Business & Logistics
4	Kankipadu	NH 65	Mandal HQ	Commuting town
5	Pamarru	NH 65, NH 214	Mandal HQ	Logistics, Aqua based Agri Business
6	Edlapadu	NH 16	Mandal HQ	Mining, Spice based Agri Business
7	Challapalle	Nh 216	Mandal HQ	Sugar, Auto Nagar
8	Phirangipuram	NH 544D	Mandal HQ	Mining & Quarrying, Industry
9	Kanchikacherla	NH 65	Mandal HQ	Service Centre - Residential & Educational
10	Atchampet	SH	Mandal HQ	Sub-Regional Service Centre, Sand Mining
11	Bhattiprolu	NH 216	Mandal HQ	Tourist Centre, Agri Business
12	Mylavaram	NH 30	Mandal HQ	Service Centre - Educational

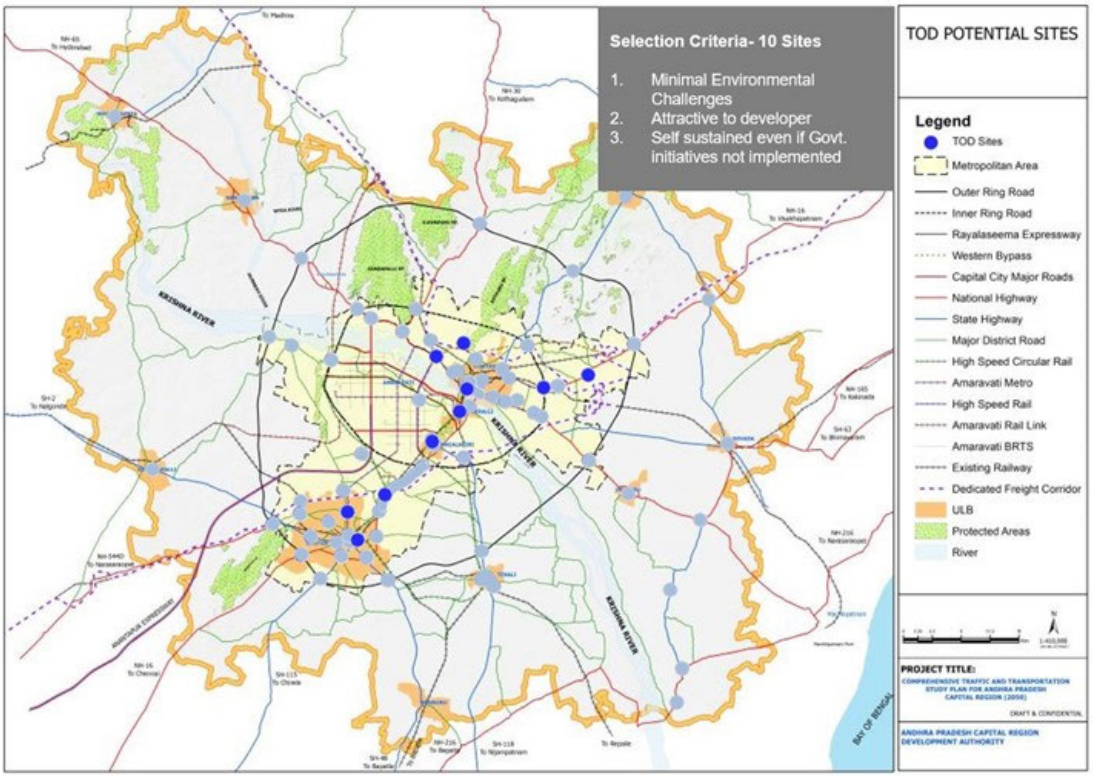
Source: CMP/DMP 2017, APCRDA

New or upgraded transport infrastructure (mainly road links) will soon be required in suburban and peri-urban areas where roads are becoming overloaded due to uncontrolled urban sprawl – notably on the periphery of Vijayawada and in the 'green gap' between Amaravati and Guntur.

The larger centers and Amaravati will serve as the region's economic engine and provide government services and social facilities to ULBs on the outskirts. However, this will require a high level of connectivity by various modes, particularly public transport, to ensure equal access to services and economic opportunity across APCR.

New or upgraded public transportation facilities can be expected to create opportunities for urban redevelopment, particularly around new bus terminals or Metro stations. These can stimulate TOD, creating new urban sub-centers with higher-density housing, commercial and employment facilities, etc. These should be carefully planned and executed to include smart city amenities.

Many potential TOD sites have been identified based on approved draft CMP/DMP land-use allocations, existing and committed strategic transport networks, government land availability, and accessibility indices. The list of sites was then further refined, taking into account local environmental considerations, likely developer interest, and long-term mixed-use/commercial sustainability of the site, as shown in Figure 6.6 and listed in Table 6.2. Figure 6.7~Figure 6.10 show a preliminary idea for the PNBT TOD site.



Source: JICA Study Team

Figure 6.6 APCR proposed strategic 10 TOD sites along the transport network

Table 6.2 Proposed strategic 10 TOD sites

S. No	ULB	Site	Type of TOD		Transit facility		Ownership
			CTTS	URDPFI	Existing	Proposed	
1	Vijayawada	PNBS	Node	Core	Bus stand	Metro/LRT, BRTS	Govt. (APSRTC)
2	Guntur	NTR Bus stand	Node	Core	Bus stand	Metro, BRTS*	Govt. (APSRTC)
3	Tadepalli	Krishna Canal	Node	Commercial	Railway station	Metro/ LRT, High Speed Rail	Govt. (IR)
4	Mangalagiri	Mangalagiri Bus stand	Node	Commercial	Bus stand	AM*	Govt. (APSRTC)
5	Vijayawada	Gannavaram - near Airport	Node	Neighborhood	Bus stop	Metro/ LRT	Private/ Govt.
6	Vijayawada	Jakkampudi	Node	Commercial	Bus stop	Metro/ LRT	Govt.
7	Vijayawada	Gollapudi	Node	Neighborhood	Bus stop	High-Speed Circular Rail, Metro/LRT	Private/Govt.
8	Vijayawada	Nidamanuru	Node	Commercial	Bus stop	MTS*, Metro/LRT	Private/Govt.
9	Guntur	Namburu railway station	Node	Commercial/ Neighborhood	Railway station	High-speed Circular Rail, DFC, Amaravati Rail Link	Govt. (IR)
10	Guntur	Gorantla	Node	Commercial/ Neighborhood	Bus stop	Amaravati Metro	Private/Govt.

MTS* Dedicated Mass Transit System proposed within RoW of IRR - APCRDA Proposal
BRTS* CTTS Proposal (Not included in 2050 Master network)
AM* Extension of Amaravati Metro till Mangalagiri Railway Station - APCRDA Proposal

Source: JICA Study Team

Table 6.3 Transit Oriented Development Matrix

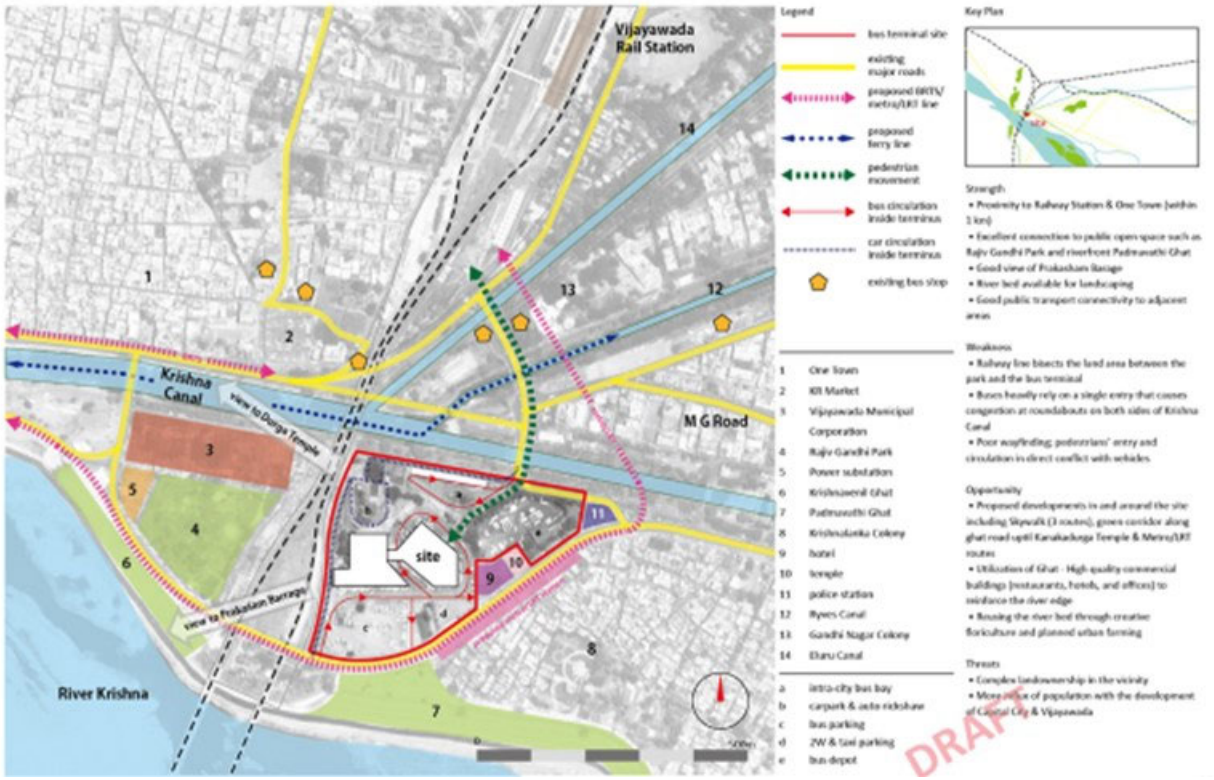
Type of TOD	Ideal Land use mix and mixed land use development (with density)	Transit mode function
Core area	• Residential: High Intensity • Commercial/Office: Medium Intensity • Mixed-Use • Supporting retail & services	• Bicycle Lanes • Pedestrian Network • Intermediate transportation supported by non-motorized vehicles • Limited Parking Lots
Commercial Zones	• Employment (commercial, office, industrial, institutional): High Intensity • Supporting retail & services • Residential: Minimal	• Parking Lots, if required • Pedestrian Network • Bicycle Lanes • BRT and Bus Stops • Intermediate transportation supported by motorized vehicles
Neighborhood	• Residential: Medium Intensity • Employment (commercial, office, industrial, institutional): Medium Intensity • Supporting retretailservices	• Pedestrian Network • Bicycle Lanes • Considerable Multi-level Parking Areas • Intermediate transportation supported by non-motorized vehicles
Peri-urban Area	• Commercial/Office: Medium Intensity	• Transition to higher density and a greater mix of uses close to the transit source • BRT and Bus Stops • Green Interconnected Pedestrian Network • Considerable Multi-level Parking Areas

Source: Urban and Regional Development Plans Formation and Implementation (URDPFI) Guidelines

Table 6.4 Strategic TOD sites – proposed zoning norms

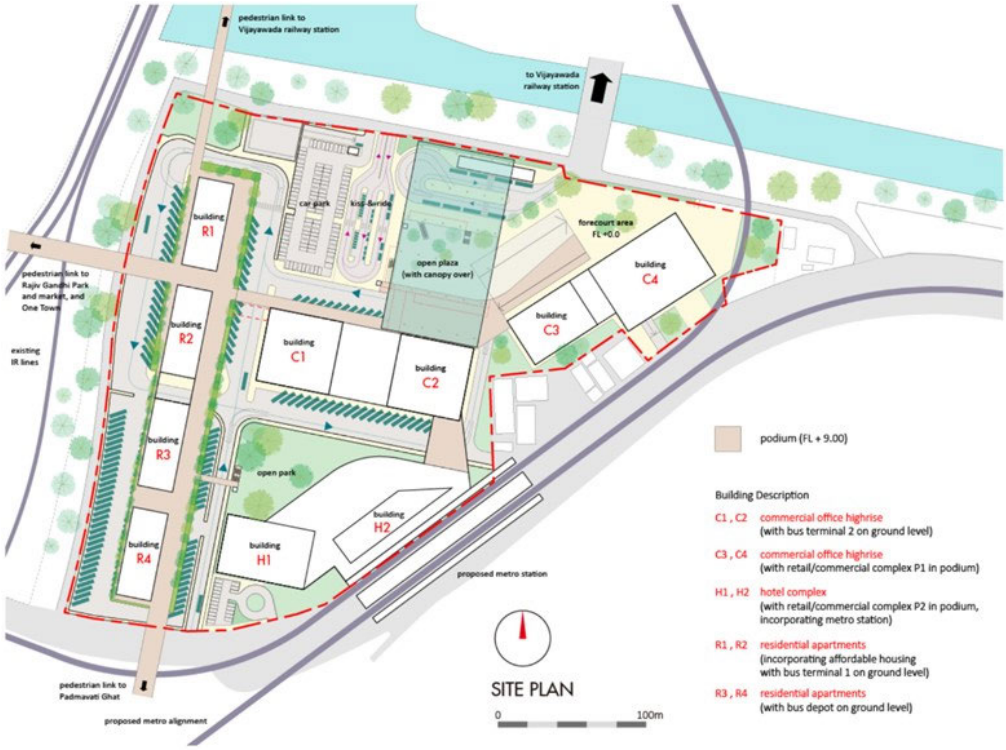
TOD norms	Proposed norms for APCR	Remarks
Influence zone	800 m on both sides of the corridor radii around a transit station	Equivalent to 10 min walking distance
Population density	175-200 PPH	To be aligned with job density per transport model
	48- 54 DU/Ha	
Green space provision	• 30% of the development area • 10-15 sqm/ person	Amaravati 16 m^2/ person & WHO 9 sq m/ person
Ground coverage	40-50%	
FAR/ FSI	Max. FAR - 3.5 – 5 Avg height - 6-10 Floors; higher in exceptional sites	5 in case of iconic and large sites of area >5 Ha
Parking	Residential – 1 stall/DU- 15% of total BUA Commercial – 1 stall/ 50-100 m^2 GFA- 30% of BUA 1. Approx 50 % reduction in parking (to be finalized) 2. Keeping existing parking provisions and changing usage as PT becomes functional as per ACC strategy	Residential, PSP- 20% High-rise commercial- 50% As in Amaravati parking requirements will be reduced as PT develops.

Note: PPH-Persons per Hectare; DU/Ha-Dwelling Units per Hectare; FAR-Floor Area Ratio; BUA-Built Up Area; GFA-Gross Floor Area;
Source: JICA Study Team



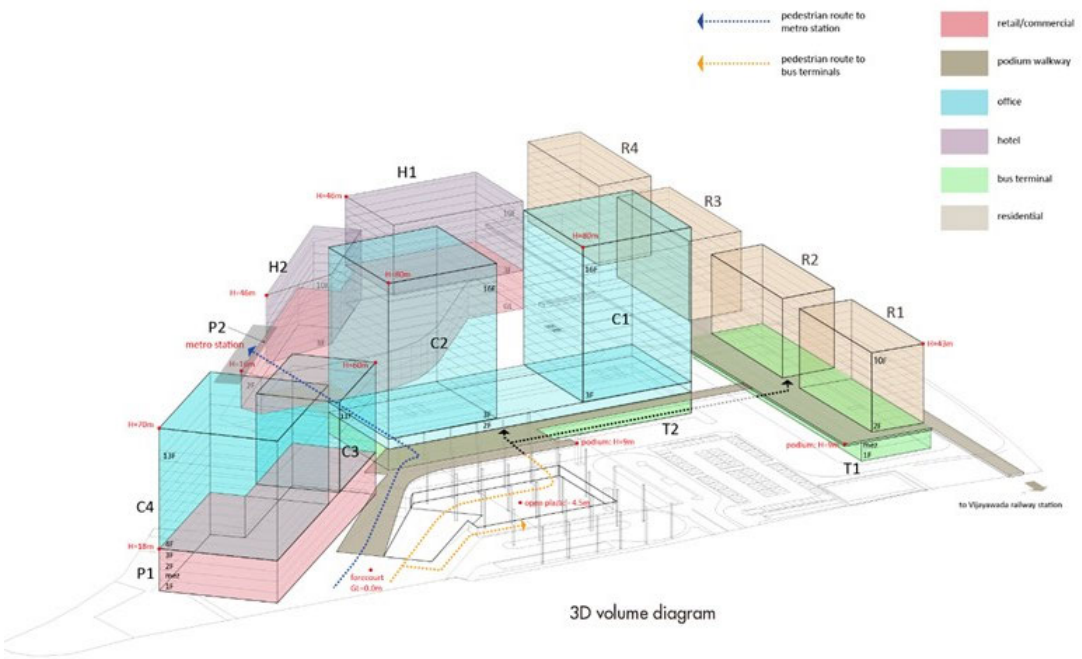
Source: JICA Study Team

Figure 6.7 PNBT TOD site and the surrounding area



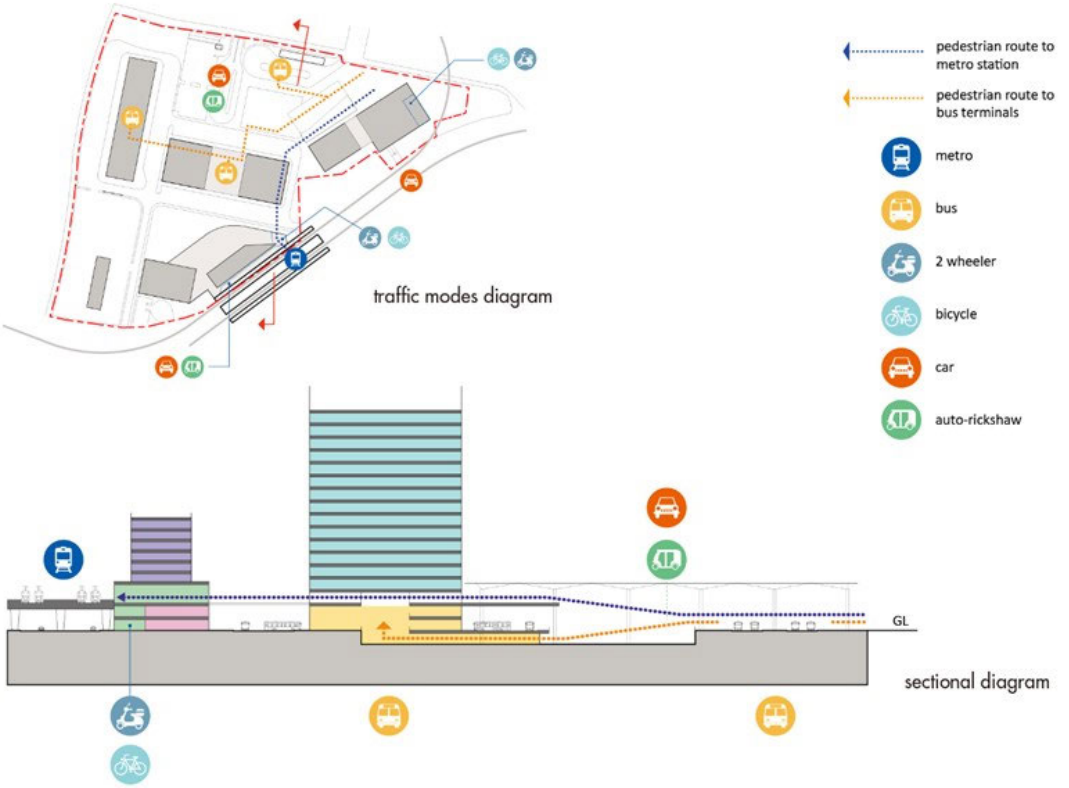
Source: JICA Study Team

Figure 6.8 PNBT TOD Conceptual Site Layout Plan



Source: JICA Study Team

Figure 6.9 PNBT TOD Conceptual Site 3D Volume Diagram



Source: JICA Study Team

Figure 6.10 PNBT TOD Conceptual Site Movement Plan

6.6 Multi-modal logistics hubs / integrated freight complex

6.6.1 National guidelines

A critical component of the regional transport strategy is the provision of strategically-located multi-modal logistics hubs to support the regional economy, particularly regionally important agro-industrial and aqua-industrial activities.

One key consideration is shifting from road to rail wherever viable – and balancing conflicting priorities. On one hand, there is an urgent need to free-up rail capacity for regional passenger services; on the other, the need to make regional agricultural products more competitive nationally. This should eventually be resolved with the construction of dedicated long-distance passenger high-speed rail lines and two Dedicated Freight Corridors (DFCs) that will meet in APCR.

Within APCR, there is a need to provide integrated freight complexes to support logistical activities. The essential functions of these, specified in the URDPFI Guidelines (Min. of Urban Development, 1996), are to provide:

- Facilities for regional & intra-urban freight movement
- Facilities for freight in transit as well as modal interchange
- Warehousing and storage facilities with links to specialized markets
- Servicing, loading and boarding, idle parking, restaurants, and related functions

As a general guideline, truck terminals (Transport Nagar) should provide one hectare per 300 tonnes of goods handled daily; or for an integrated freight complex, one hectare per 400 tonnes dealt with daily. Plus, the land-use mix for an integrated freight complex recommended in the UDPFI Guidelines is broadly summarized in Table 6.5:

Table 6.5 Integrated freight complex: broad land-use mix

Use type	Percentage of area (%)
Wholesale market	35.0
Warehousing	8.0
Booking agencies	2.0
Commercial & public/semi-public	5.0
Utilities and services	3.0
Service industry	4.0
Parking	12.0
Circulation	25.0
Others	6.0
Total	**100.0**

Source: UDPFI Guidelines, 1996.

6.6.2 Proposed multi-modal logistics hubs

Based on the guidelines above, locational criteria were derived to identify suitable sites for future multi-modal logistics hubs.

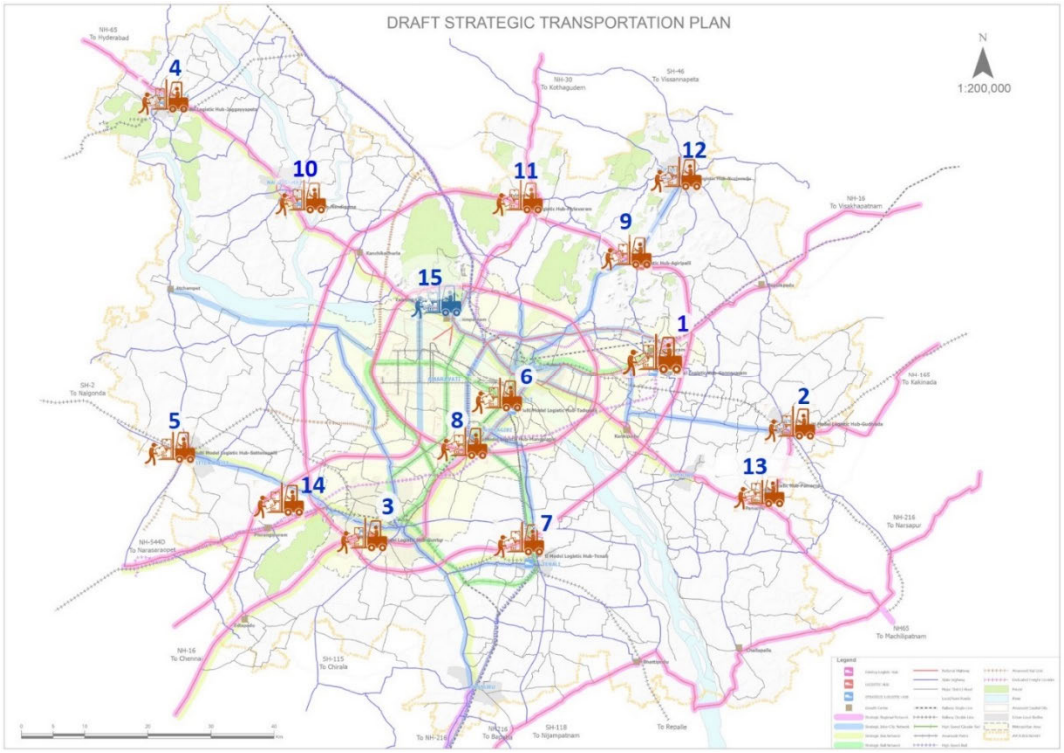
- Site adjacent to transport corridors or intersections with major freight movement flows
- Availability/potential for multi-modal links between road, rail, and ports/inland waterways
- Land-use allocation consistent with zoning under CMP/DMP & ZDP (Zonal Development Plan): transport, light industrial or commercial
- Available labor and services (e.g., affordable worker housing & healthcare)

The resulting list of proposed multi-modal logistics hubs is given in Table 6.6 and Figure 6.11 below.

Table 6.6 Proposed multi-modal logistics hubs

Sl. No.	Location	Source of site selection/ownership	Connectivity (1) to national/state highway		Connectivity (1) to IR terminal/siding		Site land-use zoning CMP/DMP/ZDP Res/Ind/Other
			<1km	<2.5km	<2.5km	<5.0km	
Multi-modal logistic hub							
1	Gannavaram	APCRDA perspective plan/private	Yes		Yes*	Yes	Industrial
2	Gudivada	JST/ private	Yes		Yes		Industrial
3	Guntur	JST/ private	Yes		Yes		Industrial
4	Jaggayyapeta	JST/ private	Yes		Yes		Industrial
5	Sattenapalli	JST/ private	Yes		Yes		Commercial
6	Tadepalle	APCRDA perspective plan/private	Yes		Yes		Public & semi-public
7	Tenali	JST/Govt- AMC	Yes		Yes		Commercial
8	Mangalagiri	JST/ private	Yes		Yes		Recreational
Logistic hub							
9	Agiripalli	Draft CMP&DMP / private	Yes		No	No	Mixed-use
10	Nandigama	JST/ private	Yes		No	No	Mixed-use
11	Mylavaram	JST/ private	Yes		No	No	Mixed-use
12	Nuziveedu	JST/ private	Yes		No	No	Industrial
13	Pamarru	Draft CMP& DMP/ private	Yes		No	No	Industrial
14	Dokiparru	JST/ private	Yes		Yes		Industrial
Existing truck terminal							
15	Ibrahimpatnam	Existing/APCRDA	Yes			Yes	Transport/industrial

*Based on the proposed draft DFC alignment
Source: JST 2019



Source: JICA Study Team

Figure 6.11 Proposed multi-modal logistics hubs

6.7 Assessment of alternative regional transport network scenarios

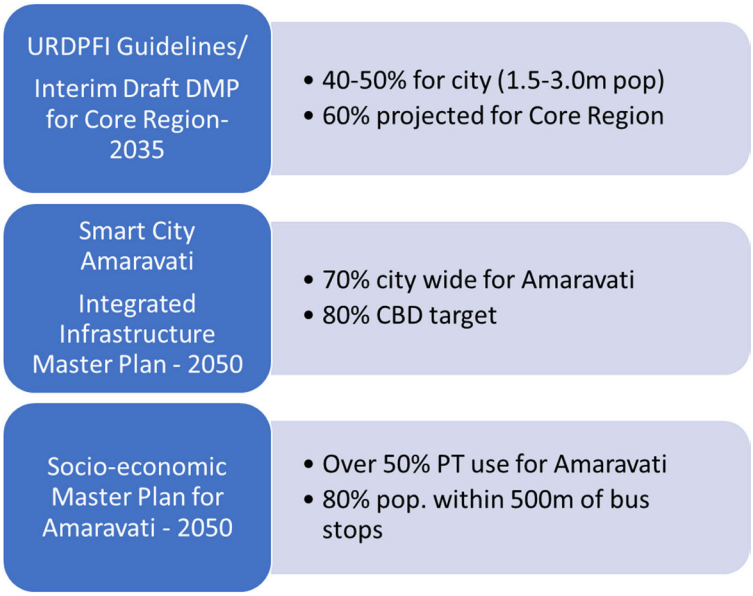
A core focus of the CTTS effort has been to assess different transport plan scenarios in the context of anticipated urban growth to determine which policy interventions best meet the strategic objectives outlined earlier. This has been done with the sophisticated IT-based modeling system custom-developed for APCR. This is essential given the prospect of regional population growth and, notably, the addition of Amaravati. These developments will significantly change the region's social, economic, and spatial structure and travel patterns.

One trend is clear. The construction of Amaravati and the provision of new river crossings will strongly orient future urban growth along a north-south axis anchored by Vijayawada, Amaravati, and Guntur. The socio-economic and transport interactions along this axis will stimulate further demand for residential and commercial intensification in core areas and peripheral growth around Vijayawada and Guntur.

This emergence of this almost magnetic axis is a positive trend. It strengthens compact city growth momentum and the viability of public transport – including future rapid transit systems – along with enhanced highway capacity and traffic management schemes throughout the metropolitan centers.

In terms of transport policy, this is in accord with the strategic objectives of CTTS: pointing the way to a comprehensive transportation system that promotes compact growth (not sprawl); that is practicable

to build; that supports economic growth; and that is sustainable, with a high modal share for public transportation and street environments conducive to walking and cycling.



Source: JICA Study Team

Figure 6.12 Public transport modal share guidelines

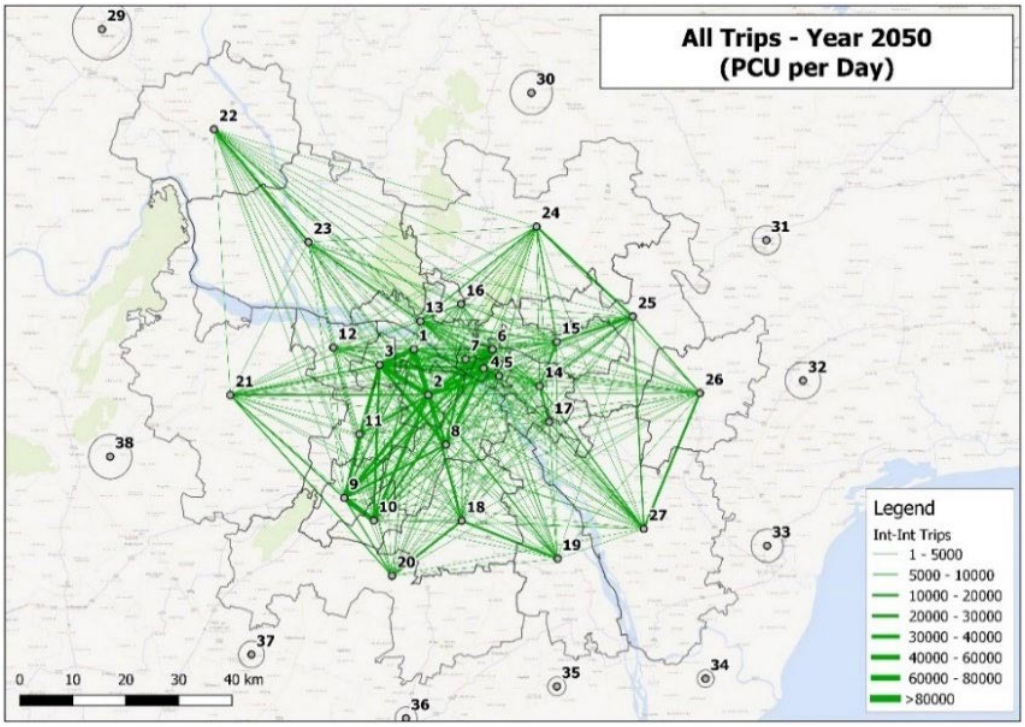
6.8 Regional transport plan

6.8.1 2050 strategic transport network

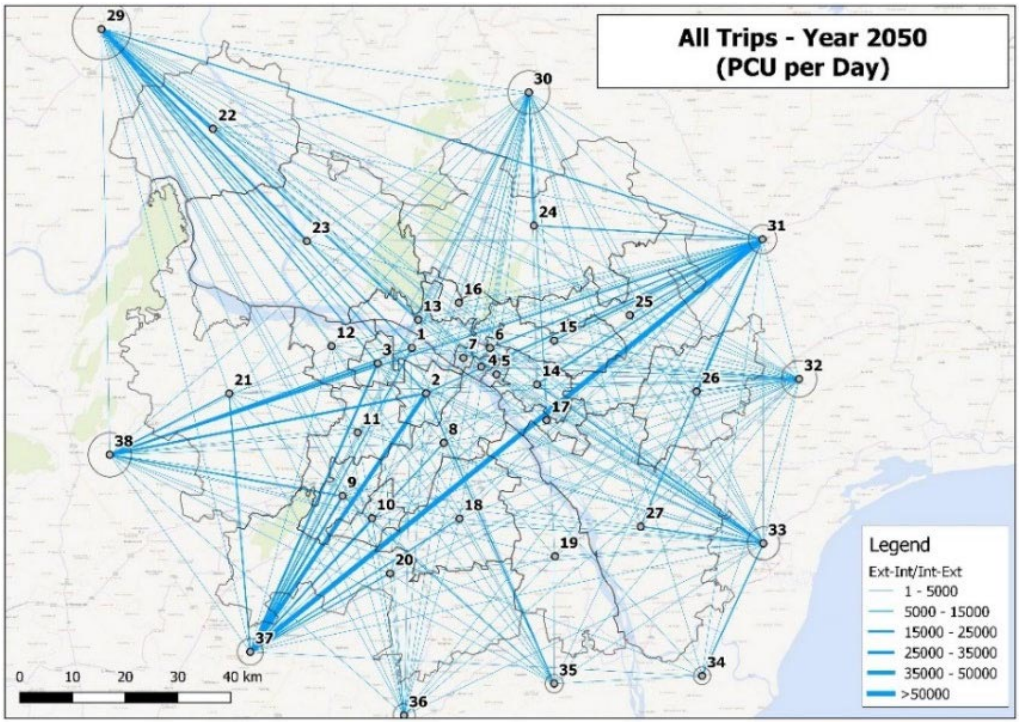
As shown in Figure 3.58, the existing traffic volumes (2017) on major highways and roads are simulated based on the traffic survey results and the newly developed strategic traffic model. In 2017, the trip production in APCR, excluding through traffic, is estimated to be auto rickshaw 29.5%, two-wheelers 27.2%, private car 9.1%, bus 31.9%, and railway (INR) 2.3%. Of the traffic volume (257.6 thousand PCU / day) observed on the cordon line (outside), about 17% (43.2 thousand PCU / day) is traffic passing through APCR with no destinations within APCR. Of this traffic volume, 35.6 thousand PCU / day (82% of the total traffic volume) is made by heavy vehicles (trucks). This passing heavy vehicle is also observed on the inner cordon line (the boundary of the metropolitan). If this passing traffic can detour the metropolitan area, it will contribute to alleviating congestion in the metropolitan area. At present, the traffic volume of NH16, including through traffic is quite large, and the crossing traffic volume of the Krishna River is already close to the capacity of the bridge. Since most freight trucks go through terminals, wholesale markets, warehouses, and industrial areas near Vijayawada, trucks having destinations at these facilities from outside the region worsen traffic congestion in Vijayawada. From these findings, the relocation of freight traffic generators to outside the city area and the development of detour routes (bypass) are recognized as planning issues to be addressed. The above trends can also be seen from the 2050 desire line diagrams. To summarize the above, APCR is located on the Visakhapatnam-Chennai Industrial Corridor. Since it is the intersection of national highways (NH16,

NH65) and main railways, modern logistics facilities with distribution and storage functions need to be installed along the ring road.

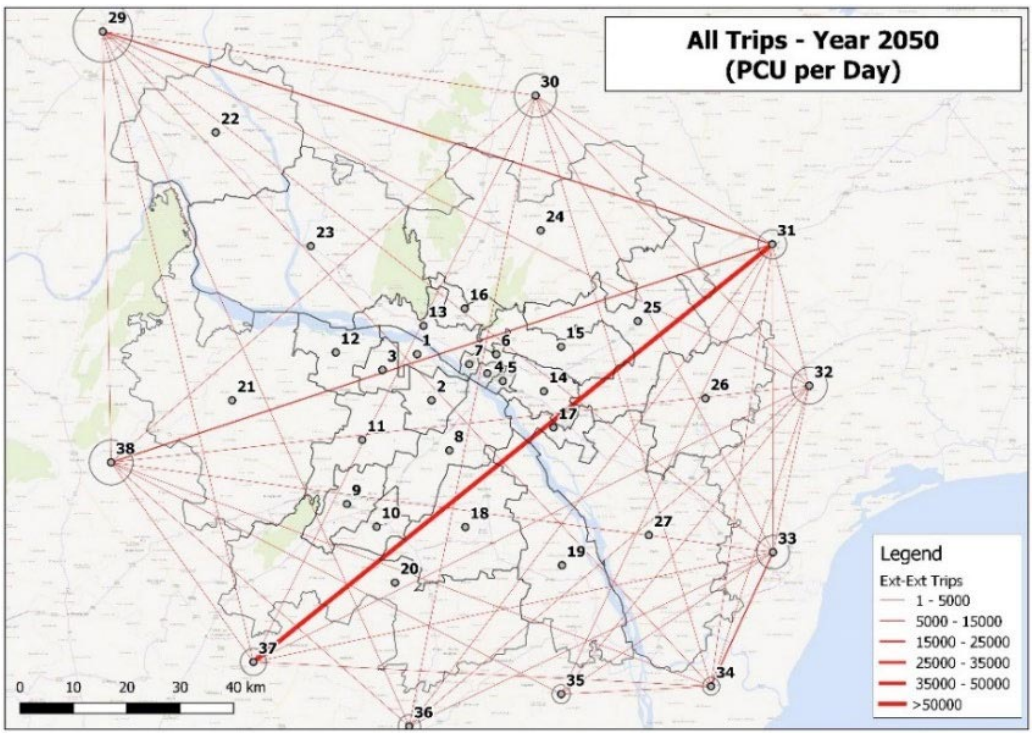
Internal trips (PCU/day, 2050)



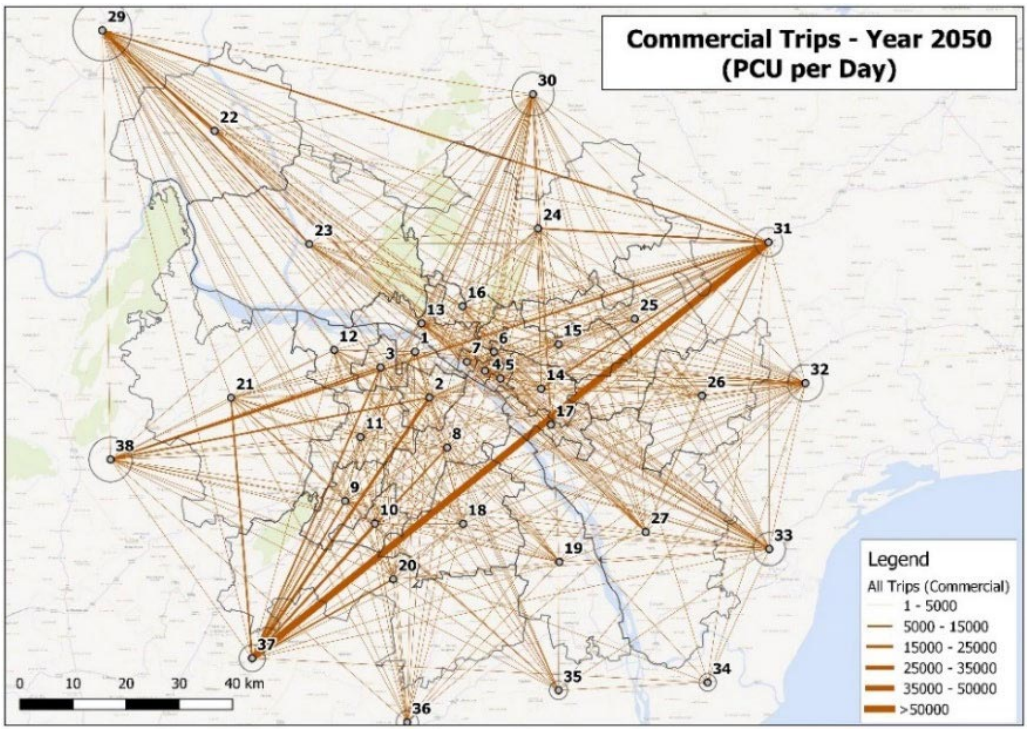
Internal-external/external-internal trips (PCU/day, 2050)



External-external trips (PCU/day, 2050)



All commercial (truck) trips (PCU/day, 2050)



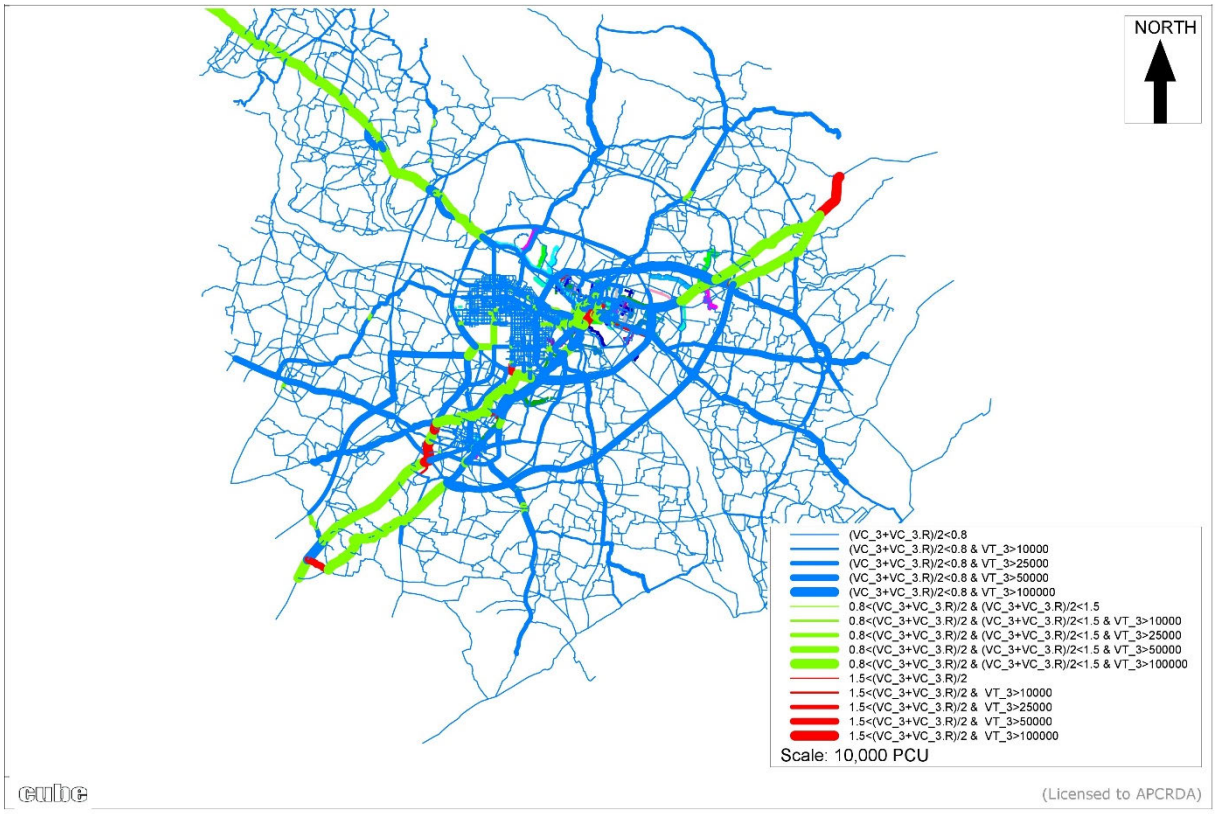
Note: Desire line - converted to PCU per day from Car, Two Wheeler, Auto Rickshaw, Bus, Truck vehicular trips

Source: JICA Survey Team

Figure 6.13 Desire line (2050)

Based on the socio-economic framework (economic growth scenario) and the spatial distribution scenario F, the road network in 2050 and the trunk public transportation network (highway bus service in the APCR and the metro network in the metropolitan area) were established.

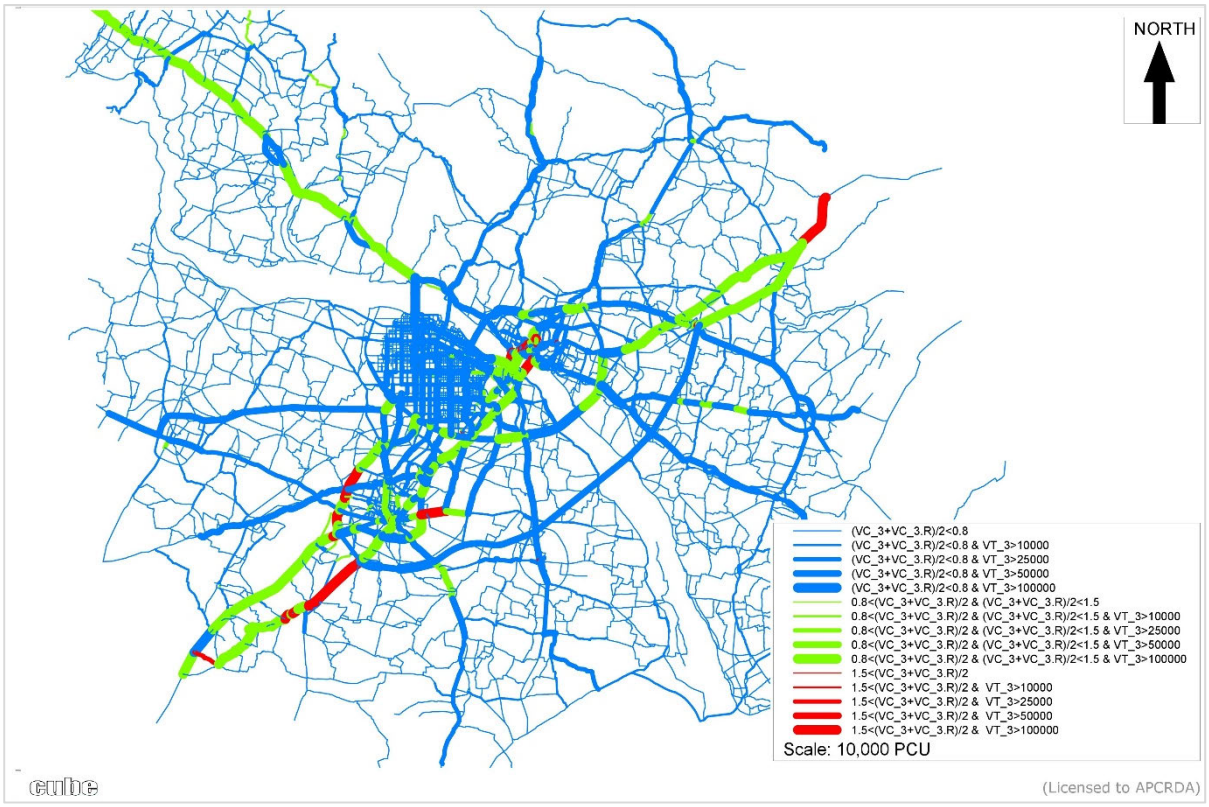
As a procedure for establishing a 2050 transportation network, all proposed strategic road networks (outer ring road, inner ring road, etc.) were envisioned at the NHIA and AP state levels and CMP/DMP roads expected by APCRDA were tested by the APCR strategic transport model. As a result of the traffic simulation, if the V / C value is low (0.5 or less) and there is an alternative road parallel to or has the same function in the neighborhood, the development of the proposed route will be postponed after 2050. As a result, the simulation results suggest that under the framework of Scenario F (2050), not all of the proposed strategic transportation network developments are necessary. As shown in Figure 6.15, even in 2050, both the outer ring road and the inner ring road will need to reach Phase 1 (eastern section) only, and it is not necessary to completely form the ring road.



Source: JICA Study Team

Figure 6.14 Simulated road traffic volume in APCR (Scenario F 2050 with all proposed strategic road networks)

These eastern ring road sections will be used by traffic passing through the APCR, which will also contribute to the alleviation of traffic congestion in the city center and between Vijayawada and Guntur. Some congestion is expected on National Highway 16 outside the outer ring road as of 2050, but this is a problem that cannot be solved by improving the road network inside APCR. To solve this problem, it is necessary to improve (widen) National Highway No. 16 itself or to develop a detour on the outside (east side) of APCR.



Source: JICA Study Team

Figure 6.15 Simulated road traffic volume in APCR (Proposed 2050 Network)

How to secure the means of crossing the Krishna River is an important planning issue in forming the APCR area and urban road (metropolitan) transportation network. In addition to the bridges on the strategic road traffic network already proposed in the past research, the existing NH16 bridge, Kanakadurga Varadhi (RB07) widening from 4 lanes to 6 lanes, and constructing a new bridge upstream of it (New Downstream Bridge:6 lanes) is proposed. On the other hand, Iconic Bridge (RB04) may be postponed after 2050 if RB03 is constructed. On the contrary, if RB04 is to be constructed first, RB03 may be postponed after 2050.

Table 6.7 Traffic volume crossing the Krishna River (2050)

Location	CODE	No. of lanes	2050	Indicative Volume / Capacity
			both directions 1,000 PCU per day	
Capital City Roads	RB03	8	111.8	0.54
Iconic Bridge	RB04	6	40.4	0.26
Western Bypass	RB05	8	79.8	0.39
Prakasam Barrage Road	RB06	2	134.8	3.93
National Highway 16	RB07	6	210.5	1.36
Inner Ring Road Phase 1	RB08	6	109.8	0.71

Location	CODE	No. of lanes	2050 both directions 1,000 PCU per day	Indicative Volume / Capacity
Outer Ring Road	RB09	6	78.8	0.51
National Highway	RB15	6	14.8	0.14
New Downstream River Bridge	NDRB	6	179.0	1.16

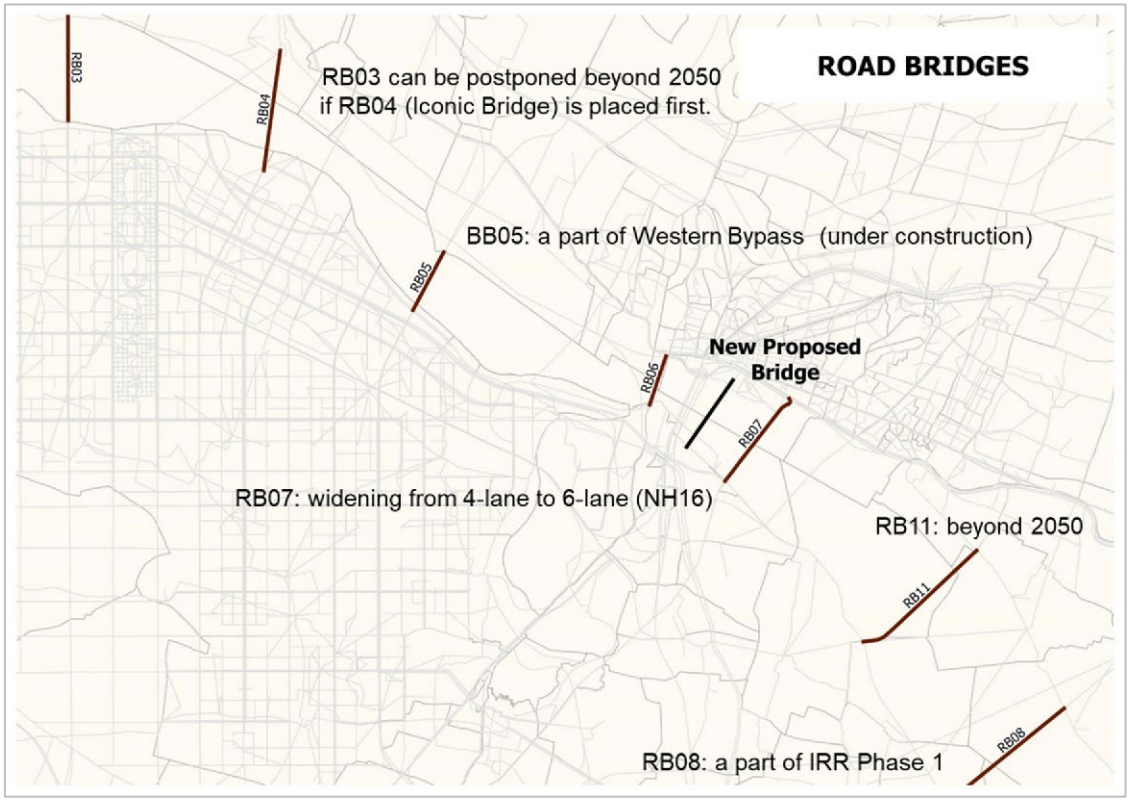
Note 1: Since RB05, RB06, New Down-stream Bridge, and RB07 are alternative routes to each other, the traffic volume and capacity can be considered by combining these four bridges.

Note 2: Both RB03 and RB04 are part of AP state highways. Either one may be postponed to 2050 or later.

Note 3: RB15 is an NHIA planned line outside the metropolitan area. Included in the 2050 network as there are no alternative routes.

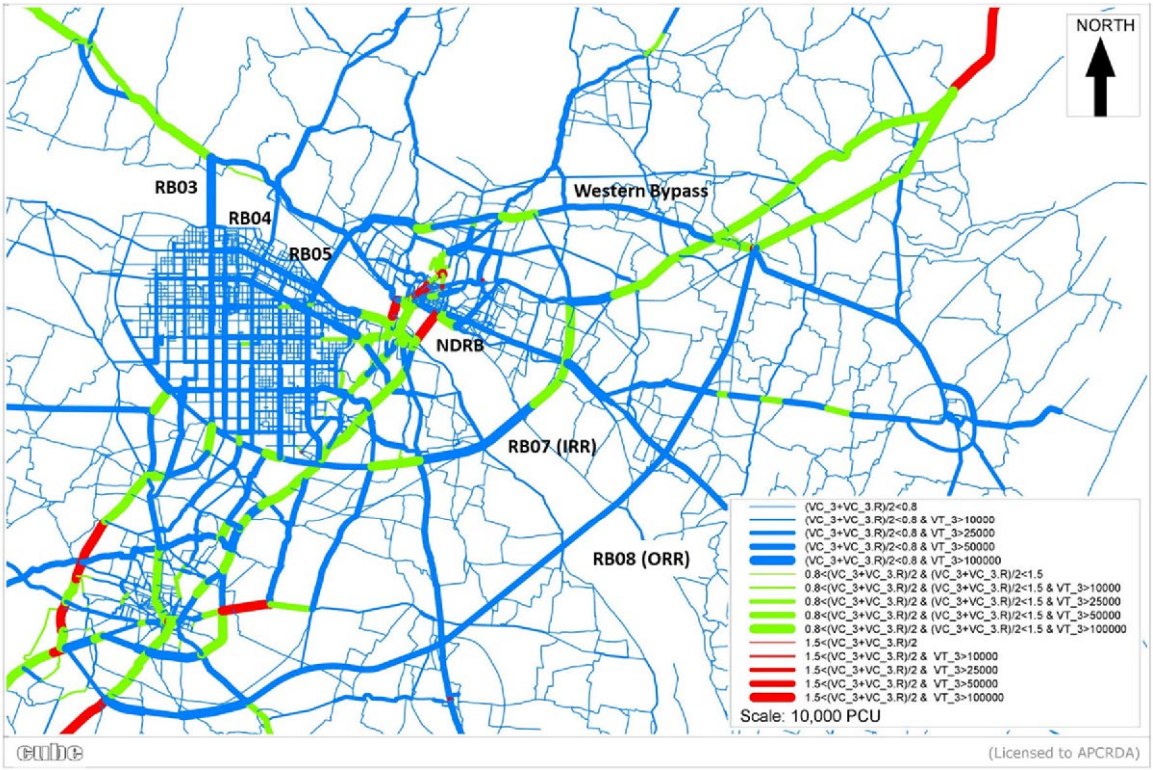
Note 4: V / C value (reference) is a reference value calculated simply as 2 lanes 1,200 PCU / hour / lane, 4 lanes 1,600 PCU / hour / lane, 6 lanes 1,800 PCU / hour / lane, peak rate 7%.

Source: JICA Study Team



Source: JICA Study Team

Figure 6.16 Proposed bridges crossing the Krishna River



Source: JICA Study Team

Figure 6.17 Simulated road traffic volume in APCR (Proposed 2050 Network in the central area)

The number of metro users in Amaravati and the circular railway connecting Amaravati-Vijayawada-Tadepalli-Guntur, which were proposed before formulating this master plan, cannot be expected to be financially and economically viable. Accordingly, the urban metro network has been reviewed and updated.

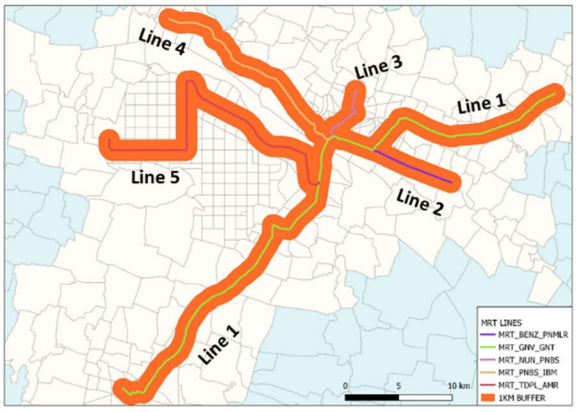
The five lines, shown in Figure 6.19 (total length 125 km), are proposed as the 2050 metro railway network. The new Indian Railways line, which runs on the west of Amaravati, will be included in the 2050 railway network.

The passenger demand for these five urban railway lines (MRT) in 2050 will be about 793,000 passengers/day, which is small for the total length of 125 km of metro railways. This is due to the influence of other traffic mode condition settings (high-speed bus service level is high) used in the forecast model, but the potential demand (resident population, employment opportunities) of the proposed MRT routes, as shown in Figure 6 13 is relatively large. The proposed MRT route serves a resident population of 2.34 million within 1 km, employment opportunities of 1.26 million, a resident population of 4.76 million who may use MRT within 2 km, and employment opportunities of 2.43 million.

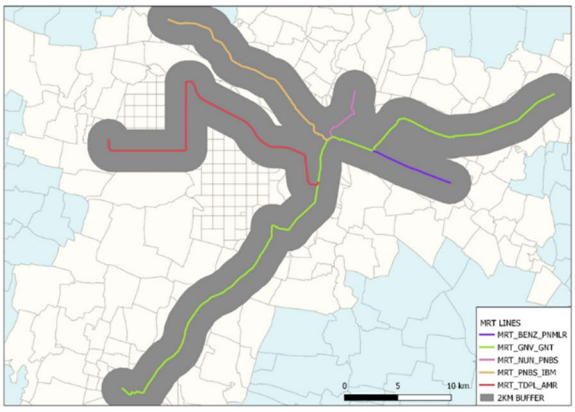
Table 6.8 Proposed MRT lines (2050)

MRT Line NAME	Forecasted Daily Boarding Passengers (1,000)	System Length (km)	Loaded passenger per system length (passenger/km)	Average passenger travel distance within the line (km per ride)
Line 1 Gannavaram-Guntur	341.6	59.4	5,753	15.6
Line 1A PNBS-Guntur	242.6	34.7	6,990	18.4
Line 1B PNBS-Gannavaram	99.0	24.7	4,013	8.8
Line 2 Benz Circle-Penamaluru	36.2	7.7	4,676	5.7
Line 3 PNBS-Nunna	68.2	6.0	11,364	3.9
Line 4 PNBS-Ibrahimpatnam	65.2	20.3	3,205	11.4
Line 5 Tadepalli-Amaravati	281.9	31.9	8,846	18.5
Total	793.1	125.3	6,328	14.8

Source: JICA Study Team



1 km area (buffer)



2 km area (buffer)

Within a range of 1km from MRT (2050 scenario F)

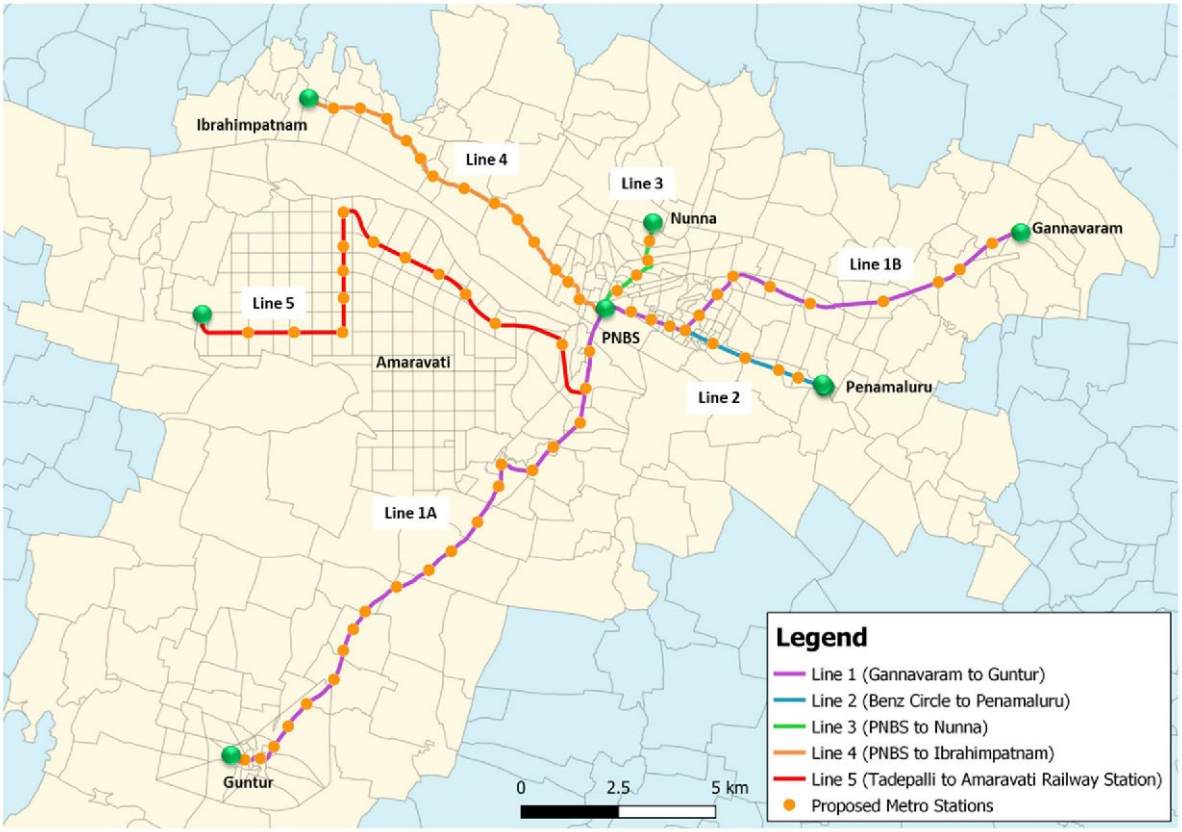
- Population: 2.34 million (26.8% of the metropolitan population)
- Employment opportunities: 1.26 million (31.6% of metropolitan employment opportunities)

Within a range of 2km from MRT (2050 scenario F4)

- Population: 4.76 million (54.5% of the metropolitan population)
- Employment opportunities: 2.43 million (60.6% of metropolitan employment opportunities)

Source: JICA Study Team

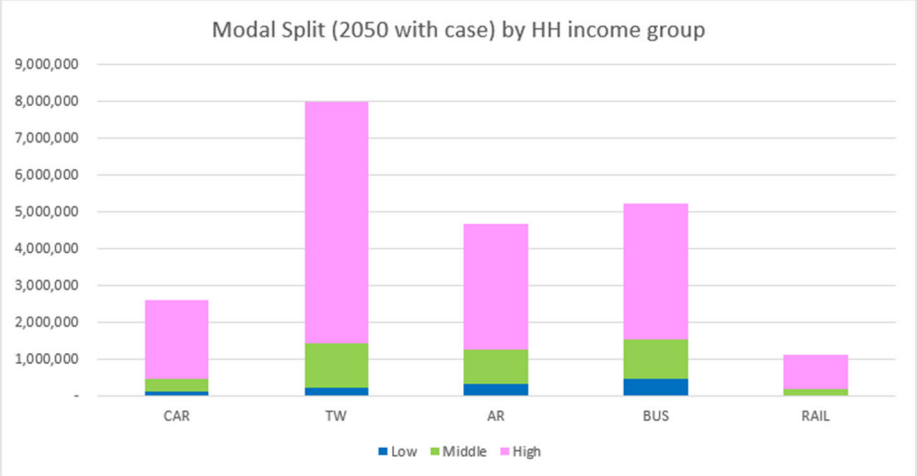
Figure 6.18 Population and employment opportunities along the metro lines (2050)



Source: JICA Study Team

Figure 6.19 Proposed CTTS MRT network in the metropolitan area (2050)

Suppose the proposed strategic transportation network development in 2050 is realized. In that case, railways (including MRT and INR), buses (including the proposed high-speed bus service), and auto-rickshaw (maintained and continued as a means of short-distance transportation), the modal share of public transportation services, including the above, account for about 51% of the total mechanized transportation demand (refer to Figure 6.20). On the other hand, if the proposed strategic transport investment is not made, the ratio of two-wheeled vehicles and auto-rickshaw users will increase. As a result, the modal share of public transportation is expected to be about 46% (refer to Figure 6.21).

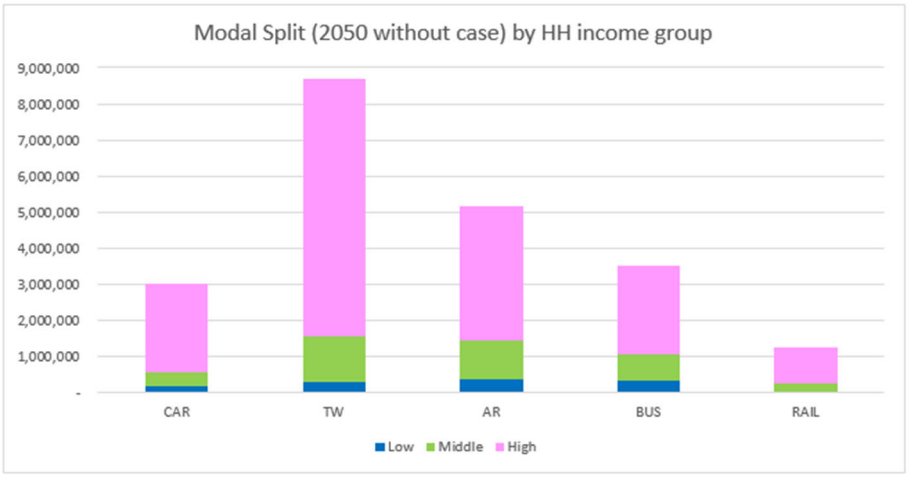


HH income	CAR	TW	AR	BUS	RAIL	TOTAL
Low	9.3%	20.7%	29.6%	39.8%	0.6%	100.0%
Middle	9.1%	31.9%	25.3%	29.1%	4.6%	100.0%
High	12.8%	39.3%	20.3%	22.1%	5.5%	100.0%
Total	12.0%	37.0%	21.6%	24.2%	5.1%	100.0%
	49.0%		51.0%			

Unit: 1,000 trips

	CAR	TW	AR	BUS	RAIL	TOTAL
Low	102.3	229.1	326.9	440.3	6.7	1,105.3
Middle	336.5	1,176.6	931.9	1,073.6	168.9	3,687.5
High	2,143.3	6,575.1	3,400.1	3,708.7	924.4	16,751.5
Total	2,582.1	7,980.8	4,658.9	5,222.5	1,100.0	21,544.3

Figure 6.20 Modal share (2050 with case)

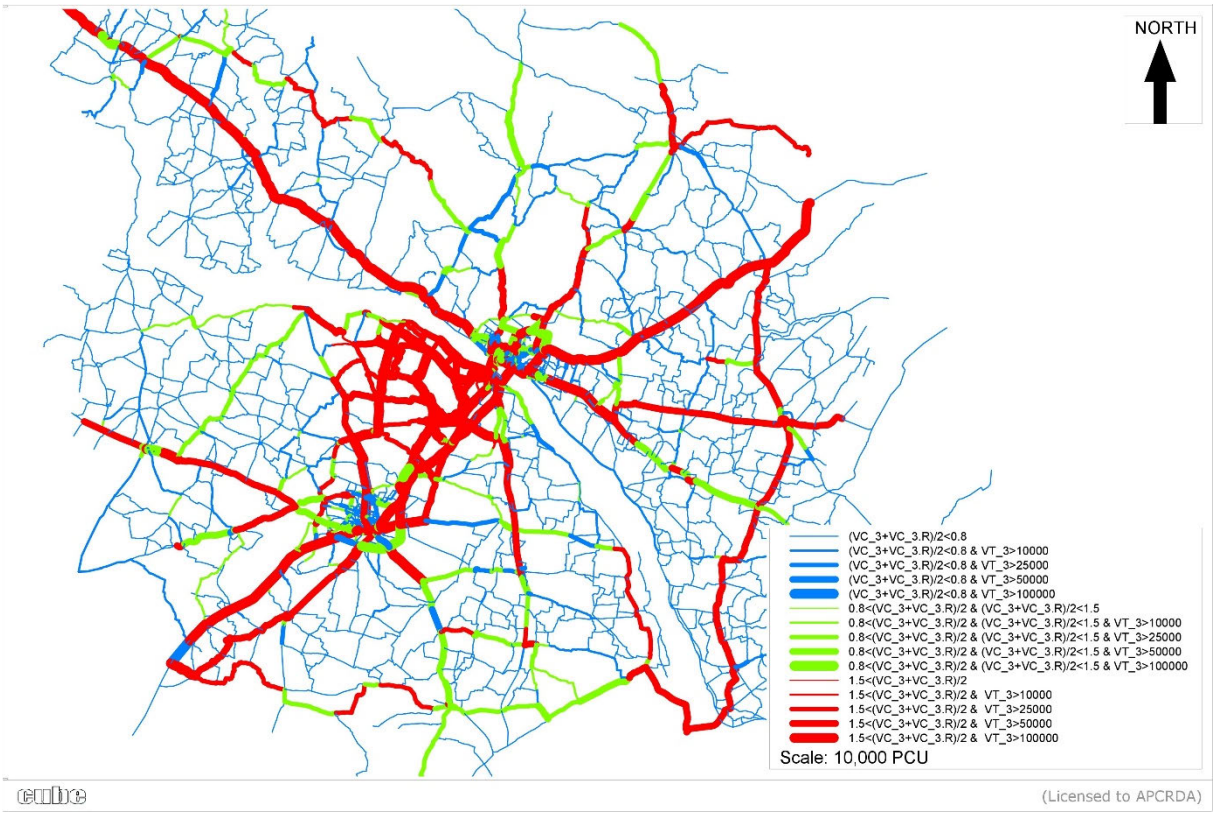


HH income	CAR	TW	AR	BUS	RAIL	TOTAL
Low	12.8%	24.9%	32.7%	28.2%	1.3%	100.0%
Middle	11.1%	34.4%	28.6%	19.6%	6.3%	100.0%
High	14.6%	42.6%	22.2%	14.7%	6.0%	100.0%
Total	13.9%	40.2%	23.9%	16.2%	5.8%	100.0%
	54.2%		45.8%			

Unit: 1,000 trips/day

	CAR	TW	AR	BUS	RAIL	TOTAL
Low	143.3	277.6	365.6	315.2	14.9	1,116.5
Middle	409.0	1,273.0	1,057.6	725.5	232.0	3,697.1
High	2,444.8	7,125.0	3,719.4	2,454.2	999.0	16,742.5
Total	2,997.2	8,675.6	5,142.5	3,494.9	1,246.0	21,556.1

Figure 6.21 Modal share (2050 without case)



Source: JICA Study Team

Figure 6.22 Simulated traffic volume in APCR (2050 without case)

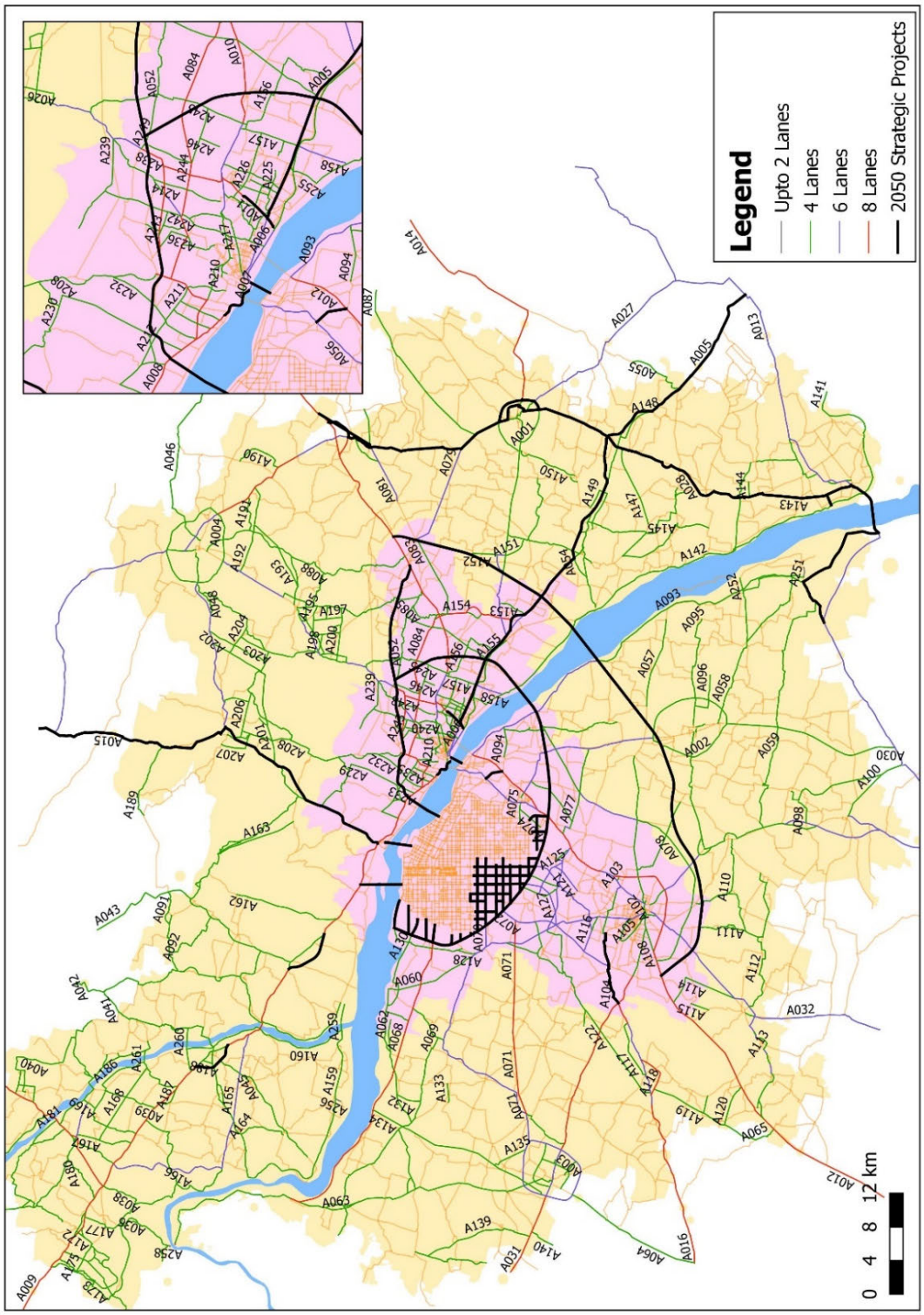


Figure 6.23 Proposed road network (2050) (1/2)

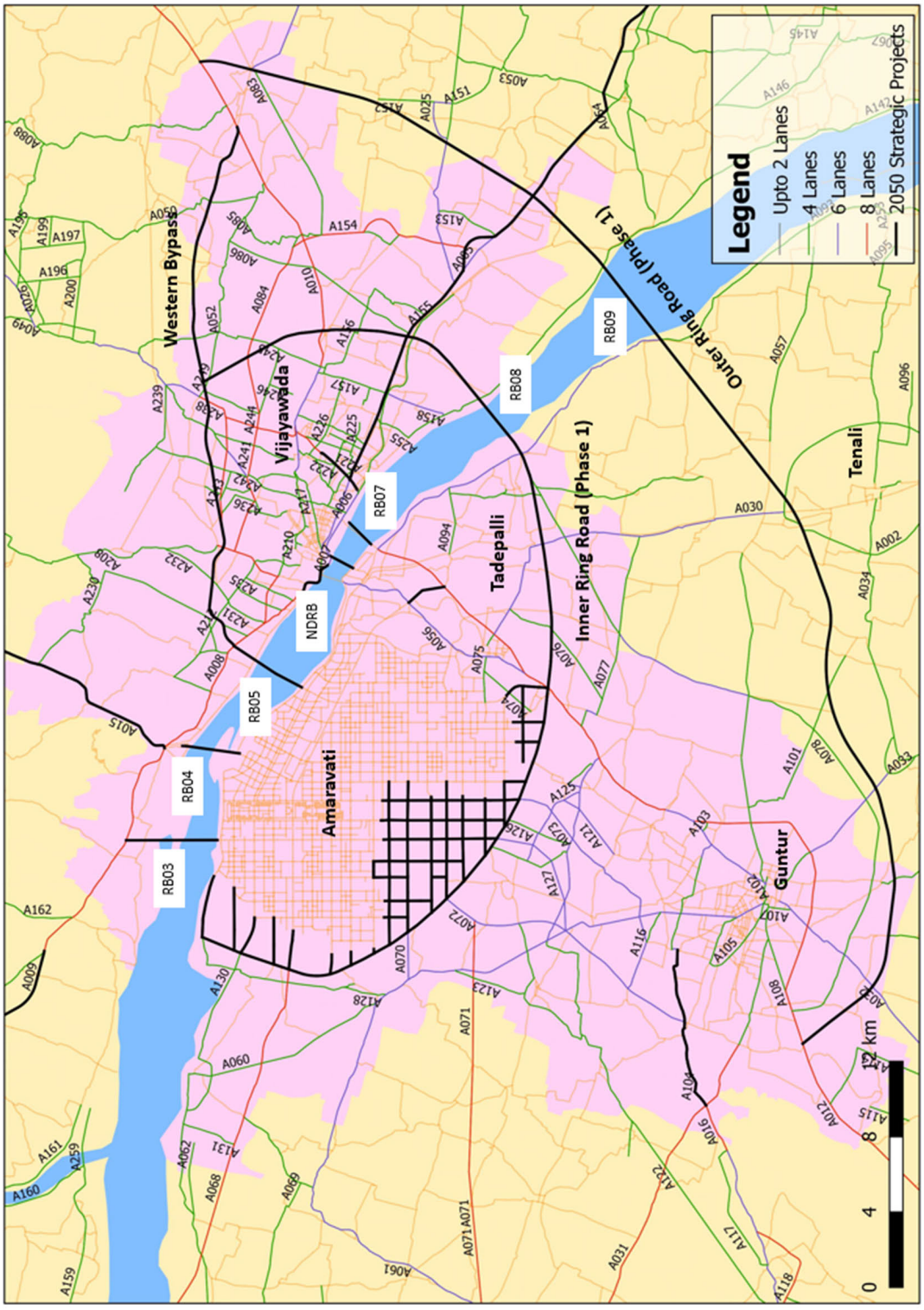


Figure 6.24 Proposed road network (2050) (2/2)

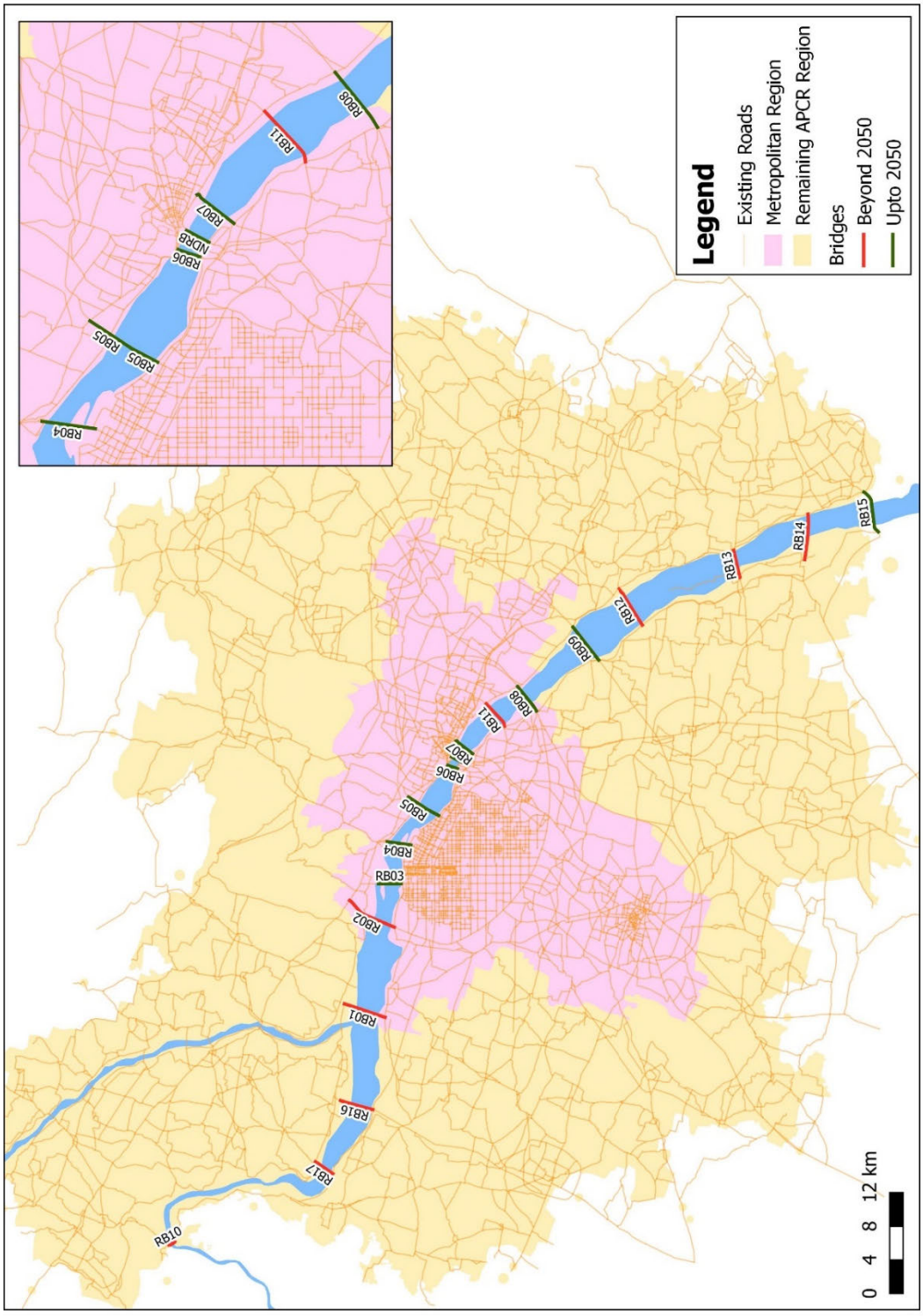


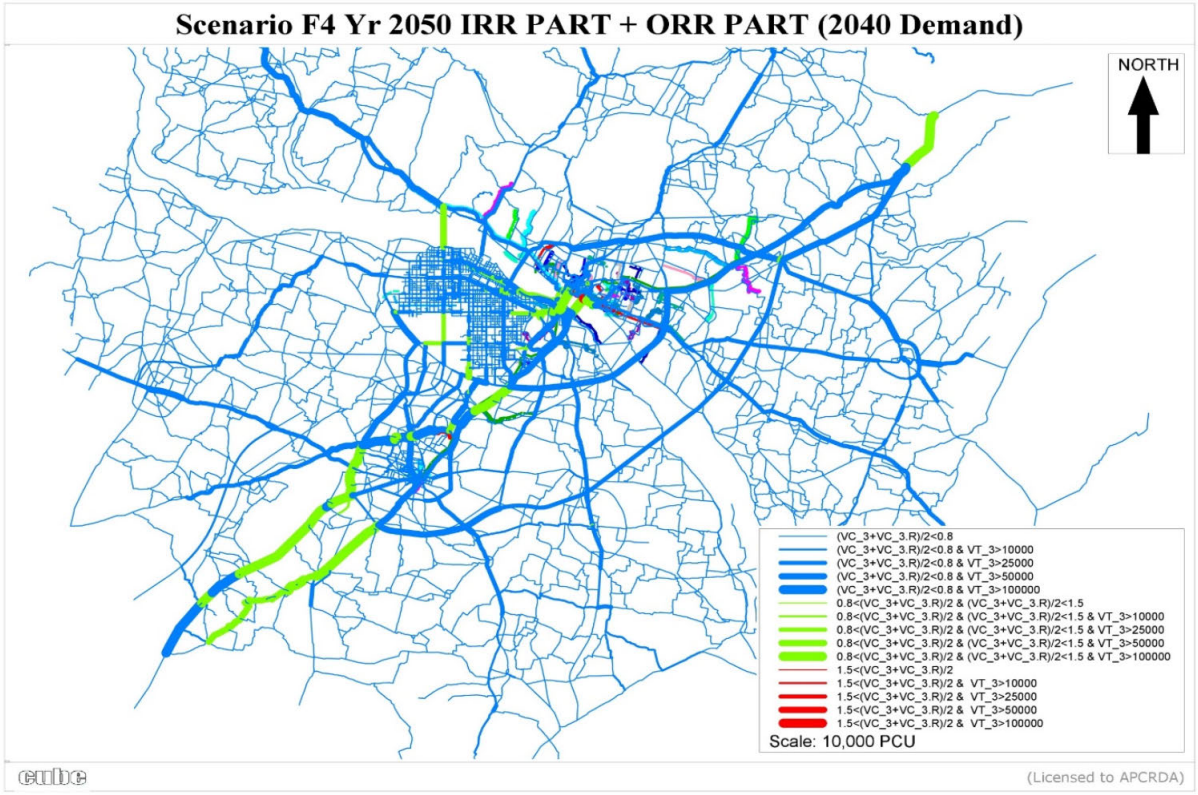
Figure 6.25 Proposed Krishna River crossing bridges

6.8.2 2040 strategic transport network

The 2040 transportation network follows the 2040 transportation network formation policy mentioned above. At the same time, by assigning the 2040 demand to the 2050 network as quantitative analysis and removing the routes with less traffic, it was finalized as the 2040 road network.

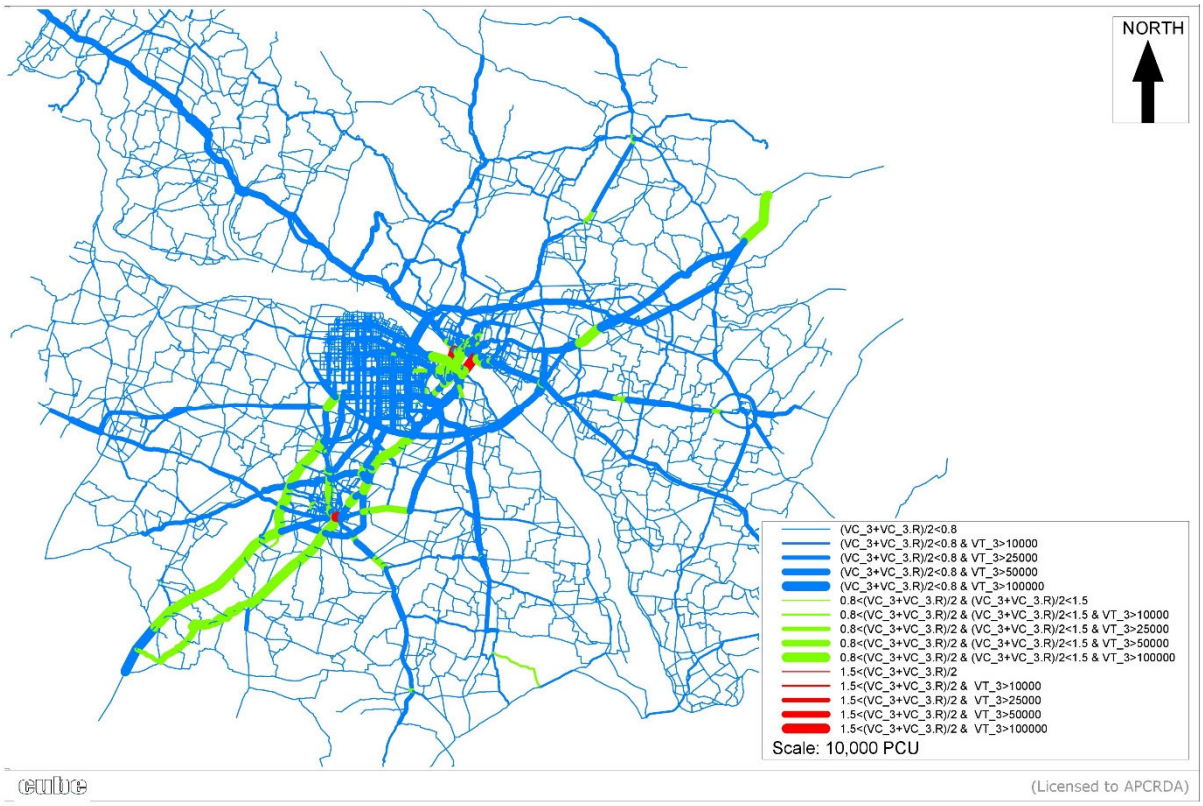
As shown in Figure 6.26, the outer ring road (ORR Phase 1 including RB09), Krishna River Crossing Bridge RB03, and RN04 were judged to be unnecessary as of 2040. Accordingly, the road network for the year 2040 is proposed, as shown in Figure 6.27.

Traffic demand for RB07 is expected to exceed the design traffic capacity. Still, if the outer ring road is completed by 2050, the demand for a river crossing at RB07 will decrease (i.e., detour to the outer ring road).



Source: JICA Study Team

Figure 6.26 Simulated traffic volume in APCR (Proposed 2050 Network with 2040 Scenario F Demand)



Source: JICA Study Team

Figure 6.27 Simulated traffic volume in APCR (Proposed 2040 Network)

Table 6.9 Traffic volume crossing the Krishna River (2040)

Location	CODE	No. of lanes	2040	Indicative
			both directions 1,000 PCU per day	Volume / Capacity
Western Bypass	RB05	8	103.8	0.50
Prakasam Barrage Road	RB06	2	124.8	3.64
National Highway 16	RB07	6	223.9	1.45
Inner Ring Road Phase 1	RB08	6	103.3	0.77
National Highway	RB15	6	10.3	0.10
New Downstream River Bridge	NDRB	6	158.2	1.03

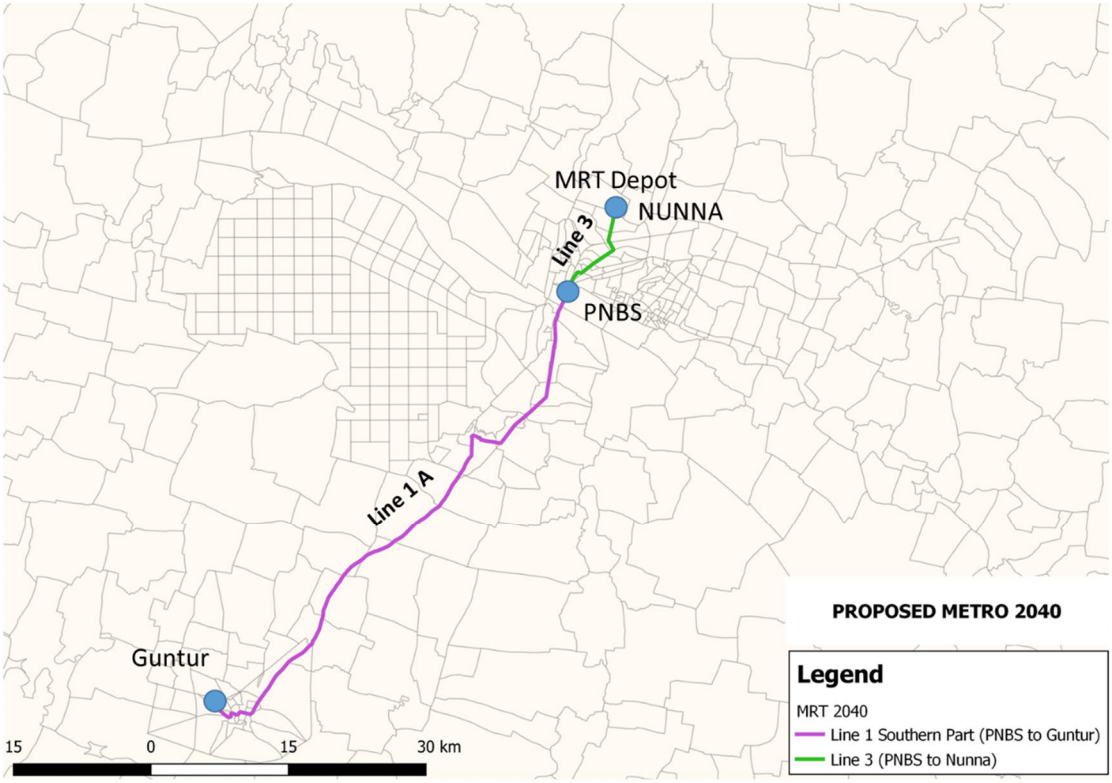
Note 1: Since RB05, RB06, New Down-stream Bridge, and RB07 are alternative routes to each other, the traffic volume and capacity can be considered by combining these four bridges.

Note 2: RB15 is an NHIA planned line outside the metropolitan area. There is no alternative route.

Note 3: V / C value (reference) is a reference value calculated simply as 2 lanes 1,200 PCU / hour / lane, 4 lanes 1,600 PCU / hour / lane, 6 lanes 1,800 PCU / hour / lane, peak rate 7%.

For the metro lines, the combination of the southern section of Line 1 (PNBS-Guntur) and Line 3 (PNBS-Nunna) is considered a highly efficient investment. In this case, PNBS is the central station of

the entire MRT network, and it should be noted that PNBS is one of the selected 10 TOD sites. The first MRT depot and workshop for this APCR metro can be secured around the Nunna station.



Source: JICA Study Team

Figure 6.28 Proposed MRT network in the metropolitan area (2040)

Table 6.10 Proposed MRT lines (2040)

MRT Line NAME	Forecasted Daily Passengers (1,000)	System Length (km)	Loaded passenger per system length (passenger/km)	Average passenger travel distance (km per ride)
Line 1 (Phase 1) PNBS-Guntur	159.2	34.7	4,600	13.4
Line 3 Nunna-PNBS	25.7	6.0	4,300	3.7
Total	172.2	40.7	4,500	11.9

Source: JICA Study Team

The strategic transportation network formation strategy for 2040 can be summarized as follows, focusing on the metropolitan area.

- Alleviation of the traffic congestion on the Krishna River Crossing
- Comprehensive access improvement in the southern part of the Krishna district
- Development of high-speed buses and the metro lines (Line 1 south line and Line 3) to improve

accessibility inside and outside the metropolitan area

- TOD in the metropolitan area as an anchor for mixed-use development
- Logistics center location that supports multi-modal logistics associated with rail freight corridors, especially enables mode shifts from freight to long-distance roads to railroads, and acts as an anchor for storage, warehousing, and related urban economic development.

As a result, the modal share of public transportation can reach 53% (48% without case).

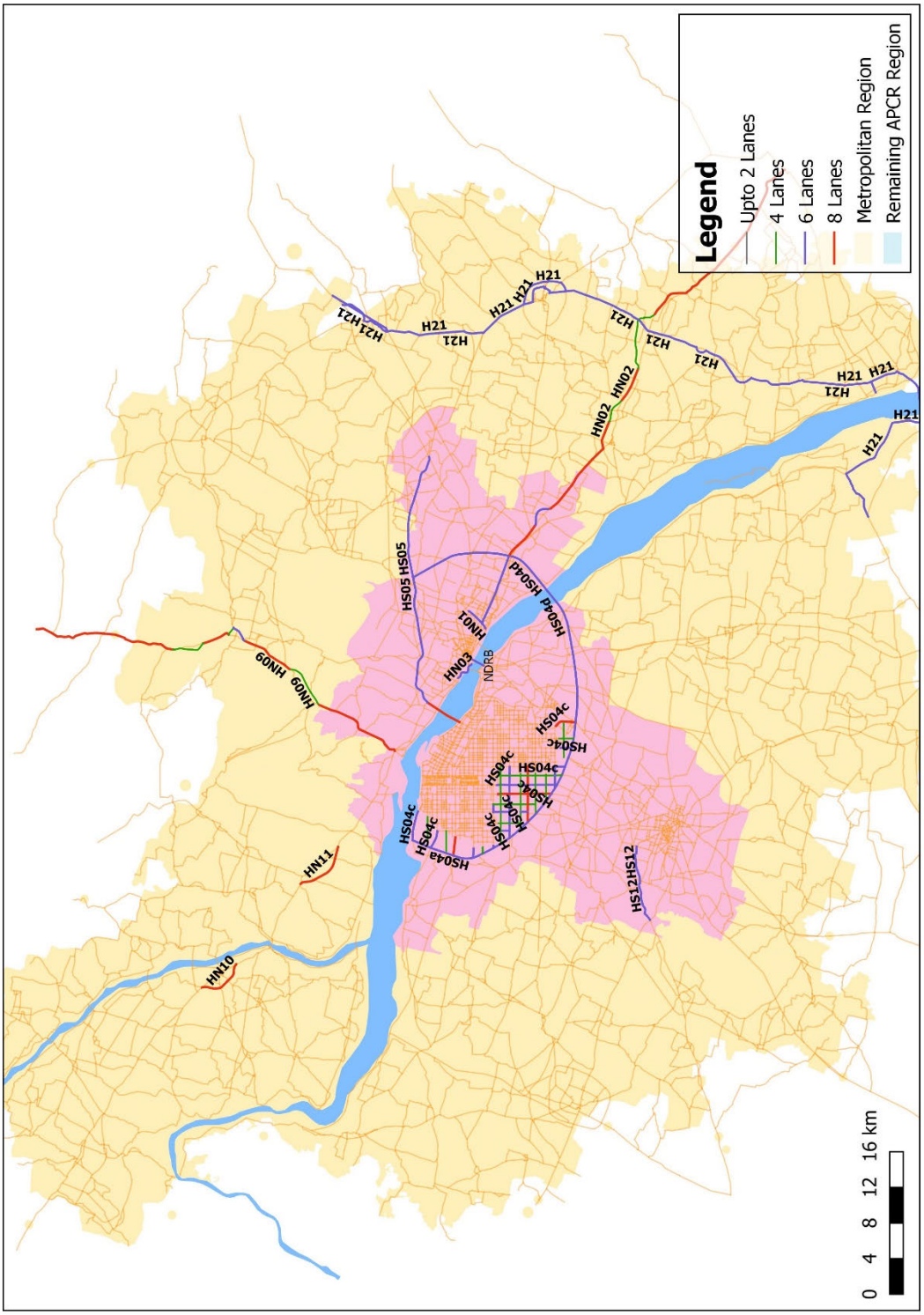


Figure 6.29 Proposed road network (2040) (1/2)

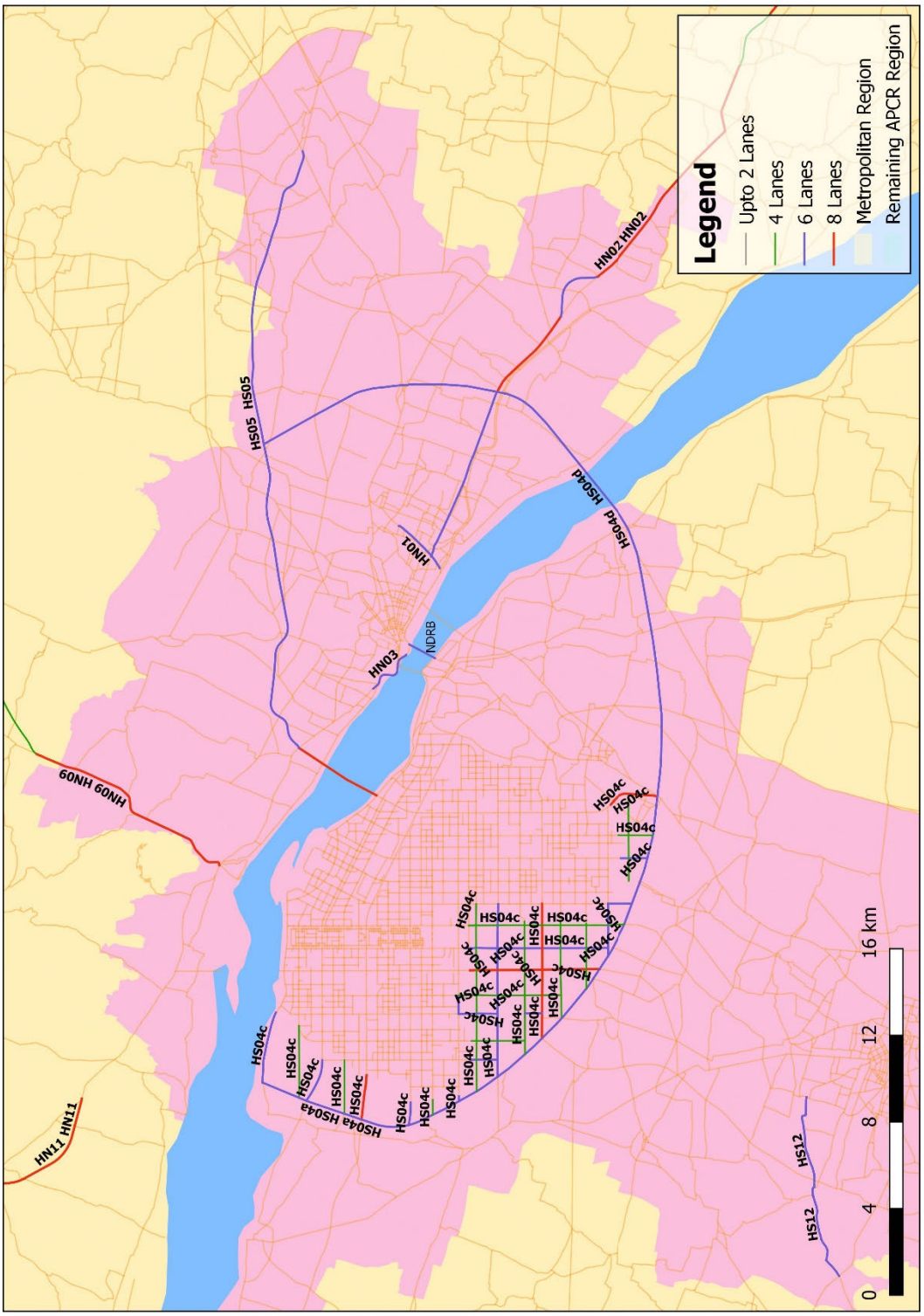
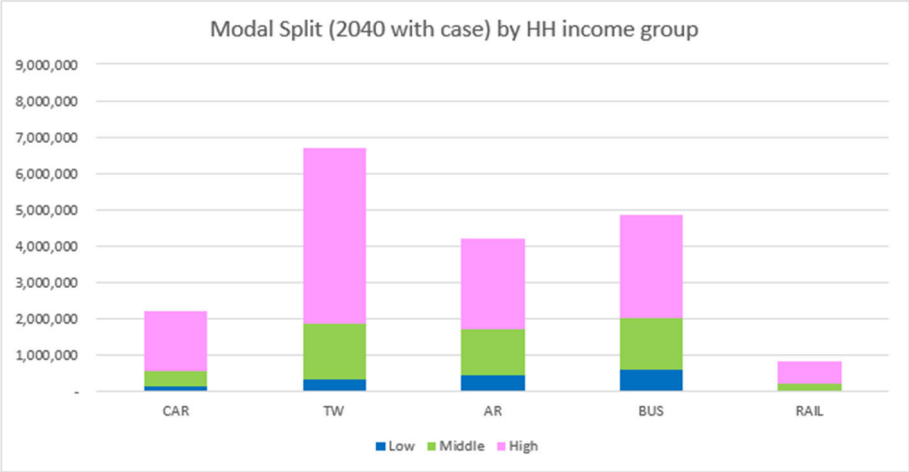


Figure 6.30 Proposed road network (2040) (2/2)

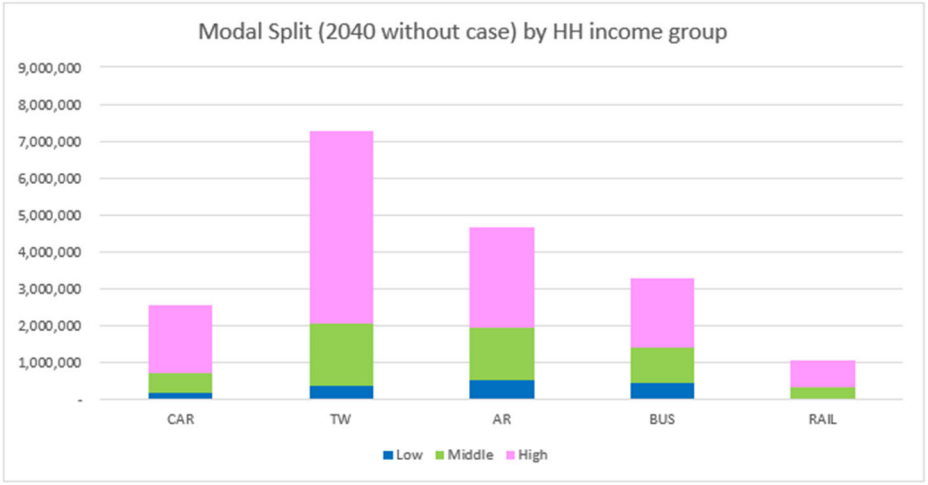


HH income	CAR	TW	AR	BUS	RAIL	TOTAL
Low	8.9%	20.7%	30.1%	39.8%	0.6%	100.0%
Middle	8.9%	31.9%	25.9%	29.2%	4.2%	100.0%
High	13.1%	38.9%	20.1%	23.0%	4.9%	100.0%
Total	11.7%	35.6%	22.4%	25.9%	4.4%	100.0%
	47.4%		52.6%			

Unit: 1,000 trips/day

	CAR	TW	AR	BUS	RAIL	TOTAL
Low	129.1	300.3	437.3	578.9	8.3	1,453.9
Middle	434.6	1,554.2	1,261.6	1,421.9	202.4	4,874.6
High	1,633.8	4,836.1	2,499.1	2,858.2	612.0	12,439.3
Total	2,197.5	6,690.5	4,197.9	4,859.0	822.7	18,767.7

Figure 6.31 Modal share (2040 with case)



HH income	CAR	TW	AR	BUS	RAIL	TOTAL
Low	11.9%	24.4%	33.7%	28.7%	1.2%	100.0%
Middle	10.5%	34.4%	29.3%	19.8%	5.9%	100.0%
High	14.9%	42.0%	22.0%	15.0%	6.0%	100.0%
Total	13.5%	38.7%	24.8%	17.3%	5.6%	100.0%
	52.2%		47.8%			

Unit: 1,000 trips/day

	CAR	TW	AR	BUS	RAIL	TOTAL
Low	174.7	357.8	492.9	420.8	17.7	1,463.8
Middle	514.1	1,682.7	1,434.0	968.4	288.2	4,887.3
High	1,849.3	5,231.4	2,743.1	1,870.1	752.1	12,446.0
Total	2,538.1	7,271.9	4,670.0	3,259.2	1,058.0	18,797.2

Figure 6.32 Modal share (2040 without case)

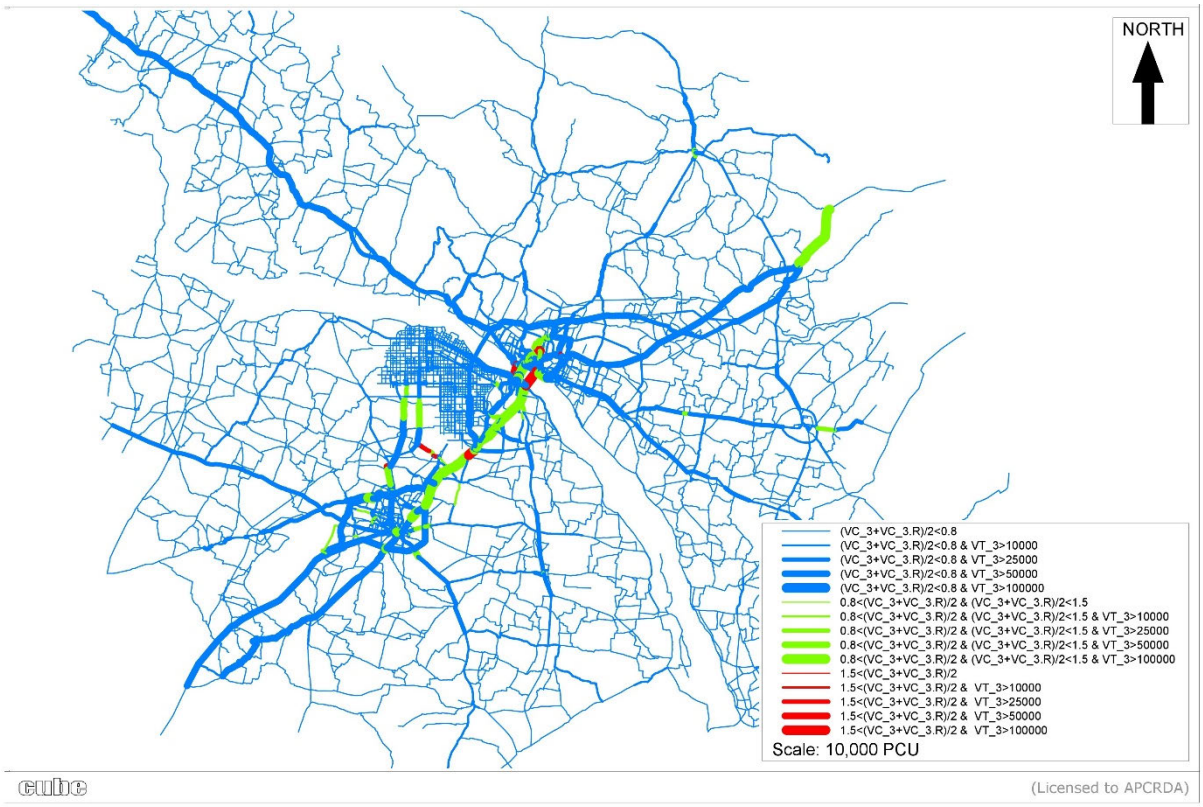
6.8.3 2030 strategic transport network

The 2030 strategic transportation network was established by assigning the 2030 demand to the 2040 network and removing the routes with less traffic as a result.

The 2030 Road Network proposes the New Downstream River Bridge (NDRB) in addition to the Western Bypass (including RB05, under construction). Of the new roads proposed by the CMP, the ring road at ULBs located outside the metropolitan is not included in the 2030 network (see 2040 UTPs for details). In addition, the number of lanes has been reduced in the 2030 Amaravati road network, reflecting the gradual improvement plan for the arterial roads in Amaravati. For example, for a 6-lane arterial road, the simulation was performed by reducing the capacity of the network in Amaravati on the assumption that only the outer two lanes would be left.

As of 2030, the need for urban railways (MRT) will not be recognized. It is judged that passenger transportation demand can be met by providing high-speed bus services within the region and existing bus routes.

As a result, we aim for a public transportation share of 54% (52% without case).



Source: JICA Study Team

Figure 6.33 Simulated traffic volume in APCR (Proposed 2030 Network)

Table 6.11 Traffic volume crossing the Krishna River (2030)

Location	CODE	No. of lanes	2030 both directions 1,000 PCU per day)	Indicative Volume / Capacity
Western Bypass	RB05	6	38.6	0.25
Prakasam Barrage Road	RB06	2	20.5	0.60
National Highway 16	RB07	6	176.7	1.15
National Highway	RB15	2	5.3	0.05
New Downstream River Bridge	NDRB	6	103.7	0.67

Note 1: Since RB05, RB06, New Down-stream Bridge, and RB07 are alternative routes to each other, the traffic volume and capacity can be considered by combining these four bridges.

Note 2: RB15 is an NHIA planned line outside the metropolitan area. There is no alternative route.

Note 3: V / C value (reference) is a reference value calculated simply as 2 lanes 1,200 PCU / hour / lane, 4 lanes 1,600 PCU / hour / lane, 6 lanes 1,800 PCU / hour / lane, peak rate 7%.

6.9 Highway decongestion proposals

The "Do Nothing" scenario revealed several capacity issues in the strategic road network. Using the transport model, a set of decongestion proposals were tested to see how their introduction might alleviate identified bottlenecks.

New river bridges are proposed to improve through traffic flows, allowing vehicles to bypass central Vijayawada. Tunnels are proposed within Vijayawada to ease traffic movement inside the city. The eastern highway connector acts as a regional bypass, routing through traffic around the metropolitan area and linking NH16 with NH216.

Based on the modeling exercise, the following projects are proposed for inclusion in the regional transportation plan for short-term implementation (by 2030). These aim to alleviate major bottlenecks and related traffic speed, delay, and safety problems.

a. Metro Region: Bridge between Prakasam Barrage and Varadhi (New Downstream River Bridge, 6-lane)
b. Metro Region: Bridge linking Kanuru 100ft road to Riverbank Rd. (East) & connector (6-lane)
c. Regional: Hanuman Jn. to GBC Rd. via Gudivada, Pamarru, Kuchipudi, Bhattipolu (NH216 & SH328) (4-lane)
d. Metro Region: Skew bridge to Kanuru 100ft road (along the canal) (4-lane); Vijayawada IRR extension to Kesarapalli (4-lane)
e. Vijayawada: Tunnels in Gunadala hill and Indrakeeladri hill (4-lane)
f. Vijayawada: ROB connecting BRTS road & 1 town ROB on Erra Katta road (4-lane)
g. Metro Region: Amaravati to Guntur SH expansion
h. Guntur: IRR connecting NH16 to SH21
i. Guntur: GT road expansion from NH16 to Guntur bus stand
j. Mangalagiri: GT/trunk road connector
k. Tadepalle: radial connector to MDR

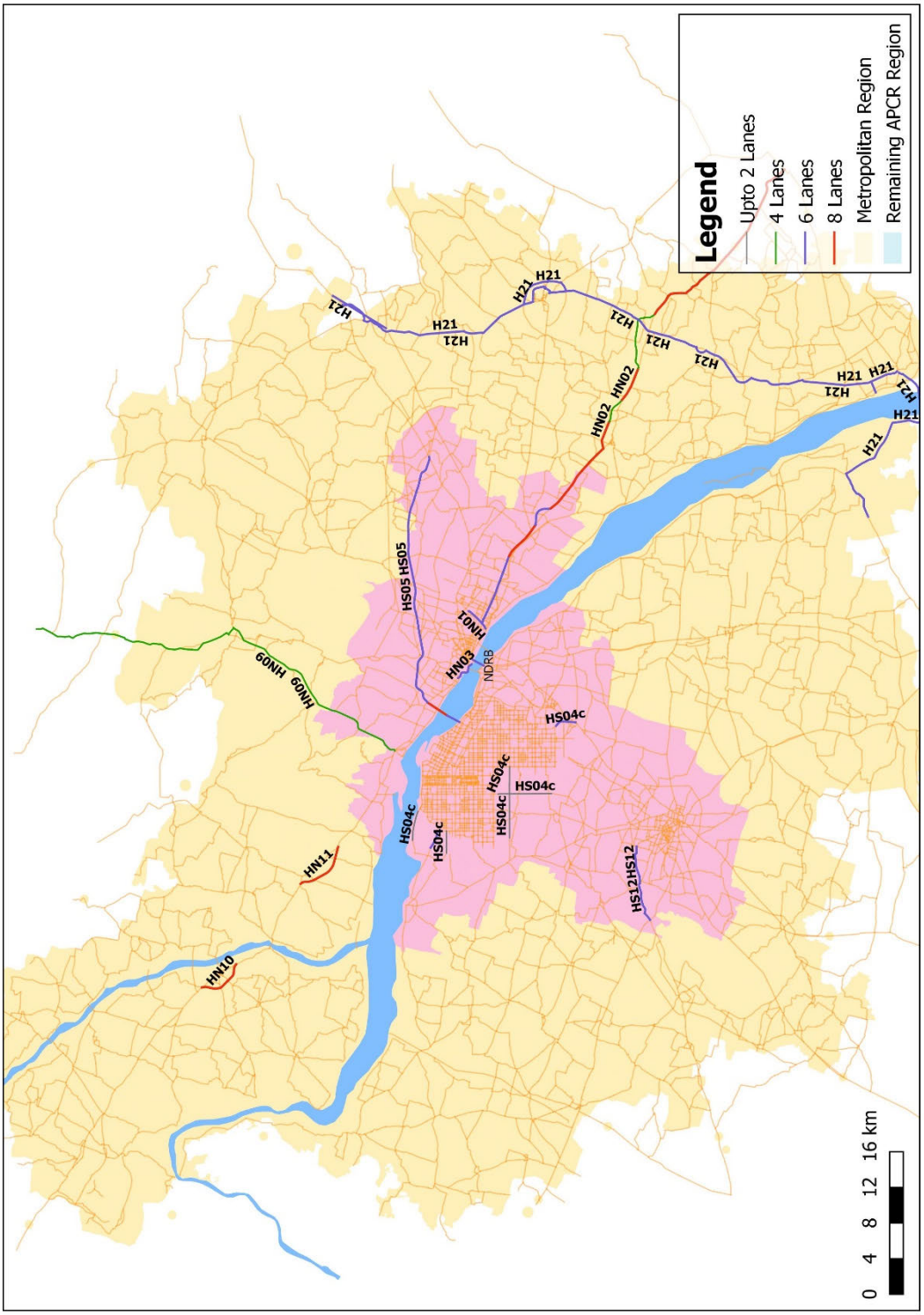


Figure 6.34 Proposed road network (2030) (1/2)

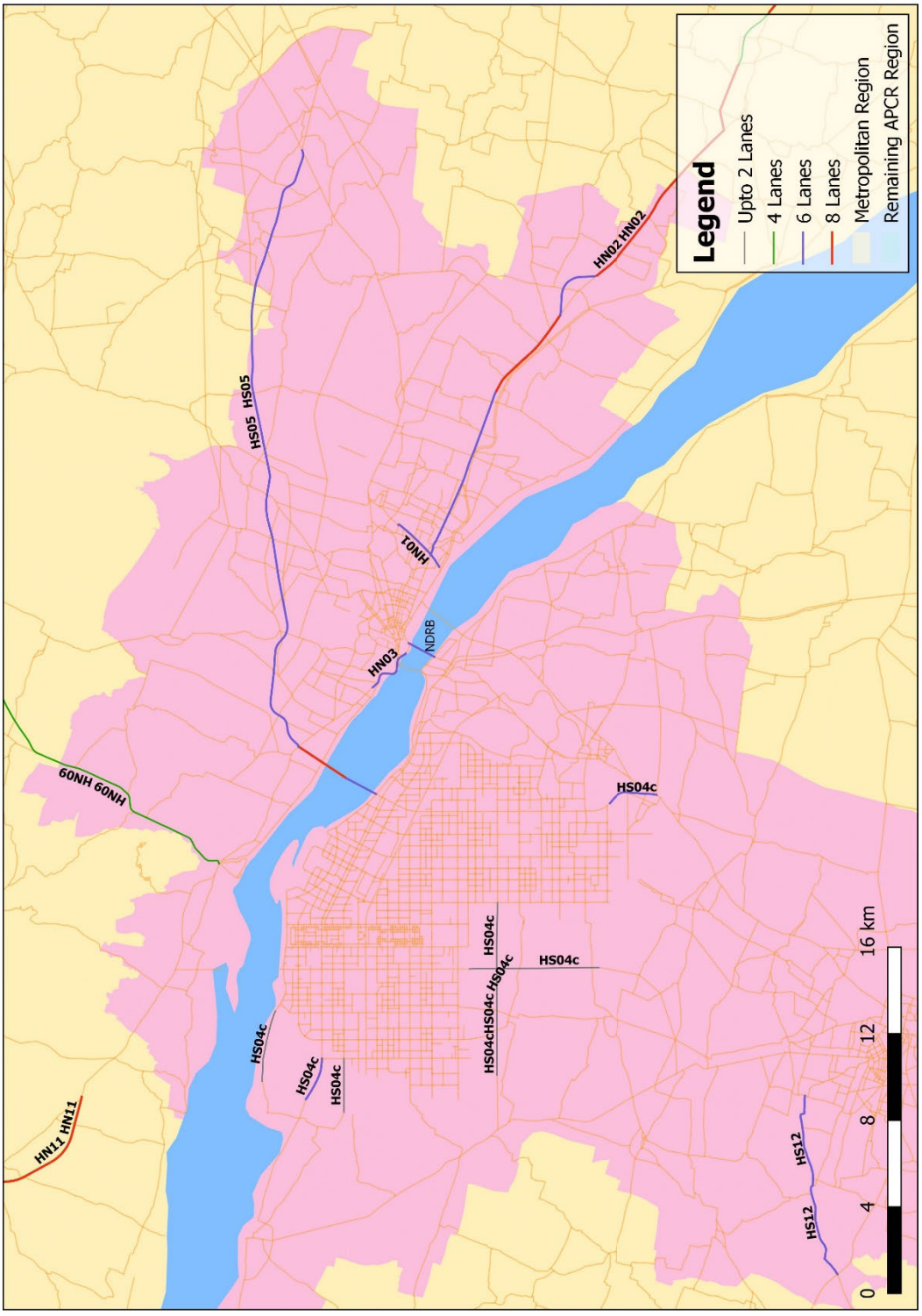
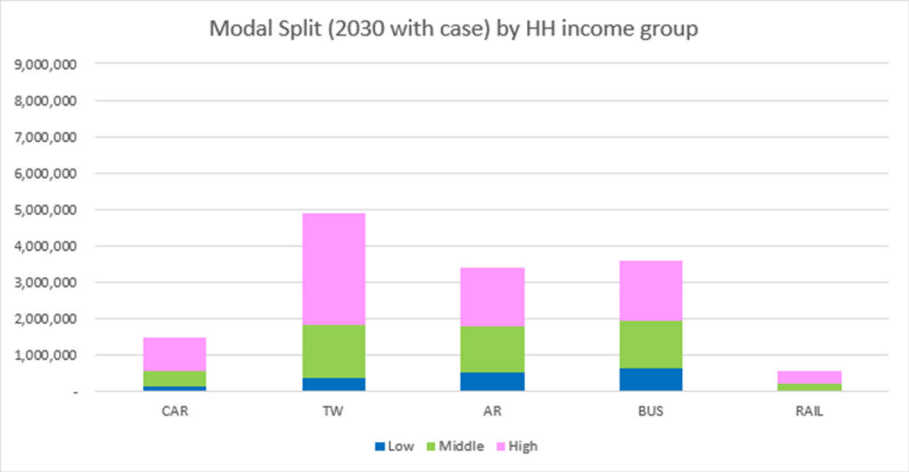


Figure 6.35 Proposed road network (2030) (2/2)

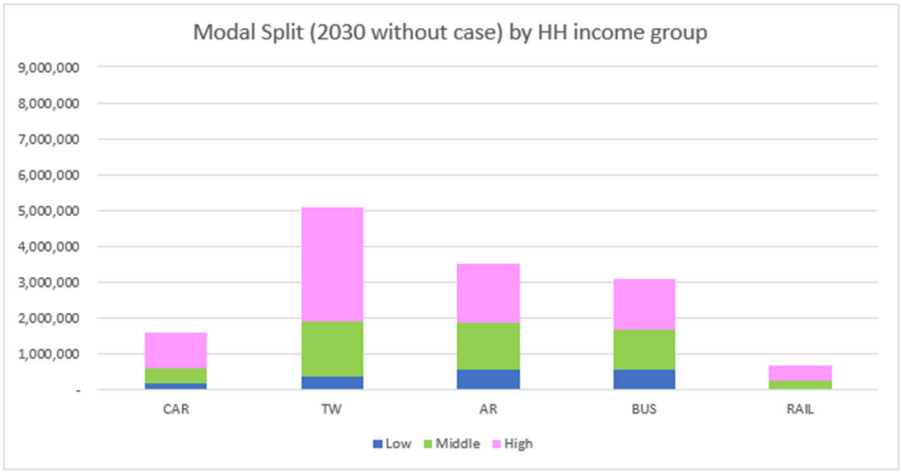


HH income	CAR	TW	AR	BUS	RAIL	TOTAL
Low	8.6%	20.9%	32.1%	37.9%	0.5%	100.0%
Middle	8.6%	31.9%	26.8%	28.6%	4.1%	100.0%
High	12.0%	40.2%	21.5%	21.7%	4.7%	100.0%
Total	10.5%	35.1%	24.5%	25.9%	4.0%	100.0%
	45.6%		54.4%			

Unit: 1,000 trips/day

	CAR	TW	AR	BUS	RAIL	TOTAL
Low	140.2	339.7	523.2	616.4	8.5	1,627.9
Middle	397.9	1,467.4	1,233.4	1,317.7	187.6	4,604.0
High	918.4	3,063.8	1,636.9	1,654.1	356.9	7,630.1
Total	1,456.5	4,870.8	3,393.5	3,588.3	553.0	13,862.0

Figure 6.36 Modal share (2030 with case)



HH income	CAR	TW	AR	BUS	RAIL	TOTAL
Low	10.2%	22.6%	33.3%	33.1%	0.7%	100.0%
Middle	9.2%	33.2%	27.9%	24.6%	5.0%	100.0%
High	12.8%	41.6%	21.8%	18.4%	5.3%	100.0%
Total	11.3%	36.6%	25.2%	22.2%	4.7%	100.0%
	47.9%		52.1%			

Unit: 1,000 trips/day

	CAR	TW	AR	BUS	RAIL	TOTAL
Low	166.9	368.3	543.1	539.9	11.7	1,630.0
Middle	425.5	1,531.9	1,289.3	1,135.7	232.3	4,614.7
High	976.5	3,177.6	1,666.3	1,404.4	406.5	7,631.4
Total	1,568.8	5,077.8	3,498.7	3,080.1	650.6	13,876.1

Figure 6.37 Modal share (2030 without case)