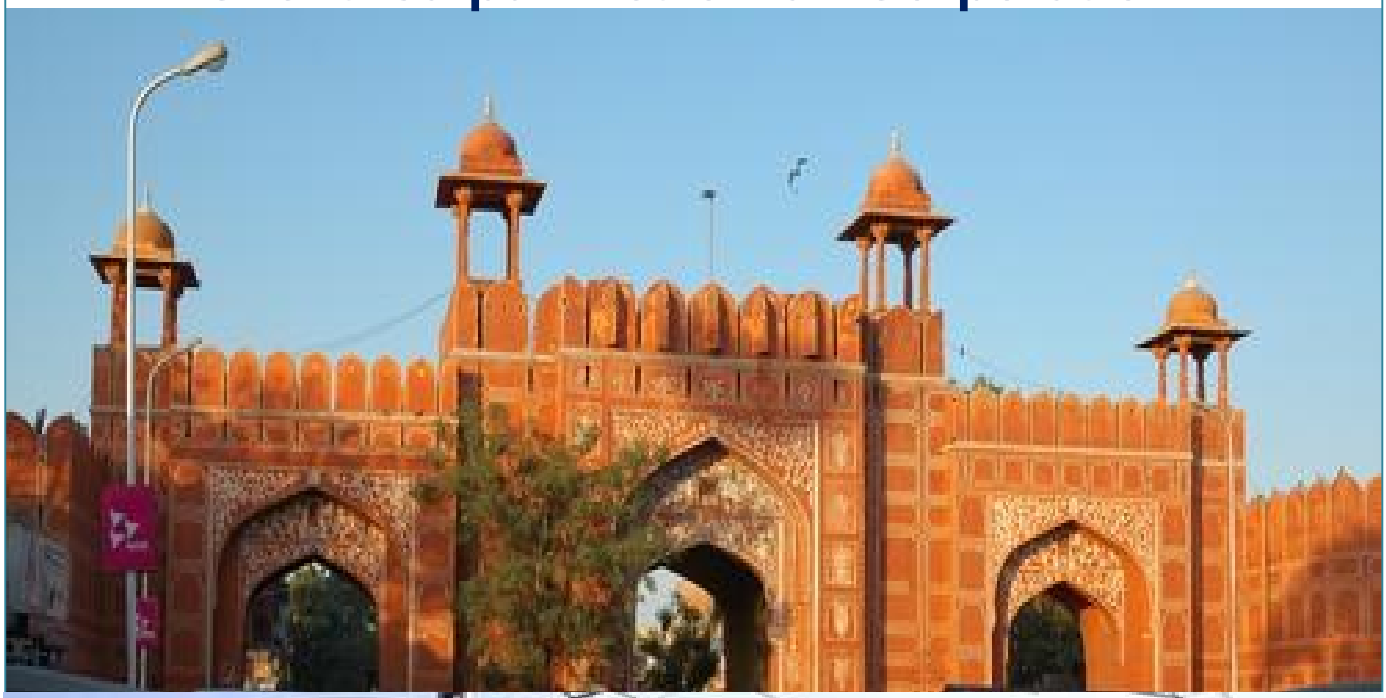
Detailed Project Report

Jaipur Metro (Phase-II)

Sitapura to Ambabari

Client: Jaipur Metro Rail Corporation



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DELHI METRO RAIL CORPORATION LTD.

March 2012

SALIENT FEATURES

1. Gauge (Nominal) 1435 mm

2. Route Length (between dead ends)

Description	Underground (km)	Elevated (km)	Total (km)
Sitapura Industrial Area to Ambabari	5.095	18.004	23.099
Total	**5.095**	**18.004**	**23.099**

3. Number of stations

Description	Underground	Elevated	Total
Sitapura Industrial Area to Ambabari	5	15	20
Total	**5**	**15**	**20**

4. Traffic Forecast (in lakhs)

Year	CORRIDOR	SECTIONAL LOAD (PHPDT)	DAILY RIDERSHIP (in lakhs)	AVERAGE LEAD (in km)
2014	Sitapura Industrial Area -Ambabari	12901	3.2	8.0
2021	Sitapura Industrial Area -Ambabari	18683	4.9	8.5
2031	Sitapura Industrial Area -Ambabari	22429	6.8	8.6

5. Train Operation

Capacity Provided for North – South Corridor

Description	YEAR		
	2017	2021	2031
Cars/trains	4	4	4
Head way (Minutes)	5	3.5	3

Max. PHPDT Demand	12901	18683	22428
PHPDT Capacity Available	12408 (15792*)	17726 (22560*)	20680 (26320*)

* @ 8 persons per square meter of standee area

Year wise Rake Requirement

Corridor	Year	Headway (min)	No. of Rakes	Rake Consist	No. of Coaches
North – South Corridor	2017	5	21	4 car	84
	2021	3.5	29	4 car	116
	2031	3	33	4 car	132

6. Speed

Designed Speed — 80kmph

Scheduled speed — 33 kmph for N-SCorridor

7. Traction Power Supply

a) Voltage — 25 KV OHE

b) Power Demand (MVA)

Corridor		Year		
		2017	2021	2031
Sitapura Indl.Area to Ambabari.	Traction	7.8	11.2	13.4
	Auxiliary	17.9	20.4	23.5
	Total	**25.7**	**31.6**	**36.9**

c) Sub Stations

Sources of Power Supply

Corridor	Grid sub-station (with Input voltage)	Location of RSS of Metro Authority	Approx. length of cables
Sitapura Industrial Area to Ambabari	1. Proposed GSS at Jawahar Circle. 2. Alternatively, existing Mansarovar GSS. (220 / 132kV).	Bambana Nala Depot (132 / 33 / 25 kV).	(1)1.0km, 132kV (2) 3 km,132kV (Double Circuit cables).
	SMS Stadium (One feeder at 132kV & second feeder at 33kV).	RSS at SMS stadium or near Ram Bagh Circle (132 / 33 / 25 kV)	(1) 0.5km,132kV (2) 4.0km, 132kV (Single Circuit cables).

d) SCADA system Provided

8. Rolling Stock

a) 2.90 m wide modern rolling stock with stainless steel body.
b) Axle load - 16 T
c) Seating arrangement - Longitudinal
d) Capacity of 4 coach unit - 1034 Passengers
e) Class of accommodation- One

9. Maintenance Facilities

Maintenance Depot for N-S Corridor - Bambala Nala Depot

10. Signalling, Telecommunication & Train Control

a) Type of Signalling — Cab signaling and continuous automatic train control with Automatic Train Protection (ATP)

b) Telecommunication
- i) Integrated System with Fibre Optic cable, SCADA, Train Radio, PA system etc.
- ii) Train information system, Control telephones and Centralized Clock System.

11. Fare Collection — Automatic Fare collection system with POM and Smart card etc.

12. Construction Methodology

Elevated viaduct consisting prestressed concrete “Box” shaped Girders on Single pier with pile / Open foundations, and underground section with Tunnel Boring and station in underground station cut and cover.

13. Total Estimated Cost (at April 2011 prices)

Description	Capital Cost (Rs. Crore) without taxes and duties	Capital Cost (Rs. Crore) with taxes and duties)
Sitapura – Ambabari	4876	5602

14. Total Estimated Completion Cost Rs. 6583Crores

15. Financial Indices

a) FIRR: Considering the 50ha property development land from government**.**

Particulars	Cost including DMRC portion
FIRR	**7.37%**

b) EIRR

The EIRR in economic terms work out to be 18.6**%** for the project.

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EXECUTIVE SUMMARY

0.1 INTRODUCTION

0.1.1 Jaipur, the 'symphony in pink', is the land of superlatives, where breathtaking beauty and rich art & culture blend superbly. It nestles amidst the Aravali ranges and is surrounded by rugged hills on three sides, each crowned by a formidable fort, while the city is studded with grand palaces, majestic mansions and gracefully landscaped gardens and parks. It is perhaps the first planned city of India, and was laid with great precision on the basis of principles of 'Shilp Shastra', the ancient Hindu treatise on architecture. The city was built in the form of a rectangle divided into blocks (Chowkries), with roads and avenues running parallel to the sides. In 1863 city of Jaipur was dressed in Pink to welcome Prince Albert, consort of Queen Victoria. The colour became an integral part of the city and it came to be known as 'The Pink City'.

After independence, Jaipur merged with the states of Jodhpur, Jaisalmer and Bikaner to become the greater Rajasthan in 1949. Under the State Re-Organization Act in 1956, Jaipur became the capital of the state of Rajasthan. Post independence, planned development of the city was taken up after the city became the capital of Rajasthan.

0.1.2 Though the city has grown into a modern metropolis and a throbbing commercial center, the city is a visitor's delight and caters to the needs of each form of tourism, ranging from historical, culture, adventure, sports, entertainment, shopping, business, conventions and conferences. Jaipur is also a renowned handicraft center and is also known for producing exquisite gold jewellery enamelled or inlaid with precious or semi-precious stones, blue pottery, carvings on wood, stone and ivory, block print and tie & dye textiles, leather articles, handmade paper, miniature painting etc.

0.1.3 **Location** - Jaipur city is located at an altitude of 431 m (above MSL) and at 26.92°N latitude & 75.82°E longitude. The geographical area of the city is 326 sq. kms. The city is bound by Sikar and Alwar districts on north, by Tonk, Ajmer and Sawai Madhopur districts on south, by Nagaur, Sikar, Ajmer districts on west and Dausa district in east. The climate of Jaipur city forms the part of the tropical summer land and therefore shows a significant variation in temperature. Climate of Jaipur is hot and dry.

0.1.4 Population

The total population of the study area in 2001 was 23,24,319. The decadal growth in Jaipur city is more than 100% in the past 3 decades. The decade wise population growth of Jaipur is given as **Table 0.1.**

Table 0.1
Decade wise population of Jaipur

S.No.	Year	Population	Percent rate of growth (%)
1	1951	304380	
2	1961	410376	3.0
3	1971	636768	4.5
4	1981	1015160	4.8
5	1991	1518235	4.1
6	2001	2324319	4.4
7	2011	3073350	3.2

Since 1961 the study area has registered an average rate of growth of around 4.45%. The estimated population figures of study area for the base year 2009, and the horizon years are given in **Table 0.2.**

Table 0.2
Estimated Population in Area of Study (lakh)

Region	2009	2011	2021	2031
Jaipur Urban Agglomeration	41.99	44.45	64.16	92.78

0.2 TRAFFIC DEMAND FORECAST

The 4-stage traffic model has been adopted to carry out transport demand forecast. This comprises trip generation, trip distribution, modal split and trip assignment

The traffic assignment was carried out with the three proposed alignments in place. The loading on the proposed metro alignments is presented in **Table 0.3**

Table 0.3 Summary of Transport Demand Projections

Year	CORRIDOR	SECTIONAL LOAD (PHPDT)	DAILY RIDERSHIP (in lakhs)	AVERAGE LEAD (in km)
2014	Sitapura Industrial Area -Ambabari	12901	3.2	8.0
2021	Sitapura Industrial Area -Ambabari	18683	4.9	8.5
2031	Sitapura Industrial Area -Ambabari	22429	6.8	8.6

The total ridership in the proposed Sitapura Industrial area to Ambabari line in the year 2014, 2021and 2031 will be 3.2, 2.9 and 6.8 lakhs passengers per day respectively.

The maximum range of PHPDT on the Sitapura Industrial area to Ambabari alignment in 2014 will be 12901 and by 2031 the maximum range of PHPDT is projected to be of the order of 22428.

0.3 NEED FOR METRO

A comprehensive transportation study for the city is already in progress. Possible options for a public mass transit system are :-

i). City Buses;

ii). Bus Rapid Transit Systems;

iii). Tramway system; and

iv). A Metro System (light or medium).

The city already has a bus system operated and maintained by Rajasthan Roadways and private operators. This is totally inadequate for the needs of the city. The Government is also contemplating to introduce Bus Rapid Transit Systems on certain selected routes. BRT has its own limitations and constraints. For one thing, the capacity of a BRT system can at best be only 10000 to 12000 PHPDT (Peak Hour Peak Direction Trips) and that of a tramway system about 8000 to 10000 PHPDT. The BRT takes away two lanes of the road for dedicated use pushing rest of the road vehicles crowded into the remaining road space. Therefore, unless the road widths are more than three lanes in each direction, BRT is not feasible and even then the non-bus riders will be put to tremendous inconvenience. In Delhi BRT has been a total failure. In the case of a Metro system, the road width is not encroached upon. If the Metro is elevated, only the central median of the road to a width of 2 to 3 m. is occupied for locating the columns carrying the rail deck. If the metro is underground, there is no encroachment at all on the road width.

Further a Metro will not cause any pollution, causes less vibration and noise, is safe and reliable. The energy needed for a passenger km. in the case of a metro is only 1/5th of the energy needed for road transport. A Light Metro will have a capacity of three lanes of BRT or 9 lanes of motor cars each way.

A tramway system shares the right of way with road vehicles and therefore reduces the available road width for other vehicles. Trams need more energy and have limited capacity. Trams have to wait at all road crossings for signals and therefore their speeds are low.

Therefore, wherever the travel demand is more than 10000 PHPDT, a Metro System is unavoidable. Any mass transit system should meet the needs of the city for the next 50 years or so and from this angle, the Metro should be the back bone for the Public Transport System, other modes being feeder services.

- **ADVANTAGES OF METRO SYSTEM**

- Requires 1/5th energy per passenger km compared to road-based system.
- Causes no air pollution in the city.
- Causes lesser noise level
- Occupies no road space, if underground and only about 2 metres width of the road, if elevated.
- Carries same amount of traffic as 5 lanes of bus traffic or 12 lanes of private motor cars (either way), if it is a light capacity system.
- Is more reliable, comfortable and safer than road based system
- Reduces journey time by anything between 50% and 75% depending on road conditions.

0.4 SYSTEM SELECTION

A. PERMANENT WAY

- **CHOICE OF GAUGE**

Standard Gauge (1435mm) is invariably used for metro railways world over due to its inherent advantages. During the last decade, 20 new metros have been constructed in various cities of the world. All these metros have gone in for Standard Gauge even though the national gauge for mainline railways in some of these countries was different from Standard Gauge. In India the national gauge is Broad Gauge (1676mm). Reasons for selection of Standard gauge are described in the Report.

- **TRACK STRUCTURE**

Track on Metro System is subjected to intensive usage with very little time for day-to-day maintenance. Thus it is imperative that the track structure selected for Metro System should be long lasting and should require minimum or no maintenance and at the same time, ensure highest level of safety, reliability and comfort, with minimum noise and vibrations. Ballastless track with continuous welded head-hardened rails has been proposed as mainline track in elevated and underground stretches. However for at-grade section and at depot the track structure shall be ballasted.

B. TRACTION SYSTEM

Keeping in view the ultimate traffic requirements, standardization, and other techno-economic considerations, 25 KV traction system is considered to be the best trade-off and hence, proposed for adoption on Jaipur Metro System.

C. SIGNALING AND TRAIN CONTROL

Metro carries large number of passengers at a very close headway requiring a very high level of safety enforcement and reliability. At the same time heavy investment in infrastructure and rolling stock necessitates optimization of its capacity to provide the best services to the public. These requirements of the metro are planned to be achieved by adopting ATP (Automatic Train Protection) and ATS (Automatic Train Supervision) signaling systems. Automatic Train Operation (ATO) will be added in future.

D. TELECOMMUNICATION

The telecommunication system acts as the communication backbone for Signaling systems and other systems such as SCADA, AFC, etc and provides telecommunication services to meet operational and administrative requirements of metro network.

The telecommunication facilities proposed are helpful in meeting the requirements for

1. Supplementing the Signaling system for efficient train operation.
2. Exchange of managerial information
3. Crisis management during emergencies
4. Passenger information system

The proposed telecom system will cater to the following requirements:

- Train Traffic Control
- Assistance to Train Traffic Control
- Maintenance Control
- Emergency Control

- Station to station dedicated communication
- Telephone Exchange
- Passenger Announcement System and Passenger Information and Display System within the station and from Central Control to each station.
- Centralized Clock System
- Train Destination Indicator
- Instant on line Radio Communication between Central Control and Moving trains and maintenance personnel.
- Data Channels for Signaling, SCADA, Automatic Fare Collection, etc.

E. AUTOMATIC FARE COLLECTION

Mass Rapid Transit Systems handle large number of passengers. Ticket issue and fare collection play a vital role in the efficient and proper operation of the system. To achieve this objective, ticketing system shall be simple, easy to use/operate and maintain, easy on accounting facilities, capable of issuing single/multiple journey tickets, amenable for quick fare changes and require overall lesser manpower. In view of above, computer based automatic fare collection system is proposed.

AFC system proves to be cheaper than semi-automatic (manual system) in long run due to reduced manpower cost for ticketing staff, reduced maintenance in comparison to paper ticket machines, overall less cost of recyclable tickets (Smart Card/Token) in comparison to paper tickets and prevention of leakage of revenue.

F. ROLLING STOCK

Rolling stock for Jaipur Metro has been selected based on the following criteria:

- Proven equipment with high reliability
- Passenger safety feature
- Energy efficiency
- Light weight equipment and coach body
- Optimized scheduled speed
- Aesthetically pleasing Interior and Exterior
- Low Life cycle cost
- Flexibility to meet increase in traffic demand
- Anti-telescopic

The controlling criteria are reliability, low energy consumption, lightweight and high efficiency leading to lower annualized cost of service. The coach should have high rate of acceleration and deceleration.

The following optimum size of the coach has been chosen for this corridor as mentioned below in **Table 0.4.**

Table 0.4
Size of the coach

Descrption	Length	Width	Height
Driver Motor Car	21.64 m	2.9 m	3.9 m
Motor/Trailer car	21.34 m	2.9 m	3.9 m

0.5 CIVIL ENGINEERING

GEOMETRIC DESIGN NORMS

The design parameters related to the Metro system described herewith have been worked out based on a detailed evaluation, experience and internationally accepted practices. Various alternatives were considered for most of these parameters but the best-suited ones have been adopted for the system as a whole.

Horizontal curves are provided with the following parameters given in **Table 0.5**.

Table 0.5

Description	Underground Section	Elevated Section
Desirable Minimum	300 m	200 m
Absolute minimum	200 m	120 m
Minimum curve radius at stations	1000 m	1000 m
Maximum permissible cant (Ca)	110mm	110mm
Maximum cant deficiency (Cd)	85 mm	85 mm

Elevated Sections

The viaducts carrying the tracks will have a vertical clearance of minimum 5.5 m above road level. For meeting this requirement with the 'Box' shaped pre-stressed concrete girders, the rail level will be about 9.8 m above the road level. However, at stations which are located above central median, the rail level will be 12.5 m above the road level with concourse at mezzanine. These levels will, however, vary marginally depending upon where the stations are located.

The track center on the elevated section is kept as 4.2m uniform through out the corridor to standardize the superstructure, except at few locations as detailed below:

- On curves below 300m Radius
  but upto 120m Radius 4.2m
- At scissors crossings 4.5m

- **Underground sections**

Rail level at midsection in tunneling portion shall be kept at least 12.0 m below the ground level so that a cover of 6m is available over the tunnels. At stations, the desirable depth of rail below ground level is 12.5m; Track centre in underground section to be constructed by Tunnel Boring Machine (TBM) is 13.05m to accommodate a 10m wide island platform. Track centre in underground section to be constructed by cut and cover method is 4.5m.

- **Gradients**

Normally the stations shall be on level stretch. In limiting cases station may be on a grade of 0.1 %. Between stations, generally the grades may not be steeper than 3.0 %. However, where existing road gradients are steeper than 2 %, gradients or for Switch Over Ramps upto 4% (compensated) can be provided in short stretches on the main line.

- **Design Speed**

The maximum sectional speed will be 80 km/h. However, the applied cant, and length of transition will be decided in relation to normal speeds at various locations, as determined by simulation studies of alignment, vertical profile and station locations.

Geometrical design norms are based on international practices adopted for similar metro systems with standard gauge on the assumption that the maximum permissible speed on the section is limited to 80 kms. Horizontal alignment and vertical alignment are dictated to a large extent by the geometry of the road followed by the alignment.

- **Route Alignment**

Corridor-1(North-South): Sitapura Industrial Area to Amba Bari

From dead end (Ch. - 450 m) of Sitapura Industrial Area station to dead end of Amba Bari station (Ch.22648.943 m), the length of the corridor is 23.099 km, out of which 5.095 km is under ground and remaining 18.004 km is elevated, including Switch Over Ramp. Total 20 number stations have been planned along this corridor out of which 15 are elevated and 5 are under ground stations

Alignment of N-S Corridoris placed at fig. 0.1.

- **Viaduct Structure**

The proposed viaduct structure for the Jaipur Metro is Pre-cast segmental box girder, carrying two tracks supported on single pier located on the median of the road. Road clearance of 5.5 m is ensured below the viaduct structure. The foundation shall be pile foundation at most of the locations. Open foundations are possible at certain isolated locations. The superstructure shall be pre-cast segmental construction which will cause minimal inconvenience to the road users during the execution stage.

- **Station Locations & Planning**

Stations have been located so as to serve major passenger destinations and to enable convenient integration with other modes of transport. However effort has also been made to propose station locations, such that inter station distances are as uniform and the average spacing of stations is close to one km as possible.

- **Sequence of Stations**

The sequence of stations along with their respective chainages, site and platform characteristics are presented in the **Table 0.6**:

Table 0.6
STATION LOCATION CHARACTERISTICS

S. No.	Name of Station	Chainage (in m)	Distance from previous station (in m)	Rail level (in m)	Ground Level (in m)	Platform type	Alignment
North - South Corridor - Sitapura to Amba Bari							
	Dead End	-450.000	0.00	377.20	-		
1	Sitapura Industrial Area	0.000	450.00	377.20	363.173	Side	Elevated
2	Pratap Nagar	1515.10	1515.10	380.20	366.221	Side	Elevated
3	Haldi Ghati Area	2461.50	946.40	385.20	371.188	Side	Elevated
4	Sanganer	4840.20	2378.70	395.60	379.479	Side	Elevated
5	Laxmi Nagar	7204.80	2364.60	402.10	388.244	Side	Elevated
6	Durgapura	8057.50	852.70	408.70	394.658	Side	Elevated
7	Mahaveer Nagar	9458.80	1401.30	417.50	403.898	Side	Elevated
8	Gopalpura	10661.20	1202.40	427.10	412.962	Side	Elevated
9	Dev Nagar	11447.10	785.90	432.00	417.794	Nagar	Nagar

S. No.	Name of Station	Chainage (in m)	Distance from previous station (in m)	Rail level (in m)	Ground Level (in m)	Platform type	Alignment
10	Tonk Phatak	12455.60	1008.50	436.00	421.985	Side	Elevated
11	Gandhi Nagar Mod	13193.90	738.30	441.800	427.672	Side	Elevated
12	Sawai Man Singh Stadium	14039.60	845.70	445.700	431.390	Side	Elevated
13	Narain Singh Circle	14757.80	718.20	447.800	434.110	Side	Elevated
14	SMS Hospital	15835.10	1077.30	447.200	434.947	Side	Elevated
15	Ajmeri Gate	17065.70	1230.60	418.500	432.503	Island	Underground
16	Government Hostel	18157.30	1091.60	420.200	433.669	Island	Underground
17	Sindhi Camp	18881.50	724.20	425.900	439.393	Island	Underground
18	Subash Nagar	20077.10	1195.60	435.850	448.368	Island	Underground
19	Pani Petch	20926.30	849.20	454.500	449.508	Side	Underground
20	Ambabari	22243.70	1317.40	454.800	440.842	Side	Elevated
	Dead End	22648.94	405.243	454.800	-		

Stations have been divided into two distinct areas, namely public and non-public (technical areas). The public area is further sub divided into unpaid and paid area. Provision for escalators are made at all stations in paid area from the beginning itself. Provision in civil structures at stations is being kept for providing lifts for disabled passengers in future.

Integration facilities at Metro stations include approach roads to the stations, circulation facilities, and pedestrian ways and circulation areas for various modes likely to come to important stations, including feeder buses. Parking for private vehicles has not been proposed in view of the scarcity of land along the alignment.

- **Geo Technical Investigations**

  Geotechnical investigation work at site was carried out to determine the existing subsoil strata, proposed type & depth of foundations and safe bearing capacity of foundations required for the proposed two Metro Corridors in Jaipur City based on the results of 35 bore holes. Core drilling was carried out by using rotary type of

boring machine with diamond bits of N_X size. Casing of 100/150 mm dia was advanced up to the firm strata as per IS1892 (1979).The description of bore logs for bore holes drilled as per IS -5313.

The top soil is generally silty sand with gravels having variable thickness. Weathered/hard rock at depth of 13 meter was met near Ajmer Puilya on East-West Corridor. The rock is metamorphic type quartz.

- **Utilities**

The proposed Metro alignment is passing along major arterial roads of the city road network, which are serving institutional, commercial and residential areas. A large number of surface and sub-surface utility services, viz. sewers, water-mains, storm water drains, telephone cables, electric poles, traffic signals, etc. are existing along the proposed alignment. Details of the existing utility services along the proposed alignment have been collected from the concerned authorities.

- **Land Requirement**

Since land is a scarce commodity especially in metropolitan areas, every effort has been made to keep land requirement to the barest minimum and acquisition of private property is minimal. Land is mainly required for Depots and route alignment on sharp bends, station buildings, platforms, entry/exit structures, traffic integration, power sub-stations, ventilation shafts, administrative buildings and temporary construction depots / work sites etc.
Abstract of land requirements for N-S Corridor is given in **Table 0.7**:

Table 0.7
Summary of Permanent Land Requirement (Ha)

SN	Description	N-S Corridor	
		Govt.	**Private**
1.	Stations	1.054	6.3509
2.	Running Section	0.839	0.124
3.	RSS/TSS	1.6	
4.	Depots		27
	Total	**3.493**	**33.475**

Total Land required for N-S corridor: 3.493 Ha (Govt.) + 33.475Ha (Pvt.) **= 36.968Ha.**

0.6 Train Operation Plan

Any public transport system, particularly a Metro system, is made attractive by providing high frequency service both during peak and off-peak hours. For this purpose 4 Car trains with different headways of 3 minutes to 10 minutes has been examined. The frequency can be brought down to 3 minutes in future depending upon the demand. The detailed train operation plan is provided in the report.

Salient Features of the proposed trains' operation plan are:

- Running of services for 19 hours of the day (5 AM to Midnight) with a station dwell time of 30 seconds,
- Make up time of 5-10% with 8-12% coasting.
- Scheduled speed for this corridor has been assumed as:
  - Corridor - I : North- South corridor : 33 kmph

Requirement of coaches is calculated based on following assumptions:-

(i) Train Composition planned as under

DTC: Driving Trailer Car

MC : Motor Car

TC : Trailer Car

4 Car Train Composition : DTC + MC + MC+ DTC

Extendable to 6 car Train Composition : DTC + MC + TC + MC + MC+ DTC

Capacity

DTC	:	247 Passengers (Sitting-43, Crush Standing-204)
TC/MC	:	270 Passengers (Sitting-50, Crush Standing-220)
4 Car Train:		1034 Passengers (Sitting-186, Crush Standing-848)
6 Car Train:		1574 Passengers (Sitting-286, Crush Standing-1288)

(ii) Coach requirement has been calculated based on headway during peak hours.

(iii) Traffic reserve is taken as one train per section to cater to failure of train on line and to make up for operational time lost.

(iv) Repair and maintenance reserve has been estimated as 8 % of total requirement (Bare +Traffic Reserve) based on Intermediate Overhaul and Periodic Overhaul interval of 3 and 6 years respectively.

(v) The calculated number of rakes in fraction is rounded off to next higher number.

Total Reversal Time is taken as 6 min at terminal stations.

Based on Train formation and headway as decided above to meet Peak Hour Peak Direction Traffic Demand, Rake requirement has been calculated and tabulated below in **Table 0.8:**

Table 0.8

Corridor	Year	Headway (min)	No. of Rakes	Rake Consist	No. of Coaches
North – South Corridor	2017	5	21	4 car	84
	2021	3.5	29	4 car	116
	2031	3	33	4 car	132

Total 84 coaches for N-S corridor are required in the year 2017 for this phase.

0.7 Power Requirements

Power supply is required for operation of Metro system for running of trains, station services (e.g. lighting, lifts, escalators, tunnel ventilation system, signalling & telecom, fire fighting etc) and workshops, depots & other maintenance infrastructure within premises of metro system. The major component of power supply is traction requirements for elevated sections and auxiliary requirements for Underground section.

The power requirements of a metro system are determined by peak-hour demands of power for traction and auxiliary applications. Broad estimation of auxiliary and traction power demand is made based on the following assumptions:-

(i) Specific energy consumption of rolling stock – 70KWh/1000 GTKM
(ii) Regeneration by rolling stock – 30%
(iii) Elevated station load – initially 200KW, which will increase to 300 KW in the year 2021
(iv) Underground Station load – initially 2000 kW, which will increase to 2250 kW in the year 2021

Keeping in view of the train operation plan and demand of auxiliary and traction power, power requirements projected for the year 2014, 2021 and 2031 are summarized in **Table 0.9** :-

Table 0.9 Power Demand Estimation (MVA)

Corridor		Year		
		2017	2021	2031
Sitapura Indl.Area to Ambabari.	Traction	7.8	11.2	13.4
	Auxiliary	17.9	20.4	23.5
	Total	**25.7**	**31.6**	**36.9**

- **Sources of Power Supply**

The high voltage power supply network of Jaipur city has 220kV and 132kV network to cater to various types of demand in vicinity of the proposed corridor. 220/132 kV sub stations are located to the alignment of Corridors. Keeping in view the reliability requirements, two input sources of 132 kV Voltage level are normally considered for each corridor. As per the sequence of construction, the revenue operation of elevated sections of the two corridors will begin before the Underground sections are completed. The intersection of the two corridors will be at Sindhi Camp station (Underground station of N-S Corridor). Therefore, to achieve the desired reliability, two Receiving Sub Stations (132 / 33 / 25 kV) are proposed to be set up for N-S Corridor & E-W Corridor each. Based on the discussions with Rajasthan Rajya Vidyut Prasaran Nigam Limited (RVPN), it is proposed to avail power supply for traction as well as auxiliary services from the following grid sub-stations at 132kV voltage through cable feeders. Sources of Power Supply are given in **Table 0.10.**

Table 0.10 Sources of Power Supply

Corridor	Grid sub-station (with Input voltage)	Location of RSS of Metro Authority	Approx. length of cables
(Sitapur Industrial Area to Ambabari.)	1. Proposed GSS at Jawahar Circle. 2. Alternatively, existing Mansarovar GSS. (220 / 132kV).	Bambala Nala Depot (132 / 33 / 25 kV).	(1)1.0km, 132kV (2) 3 km,132kV (Double Circuit cables).
	SMS Stadium (One feeder at 132kV & second feeder at 33kV).	RSS at SMS stadium or near Ram Bagh Circle (132 / 33 / 25 kV)	(1) 0.5km,132kV (2) 4.0km, 132kV (Single Circuit cables).

- **Auxiliary Supply Arrangements for Stations & Depot**

  Auxiliary sub-stations (ASS) are envisaged to be provided at each station (3 ASS's for Underground stations and 1 ASS for elevated station) for stepping down 33 kV supply to 415 V for auxiliary applications. A separate ASS is required at depot. The ASS will be located at mezzanine or platform level inside a room. The auxiliary load requirements have been assessed at 200kW for elevated / at-grade stations which is likely to increase up to 300 KW in the year 2031 and 2000 kW for Underground Station which is likely to increase up to 2500 KW in the year 2031. In order to meet the requirement of auxiliary power two dry type cast resin transformers (33/0.415kV) of 500kVA capacity are proposed to be installed at the elevated stations (one transformer as standby) and one transformer of 1.6 MVA at each underground ASS. For Property Development within the footprints of the station, a provision to add third transformer at a later date may be kept at elevated station.

- **Standby Diesel Generator (DG) Sets**

  In the unlikely event of simultaneous tripping of all the input power sources or grid failure, the power supply to stations as well as to trains will be interrupted. It is, therefore, proposed to provide a standby DG set of 200 KVA capacity at the elevated stations and 2 X 1000/750 KVA at Underground stations to cater to the following essential services:

  (i) Essential lighting
  (ii) Signaling & telecommunications
  (iii) Fire fighting system
  (iv) Lift operation
  (v) Fare collection system
  (vi) Tunnel Ventilation (for Underground Stations)

  Silent type DG sets with low noise levels are proposed, which do not require a separate room for installation.

0.8 VENTILATION AND AIR-CONDITIONING SYSTEM

The underground stations of the Metro Corridor are built in a confined space. A large number of passengers occupy concourse halls and the platforms, especially at the peak hours. The platform and concourse areas have a limited access from outside and do not have natural ventilation. It is therefore, essential to provide forced ventilation in the stations and inside the tunnel for the purpose of:

- Supplying fresh air for the physiological needs of passengers and the authority's staff;
- Removing body heat, obnoxious odours and harmful gases like carbon dioxide exhaled during breathing;
- Preventing concentration of moisture generated by body sweat and seepage of water in the sub-way;
- Removing large quantity of heat dissipated by the train equipment like traction motors, braking units, compressors mounted below the under-frame, lights and fans inside the coaches, A/c units etc.;
- Removing vapour and fumes from the battery and heat emitted by light fittings, water coolers, Escalators, Fare Gates etc. working in the stations;
- Removing heat from air conditioning plant and sub-station and other equipment, if provided inside the underground station.

This large quantity of heat generated in M.R.T. underground stations cannot be extracted by simple ventilation. It is, therefore, essential to provide mechanical cooling in order to remove the heat to the maximum possible extent. As the passengers stay in the stations only for short periods, a fair degree of comfort conditions, just short of discomfort are considered appropriate. In winter months it may not be necessary to cool the ventilating air as the heat generated within the station premises would be sufficient to maintain the comfort requirement.

0.9 MAINTENANCE DEPOTS

The depot planning is based on following assumptions:

i) There is no connectivity between North-South corridor and East-West corridor to transfer trains from one line to another else it would have reduced depot requirement in East-West corridor.

ii) Enough space is available at Bambala Nala and Mansarovar terminals for establishment of Depot-cum-workshop and a satellite depot respectively.

iii) Road transport shall be available for transporting heavy equipments for IOH/POH and heavy repairs from Mansarovar depot to Sitapura depot-cum-workshop and vice-versa.

iv) All inspection and workshop lines are designed to accommodate 6 car trains.

v) SBLs at terminal stations shall accommodate 6 car trains and SBLs within depots shall accommodate composite fleet of 4 car and 6 car trains.

It is proposed to establish a depot-cum-workshop at Sitapura Indl.Area and a small depot at Mansarovar with following distribution of activities.

Bambala Nala

i) All minor inspection of North-South corridor

ii) All POH/IOH, heavy repair work of North-South corridor

iii) All POH/IOH & heavy repairs work of all equipments of all the trains of East-West corridor

iv) Stabling of rakes of North-South corridor.

0.10 ENVIRONMENT IMPACT ASSESSMENT AND MANAGEMENT

A detailed Environmental Impact Assessment Study has been carried out along the proposed alignment. As a part of this study, comprehensive environmental baseline data was collected. Both positive and negative impacts of the project were assessed in detail. The project has many positive environmental impacts like reduction in traffic congestion, saving in travel time, reduction in air and noise pollution, lesser fuel consumption, lesser road accidents etc. However, the project has some negative impacts especially during implementation of the project. An important environmental consideration of this project is that neither any forest area nor any plants/ trees of endangered species exist along the proposed alignment, though 1158 trees will need to be uprooted including phase-I. A few residential/commercial structures are affected. To minimize the negative environmental impacts, an Environmental Management Plan has been drawn up.

0.11 COST ESTIMATES

The overall capital cost for Sitapura - Ambabari Corridor, at April 2011price level, works out to **Rs. 4876.00 Crore**, excluding taxes and duties, but including general charges & design charges @ 7% on all items except land and 3% contingencies on all items.

TAXES AND DUTIES

The component of Import Duty, Excise Duty and VAT is not included in the Capital cost estimated. The estimated taxes and duties work out to **Rs. 726crore** for this phase.

0.12 FINANCIAL VIABILITY, FARE STRUCTURE AND FINANCING OPTIONS

Investment Cost

For the purpose of calculating the Financial Internal Rate of Return (FIRR), the completion cost with central taxes have been calculated by taking escalation factor @5% PA. It has been assumed that Government of Rajasthan will exempt local taxes or reimburse the same. The impact of proposed Goods & Service Tax Act (GST) has not been considered in the calculation.

The construction work in respect of DMRC portion (9.718 KMs-Civil works) has already taken up and slated for commercial operation from July-2013. However for the balance portion the work will be taken up in April, 2012 and expected to be completed by March 2016. The Revenue Opening Date (ROD) has been assumed as 01.04.2016. The total completion cost and cash flow shown in the table 0.11.

Table 0.11: Year wise Investment with Central Taxes (Rs. Cr.)

F/Y	Estimated Cost at April 2011	Completion Cost
2012-13	638.00	686.00
2013-14	872.00	983.00
2014-15	1341.00	1594.00
2015-16	1131.00	1390.00
2016-17	703.00	942.00
2017-18	702.00	988.00
Total	5387.00	6583.00

Although the construction is expected to get over by 31st March 2016, the cash flow spills up to March 2018 on account of payment normally required to be made to the various contractors up to that period necessitated by contractual clauses.

Fare Structure

The fare structure of Delhi Metro was compared with the existing fare of Buses, Auto and other general modes of public transport in Jaipur and it was reported that the same is mostly coming at par of the Delhi Metro Fares structures as fixed by a fare fixation committee in 2009. The same have therefore have been assumed which have been duly escalated @10% for every two years and is placed in table 0.12.

Table 0.12: Fare Structure in 2013-14

Distance in km.	Metro Fare (Rs.)
0-2	9.00
2-4	12.00
4-6	14.00
6-9	18.00
9-12	19.00
12-15	21.00
15-18	23.00
18-21	25.00
21-24	26.00
24-27	27.00
27-31	28.00

Other sources of revenues

i) Advertisement & Other revenue have been taken as 10% of fare box revenue. It mainly includes the commercial earnings from rentals at Stations and Depot, leasing of parking rights at stations, advertisement on trains and tickets, advertisements within stations and parking lots, advertisements on viaducts, columns and other metro structures, co-branding rights to corporate, film shootings and special events on metro premises.

ii) Revenue from Real Estate development , as per the details provided by JMRC is proposed for 37.50 hectors of lands for this Phase with the involvement of established Developers. The estimated upfront payment is Rs. 200 crore. The property development models can be designed in a way that not only the upfront receipts but also the regular receipts in the development of lease rentals can be ensured to supplement the fare box collection and reduce the fare structure. The SPV i.e., JMRC will give the land free of cost to the developer. The developer will bring equity to the extent of Rs.687crore and the balance amount towards construction and upfront money to be arranged as Market Debt. The estimated development cost will be Rs.2550 crore. It is assumed that the rental revenue will accrue to the developer from the FY 2017-18 which has been escalated @5% every year. Out of the estimated rental income, apart from meeting maintenance expenditure, the developer will repay the loan and interest. After meeting these obligations and retaining 15% return on his equity with an escalation @5% every

year, the residual rental earnings will accrue to JMRC, which has been taken into account in the FIRR calculations.

The income from PD from standalone land parcel have been worked out based on the experience of DMRC by taking lease rent @ Rs.45/sq. ft., in 2013-14 construction cost of the development @ Rs.20,000/- per sq.mtr., maintenance charge of the development @ 20% of the lease rent income and FAR of 3 which is as per enclosed Table 12.17.11. DMRC recommends that land parcels will be developed by JMRC itself as above and not handed over to concessionaire. The up front, earnings received from property development will be provided to concessionaire.

Financial Internal Rate of Return (FIRR)

The Financial Internal Rate of Return (FIRR) with consideration that 37.5 ha of land will be provided by government for property development for this phase, obtained with the above revenues and costs for 35 years are placed in table 0.13: -

Table 0.13: FIRR (Cost with central taxes)

Particulars	On total completion cost of Phase-II
FIRR	**7.37%**

Financing Options

The objective of funding metro systems is not necessarily enabling the availability of funds for construction but coupled with the objective of financial closure are other concerns, which are of no less importance: -

- Ensuring low project cost
- Ensuring debt funds at low rates of interest
- Creating self sustainable system in the long run by
    - Low infrastructure maintenance costs
    - Longer life span
    - Setting fares which minimise dependence on subsidies
- Recovering returns from both direct and indirect beneficiaries

Rail based mass transit systems are characterised by heavy capital investments coupled with long gestation period leading to low financial rates of return although the economic benefits to the society are immense.

ALTERNATIVE MODELS OF FINANCING

The prominent models are: -

(i) Special Purpose Vehicle under the State Control (Delhi Metro Rail Corporation (DMRC) /Bangalore Metro Rail Corporation (BMRC)/Jaipur Metro model)

(ii) Public-Private Partnership (PPP) mode

- Built Operate and Transfer (BOT) model
- Other PPP Model

Table 0.14 - Funding pattern under EPC model

Particulars	Government of India		Government of Rajasthan		Total	
	%	Rs/Crore	%	Rs/Crore	%	Rs/Crore
Equity by GOI & GOR	15.00%	987.50	15.00%	987.50	30.00%	1975.00
SD for land cost by GOR	0.00%	0.00	10.65%	701.00	10.65%	701.00
Additional SD for Central Taxes by GOI & GOR Equally	5.00%	329.00	5.00%	329.00	10.00%	658.00
Property Development	0.00%	0.00	3.04%	200.00	3.04%	200.00
JICA Loan /Market Borrowing	0.00	0.00	46.31%	3049.00	46.31%	3049.00
Total	**20%**	**1316.50**	**80%**	**5266.50**	**100.00%**	**6583.00**

Jaipur Metro proposed to undertake Phase-II constructions and operation of Phase-I & Phase-II through a BOT operator. The operating revenue, expenses has been considered to be transferred to BOT operator from 2017-18 onwards. The option under the assumption that the Loan liability of Phase-I would also be transferred to the BOT operator has also been calculated. The funding pattern to ensure 14% post tax EIRR (only MAT has been considered) is shown in table 0.15 below separately with and without transfer of Phase-I loan:

Table 0.15 - Funding pattern under BOT model (With central taxes but excluding state taxes)

Particulars	**With transfer of Phase-I loan to BOT operator**		**Without transfer of Phase-I loan to BOT operator**	
Particulars	% Of contribution	Amount (Rs/Crore)	% Of contribution	Amount (Rs/Crore)
VGF by GOI	17.86%	1176.00	17.86%	1176.00
VGF by Government of Rajasthan	33.01%	2173.00	17.89%	1178.00
Land to be provided free of cost by State	10.65%	701.00	10.65%	701.00
Upfront revenue from Property Dev.	3.04%	200.00	3.04%	200.00
Equity by Concessionaire	11.82%	778.00	13.49%	888.00
Concessionaire's debt @12% p.a.	23.62%	1555.00	37.07%	2440.00
Total	**100%**	**6583.00**	**100%**	**6583.00**

0.13 ECONOMIC INTERNAL RATE OF RETURN

The cost and benefit streams for 30-year period in the economic prices have been worked out and presented in Annexure 13.1 of Chapter 13. The residual value of the metro facilities in last year has not been taken into account as benefit in these tables.

In the analysis, the 'with project' alternative of providing metro system is compared with the base option of 'without project (Do- nothing scenario)' alternative of using the existing transport facilities. This is to arrive the net economic benefits, which consist of reduction in vehicle operation cost and reduction in travel time. The total cost worked out on the above basis is then subtracted from the total benefits to estimate the net benefit of the project. This flow is then subjected to the process of discounting to work out the EIRR and ENPV on the project, to examine the viability of the Project in Economic terms. The results are given in Table 0.16.

Table 0.16: Results of Economic Analysis

Parameter	Results
EIRR (%)	**18.6%**

The EIRR for the proposed metro project is worked out to be 18.6%.

Sensitivity Analysis

A sensitivity analysis is carried out for the following scenarios;

- Increase in cost by 10%
- Decrease in benefits by 10%
- Combined scenario of Increase in cost by 10% and Decrease in benefits by 10%

The EIRR under these scenarios are given in Table 0.17.

Table 0.17 Results of Sensitivity Analysis

Sl. No.	Sensitivity	EIRR (%)	ENPV (Rs. in Crores @ 12% discount rate)
1	Normal Scenario	18.6.0%	5598
2	With increase in cost by 10%	17.6%	5066
3	With reduction in benefits by 10%	17.5%	4506

Sl. No.	Sensitivity	EIRR (%)	ENPV (Rs. in Crores @ 12% discount rate)
4	With 10% reduction in benefits and increase in cost by 10%	16.6%	3974

In the sensitivity analysis, the EIRR is found to be at 16.6%, under the combined scenario of increase in cost by 10% and decrease in benefits by 10%. Hence the project is found to be economically viable.

0.14 IMPLEMENTATION OF PROJECT

1 JMRC has awarded work of part East-West corridor from Mansarover to Chandpole(All Works) to DMRC on deposit terms basis. The works are in full progress.

2 JMRC has already appointed Legal, Financial and General Consultants for implementation of Phase-II on PPP Mode.

3 The project is already approved by state government, a suggested project implementation schedule is given below. The proposed date of commissioning of the section with suggested dates of important milestones is given in Table 0.18

Table 0.18
Implementation Schedule for Phase II

S. No.	Item of Work	Completion Date
1	Approval of Project as agreed by MOUD	14.02.2012
2	Appointment of General Consultant or IE	31.12.2011
3	Sanction of Project by EGOM (GOI)	30.04.2012
4	Finalization of PPP Operator	31.12.2012
5	Execution of Work, Procurement of Coaches & Installation, Testing and Commissioning	31.01.2017
6	Revenue Operation	31.03.2017

3.13 CONCLUSIONS

After examining the various options for execution of Jaipur Metro Project**,** GoR has decided to execute Phase I i.e. Mansarovar to Badi Chauper (East- West corridor) on Chennai, Bnagalore and DMRC model. The implementation of this corridor is recommended on BOT basis as large land area is available with JMRC for commercial exploitation for this corridor. However, DMRC recommends that the land parcels will be developed only by JMRC and not handed over to Concessionaire.

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

DPR for Jaipur Metro was last prepared and submitted in June 2011. The DPR contained the under-mentioned combinations of financing of two corridors:-

Combination – I: Funding under DMRC model (total cost including DMRC's portion of cost of Corridor-2)

Combination - II: Funding pattern under DMRC model (total cost excluding DMRC's portion of cost of Corridor-2)

Combination – III: Funding pattern under DMRC model (cost excluding Total cost of 9.718 km.)

Funding on BOT basis for under-mentioned two scenarios was also furnished:-

Scenario-1: **Cost excluding the work entrusted to DMRC (9.718 km) of Corridor-2 (only civil).**

Scenario-2: **Cost excluding the cost of Civil, S&T and Rolling Stock of the stretch entrusted to DMRC (9.718 km).**

The development of the Jaipur Metro is being done in two phases and accordingly, now JMRC has approached that two separate DPRs to be prepared for Phase-I (East-West Corridor) and Phase-II (North-South Corridor). A copy of letter No.F.7(C-3)JMRC/DPR/2011/4776, dt. 21/2/2012 is put up at Annex 1.1.

Route Length (between dead ends)

Phase-I	**Underground/km**	**Elevated/km**	**Total/km**
Mansarovar to Badi Chaupar (East-West Corridor)	2.789	9.278	12.067
Phase-II			

Sitapura to Ambabari (North-South Corridor	5.095	18.004	23.009
Total:	**7.884**	**27.282**	**35.166**

This DPR is prepared for N-S Corridor with funding pattern with the option of BOT model and the report is named as Phase-II Report.

The other Paras of Chapter as given in the previous Report are also reiterated as under:-

1.1.1 Jaipur, the 'symphony in pink', is the land of superlatives, where breathtaking beauty and rich art & culture blend superbly. Until the eighteenth century, Amber served as the capital of the Kachwaha clan of the Rajputs. However, due to its inaccessible tract on the Aravalli hills, it was unable to meet the demands of a growing population. Sawai Jai Singh in 1727 decided to move his capital to the plains, 11 km south of Amber. Jaipur, situated in North - West part of India, was thus founded in 1727 AD and was named after its founder Sawai Jai Singh. Jaipur City was not only planned but its execution was also coordinated by Sawai JaiSingh II, in such a manner that a substantial part of the city developed up within seven years of its foundation. It nestles amidst the Aravali ranges and is surrounded by rugged hills on three sides, each crowned by a formidable fort, while the city is studded with grand palaces, majestic mansions and gracefully landscaped gardens and parks. It is perhaps the first planned city of India, and was laid with great precision on the basis of principles of 'Shilp Shastra', the ancient Hindu treatise on architecture. The city was built in the form of a rectangle divided into blocks (Chowkries), with roads and avenues running parallel to the sides. In 1863 city of Jaipur was dressed in Pink to welcome Prince Albert, consort of Queen Victoria. The colour became an integral part of the city and it came to be known as 'The Pink City'.

In 19th and 20th centuries the city's population spread beyond its walls. In 1922 Man Singh II, Jaipur's Maharaja ascended the throne and it was during his reign that civic buildings like the secretariat, schools, hospitals and other public buildings were built. The municipality was reorganized in 1926 and a new municipal act was prepared in 1929.

After independence, Jaipur merged with the states of Jodhpur, Jaisalmer and Bikaner to become the greater Rajasthan in 1949.Under the State Re-Organization Act in 1956, Jaipur became the capital of the state of Rajasthan. Post independence, planned development of the city was taken up after the city became the capital of Rajasthan

1.1.2 Though the city has grown into a modern metropolis and a throbbing commercial center, the city is a visitor's delight and caters to the needs of each form of tourism, ranging from historical, culture, adventure, sports, entertainment, shopping, business, conventions and conferences. Jaipur is also a renowned handicraft center and is also known for producing exquisite gold jewellery enamelled or inlaid with precious or semi-precious stones, blue pottery, carvings on wood, stone and ivory, block print and tie & dye textiles, leather articles, handmade paper, miniature painting etc.

1.1.3 **Location** - Jaipur city is located at an altitude of 431 m (above MSL) and at 26.92°N latitude & 75.82°E longitude. The geographical area of the city is 326 sq. kms. The city is bound by Sikar and Alwar districts on north, by Tonk, Ajmer and Sawai Madhopur districts on south, by Nagaur, Sikar, Ajmer districts on west and Dausa district in east. The climate of Jaipur city forms the part of the tropical summer land and therefore shows a significant variation in temperature. Climate of Jaipur is hot and dry.

1.1.4 SEISMIC ACTIVATY

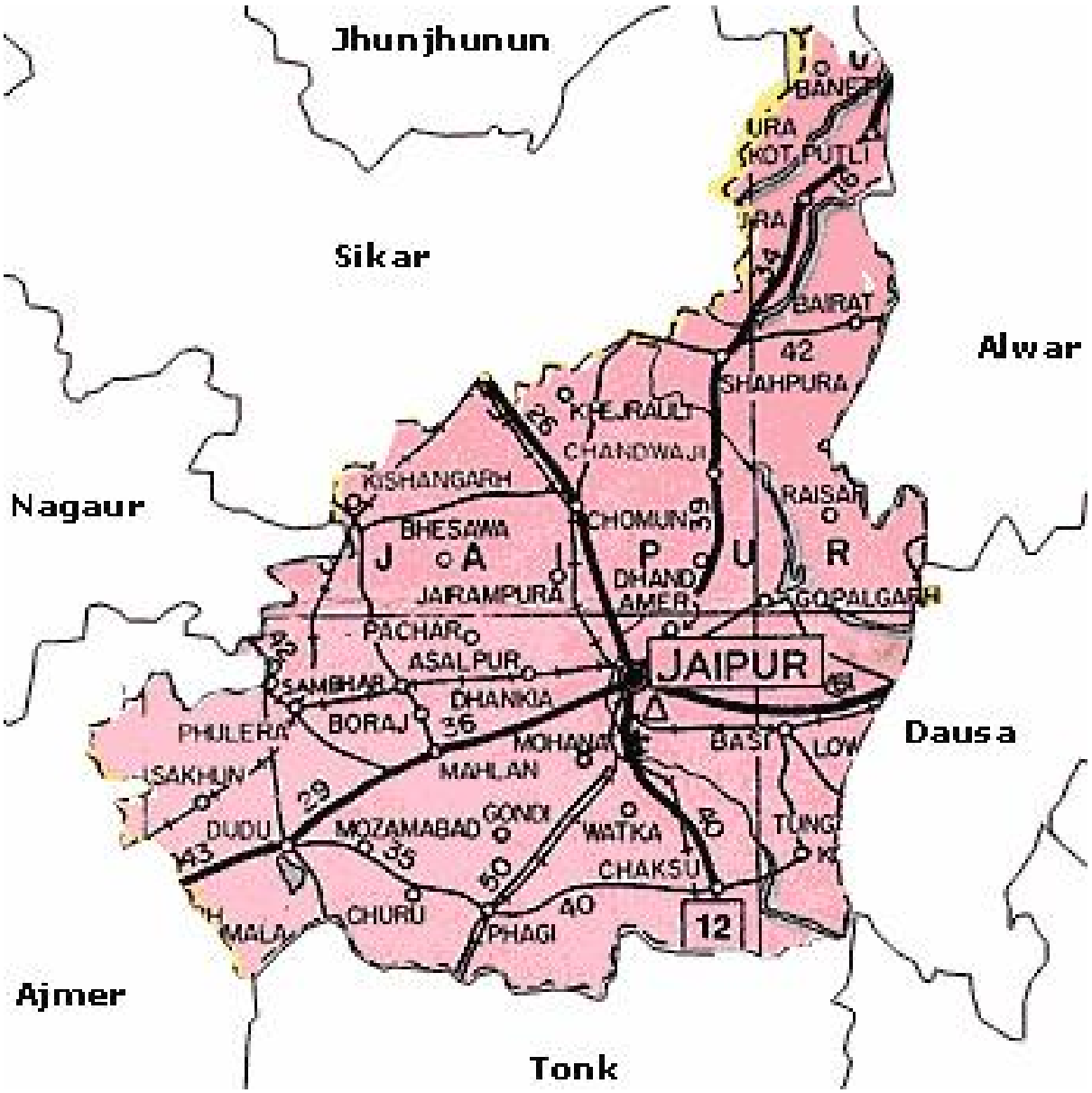
The city falls under zone-II which is classified as Low Damaged Risk Zone & is assigned zone factor of 0.10.

There has been no major earthquake in recent years in Jaipur City.

1.1.5 RAINFALL

No major river passes through the city of Jaipur. The average rain fall of the city is 620 mm.

Location of Jaipur City in Rajasthan State



1.1.6 Road Network

Jaipur city is well connected with other important cities of Rajasthan such as Ajmer, Udaipur, Jodhpur, Bikaner, Alwar, Bharatpur, Jaisalmer and other places of historical importance such as Agra, Gwalior, Khajuraho, Delhi, Chandigarh, Kolkata, Ahmedabad, Mumbai & Lucknow through road and rail linkages. The road network consists of National Highways, State Highways and Major & other Roads. Following National Highways pass through the city:

1 National Highway No. 8 (Delhi - Mumbai)
2 National Highway No. 11 (Agra - Bikaner)
3 National Highway No. 12 (Jaipur - Jabalpur)

1.1.7 Rail Network

Jaipur is the headquarters of the North Western Railway Zone of the Indian Railways. Jaipur is a major junction station.

Following are the three Broad Gauge routes passing through the city:
1 Delhi-Jaipur-Ahmedabad
2 Sawai Madhopur - Jaipur- Jodhpur
3 Agra – Jaipur

Jaipur at present is connected to Bikaner, Sri Ganganagar, via Sikar and Churu by Meter Gauge network shall also be connected by Broad Gauge after gauge conversion of Jaipur- Ringus- Sikar- Churu (MG to BG). The GC work of this section is sanctioned and is in progress.

1.1.8 Air Route

Jaipur has well connected domestic air links with all metropolitan & other important cities of India. The airport located at Sanganer has recently acquired the status of an international airport and offers direct flight to Muscat, Sharjah, Dubai and Bangkok.

1.2 STUDY AREA

The study area has been taken as the area comprising 94 internal and 10 external zones. The area are under the control of Jaipur Nagar Nigam and Jaipur Development Authority. The zone map is given in **Figure – 1.1.**

Ward map of JNN & JDA Area

In terms of share, 87% of the total population lives in the JNN area, of which 7% lives in the walled city. While the proportion of population living within the JNN has increased (primarily due to expansion in area), the proportion of population in the walled city has declined. This can be regarded as positive phenomena as the walled city is already very densely populated. The Walled City has a spatial extent of only 6.7 sq.km but houses nearly four lakh people. The 2001census shows that the population of the Walled City has declined from 1991. The reason for this is out movement of inhabitants from the area to new residential colonies being developed in the periphery in want of better living environment.

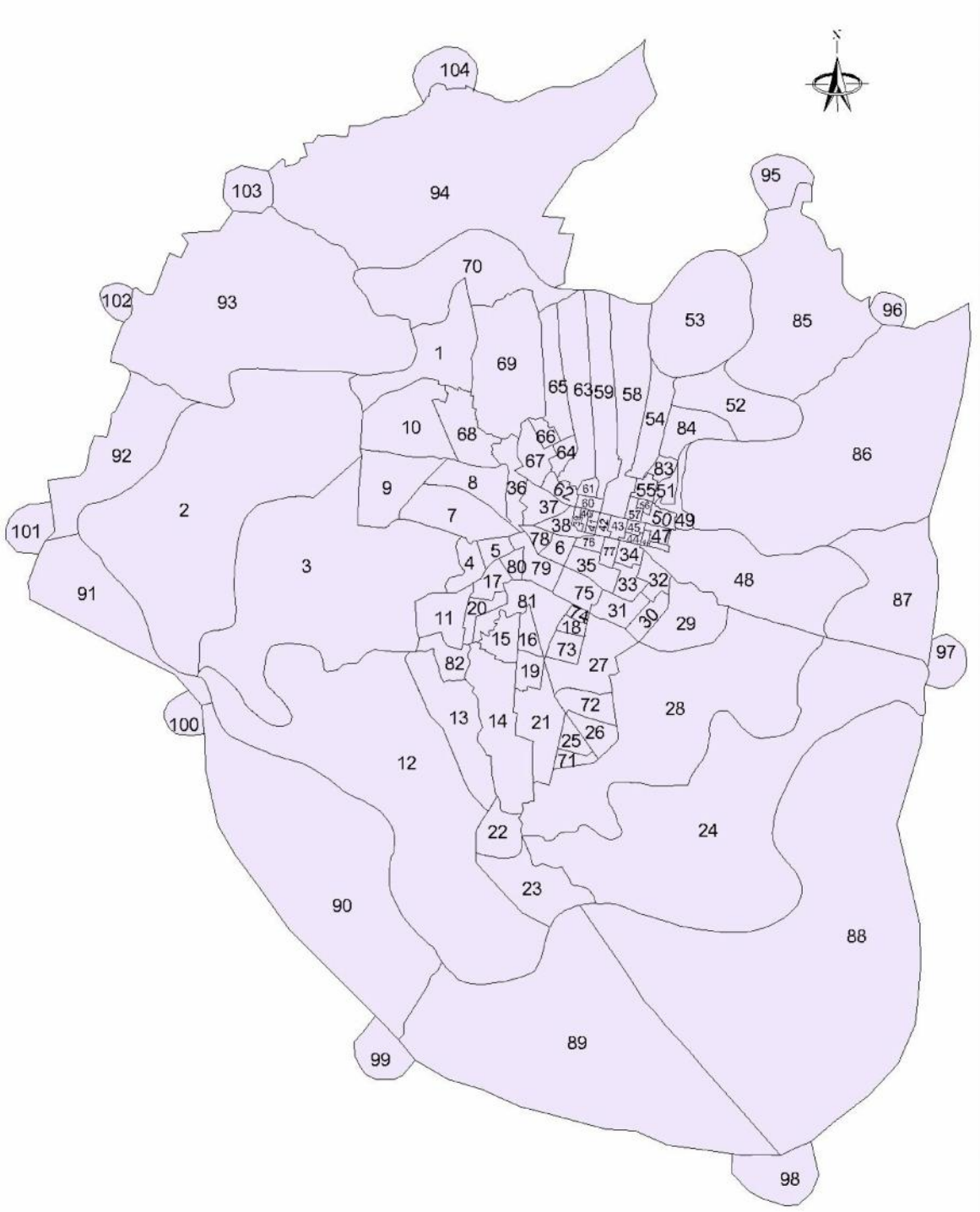


Figure – 1.1

1.3 DEMOGRAPHIC PROFILE

The total population of the study area in 2001 was 23,24,319. The decadal growth in Jaipur city is more than 100% in the past 3 decades. The decade wise population growth of Jaipur is given as Table 1.

Table 1
Decade wise population of Jaipur City

S.No.	Year	Population	Percent rate of growth (%)
1	1951	304380	
2	1961	410376	3.0
3	1971	636768	4.5
4	1981	1015160	4.8
5	1991	1518235	4.1
6	2001	2324319	4.4
7	2011	3073350	3.2

Since 1961 the study area has registered an average annual rate of growth of around 4.45%. The estimated population figures of study area for the base year **2010**, and the horizon years are given in Table 2.

Table 2
Estimated Population in Area of Study (lakh)

Region	2009	2011	2021	2031
Jaipur Urban Agglomeration	41.99	44.45	64.16	92.78

1.4 PRESENT STUDY

As already explained in the beginning of the Chapter, this Report is prepared as revision to earlier DPR submitted for Phase-I of Jaipur Metro. The need of a Metro system for a city is brought out in the subsequent paras.

1.4.1 Rapid industrialization and intense commercial developments in the past decades have resulted in steep rise in travel demand, putting Jaipur's transport infrastructure to stress. With the projected increase in the city's population, strengthening and augmenting the existing transport infrastructure has assumed urgency.

1.4.2 The present public transport system available for the city is not properly organized and is inadequate in terms of frequency & comfort. The fleet of about 250 buses is being operated under public transport system which connects the suburban areas to core area of the city. The private mini bus operators operate about 1800 buses mostly in city area. The private mini bus operators dominate and compete with public bus system. Their routes are in-efficiently rationalized

and are not properly regulated with too many buses on some routes where as other routes have very less frequency.

The other transport facility available is Rickshaws. Cycle Rickshaws operates mostly inside walled city area for short trips and Auto Rickshaws operates in whole study area. The present bus transport system is insufficient to cater the need of city due to which the share of public transport has decreased from 26% to 19% in last decade. Commuters prefer to use personalized transport. The average annual growth rate of the vehicles in Jaipur is about 12% which is causing congestion on city roads.

The State Government has taken up the project of Bus Rapid Transport System (BRTS) under JNNURM scheme at a cost of Rs. 480.00 crores. Under BRTS project, pilot dedicated corridor has been developed from C-Zone bypass to Ambabari in a length of 7.1 km. Further, it has been reported that it is proposed to develop 45.0 km BRT corridor on wider road sections of the city. 400 new low floor modern buses are being procured for induction into city transport system. BRTS routes are being modified to act as feeder to Jaipur Metro.

CHAPTER 2

TRAFFIC FORECAST

2.0 TRANSPORT DEMAND FORECAST

2.1 TRAVEL CHARACTERISTICS

2.1.1. GENERAL

Two metro alignments with a combined length of 35.166 km have been identified for the city of Jaipur.

- E-W corridor starts from Manasarovar and ends at Badi Chopar with a total length of 12.067 km.
- N-S corridor starts from Sitapura industrial area to Ambabari via SMS hospital with a total length of 23.099 km.

This chapter covers the transport demand projections for above mentioned corridors and section and station loadings for the same.

2.1.2. TRANSPORT DEMAND MODELLING

Data Base

Detailed household surveys and various traffic surveys were carried out during the DPR study. A transport demand model was developed and the future OD-Matricies based on the projected population and employment was developed.

The network for the transport demand model including the metro alignments has been developed from the primary database.

The four-stage transport Demand Model involving Trip Generation, Trip distribution, Modal Split and Assignment has been used.

The basic functions included in the transportation study process are:

- Trip-end prediction or trip generation and attractions – i.e., the determination of the number of person trips leaving a zone irrespective of destination and the number of trips attracted to a zone, irrespective of origin.
- Trip distribution – the linking of the trip origins (generation) with their destinations (attraction).
- Modal split – the division of trips between public transport modes and different private modes
- Assignment – the allocation of trips between a pair of zones to the most likely route(s) on the network.
- Evaluation – assessing the effectiveness of the network in meeting the transport demand.

The details of the planning process as adopted for this study is shown in **Figure 2.1**.

2.1.3 ZONING

The entire study area has been delineated into 104 zones as shown in **Figure 2.2.** Among them 94 are the internal zones and the remaining zones (10 zones) are external zones. Detailed list of all these zones is given in the **Annexure 2.1.**

Summary of population projection and employment projections is presented in the **Table 2.1**.

Table 2.1 Population and Employment projection (Urban Agglomeration)

Description	Horizon Year			
	2009	2011	2021	2031
Population (in lakhs)	41.99	44.45	64.16	92.78
Employment (in lakhs)	14.69	15.55	22.44	32.47

These figures are based on the Census (2001) and projected for future in consultation with the city development authorities.

2.1.4 TRIP INFORMATION

The trip information obtained from the survey has been analyzed with respect to distribution of total trips by mode. The share of trips by various modes are presented in **Table 2.2 and Figure. 2.3.**

Table 2.2 Distribution of Trips (All modes)

Mode	Share
Walk	28%
Bicycle	5%
Car	9%
Two Wheeler	24%
Auto Rickshaw	5%
Taxi	8%
Public transport	21%
Total	100%

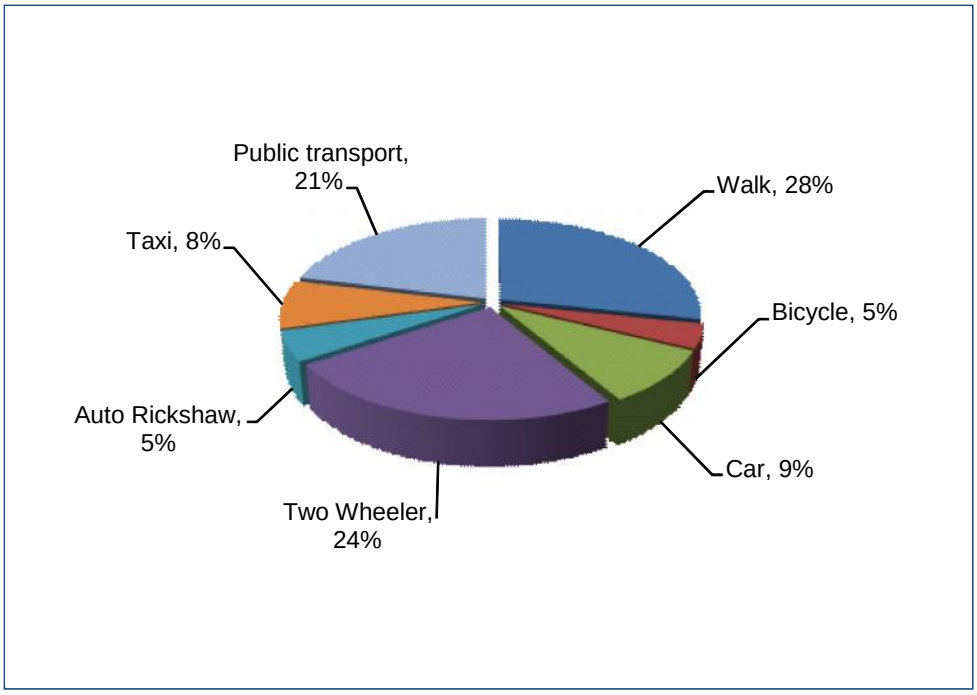


Figure 2.3. Mode Share (all modes)

Public transport trips constitute about only 21% of the total trips while Two-wheeler trips are 24 %, Auto trips 5%, Car trips constitutes 9% and taxi trips 8%.

2.2 TRANSPORT DEMAND MODEL AND PARAMETERS

2.2.1 MODEL DESCRIPTION

As stated earlier, the standard four stage Model constituting Trip generation, trip Distribution, Modal split and Assignment is used. Extensive household surveys and traffic surveys were carried out to develop the four stage model. The horizon year Origin-Destination (O – D) Matrices for private and public modes were developed using the Gravity Model. The parameters obtained from the Model have been used for the transport demand projections for the proposed alignments.

2.2.2 SPEED FLOW RELATIONSHIP

The speed flow curves were developed for different functional classes. Speed flow curves have been adjusted to take into account delays at junctions. These speed flow curves were converted into Bureau of Public Roads(BPR) functions and fed into the model as input in the highway network. The form of the BPR function is

$$T_C = T_0 * (1 + \alpha * (v/c)^{\beta})$$

Where
Tc – Congested Link Travel time
T0 – Link Free flow time
V - Link Volumes
C – Link Capacity
α and β – Calibrated Parameters

The BPR functions developed for different categories of roads is given in Table 2.3.

Table 2.3. BPR functions

Road way Class	Functional Characteristics	Directional Capacity	ALPHA	BETA

6	2L-2W-UD	1900	4.1	3.5
11	4L-2W-UD	3800	3.0	3.5
12	4L-2W-D	4500	3.3	3.0
15	6L-2W-D	6700	5.0	3.8

(Note: L: Lanes, 1w- One Way, UD- Undivided, D- Divided, 2W- Two way)

The initial free flow speeds taken for the assignment of public and private modes are summarized in **Table 2.4.**

Table 2.4 Free flow Speeds

Mode	Free Flow Speed (kmph)		
	2-lane	4-lane	6-lane
All modes	36	40	49

2.2.3 TRIP CATEGORIZATION

The passenger transport demand in terms of daily passenger trips has been broadly categorized as intra-city and inter-city trips. The inter-zonal trips are the most important, so far as transport system development is concerned. The trips were classified by different motorized modes including private, hired and public motorized vehicles.

2.2.4 TRIP GENERATION

The first of the sub-models in the study process is that which predicts the number of trips starting and ending in each zone. The techniques developed attempt to utilize the observed relationships between travel characteristics and the urban environment and are based on the assumption that 'trip making' is a function of three basic factors:

- Land use pattern and development in the study area,
- Socio-economic characteristics of the trip-making population of the study area, and

- Nature, extent and capabilities of the transportation system in the study area

Mathematically, trip generation can be expressed as:

Trips Generated = Function (socio-economic, locational etc. variables)

Various techniques for developing the trip generation sub-models are available and notable among them are:

- Regression Analysis
- Category Analysis or Cross Classification Analysis

A typical regression analysis for trip generation model is

$$G = A_o + \sum_{I=1}^{k} a_{ij} x_i$$

Where

G	=	No. Of trips (produced/attracted) in a zone for a specific purpose.
A_0	=	Constant term to be calibrated.
$a_o, a_1 \ldots\ldots a_K$	=	Coefficients to be determined by the regression analysis
$X_1, x_{2.}$	=	Zonal planning input factor (independent) variable)

The significance of the regression equation is tested on the basis of R^2 value and the t-statistics value (for each of the coefficients).

Typical inputs for trip generation sub-models are population, employment, vehicle ownership, household income, residential density, etc. These models are developed using standard computer programs.

Population is a major influencing factor for trip generation. As it is one of the major variables in the trip end models used for obtaining the future trip ends, it has an influence in the over all trip productions / attractions.

For the generation of trip generation sub-models, analysis has been carried out at zonal level utilizing regression analysis technique. The generalized form of the trip generation equation to be developed is as under: -

Y=A+BX
Where
Y=Trips produced or attracted
A=Constant term
B=Trip rate to be determined from least square Analysis
X=Independent variable e.g., population, employment, Vehicle ownership

The results of calibration of different models are given in **Table 2.5**

Table 2.5 Generation for Total Trips

	Co-off.
Intercept	98.71
X Variable	0.054

By using the above table the value of R^2 was found to be 0.65, T-value – 8.5, F-value-72.3 (**Assuming Population in zones as the variable**).

Table 2.6 Trip attraction for total trips

	Co-off.
Intercept	524.6
X Variable	0.134

By using above expression the value of R^2 was found to be 0.55, T value-6.6, F Value-43.24 (**Assuming Employment in zone as variable).**

The population and employment projection for the horizon years is presented in **Table 2.7** below:

Table 2.7 Population and employment projections

Year	Population (Lakhs)	Employment (Lakhs)
2009	41.99	14.69
2011	44.45	15.55
2021	64.16	22.44
2031	92.78	32.47

2.2.5 PER CAPITA TRIP RATE (PCTR)

Adopted Per Capita Trip Rate for base and horizon years i.e., 2009, 2014, 2021 and 2031 are as given in the **Table 2.8.**

Table 2.8 Adopted PCTR (Motorized) Value

Year	PCTR Value
2009	0.68
2014	0.71
2021	0.77
2031	0.85

2.2.6 TRIP DISTRIBUTION AND MODE CHOICE

A regular four stage transport model distributes the trip ends to the zones initially and then selects the choice of the mode. Trip distribution normally is carried out using the traditional gravity function. Many methods are available for mode choice including diversion curve, utility based logit model etc. The present study combines the trip distribution and mode choice to form a combined Trip Distribution and Modal Split phase using a conventional doubly constrained gravity model of the form:

$T_{ijm} = r_i G_i s_j A_j F_{ijm}$

Where T= number of inter zonal trips between zone i & j and by mode m
G= Total generation trip ends by zone
A= Total attraction trip ends by zone

i=Generation Zone
j= Attraction Zone
r,s=Balancing factors (constants)
Fijm= Deterrence function for mode m

Fijm= Km e-βcijm Cijm α ---------- Eqn 1

Where K= Constant Factor
C=Generalized Cost
β= Calibration Constant –Exponential function
α=Calibration Constant- Power function
Double Constraints are imposed by ensuring that

$$\sum_{Jm} T_{ij} = G_i \quad \text{and} \quad \sum_{\text{Im}} T_{ij} = A_i$$

The calibration includes estimation of parameters of the deterrence function is in the form of Gamma (Refer Eqn 1). The calibration process for combined trip distribution and mode choice is explained in flowchart as shown in **Figure 2.4**.

The cost of travel (C- generallised cost) between the zones has been estimated based on skims from the Highway and Public Transport assignment. The estimation of generallised cost for the base year is explained in the following section.

2.2.7 DETERENCE FUNCTIONS

Calibrated parameters for the Deterrence function by mode is given in **Table 2.9**

Table 2.9 Calibrated Deterrence Functions for Morning peak hour

Mode	Morning Peak		
	K	ALPHA	BETA
Two wheeler	0.92	-0.4	44.8
Car	7.9	0.4	26.8

Auto Rickshaw	3.3	1.73E-13	36.6
Taxi	4.5	-0.2	29.4
Public transport	4.7	0.2	49.8

2.2.8 TRIP ASSIGNMENT

2.2.8.1 Trip assignment is the process of allocating a given set of trip interchanges to a specific transportation system and is generally used to estimate the volume of travel on various links of the system to simulate present conditions for validation purposes and to use the same for horizon years for developing forecast scenarios. The process requires as input, a complete description of either the proposed or existing transportation system, and a matrix of inter-zonal trip movements. The output of the process is an estimate of the trips on each link of the transportation system, although the more sophisticated assignment techniques also include directional turning movements at intersections.

The purposes of trip assignment are:

1. To assess the deficiencies of the existing transportation system by assigning estimated future trips to the existing system – **Do Nothing Scenario**.
2. To evaluate the effects of limited improvements and extensions to the existing transportation system by assigning estimated trips to the network which included these improvements.
3. To develop system development priorities by assigning estimated future trips for intermediate years to the transportation system proposed for these years.
4. To test alternative transportation system proposals by systematic and readily acceptable procedures.
5. To provide design hours volumes and turning movements.

2.2.8.2 ASSIGNMENT PROCEDURE ADOPTED

The observed highway and public transport matrices were assigned on the network to check the validation across the screen lines. The assigned traffic

volume has been compared with the observed traffic counts. The assignment is carried out in two stages with the assignment of Transit trips following the Highway PCU Assignment. The highway assignment is the assignment of vehicles on Roads and this is carried out also in stages with commercial vehicles and buses taken as pre loads. The transit assignment is the assignment of commuters on a Public Transit network which comprises of buses; metros etc which are linked on to the zonal system via walk links. This methodology is presented in **Figure 2.5**.

2.2.8.3 PCU CONVERSION FACTOR

The results from the trip assignment, which is in terms of person trips, have to be converted to PCU trips for updating the link speeds. As the occupancy levels of the private modes are quite different from the road-based public transport modes, separate passenger to PCU conversion factors were derived for the two types of travel. The factors used for the study area are given in **Table 2.10**

Goods vehicles and other slow moving vehicles use the roads simultaneously. Thus the capacity comparison and speed modifications must take movement of these vehicles in mixed traffic conditions into account. Thus, after the person trips are converted to vehicles trips in terms of PCUs, the goods traffic factor is added to boost up the value to incorporate the mixed flow conditions because of goods vehicles and the slow moving vehicles.

TABLE 2.10 PCU CONVERSION FACTORS

	Modes	**PCU Values**
Private Vehicles& IPT	Two wheeler	0.75
	Car	1.0
	Auto rickshaw	2.0
	Taxi	1.0
Commercial Vehicles	**Modes**	**PCU Values**
	Truck	2.2
	MAV	3.7
	LCV	1.4

(As per IRC 106: 1990)

2.3 TRANSPORT DEMAND PROJECTIONS

2.3.1 The proposed stations on the North-south corridor distance between the stations is given in **Table 2.11**

Table 2.11 – Inter -Station Distances on the Sitapura Industrial Area to Ambabari Corridor

Station No	Station Name	Distance (in km)
1	Sitapura Industrial Area	0
2	Pratap Nagar	1.515
3	Haldi Ghati Gate	0.946
4	Sanganer	2378
5	Laxmi Nagar	0.933
6	Durgapura	0.852
7	Mahavir Nagar	1.401
8	Gopal Pura	1.202
9	Dev Nagar	0.785
10	Tonk Phathak	1.008
11	Gandhi Nagar Mode	0.738
12	Swai Mansingh Stadium	0.845
13	Narayan Singh Circle	0.718
14	SMS Hospital	1.077
15	Ajmeri Gate	1.230
16	Government Hostel	1.091
17	Sindhi Camp	0.724
18	Subash Nagar	1.195
19	Pani Pech	0.849
20	Ambabari	1.317

Sitapura Industrial area to Ambabari the alignment is 23.099 km in length with 20 proposed stations.

2.3.2 SECTION LOADING

The traffic assignment was carried out with the two proposed alignments in place. The loading on the proposed metro alignments is presented in **Table 2.13**

Table 2.13 Summary of Transport Demand Projections

2014				
CORRIDOR	**SECTIONAL LOAD**	**DAILY RIDERSHIP**	**DAILY PASSENGER KM**	**AVERAGE LEAD (Km)**
Sitapura Industrial Area to Ambabari	12,901	3,21,891	25,75,125	8.0
2021				
CORRIDOR	**SECTIONAL LOAD**	**DAILY RIDERSHIP**	**DAILY PASSENGER KM**	**AVERAGE LEAD (Km)**
Sitapura Industrial Area to Ambabari	18,683	4,85,577	41,27,401	8.5
2031				
CORRIDOR	**SECTIONAL LOAD**	**DAILY RIDERSHIP**	**DAILY PASSENGER KM**	**AVERAGE LEAD (Km)**
Sitapura Industrial Area to Ambabari	22,428	6,76,874	58,21,120	8.6
2041				
CORRIDOR	**SECTIONAL LOAD**	**DAILY RIDERSHIP**	**DAILY PASSENGER KM**	**AVERAGE LEAD (Km)**
Sitapura Industrial Area to Ambabari	24,774	7,47,698	64,30,200	8.6

The total ridership in the proposed Sitapura Industrial area to Ambabari line in the year 2014 and 2031 will be 3.2 and 6.8 lakhs passengers per day respectively.

The maximum range of PHPDT on the Sitapura Industrial area to Ambabari alignment in 2014 will be 12901 and by 2031 the maximum range of PHPDT is projected to be of the order of 22428. The section wise loading and PHPDT is presented in **Annexure 2.2.**

2.3.3 STATION LOADING

Peak hour station loading (two way boardings) for the alignment is presented in **Table 2.14**

Table 2.14 Station Loading for (Sitapura Industrial area to Ambabari)

S.No.	STATION NAME	2014	2021	2031	2041
1	Sitapura Industrial Area	854	1257	2134	2357
2	Pratap Nagar	496	942	2002	2211
3	Haldi Ghati Gate	1087	1668	2388	2638
4	Sanganer	1582	2517	4342	4796
5	Laxmi Nagar	2899	3922	5590	6175

S.No.	STATION NAME	2014	2021	2031	2041
6	Durgapura	1090	1777	2982	3294
7	Mahavir Nagar	979	1972	2736	3022
8	Gopal Pura	1426	2397	3613	3991
9	Dev Nagar	1479	2138	3312	3659
10	Tonk Phathak	2799	3958	6685	7384
11	Gandhi Nagar Mode	1087	1479	2610	2883
12	Swai Mansingh Stadium	1261	1661	2650	2927
13	Narayan Singh Circle	1533	1866	3045	3364
14	SMS Hospital	1693	2182	2608	2881
15	Ajmeri Gate	376	648	830	917
16	Government Hostel	1298	2403	3759	4152
17	Sindhi Camp	4758	5758	5917	6536
18	Subash Nagar	2441	3190	3958	4372
19	Pani Petch	1618	2048	2719	3003
20	Ambabari	5010	10270	11329	12514

(Note: Numbers are total Boardings on both directions (Up and Down)

2.3.4 TRIP LENGTH FREQUENCY DISTRIBUTION

The trip length frequency distribution of the Metro trips is presented in **Annexure 2.3** it can be observed that the average trip length for the years 2014 and 2031 for Sitapura industrial area to Ambabari is 7.8 km and 8.5 km respectively.

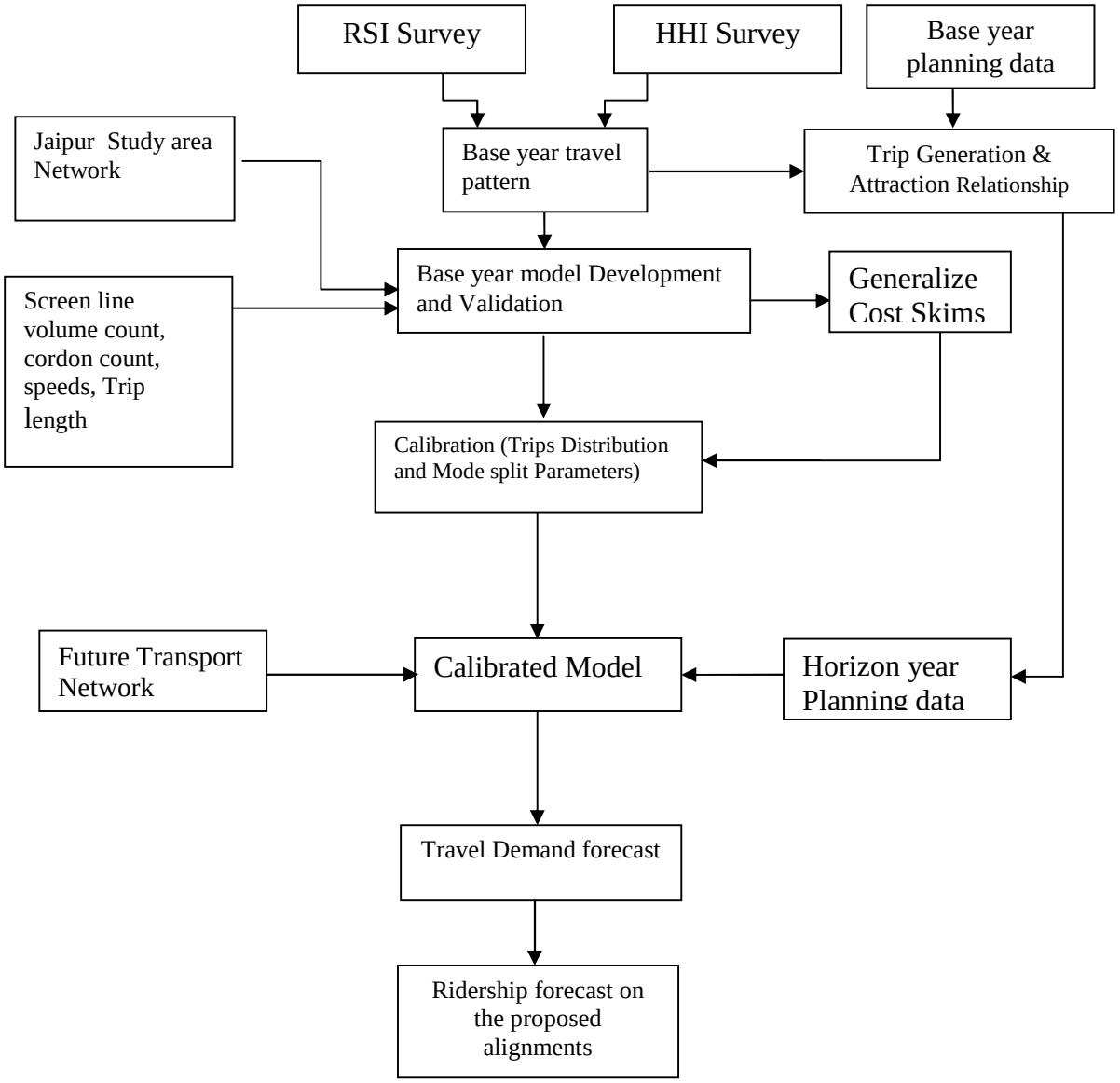


Figure 2.1: Modeling approach

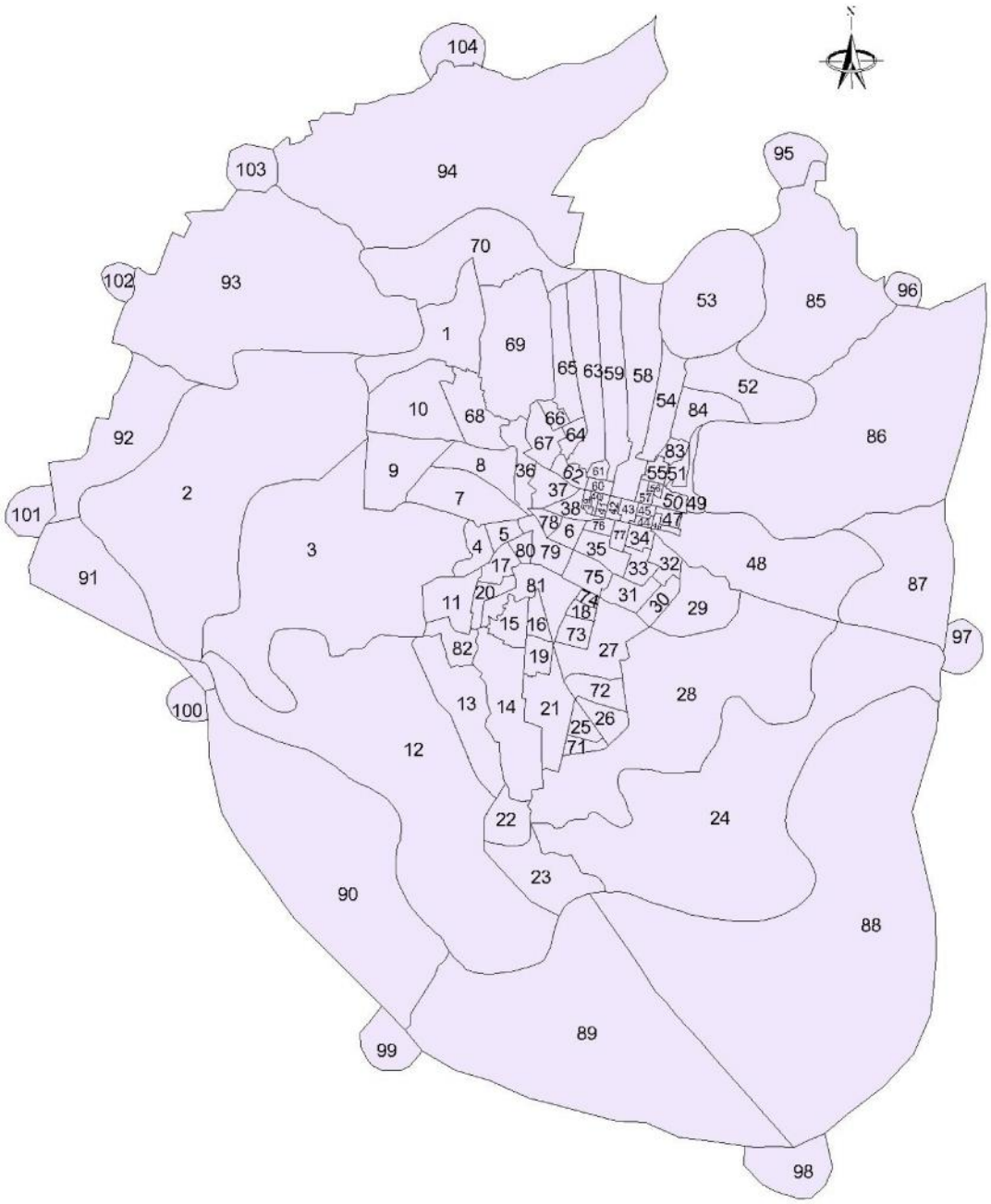


Figure 2.2: Zoning system

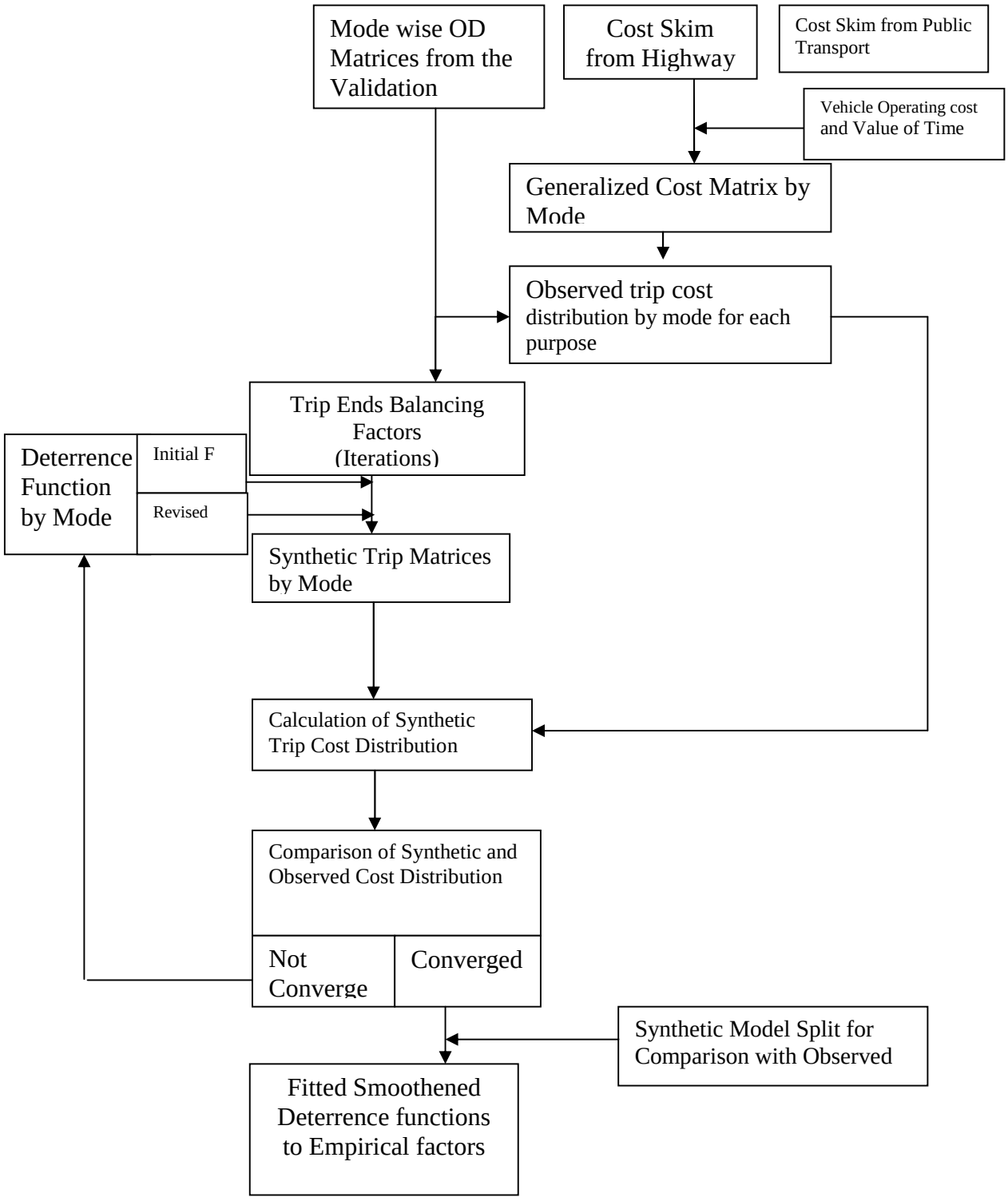


Figure 2.4: Calibration process

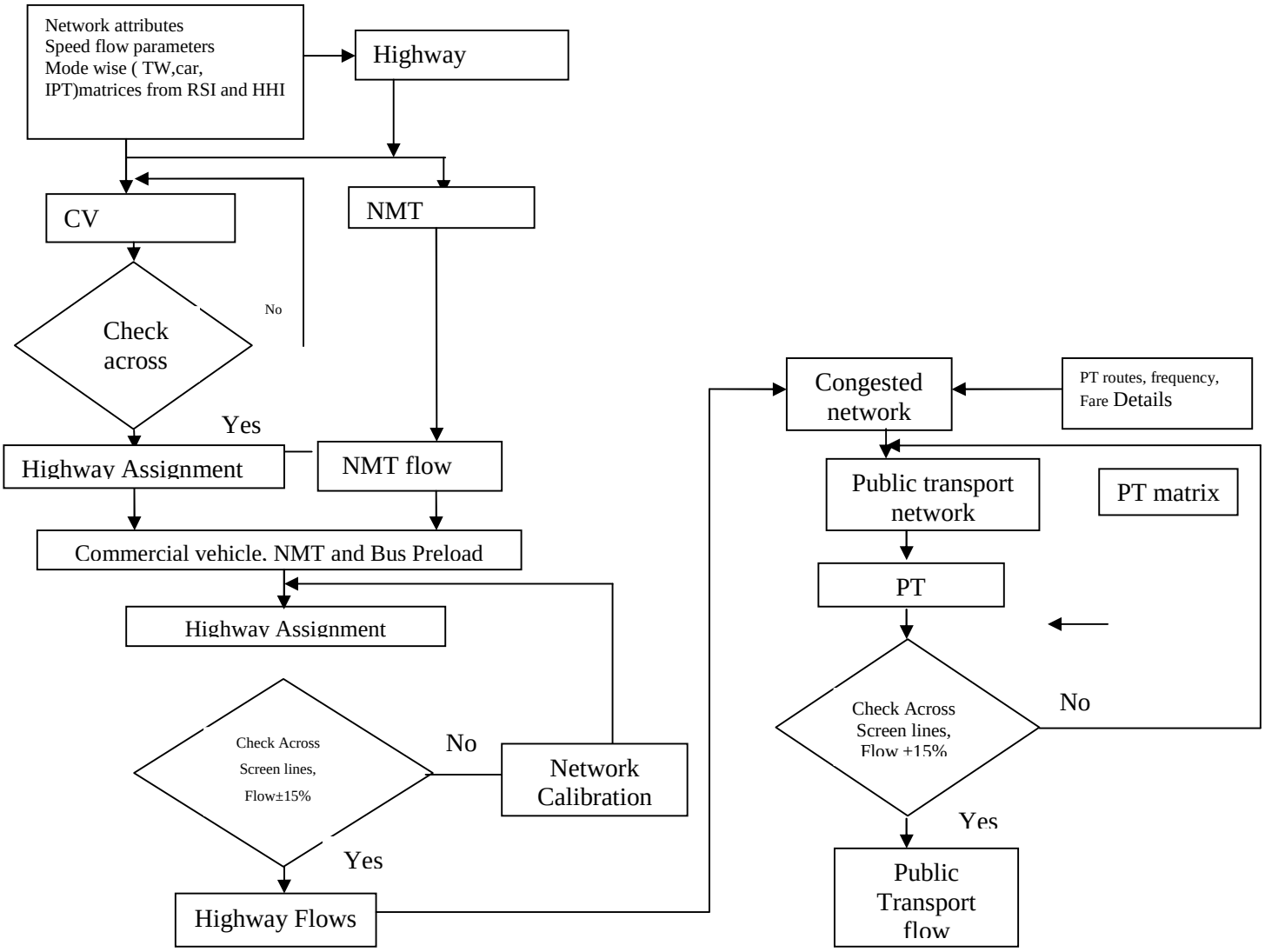


Figure 2.5. Trip Assignment

ANNEXURE -2.1
ZONE NUMBERS AND ZONE NAMES

Zone No.	Zone Name
1	Muralipura & Society
2	West Outer Zone
3	Vidhyut Nagar
4	Shanti Nagar
5	ESI Hospital Area
6	C-Scheme
7	NBC Army Area
8	Ram Mandir
9	Khatipura
10	Jhotwara Industrial Area
11	Shyam Nagar
12	Prathviraj Nagar
13	Mansarovar Colony
14	Triveni Nagar
15	Mahesh Nagar
16	SMS Stadium
17	Civil Lines
18	Gandhi nagar
19	Barkat Nagar North
20	Barkat Nagar South
21	Vasundhara Colony
22	Sanganeer
23	Sanganeer wards 11-19
24	East South Outer Area
25	Malviya Nagar South
26	Malviya Nagar North
27	University
28	Sawai Gator
29	Hills Beyond Jawahar
30	Jawahar Nagar
31	Raja Park
32	Janta Colony
33	Adarsh Nagar
34	Central jail

35	Rambagh Palace
36	Banipark West
37	Banipark East
38	Sansar Chandra Road
39	Walled City Area
40	Walled City Area
41	Walled City Area
42	Walled City Area
43	Walled City Area
44	Walled City Area
45	Walled City Area
46	Walled City Area
47	Walled City Area
48	Transport nagar
49	Laxmi Narayanpuri
50	Walled City Area
51	Basant Pura
52	Jal Mahal
53	Amer
54	Kagdiwala
55	Chandi ki Taksal
56	Walled City Area
57	Walled City Area
58	City Palace
59	Part Brahmpuri
60	Walled City Area
61	Walled City Area
62	Sikar House
63	Part Nahari Ka Naka
64	Bhatta Basti
65	Kacchi Basti
66	Shastri Nagar
67	Nehru Nagar
68	Ambabari
69	Vidhya Dhar Nagar
70	North Outer Area
71	Malviya Nagar South

72	Universit
73	Gandhi nagar
74	Gandhi nagar
75	Rambagh Palace
76	Rambagh Palace
77	Rambagh Palace
78	C-Scheme
79	C-Scheme
80	Civil Lines
81	Civil Lines
82	Shyam Nagar
83	Jal Mahal
84	Jal Mahal
85	Kukas, Chandwaji
86	Jamuva Ramgarh
87	Naila
88	Shivdaspura, Padampura
89	Chandlai, Chittoda, Knowledge city, Pahariya, Rohini Nagar Phase-2
90	Shivraj Colony, Rohini Nagar Phase-1, Renwal, Harsooliya, Narsi
91	Vatika Infotech city
92	Kalwad
93	Bhesawa, Jahota
94	Nindor, Nahargarh fort
95	Alwar district
96	Delhi, Haryana, Utter Pradesh
97	Dausa, Sawai Madhopur, Karauli districts of Rajasthan
98	Tonk, Bundi, Kota districts of Rajasthan, Madhya Pradesh
99	Ajmer, Bhilwara districts of Rajasthan
100	Rest of India
101	Nagur, Jodhpur districts of Rajasthan
102	Bikaner district
103	Rest of Rajasthan, Gujarat, Punjab
104	Sikar, Jhunjhunun, Churu districts of Rajasthan

ANNEXURE 2.2

Peak Hour Section Loadings – 2014 – Sitapura Industrial Area to Ambabari

S.No	Station name	Boarding	Alighting	Sectional Loading	S.No	Station Name	Boarding	Alighting	Sectional Loading
1	Sitapura Industrial Area	854	0	854	20	Ambabari	5010	0	5010
2	Pratap Nagar	458	34	1278	19	Pani Pech	1539	190	6359
3	Haldi Ghati Gate	727	114	1891	18	Subash Nagar	2244	297	8306
4	Sanganer	1079	460	2510	17	Sindhi Camp	4039	288	12057
5	Laxmi Nagar	2140	648	4002	16	Government Hostel	1238	419	12876
6	Durgapura	734	448	4288	15	Ajmeri Gate	325	300	12901
7	Mahavir Nagar	601	475	4414	14	SMS Hospital	1336	4151	10086
8	Gopal Pura	910	393	4931	13	Narayan Singh Circle	761	355	10492
9	Dev Nagar	605	377	5159	12	Swai Mansingh Stadium	598	209	10881
10	Tonk Phathak	1550	588	6121	11	Gandhi Nagar Mode	536	172	11245
11	Gandhi Nagar Mode	551	367	6305	10	Tonk Phathak	1249	894	11600
12	Swai Mansingh Stadium	663	462	6506	9	Dev Nagar	874	1007	11467
13	Narayan Singh Circle	772	526	6752	8	Gopal Pura	516	1368	10615
14	SMS Hospital	357	3798	3311	7	Mahavir Nagar	378	1223	9770
15	Ajmeri Gate	51	350	3012	6	Durgapura	356	1910	8216
16	Government Hostel	60	466	2606	5	Laxmi Nagar	759	2253	6722
17	Sindhi Camp	719	1466	1859	4	Sanganer	503	4796	2428
18	Subash Nagar	197	501	1555	3	Haldi Ghati Gate	360	837	1951
19	Pani Pech	79	993	641	2	Pratap Nagar	38	1069	920
20	Ambabari	0	641	0	1	Sitapura Industrial Area	0	920	0

Peak Hour Section Loadings – 2021 – Sitapura Industrial Area to Ambabari

S.No	Station Name	Boarding	Alighting	Sectional Loading	S. No	Station Name	Boarding	Alighting	Sectional Loading
1	Sitapura Industrial Area	1257	0	1257	20	Ambabari	10270	0	10270
2	Pratap Nagar	880	55	2082	19	Pani Pech	1960	373	11857
3	Haldi Ghati Gate	1279	183	3178	18	Subash Nagar	2871	801	13927
4	Sanganer	1806	521	4462	17	Sindhi Camp	4681	829	17779
5	Laxmi Nagar	2728	881	6310	16	Government Hostel	2311	1407	18683
6	Durgapura	999	514	6795	15	Ajmeri Gate	570	599	18654
7	Mahavir Nagar	946	529	7212	14	SMS Hospital	1759	5997	14416
8	Gopal Pura	1167	596	7783	13	Narayan Singh Circle	785	477	14724
9	Dev Nagar	894	458	8219	12	Swai Mansingh Stadium	758	243	15329
10	Tonk Phathak	2129	903	9445	11	Gandhi Nagar Mode	695	195	15379
11	Gandhi Nagar Mode	784	594	9635	10	Tonk Phathak	1829	1347	16221
12	Swai Mansingh Stadium	903	625	9913	9	Dev Nagar	1244	1476	15989
13	Narayan Singh Circle	1081	756	10238	8	Gopal Pura	1230	1879	15340
14	SMS Hospital	423	5907	4754	7	Mahavir Nagar	1026	1768	14598
15	Ajmeri Gate	78	519	4313	6	Durgapura	778	2876	12500
16	Government Hostel	92	705	3700	5	Laxmi Nagar	1194	3989	9705
17	Sindhi Camp	1077	2294	2483	4	Sanganer	711	6124	4292
18	Subash Nagar	219	620	2082	3	Haldi Ghati Gate	389	1732	2949
19	Pani Pech	88	1360	810	2	Pratap Nagar	62	1661	1350
20	Ambabari	0	810	0	1	Sitapura Industrial Area	0	1350	0

Peak Hour Section Loadings – 2031 – Sitapura Industrial Area to Ambabari

S.No	Station Name	Boarding	Alighting	Sectional Loading		S.No	Station Name	Boarding	Alighting	Sectional Loading
1	Sitapura Industrial Area	2134	0	2134		20	Ambabari	11329	0	11329
2	Pratap Nagar	1917	109	3942		19	Pani Pech	2612	413	13528
3	Haldi Ghati Gate	1953	360	5535		18	Subash Nagar	3733	834	16427
4	Sanganer	3422	667	8290		17	Sindhi Camp	4799	893	20333
5	Laxmi Nagar	3949	1331	10908		16	Government Hostel	3553	1458	22428
6	Durgapura	1752	626	12034		15	Ajmeri Gate	743	745	22426
7	Mahavir Nagar	1123	617	12540		14	SMS Hospital	2169	7114	17481
8	Gopal Pura	1565	873	13232		13	Narayan Singh Circle	1141	667	17955
9	Dev Nagar	1462	505	14189		12	Swai Mansingh Stadium	1028	353	18630
10	Tonk Phathak	4082	1165	17106		11	Gandhi Nagar Mode	1119	308	19441
11	Gandhi Nagar Mode	1491	763	17834		10	Tonk Phathak	2603	1594	20450
12	Swai Mansingh Stadium	1622	984	18472		9	Dev Nagar	1850	1905	20395
13	Narayan Singh Circle	1904	1205	19171		8	Gopal Pura	2048	2373	20070
14	SMS Hospital	439	13220	6390		7	Mahavir Nagar	1613	1917	19766
15	Ajmeri Gate	87	703	5774		6	Durgapura	1230	4163	16833
16	Government Hostel	206	895	5085		5	Laxmi Nagar	1641	6359	12114
17	Sindhi Camp	1118	3157	3046		4	Sanganer	920	6975	6059
18	Subash Nagar	225	761	2510		3	Haldi Ghati Gate	435	2293	4202
19	Pani Pech	107	1534	1083		2	Pratap Nagar	85	2039	2248
20	Ambabari	0	1083	0		1	Sitapura Industrail Area	0	2248	0

Peak Hour Section Loadings – 2041 – Sitapura Industrial Area to Ambabari

S.No	Station Name	Boarding	Alighting	Sectional Loading
1	Sitapura Industrial Area	2357	0	2357
2	Pratap Nagar	2118	120	4354
3	Haldi Ghati Gate	2157	398	6114
4	Sanganer	3780	737	9157
5	Laxmi Nagar	4362	1470	12049
6	Durgapura	1935	691	13293
7	Mahavir Nagar	1240	682	13852
8	Gopal Pura	1729	964	14616
9	Dev Nagar	1615	558	15673
10	Tonk Phathak	4509	1287	18896
11	Gandhi Nagar Mode	1647	843	19700
12	Swai Mansingh Stadium	1792	1087	20405
13	Narayan Singh Circle	2103	1331	21177
14	SMS Hospital	485	14603	7059
15	Ajmeri Gate	96	777	6378
16	Government Hostel	228	989	5617
17	Sindhi Camp	1235	3487	3365
18	Subash Nagar	249	841	2773
19	Pani Pech	118	1694	1196
20	Ambabari	0	1196	0

S.No	Station Name	Boarding	Alighting	Sectional Loading
20	Ambabari	12514	0	12514
19	Pani Pech	2885	456	14943
18	Subash Nagar	4124	921	18146
17	Sindhi Camp	5301	986	22460
16	Government Hostel	3925	1611	24774
15	Ajmeri Gate	821	823	24772
14	SMS Hospital	2396	7858	19310
13	Narayan Singh Circle	1260	737	19833
12	Swai Mansingh Stadium	1136	390	20579
11	Gandhi Nagar Mode	1236	340	21475
10	Tonk Phathak	2875	1761	22590
9	Dev Nagar	2044	2104	22529
8	Gopal Pura	2262	2621	22170
7	Mahavir Nagar	1782	2118	21834
6	Durgapura	1359	4599	18594
5	Laxmi Nagar	1813	7024	13382
4	Sanganer	1016	7705	6694
3	Haldi Ghati Gate	481	2533	4642
2	Pratap Nagar	94	2252	2483
1	Sitapura Industrail Area	0	2483	0

Annexure 2.3.

Trip Length Distribution for Metro Trips
Sitapura Industrial Area to Ambabari Corridor

Trip Length in KM	Trips-2014	Trips-2021	Trips -2031	Trips -2041
0-3	7671	10395	14382	15887
3-6	8161	11616	16085	17768
6-9	7523	9908	13513	14927
9-12	4555	7672	11603	12817
12-15	5687	9792	13151	14528
15-18	1720	3793	5292	5846
>18	448	777	1183	1306

CHAPTER 3

NEED FOR METRO

3.1 Why a Metro?

Public Transport System is an efficient user of space and energy, with reduced level of air and noise pollution. As the population of a city grows, share of public transport, road or rail-based, should increase. For a city with population of 1.0 million, the share of public transport should be about 40% - 45%. The percentage share of public transport should progressively increase with further growth in the city population, reaching a value of about 75% when the population of the city touches 5 million mark.

A comprehensive Mobility Plan for the city is already prepared. Possible options for a public mass transit system are:-

i). City Buses;

ii). Bus Rapid Transit Systems;

iii). Tramway system; and

iv). A Metro System (light or medium).

The city already has a bus system operated and maintained by Rajasthan Roadways and private operators. This is totally inadequate for the needs of the city. The Government is also contemplating to introduce Bus Rapid Transit Systems on certain selected routes. BRT has its own limitations and constraints. For one thing, the capacity of a BRT system can at best be only 10000 to 12000 PHPDT (Peak Hour Peak Direction Trips) and that of a tramway system about 8000 to 10000 PHPDT. The BRT takes away two lanes of the road for dedicated use pushing rest of the road vehicles crowded into the remaining road space. Therefore, unless the road widths are more than three lanes in each direction, BRT is not feasible and even then the non-bus riders will be put to tremendous inconvenience. In Delhi BRT has been a total failure. In the case of a Metro

system, the road width is not encroached upon. If the Metro is elevated, only the central median of the road to a width of 2 to 3 m. is occupied for locating the columns carrying the rail deck. If the metro is underground, there is no encroachment at all on the road width.

Jaipur City, with its present agglomeration population of 4.45million and employment of 15.55 lakh has a travel demand of 36 lakh passenger trips every day with 3.6 lakh trips performed during peak hour. With growing population and mega development plans coming up for the Port City, the travel demand is expected to grow steeply. With the growing economy and inadequate public transport services, the passengers shall shift to private modes, which is already evident from the high vehicle ownership trends in the region. This would not only aggravate the congestion on streets but also increase the pollution. Hence, it is essential to plan and provide for a Light to medium Metro System in Jaipur.

The peak traffic demand on North –South corridor of Jaipur Metro has been assessed 12901 in 2014 and this is likely to increase to 27750 PHPDT by the year 2031. Road accidents are on the rise. Therefore, it is not possible to introduce road based transport system all along the proposed metro corridors. Moreover, traveling time on the road will be much higher. Also, bus travel is not as comfortable as that of metro. There is an urgent need to introduce a Metro system to provide fast, safe and hastle free movement of the public in the city.

3.2 Types of metros and their capacity

Rail based mass transport in cities can be brought mainly under three categories:-

Mode		Carrying capacity (passengers/hour) phpdt
a)	Light Rail Metro System (LRTS)	Up to 25,000
b)	Medium Capacity Metro System	25,000-50,000
c)	Heavy Capacity Metro System	50,000-80,000

Since, the number of commuters to be dealt is relatively less in Medium Metro System, its trains consist of 3 Coaches (which can be increased to 6 Coaches in future) and other related infrastructure is also of a smaller size.

For medium capacity Metro systems, the train generally comprises 3 to 6 coaches with ultimate train headway of about 3 minutes. The other related infrastructure, e.g. civil works, stations, passenger-handling equipment etc. are also planned accordingly.

Heavy capacity metro systems have to deal with large traffic densities ranging from 50,000 to 80,000 phpdt. Accordingly, the trains have 6 to 9 coaches and other related infrastructure is also of large size. Beyond the traffic level of 80,000 phpdt, additional parallel lines are normally planned. The metro system being planned for Delhi is heavy capacity system.

In view of the present and projected PHPDT on the proposed corridor of Jaipur city, Medium Metro System is adequate for meeting the demand.

3.3 Advantages of a Metro system

Metro systems are superior to other modes because they provide higher carrying capacity, faster, smoother and safer travel, occupy less space, and are non-polluting and energy-efficient. To summarise, a Metro system:

(i) Requires 1/5th energy per passenger km compared to road-based system
(ii) Causes no air pollution in the city
(iii) Causes lesser noise level
(iv) Occupies no road space if underground and only about 2 metres width of the road if elevated
(v) Carries same amount of traffic as 5 lanes of bus traffic or 12 lanes of private motor cars (either way), if it is a light capacity system.
(vi) Is more reliable, comfortable and safer than road based system
(vii) Reduces journey time by anything between 50% and 75% depending on road conditions.
(viii) Maximize growth of the Jaipur economy by enhancing its competitive position and facilitating future employment and population growth;
(ix) Delivers a step change by opening a new era in the speed and quality of public transport service linking major growth locations in and around Jaipur area with the city centre and strategic employment areas;
(x) Supports and facilitate the sustainable growth of Jaipur, recognizing the importance of its city centre to the future economy of the Jaipur city region;
(xi) Improves the efficiency of the city's public transport and road networks;

(xii) Creates a system with the flexibility to adapt to development phased over several years;

(xiii) Promote quality of life through a safe and healthy built and natural environment;

(xiv) Increases overall public transport patronage on the corridors served and achieves a mode shift from the car;

(xv) Promotes equality of opportunity by improving accessibility to employment, goods and services;

(xvi) Improve the overall journey experience for passengers using the system by providing high quality information, better waiting and vehicle environments and enhanced safety and security;

(xvii) Assists in building vibrant, confident and cohesive communities in the city;

(xviii) Provides levels of segregation from traffic and public transport priority sufficient to ensure consistently high standards of punctuality and reliability;

(xix) Creates a system that is well integrated with the wider transport network and public real.