JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

A GOVERNMENT OF THE PUNJAB PROJECT

TRANSPORT DEPARTMENT

THE PROJECT FOR LAHORE URBAN TRANSPORT MASTER PLAN IN THE ISLAMIC REPUBLIC OF PAKISTAN

FINAL REPORT VOLUME II

March, 2012

ALMEC CORPORATION

ORIENTAL CONSULTANTS CO. LTD.

Exchange Rate:

USD 1.00 = PKR80.00

(2010 Prices)

PREFACE

In response to a request from the Government of the Punjab in the Islamic Republic of Pakistan, the Government of Japan decided to conduct “The Project for Lahore Urban Transport Master Plan in the Islamic Republic of Pakistan” and entrusted to the study to Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Takashi Shoyama of ALMEC Co., LTD. and consists of ALMEC Co., LTD. and Oriental Consultants Co., LTD. between April, 2010 and March, 2012.

The study team held discussions with the officials concerned of the Government of the Punjab, conducted field surveys in the study area, prepared a Lahore Urban Transport Master Plan (LUTMP) and its Action Plan, conducted a capacity development through On-the-Job-Training (OJT), and prepared this final report.

The project was composed of two phases; i) Phase I to conduct a Home Interview Survey (Person Trip Survey) and other transport/ traffic surveys and develop a transport demand analysis model, and ii) Phase II to prepare a master plan and its action plan. This report is presents the study findings of both Phases.

I hope that this report will contribute to the promotion of this project and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of the Punjab for their close cooperation extended to the study team.

March, 2012

KONISHI Atsufumi,
Director, Economic Infrastructure Department
Japan International Cooperation Agency

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ABBREVIATIONS & ACRONYMS

AASHTO	American Association of State Highway and Transportation Officials
AD	Assistant Director
ADB	Asian Development Bank
ADP	Annual Development Program
ALOS	Advanced Land Observation Satellite
BOT	Build Operate Transfer
C&W	Communication and Works Department
CantB	Cantonment Board
CBD	Central Business District
CDG	City District Government
CDGK	City District Government, Kasur
CDGL	City District Government, Lahore
CDGS	City District Government, Sheikhupura
CNG	Compressed Natural Gas
DCO	District Coordination Officer
DHA	Defence Housing Authority
DIG	Deputy Inspector General
DPL	Development Policy Loan
DRTA	District Regional Transport Authority
DSMD	District Support and Monitoring Department
E&T	Excise and Taxation Department
EDO	Executive District Officers
EPA	Environment Protection Agency
EPD	Environmental Protection Department
ETC	Electronic Toll Collection
F&P	Finance and Planning
FDI	Foreign Direct Investment
FMR	Farm to Market Roads
GDP	Gross Domestic Product
GIS	Geographic Information System
GoPb	Government of the Punjab
H&PP	Housing and Physical Planning Provincial Department
H&UPDD	Housing and Urban Physical Development Department
HIS	Household Interview Surveys
HOV	High Occupancy Vehicle
HP&EP	Housing Physical & Environmental Planning
HRT	Heavy Rapid Transit
HUD&PHED	Housing, Urban Development and Public Health Engineering Department
ICT	Information and Communication Technology
IFC	International Finance Corporation
IMF	International Monetary Fund
ITS	Intelligent Transport System
LCCHS	Lahore Cantonment Cooperative Housing Society
LDA	Lahore Development Authority
LDRTA	Lahore District Regional Transport Authority
LIT	Lahore Improvement Trust
LRMTS	Lahore Rapid Mass Transit System
LRR	Lahore Ring Road
LRRP	Lahore Ring Road Project
LRT	Light Rail Transit
LSE	Lahore School of Economics
LTC	Lahore Transport Company
LTD	Lahore Transport Database
LUTMP	Lahore Urban Transport Master Plan
MCC	Manual Classified Count
MD	Managing Director
MRT	Mass Rapid Transit
MS	Municipal Services

MTDF	Medium Term Development Framework
MVO	Motor Vehicles Ordinance
MVR	Motor Vehicle Rules
NEC	National Economic Council
NESPAK	National Engineering Services Pakistan
NFC	National Finance Commission
NHA	National Highway Authority
NHMP	National Highway and Motorway Police
NHSO	National Highway Safety Ordinance
NMT	Non-Motorized Transport
NTCIP	National Trade Corridor Improvement Program
NTRC	National Transport Research Centre
NWFP	North West Frontier Province
O&M	Operation and Management
OBU	On Board Unit
OD	Origin-Destination
OJP	On-the-Job Participation
OJT	On-the-Job Training
P&D	Planning and Development Department
PHA	Parks and Horticultural Authority
PHATA	Punjab Housing and Town Planning Agency
PHED	Public Health Engineering Department
PMDGP	Punjab Millennium Development Goal Program
PMU	Project Management Unit
PNR	Pakistan National Railway
PPHPD	Passenger Per Hour Per Direction
PPO	Punjab Police Office
PPP	Public Private Partnership
PPTA	Punjab Provincial Transport Authority
PRTC	Punjab Road Transport Corporation
PSP	Private Sector Participation
PTA	Provincial Transport Authority
PTPS	Pakistan Transport Plan Study
PTUIS	Public Transport User Interview Survey
PUTC	Punjab Urban Transport Corporation
R&B	Rehabilitation and Building
RCC	Roller Compacted Concrete
RIS	Road Interview Survey
RMTS	Rail-based Mass Transit System
RTAs	Regional Transport Authorities
STREAM	Sustainable Transport in East Asian Mega-cities
TD	Transport Department
TDM	Traffic Demand Management
TEPA	Traffic Engineering and Transport Planning Agency (Under LDA)
TEVTA	Technical Education and Vocational Training Authority
TEVTC	Technical Education and Vocational Training Council
TMA	Town Municipal Administrations
TPU	Transport Planning Unit
TSDI	Transport Sector Development Initiative
UA	Union Administration
UCs	Union Councils
UN	United Nations
UNESCO	United Nations Educational Scientific Cultural Organisation
UU	Urban Unit
W&S	Works and Services
WASA	Water and Sanitation Agency (Under LDA)
WB	World Bank

Volume-II – Chapter-1

TRANSPORT/ TRAFFIC SURVEYS

FINAL REPORT

1 TRANSPORT/ TRAFFIC SURVEYS

1.1 Introduction

Transport/ traffic surveys are an integral component of a comprehensive transport planning study. These helps to understand the current socio-economic conditions, travel patterns, travel characteristics, existing transport system demand and supply linkages both for private and public transport modes in the Study Area. The baseline data, apart from helping in understanding the existing transport situation along with its problems and constraints; is used in the development, calibration, and validation of the travel demand forecast models. Eleven different surveys were conducted as a part of the Study.

In addition, significant data from secondary sources pertaining to demographic, socio-economic characteristics, and public transport system was collected to supplement the survey data. The final transport database is analysed at various stages by different transport planning experts with respect to requirement to understand the prevailing problems, issues in the sector of their interest.

1.2 Outline of Surveys

Eleven different types of transport/ traffic surveys were conducted for the Study. Brief detail of each survey conducted is given in Table 1.2.1. Each survey was designed with specific objectives as an integral part of transport/ traffic database.

The following section provides detail of surveys undertaken for the Study with their objectives, methodology, and survey locations. The complete details of each survey including the survey forms, survey locations, and survey manuals could be found in previous reports of this Study. Procedures and guidelines specifically designed for the implementation of the Household Interview Survey (HIS) with respect to local conditions are described in Section 1.3.

Table 1.2.1 List of Surveys with Their Objective, Methodology and Scope

No.	Survey	Objective	Methodology	Scope
1	**Household Interview Survey (HIS)**	• Capture travel behaviour of residents in relation to their socio-economic characteristics.	• Household interview by interviewers. • Stratified random sampling.	• Entire Study Area. • Sampling rate of 1 % (18,000 households)
2	**Cordon Survey**	• Capture travel behaviour and travel patterns to and from the Study Area.	• Traffic count by vehicle type and by direction (18/24hrs) • Interview 10~20% sampled vehicles: O/D, trip purpose, type of load, vehicle occupants.	• 13 locations at the outer boundary of the Study Area, railway station and airport
3	**Screenline Survey**	• Count traffic volume by vehicle type and record vehicle occupancy at screenlines to validate O/D matrices obtained from HIS and Cordon surveys.	• Traffic count by vehicle type and by direction (18/ 24 hrs). • Observation survey of vehicle occupancy by vehicle type.	• 64 locations crossing the Railway and Canal Bank Road Screenlines.

No.	Survey	Objective	Methodology	Scope
4	**Traffic Count Survey**	• Count traffic volume by vehicle type at key junctions, and roads, including turning volumes.	• Traffic count by vehicle type and by direction (18/ 24 hrs). • At some locations occupancy counts.	• 14 locations, similar to those of the 1991 JICA study, and two sections of LRR.
5	**Public Transport (PT) User Interview Survey**	• Capture PT users' characteristics and perception to assess and plan improved public transport service.	• Interview survey of users of large bus, AC-bus, wagon, auto rickshaw, and Qingqi.	• 1,000 samples at major bus terminals and bus stops.
6	**Travel Speed Survey**	• Identify the current average journey times.	• Measurement of travel speed by moving observer method.	• Surveys along 10 major routes in the morning, evening and off-peak periods.
7	**Bus Occupancy Survey**	• Determine the utilization of public transport.	• Record the number of passengers boarding and alighting.	• 10 bus routes in morning, evening and off-peak periods.
8	**Parking Survey**	• Capture characteristics of on-street and off-street parking.	• Periodic observation and recording of parked vehicles by surveyors. Recording on entry and exit of off-street parking facilities.	• Seven 100 -m sections of urban streets and four shopping mall parking areas.
9	**Road Inventory Surveys**	• To collect data on physical structure of road network, Junctions along the road.	• By site visit and measurements	• About 2,300 +km of road network surveyed.
10	**Willingness to Pay Survey**	• To collect information on user value of time by different transport modes: private car, bus, Rickshaw, and Qingqi users.	• By interviewing different transport mode users in different parts of the Study Area. All income class people.	• 2,000 sample interviews of car, Rickshaw, Qiqnqi, wagon, and bus users.
11	**Road Junctions and Traffic Signal Survey**	• To collect junction geometry and signal operation data.	• Junction field survey to record existing condition. Drawing AutoCAD plans and measure phasing time of each signalized junction.	• Total 26 junctions out of which five were non-signalized, three roundabouts, and 18 signalized.

Source: JICA Study Team

For the Study vehicles were classified into thirteen categories for all type of surveys. Vehicles classification is given in Table 1.2.2.

Table 1.2.2 Vehicle Classification for the Study

No.	Description
1	Bicycle
2	Motorcycle
3	Rickshaw, Qingqi (Motorcycle Rickshaw)
4	Car, Taxi, 4 WD, Jeep, Land Cruisers, Hiace, Single/ Twin-cabin passenger pick-up
5	Wagon, Suzuki, Minibus (up to 16 seats)
6	Mazda, Coaster (up to 30 seats)
7	Large bus (>30 seats)
8	Pick-up, Delivery truck, Utility vehicles, Ambulances
9	2 Axle truck
10	3 -Axle truck, 3 +-Axle truck
11	Tractors (with or without trolley)
12	Other mechanized vehicles (including construction vehicles)
13	Animal-driven carts

Source: JICA Study Team

All type of transport/ traffic surveys were completed on schedule, the start and finish dates of surveys are given in Table 1.2.3.

Table 1.2.3 Transport/ Traffic Surveys Schedule

No.	Survey Type	Survey Start Date	Survey End Date
1	Household Interview Survey	5-Oct-2010	15-Dec-2010
2	Cordon Survey	13-Dec-2010	4-Jan-2011
3	Screenline Survey	20-Sep-2011	4-Oct-2011
4	Traffic Count Survey	5-Oct-2010	11-Oct-2010
5	Public Transport User Interview Survey	13-Dec-2010	13-Dec-2010
6	Travel Speed Survey	14-Oct-2010	25-Oct-2010
7	Bus Occupancy Survey	14-Oct-2010	22-Oct-2010
8	Parking Survey	26-Oct-2010	4-Dec-2010
9	Road Inventory Survey	15-July-2010	31-Aug-2010
10	Willingness to Pay Survey	1-Jul-2011	31-Jul-2011
11	Road Junctions and Traffic Signal Survey	1-Aug-2011	31-Aug-2011

Source: JICA Study Team

1.2.1 Household Interview Survey

The Household Interview Survey (HIS) is designed to capture the travel behaviour of the residents by survey zone with respect to their socio-economic information, their daily travel activity, opinions of transport users on existing transport issues and environment (traffic congestion and safety, public transport and transport measures), and for making assessment indicators for the future strategies. HIS was used to explain the following issues broadly:

- Socio-economic information of the randomly selected households by each zone;
- Total travel activity generated by the each household resident above 5 years of age by mode, and by time; and
- Resident's opinions on existing transport situation and environment.

HIS field survey was systematically planned, designed and executed with the help of local survey company under the daily guidance, supervision, and control of JICA Study Team. Sample size calculation for the HIS survey was estimated keeping in view the statistical reliability of the data, budget and time constraints. JICA Study Team has designed sample rate based on conditions explained next;

Statistical Reliability of Sample:

Assuming 80 % reliability and a 20 % relative error, a 1 % sampling rate would be sufficient for estimating the trip generation/ attraction for a 100-zone system and with two modes (public and private). In terms of O/D matrices, although 1 % would not be enough for a 100-zone system, its accuracy would be satisfactory for a 60-zone system, as it is highly unlikely that one would observe 100x100 zone to zone movements.

Note: The relationship between relative error, sampling rate, reliability coefficient, number of categories and population is expressed below (assuming r=0.01, k=1.28, C=7200 (that is 60 Zones x 60 Zones x 2 Modes (Private and Public)), and N=17,160,000 (two trips per day by 8,580,000 population above 5 year), and RE becomes 0.18).

$$RE = k\sqrt{\frac{1-r}{r} * \frac{C-1}{N}}$$

Where:
- RE: relative error (0.18)
- r: sampling rate 1 %
- k: reliability coefficient (1.28 at 80 % reliability)
- C: number of categories (number of zones (60), and modes (2))
- N: population (number of total trips)

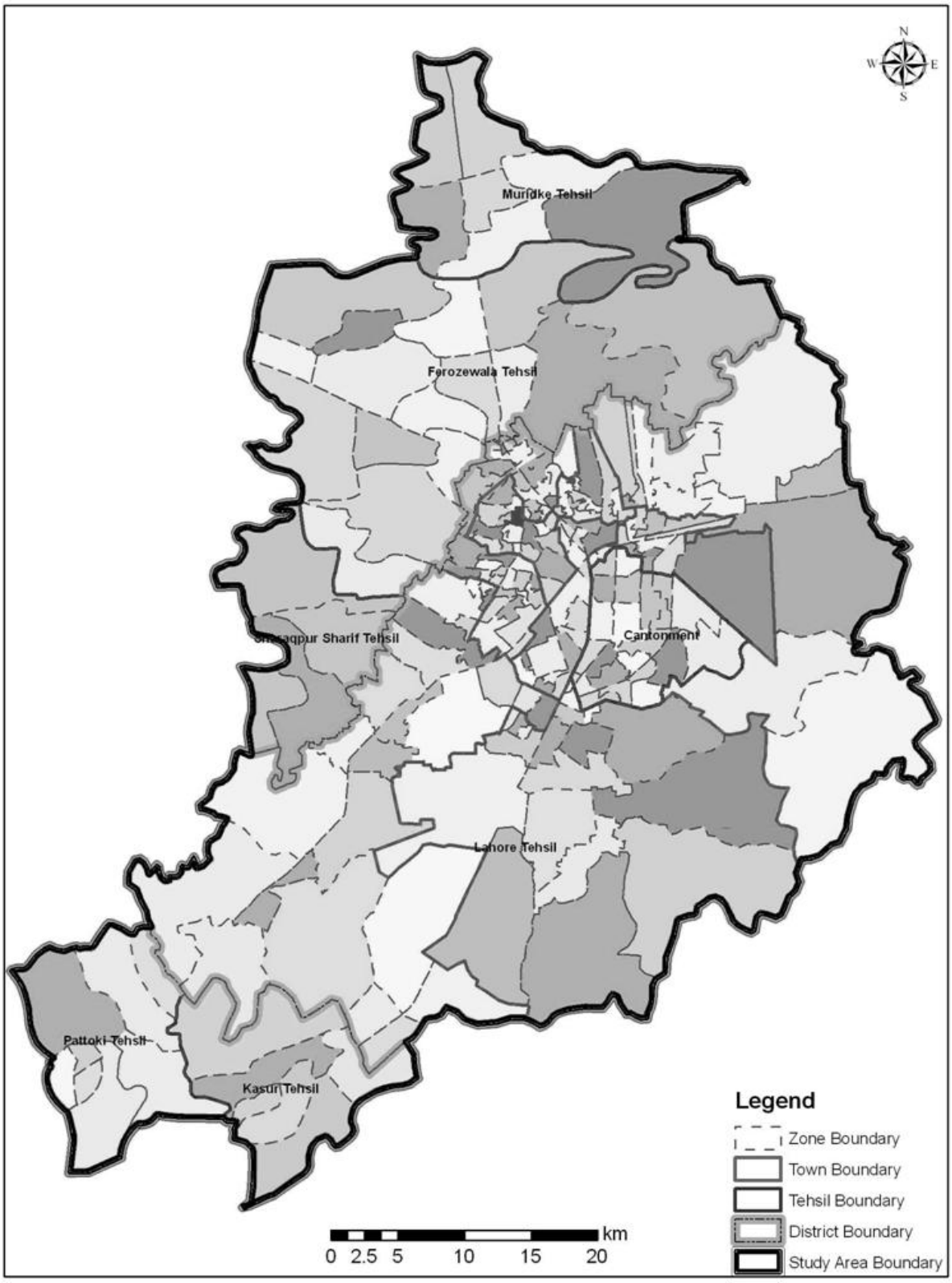
Different steps were involved in planning of HIS survey; which are described next.

1) Study Area and Traffic Zone System

The Study Area, comprising 3,044 km^2, covers the whole district of Lahore and parts of the Kasur and Sheikhupura districts as shown in Figure 1.2.1. Existing administrative division system of the Study Area has been used as base for developing the zone system. Local administrative division is selected because of several reasons: like availability of administrative boundaries, socio-economic information, and census data by union council.

This administrative division (Union Councils) were then further allocated sequential zone numbers and some of the union councils were further divided in to several zones as Railway or Canal Screenlines crossed through these union councils. It was necessary to split these zones to capture the cross screenline trips from HIS and Cordon surveys.

Figure 1.2.1 Household Interview Survey – Study Area and Zone System



Source: JICA Study Team

The Study Area zoning system consist of total of 228 internal zones, 30 external zones for covering trips made from outside the Study Area, and 68 special generator zones for modal interchange facilities like Airport, Railway Stations, Intra-city and Inter-city Bus Termini. A complete list of Zone System with area coverage is given in Annex-I to this volume.

2) Number of Samples

HIS was conducted to record socio-economic characteristics and travel patterns of all household members of 5 years of age or above. Sampling rate was set at 1 % of the Study Area households. The detail of the number of samples by each Town/ Tehsils is given in Table 1.2.4.

Table 1.2.4 Household Interview Survey – Estimated Number of Samples

No.	Town / Tehsil	Total 2010		HIS Samples (Sampling Rate: 1%)	
		Population	Households	Population above 5 Years	Households
1	Ravi Town	1,007,335	183,200	8,870	1,832
2	Data Gunj Baksh Town	969,922	176,400	8,540	1,763
3	Samanabad Town	984,013	179,000	8,660	1,791
4	Shalimar Town	854,223	155,400	7,520	1,553
5	Gulberg Town	778,106	141,500	6,850	1,413
6	Aziz Bhatti Town	666,724	121,300	5,870	1,212
7	Wahga Town	655,928	119,300	5,780	1,193
8	Nishtar Town	945,064	171,900	8,320	1,719
9	Iqbal Town	960,377	174,700	8,460	1,746
10	Cantonment	830,747	151,100	7,320	1,512
11	Ferozewala Tehsil	533,816	97,100	4,700	972
12	Muridke Tehsil	266,232	48,500	2,350	484
13	Sharaqpur Sharif Tehsil	100,804	18,400	890	183
14	Kasur Tehsil	167,504	30,500	1,480	305
15	Pattoki Tehsil	207,246	37,700	1,830	376
1-10	**Lahore**	**8,652,439**	**1,573,200**	**76,150**	**15,734**
11-13	**Sheikhupura**	**900,852**	**163,800**	**7,930**	**1,639**
14-15	**Kasur**	**374,750**	**68,200**	**3,300**	**681**
1-15	**The Study Area**	**9,928,041**	**1,805,100**	**87,370**	**18,062**

Source: JICA Study Team
Note: Average household size at 5.5 persons/HH and percentage of population of above 5 years is estimated to be 88 %.

The method of sampling was geographically stratified random sampling, where samples within each area were randomly selected in the field.

1.2.2 Cordon Survey

The Study Area is encircled by an imaginary line, and all roads entering or exiting to or from the Study Area are marked as cordon survey locations – location map is at Figure 1.2.2. The survey conducted: covered 100 % vehicle counts by vehicle type, and 10~20 % sample of roadside interviews of drivers of private vehicles, and passengers of public vehicles.

The cordon survey is used to estimate the volume of traffic that enters and leaves the Study Area within a typical day, and the volume that passes through, with neither origin nor destination in the Study Area.

Cordon survey is to collect following information:

1. Trip information (origin and destination, purpose, mode, vehicle occupancy, freight type, access mode, 10~20 % sample)
2. Vehicular traffic count (100 % sample by 13 vehicle types)

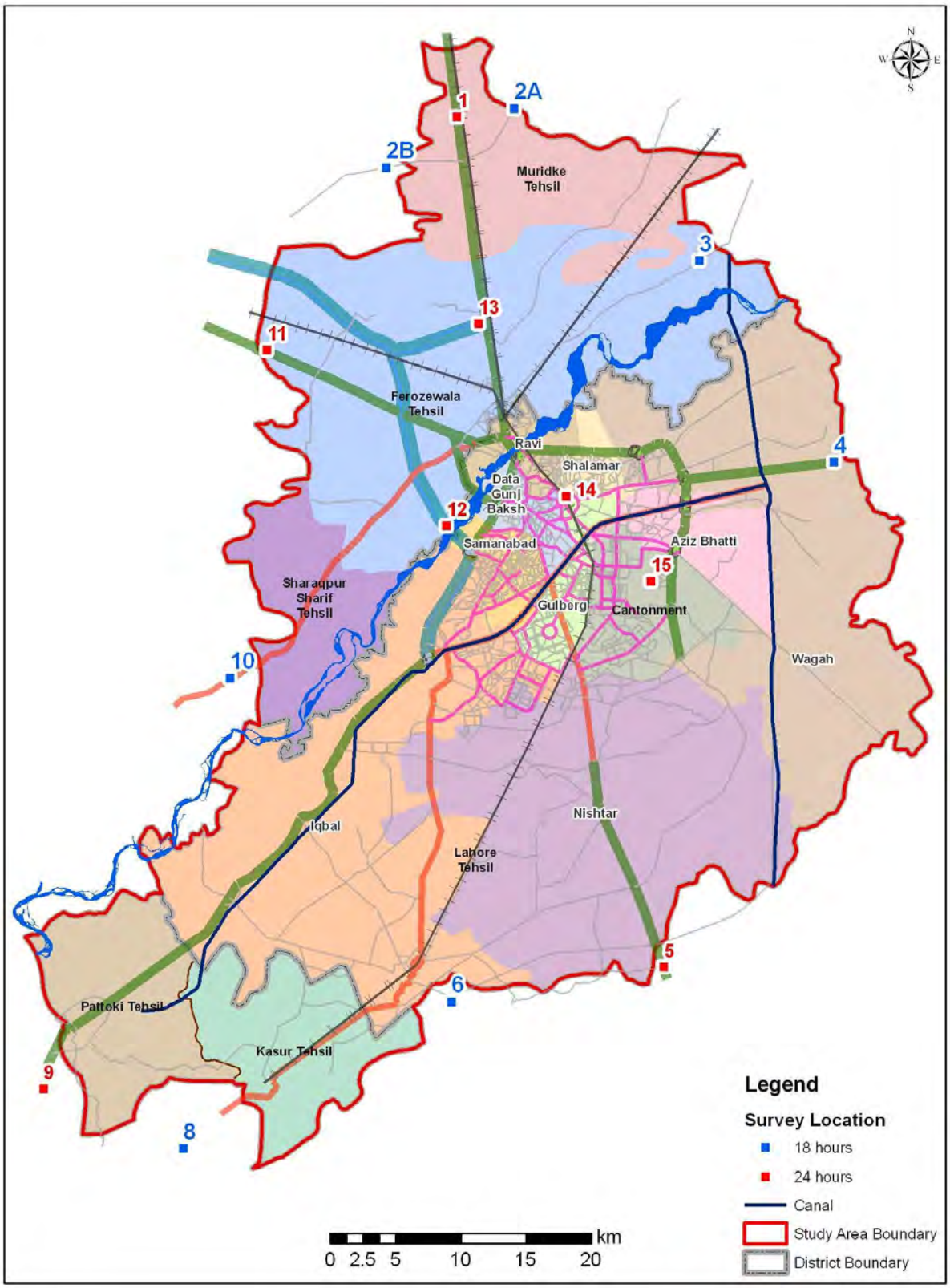
The interviews were conducted by surveyors flagged down vehicles with the help of policemen. The survey was conducted at a total 15 locations, 13 major roads, Allama Iqbal International Airport and Lahore Railway Station. Survey detail is given in Table 1.2.5.

Table 1.2.5 Cordon Survey Locations

Site	Survey Station (Boundary)	Survey Date	Survey Duration	
			Traffic Count	OD Interview
1	G.T. Road near Muridke	**27-Dec-2010**	**24 hour**	**24 hours**
2A	Narowal - Muridike Road	21-Dec-2010	18 hour	18 hours
2B	Sheikhupura - Muridike Road	21-Dec-2010	18 hour	18 hours
3	Kala Khatie - Narang Mandi Road	22-Dec-2010	18 hour	18 hours
4	G.T. Road near Wahga Border	6-Jan-2011	18 hour	18 hours
5	Lahore-Kasur Road near Mustafa Abad	**28-Dec-2010**	**24 hour**	**24 hours**
6	Kasur – Raiwind Road near Raiwind	23-Dec-2010	18 hour	18 hours
8	Pattoki-Raiwind Road near Changa Manga	23-Dec-2010	18 hour	18 hours
9	Multan Road near Bhai Pheru	**3-Jan-2011**	**24 hour**	**24 hours**
10	Jaranwala-Lahore Road near Sharaqpur Sharif	22-Dec-2010	18 hour	18 hours
11	Lahore-Sheikhupura Road (near Sheikhupura)	**1-Jan-2011**	**24 hour**	**24 hours**
12	Ravi Motorway (M-2) Toll Plaza	**29-Dec-2010**	**24 hour**	**24 hours**
13	Kala Shah Kaku Toll Plaza (Lahore Bypass)	**28-Dec-2010**	**24 hour**	**24 hours**
14	Lahore Railway Station	**4-Jan-2010**	**-**	**24 hours**
15	Allama Iqbal International Airport	**13-Dec-2010**	**-**	**24 hours**

Source: JICA Study Team

Figure 1.2.2 Cordon Survey Sites



Source: JICA Study Team

1.2.3 Screenline Survey

The Study Area is divided into four main parts by the BRB Canal and Pakistan Railway Line. Two screenlines were selected, and named as the "Rail Screenline" and the "Canal Screenline". 100 % Vehicular traffic was counted by 13 vehicle types in both directions. Vehicle occupancy survey counted the number of vehicle occupants (passenger and driver) for a target of 10 to 50 % sample of vehicles crossing the screenline.

The surveys were conducted at 64 locations at main railway crossings or bridges on the two screenlines; 20 sites were surveyed for a period of 24 hours, while 44 sites were surveyed for 18 hours (6:00-24:00). Location map of both screenlines is given in Figure 1.2.3, and survey details are given in Tables 1.2.6 and 1.2.7.

Table 1.2.6 Railway Screenline Survey Locations

No	Site Code	Roads Crossing Railway Screenline	Duration (Hours)	Survey Date
1	R-1	Hardosohal Muslim Road	18	4-Oct-2010
2	R-2	Kala Khatai Narang Mandi Road	18	
3	R-3	Shahdara Town Underpass	18	
4	R-4	Jahangir Tomb Road	18	
5	R-5	Lahore Ring Road	24	
6	R-5A	Lahore Ring Road Underpass Level-crossing	18	
7	R-6	Badami Bagh Flyover	18	1-Oct-2010
8	R-6A	Badami Bagh Level-crossing	18	
9	R-6B	Mandi Wala Level-crossing	18	4-Oct-2010
10	R-7	Misri Shah Underpass	18	1-Oct-2010
11	R-8	Ek Moria - Underpass	18	
12	R-9	Do Moria Underpass	18	
13	R-10	Garhi Shahu Bridge	24	
14	R-11	Mughalpura Road (to Workshop)	18	30-Sep-2010
15	R-12	Allama Iqbal Road Underpass	24	
16	R-13	Dharumpura Underpass (to Mall Road)	24	
17	R-13A	Dharumpura Underpass (to Mughalpura)	24	
18	R-13C	Dharumpura Level-crossing (to Mughalpura)	24	
19	R-13B	Dharumpura Underpass (to Mall Road)	24	
20	R-13D	Level-crossing (to Mall Road)	24	
21	R14	Mian Mir Bridge (to Mall Road)	18	29-Sep-2010
22	R14A	Mian Mir Underpass (Sikandar Road)	18	28-Sep-2010
23	R15	Abid Majeed Road (Sherpao Bridge)	18	29-Sep-2010
24	R16	Allaudin Road	18	
25	R17	Jinnah Flyover	18	
26	R17A	Jinnah Flyover (Level-crossing)	18	
27	R17B	Jinnah Flyover (Underpass)	18	
28	R18	Ferozepur Road (Flyover)	24	28-Sep-2010
29	R18A	Ferozepur Road (Level-crossing)	24	
30	R18B	Between Ferozepur Road and Peco Road	24	
31	R19	Peco - Ferozepur Road Link	18	
32	R20	Depot Road	18	

No	Site Code	Roads Crossing Railway Screenline	Duration (Hours)	Survey Date
33	R21	Defense Road - College Road	18	27-Sep-2010
34	R22	Defense Road - Ferozepur Road Link	18	
35	R23	Raiwind Road - Lahore Road	18	
36	R23A	Kasur Road - Manga Road	18	
37	R-2A	G.T. Road	24	4-Oct-2010

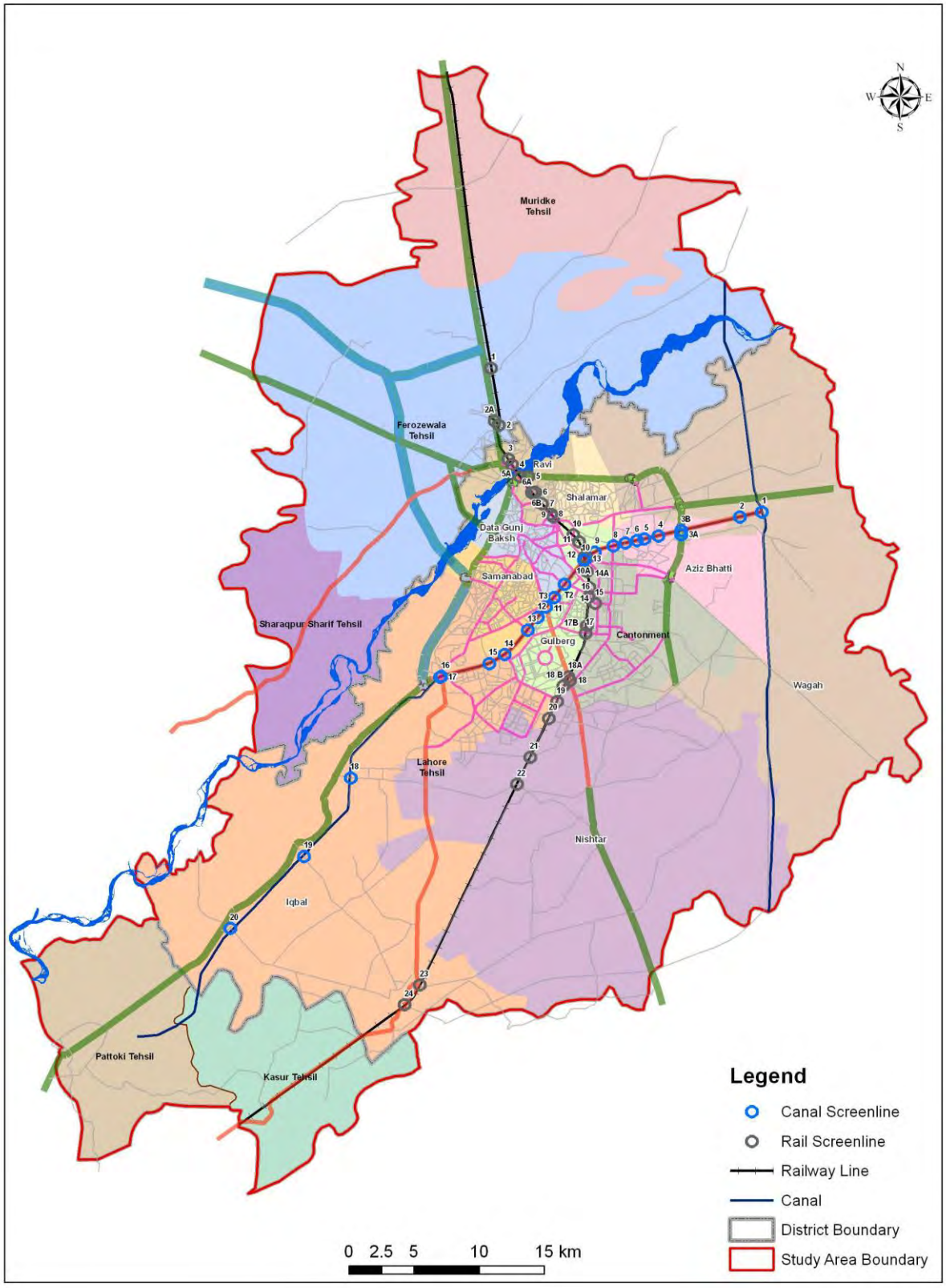
Source: JICA Study Team

Table 1.2.7 Canal Screenline Survey Locations

No	Site Code	Roads Crossing Canal Screenline	Duration (Hours)	Survey Date
1	C1	GT Road - Barki Road Link	18	20-Sep-2010
2	C2	Jallo Park Access Road	18	
3	C3A	Lahore Ring Road / Harbanspura flyover	18	
4	C3B	Lahore Ring Road / Harbanspura on road	18	
5	C4	Taj Bagh Bridge	18	
6	C5	Fatah Garh Bridge	18	
7	C6	Trasburaski Road (Nawan Bridge)	18	21-Sep-2010
8	C7	Lal Pul Bridge	18	
9	C8A	Shalamar Link Road Flyover	18	
10	C8B	Shalamar Link Road on Road	18	
11	C9	Chobacha Bridge	18	
12	C10	Zarrar Shaheed Road (Dharumpura Bridge)	24	22-Sep-2010
13	C10A	Sundardas Road (Dharumpura Bridge)	24	
14	T3	Mall Road	24	7-Oct-2010
15	T2	Jail Road	24	8-Oct-2010
16	C11	Zahoor Elahi Road (FC College Bridge)	18	21-Sep-2010
17	T1	Ferozepur Road	24	11-Oct-2010
18	C12	New Muslim Town	18	22-Sep-2010
19	C13	Campus Road	24	
20	C14	Jinnah Hospital Bridge	18	23-Sep-2010
21	C15	Doctors Hospital Bridge	18	
22	C16	Canal View Main Road Bridge	18	24-Sep-2010
23	C17	Thokar Niaz Baig on Road	24	23-Sep-2010
24	C17A	Thokar Niaz Baig Flyover	24	
25	C18	Defense Road	18	24-Sep-2010
26	C19	Sundar Road	18	
27	C20	Raiwind Road	18	

Source: JICA Study Team

Figure 1.2.3 Canal and Railway Screenline Survey Locations



Source: JICA Study Team

1.2.4 Traffic Count Surveys at Key Roads near Major Intersections

Traffic counts survey was conducted to collect traffic characteristics in relation to the 1991 JICA study traffic counts at the same 14 intersections in the Study Area. The additional locations selected are Old Ravi Bridge and Lahore Ring Road.

The survey counted the vehicle volume by 13 vehicle type, in two directions and by two time period: 6 sites were selected for 24 hour counts; whereas the 8 other sites were surveyed for 18 hour (6:00-24:00). Location map of survey sites is shown in Figure 1.2.4, and details are given in Table 1.2.8.

Table 1.2.8 Traffic Count Survey Locations

No.	Duration	Survey Station		Survey Date
T1	24 hour Turning Movement Count	Canal Bank Road / Ferozepur Road Intersection		11-Oct-10
T2		Canal Bank Road / Jail Road Intersection		8-Oct-10
T3		Canal Bank Road / Mall Road Intersection		7-Oct-10
No.	**Duration**	**Road**	**Road Section**	
T4	24 hour Vehicular Traffic Count	Multan Road	between Bund Road E and Sodiwal Road	5-Oct-10
T5		G.T, Road	between Shalamar Link Road and Shalimar Garden	6-Oct-10
T6		Ravi Bridge	between with Bund Road E and G.T. Road	6-Oct-10
T7	18 hour Vehicular Traffic Count (6:00 to 24:00)	Old Ravi Bridge	between Lahore Ring Road and Jahangir Tomb Road	6-Oct-10
T8		Multan Road	between Bahawalpur Road and Samnabad Main Boulevard.	5-Oct-10
T9		Ferozepur Road	between Bahawalpur Road and Camp Jail	5-Oct-10
T10		Ferozepur Road	between Gulberg main Blvd and Model Town	5-Oct-10
T11		Jail Road	between Gulberg Main Blvd and Zafar Ali Road	5-Oct-10
T12		Allama Iqbal Road	between Canal bank Road and Mughalpura Road	1-Nov-10
T13		Lahore Ring Road	between Ring road BRB Canal and Band Road S	6-Oct-10
T14		Lahore Ring Road	between Amjad Chaudhry Road and Canal Bank Road	6-Oct-10

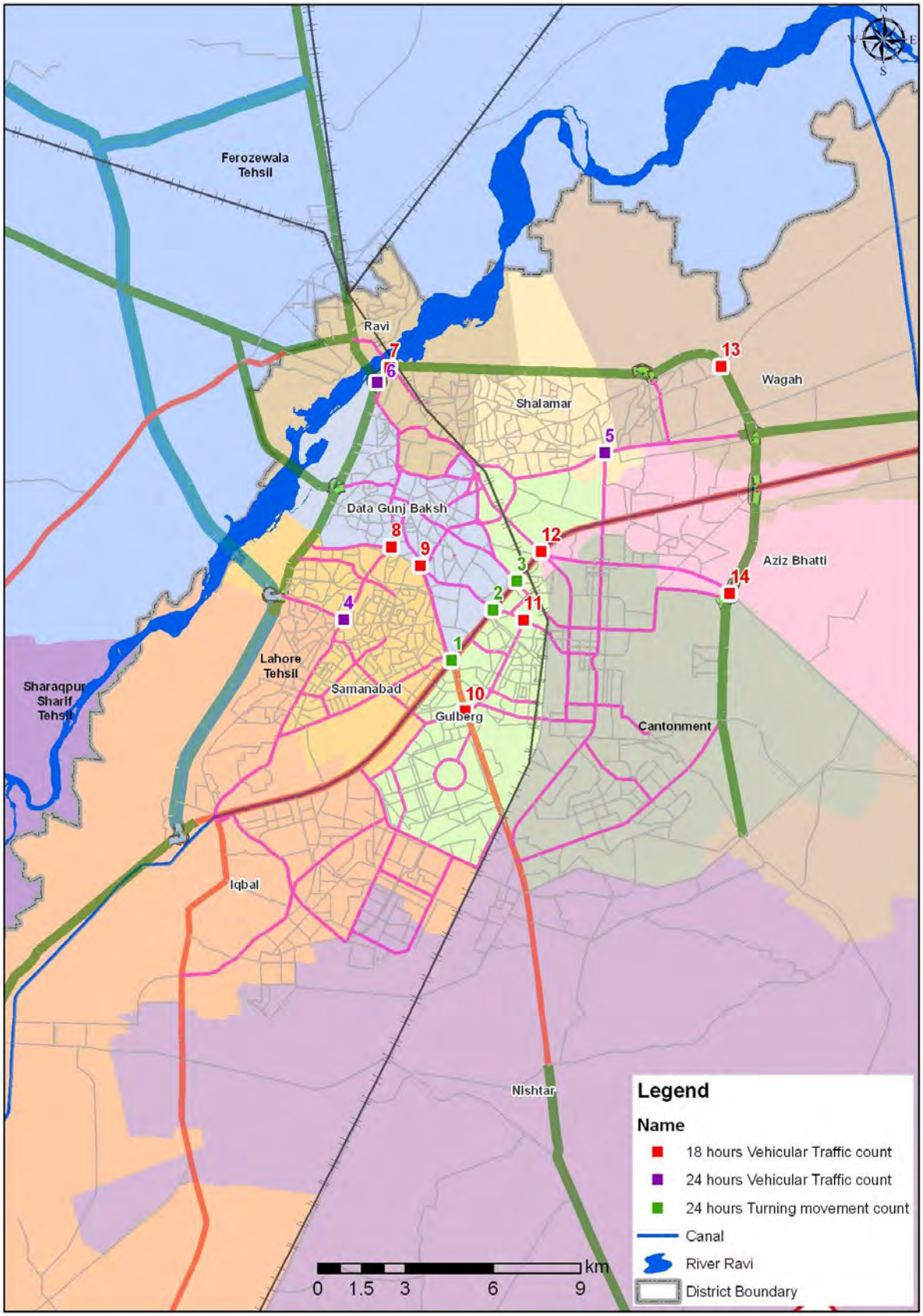
Source: JICA Study Team

1.2.5 Public Transport (PT) User Interview Survey

PT user interview survey (passengers of: Bus, AC-bus, Wagon, Rickshaw, and Qingqi collected information on: Socio-economic characteristics of user, O/D, trip purpose, travel time and fare paid, and perceptions of existing and proposed public transport services. This is to ascertain the current urban transport situation in Lahore, and prepare database for future public transport facilities, Table 1.2.9 gives the detail of surveys.

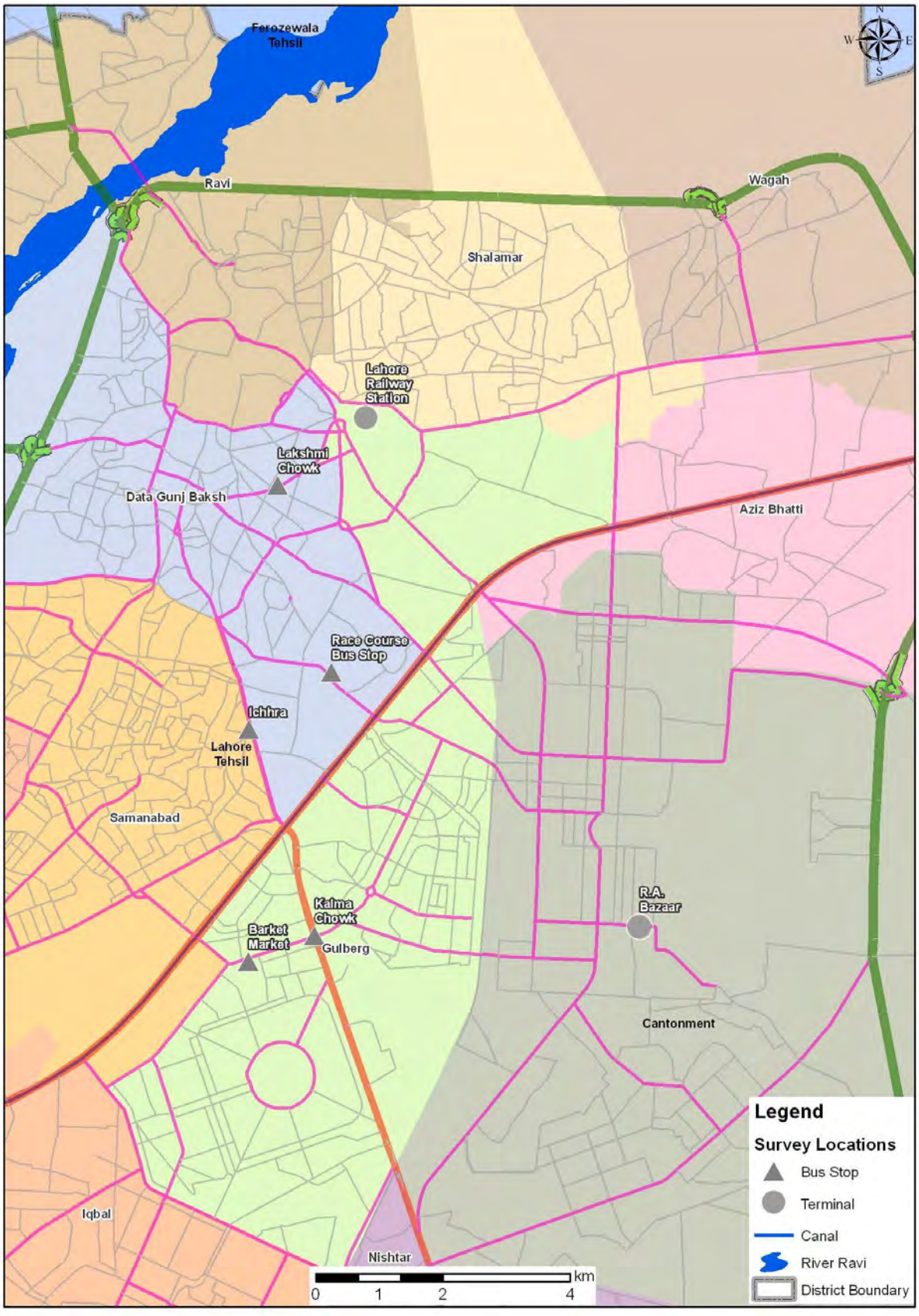
One thousand (1,000) interview samples were randomly conducted at major intra-city terminals and bus stops for 12 hours, with a predetermined proportion of samples for each public transport mode. Socio-economic characteristics of user, public transport journey time, opinion of public transport services and perceptions of likely future facilities were recorded. Location map of survey sites is given in Figure 1.2.5.

Figure 1.2.4 Traffic Count Survey Locations



Source: JICA Study Team

Figure 1.2.5 Public Transport User Interview Survey Locations



Source: JICA Study Team

Table 1.2.9 Public Transport User Interview Survey Locations

No.	Description	Survey Date
1	Lahore Railway Station	13-Dec-2010
2	R.A. Bazaar	
3	Race Course Bus Stop	
4	Kalma Chowk	
5	Barkat Market	
6	Icchra	
7	Lakshmi Chowk	

Source: JICA Study Team

1.2.6 Travel Speed Survey

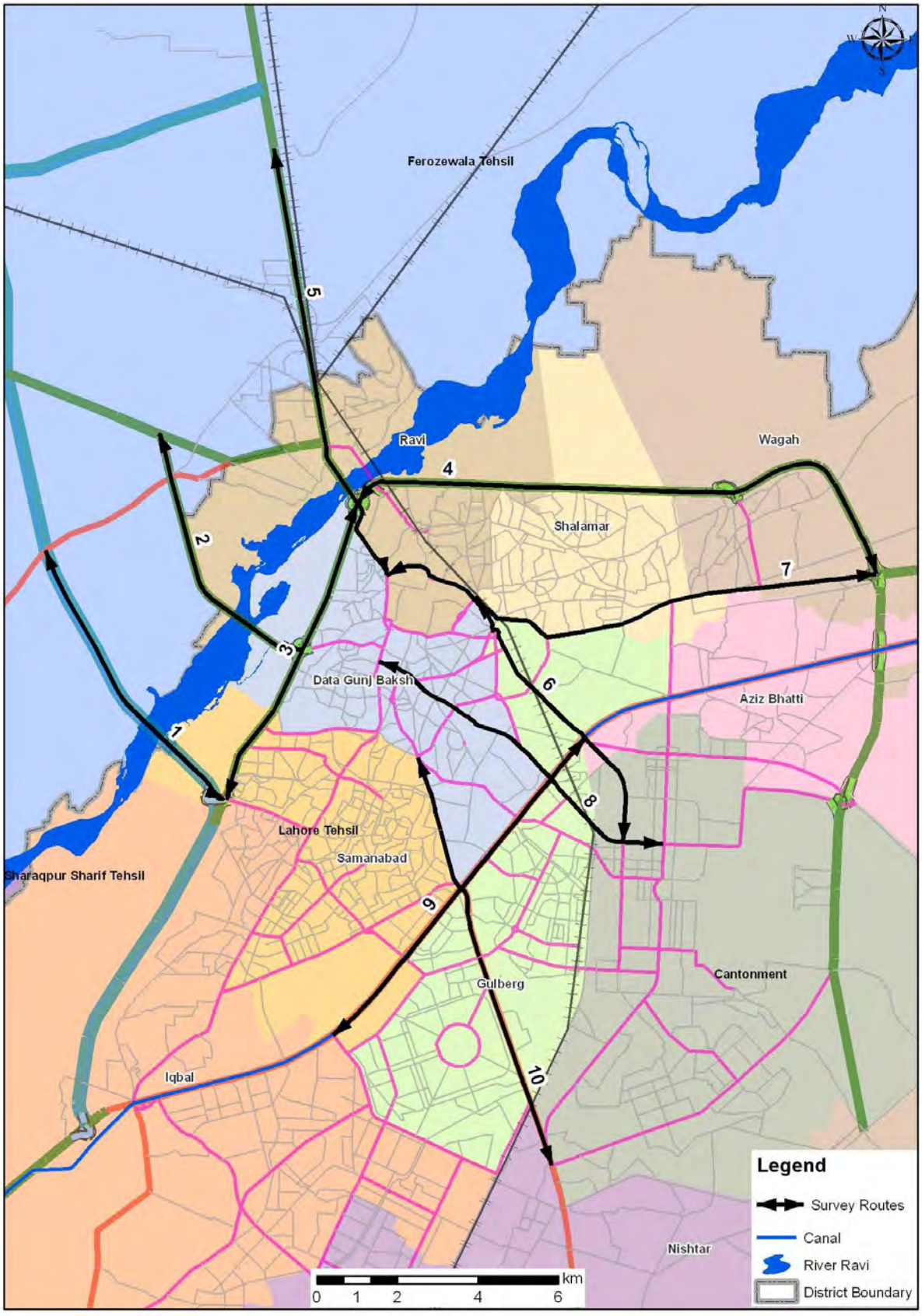
Travel speed survey (Journey Time Survey) was conducted along 10 major road corridors in the city in order to ascertain travel speed and major congestion issues. Travel speed surveys were conducted during morning, evening, and off-peak periods in both directions. The survey followed the 'floating car method', which requires the survey vehicles to keep the same position in the traffic flow. Travel time, time of passing intersection and reasons for delays were recorded. Survey routes are illustrated in Figure 1.2.6, and routes descriptions are given in Table 1.2.10.

Table 1.2.10 Travel Speed Survey Routes

No.	Journey Time Survey Route Description	Length (km)	Survey Date
1	Motorway M-2 (Babu Sabu interchange to Faizpur interchange)	7	14-Oct-10
2	Sagian Wala Bypass (intersection with Sheikhupura Road to intersection with Bund Road)	7	14-Oct-10
3	Bund Road and Lahore Ring Road (intersection with Bund Road to Ravi Bridge interchange)	7	15-Oct-10
4	Lahore Ring Road (Ravi Bridge interchange to intersection with G.T. Road)	14	15-Oct-10
5	G.T. Road (Yadgar Chowk to intersection with Hardosohal Muslim Road)	11	18-Oct-10
6	Circular Road, Allama Iqbal Road, Infantry Road, Shami Road (Yadgar Chowk to intersection with Aziz Bhatti Road)	8	19-Oct-10
7	G.T. Road (intersection with circular Road to intersection with Lahore Ring Road)	8	20-Oct-10
8	Mall Road, Aziz Bhatti Road (from Mahfooz Chowk to intersection Lower Mall Road)	8	21-Oct-10
9	Canal Bank Road (intersection with Allama Iqbal Road – intersection with Maulana Shaukat Ali Road)	10	22-Oct-10
10	Ferozepur Road (Intersection with Defense Road to Qartba Chowk)	10	25-Oct-10

Source: JICA Study Team

Figure 1.2.6 Travel Speed Survey Routes



Source: JICA Study Team

1.2.7 Bus Occupancy Survey

Bus occupancy survey was conducted along ten (10) 'notified' bus routes during bus operating hours, in both directions of operation. Data was collected with surveyors riding a bus from origin to its destination, counting the number of boarding and alighting passengers, and start time at each bus stop. This provided the passengers boarding, alighting and loading profile by individual bus route, and by time of day. Location of bus survey routes are given in Figure 1.2.7, and detailed in Table 1.2.11.

Table 1.2.11 Bus Occupancy Survey Routes Ten

Route No.	Bus Company	From	To	Survey Date
4	New Khan	Lari Adda	Jallo More	14-Oct-2010
5	Daewoo	Railway Station	DHA Y-Block Market	20-Oct-2010
8	New Khan	Lari Adda	Airport	21-Oct-2010
9	Premier Bus Service	Railway Station	Purana Khana	15-Oct-2010
12	Premier Bus Service	Railway Station	Youhanna Abad	19-Oct-2010
16	Daewoo	Railway Station	Umer Chowk	20-Oct-2010
17	New Khan	Railway Station	Jallo Pind	21-Oct-2010
19	Premier Bus Service	Purana Ravi Pull	Chungi Amar Sidhu	18-Oct-2010
22	New Khan	Jallo More	Thokar Niaz Baig	22-Oct-2010
33	METRO	Railway Station	Green Town	22-Oct-2010

Source: JICA Study Team

1.2.8 Parking Survey

Parking survey objective was to capture parking characteristics including: number of parked vehicles and duration by vehicle type in an area. This survey was conducted by periodic (1/2 hour beat) observation and by recording of number plate of parked vehicles along the road-side. At all closed sites number plates were recorded at entry and exit points. Seven 100-meter sections of roads and five off-street parking facilities (shopping malls) were surveyed in the LUTMP urban area. Locations of survey sites are given in Figure 1.2.8, and detailed in Table 1.2.12.

Table 1.2.12 Parking Survey Locations

NO.	Road Section	Survey Site Description	Survey Date	Survey Duration
1	Mall Road	In front of Croweater Gallery and restaurant	26-Oct-10	06:30-23:00
2	Mall Road	In front of Dubai Islamic Bank	27-Oct-10	06:30-23:00
3	Mall Road	In front of Panorama Shopping Centre	26-Oct-10	07:00-23:00
4	Mall Road	In front of Bank Alfalah	27-Oct-10	07:00-23:00
5E	Khayaban-e-Aiwan-e-Iqbal	In front of Lahore Stock Exchange	28-Oct-10	07:00-23:00

NO.	Road Section	Survey Site Description	Survey Date	Survey Duration
5W	Khayaban-e-Aiwan-e-Iqbal	Opposite side of Lahore Stock Exchange	28-Oct-10	07:00-23:00
6	Kashmir Road	Opposite side of LDA Plaza in front of Passco	28-Oct-10	06:30-23:00
7	Liberty Market	At Entry and Exit Points of Liberty Market	29-Oct-10	11:00-22:30
8	Gulberg Main Boulevard	In front of Hafeez Center	29-Oct-10	07:00-2300
9A	METRO – Model Town	at Entry and Exit Points	4-Nov-10	12:00-23:00
9B	MACRO – Link Road	at Entry and Exit Points	4-Nov-10	13:30-23:30
C	MACRO – Ravi Road	at Entry and Exit Points	4-Nov-10	16:45-22:15

Source: JICA Study Team

1.2.9 Road Inventory and Junction Characteristics Surveys

The Study Area road network inventory survey covered primary, secondary, and tertiary roads, whereas small streets and roads inside the closed housing societies were not surveyed. For each key road section; road length, right of way width, carriageway width, footpath width, no of lanes, proportion of road section (link) used for parking, encroachment, bus stop, and predominant land use; were recorded.

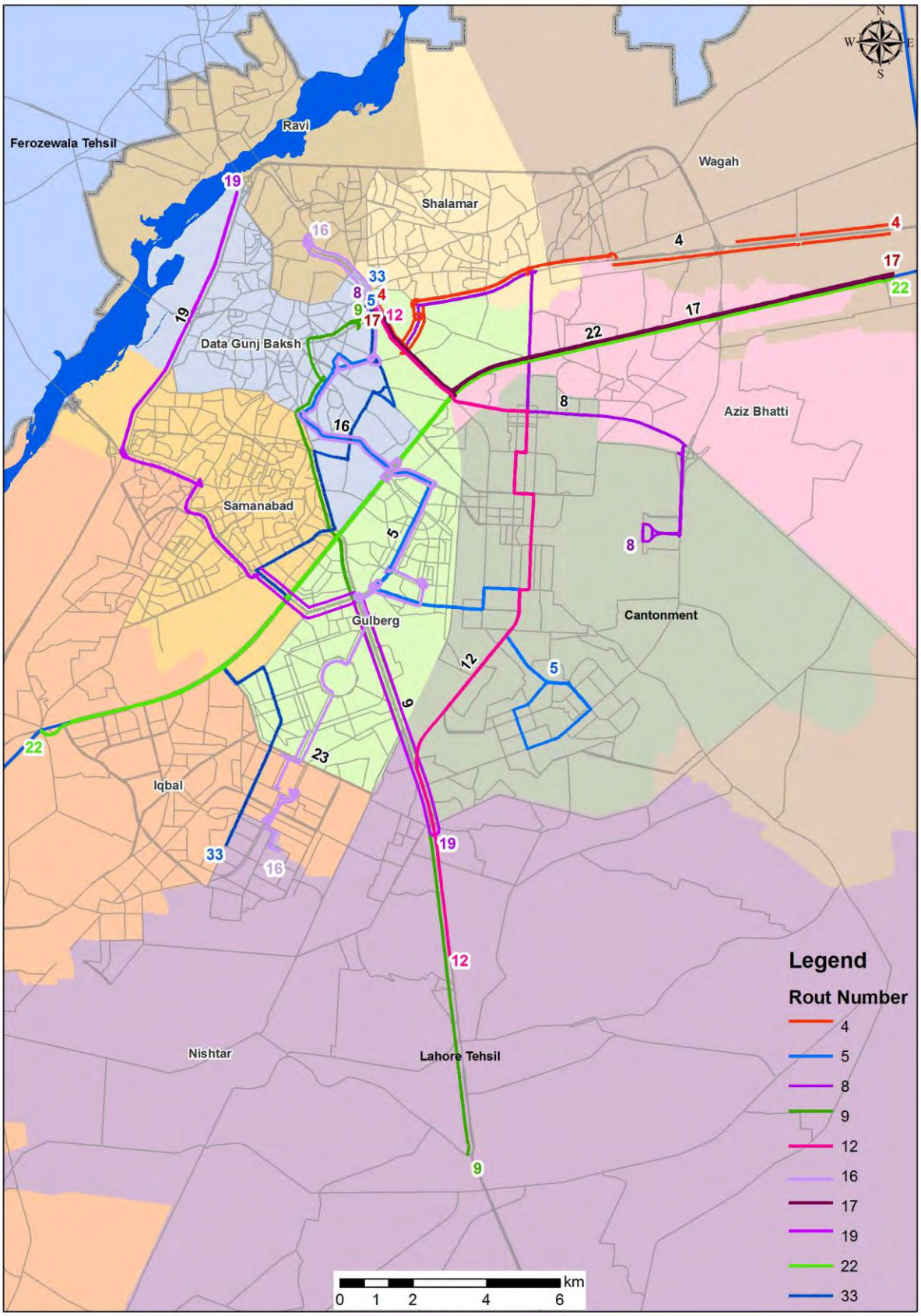
The junction survey recorded data for each key junction at major and minor cross roads. The recorded data included number of lanes entering the junction, type of junction. Road network covered by inventory survey is shown in Figure 1.2.9, and a summary is given Table 1.2.13.

Table 1.2.13 Road Inventory Survey Summary

Type	Unit	Total
Roads (sections)	Count	1021
Junctions	Count	264
Total Length	Km	2,233
Average Right of Way	Meter	18.85
No. of Links	Count	2,412
Bus Stops	Count	373
One-way Links	Count	939
Two-way Links	Count	1,473
Single Carriageway Links	Count	765
Dual Carriageway Links	Count	1,647

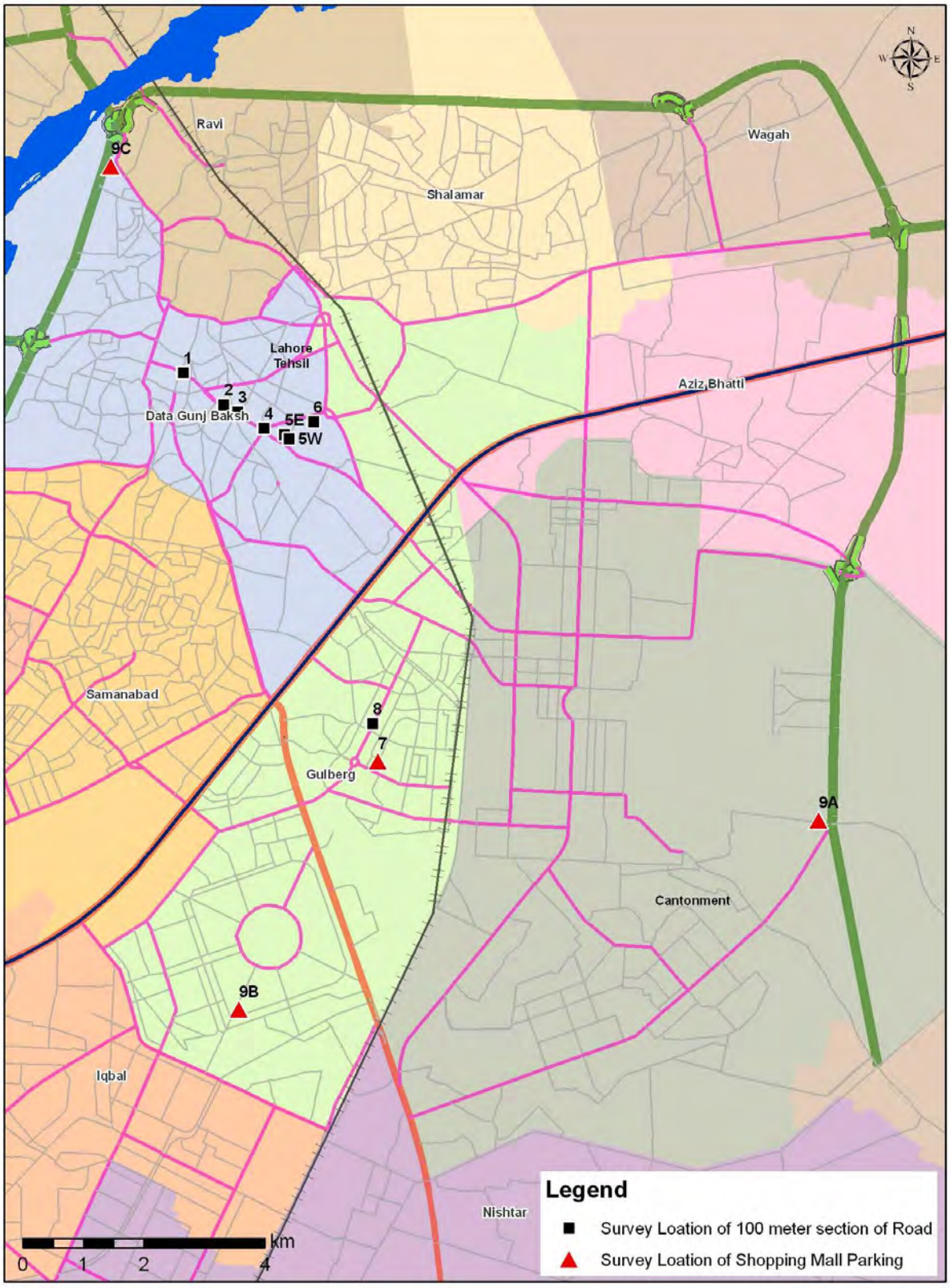
Source: JICA Study Team

Figure 1.2.7 Bus Occupancy Survey – Ten Bus Routes



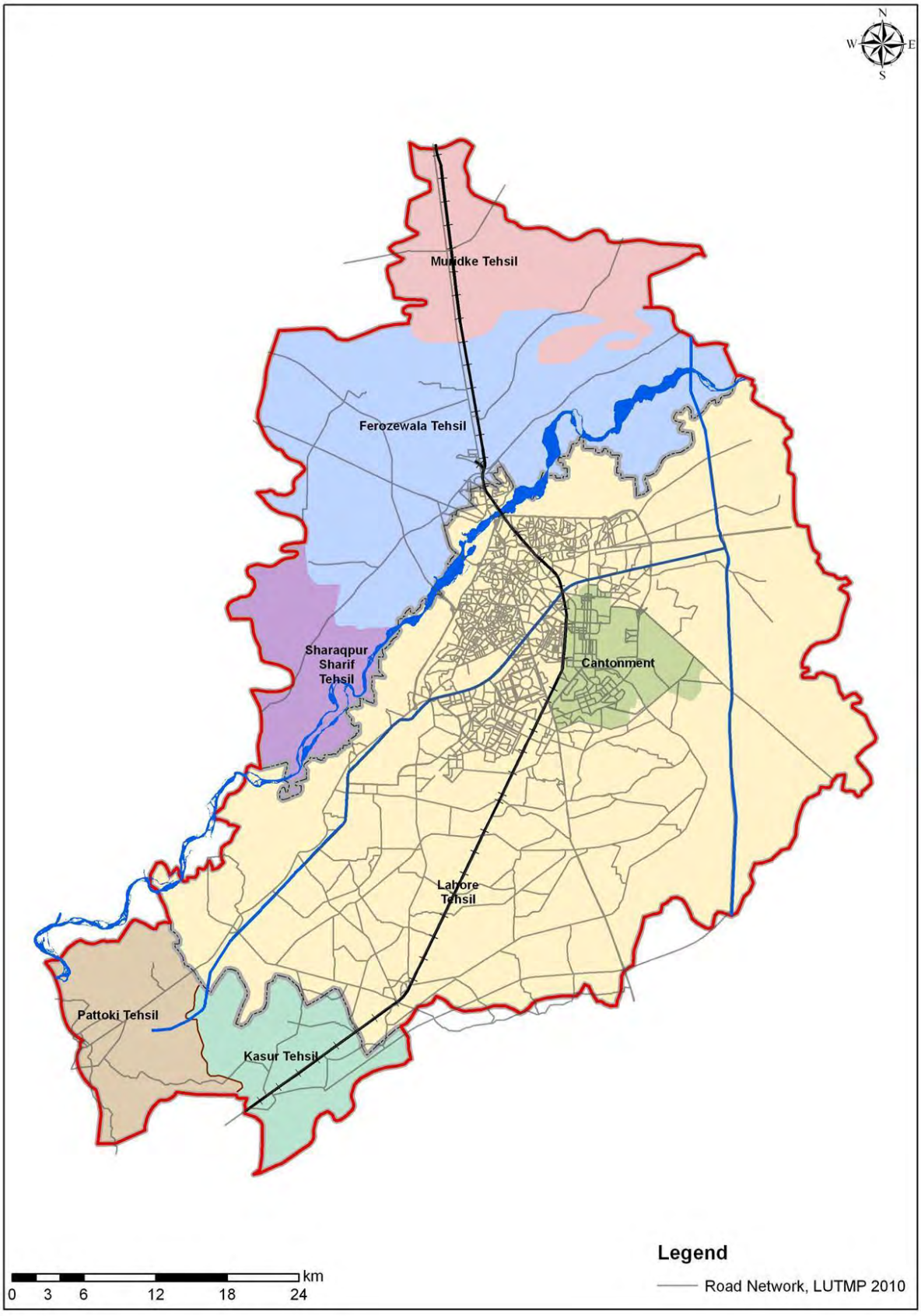
Source: JICA Study Team

Figure 1.2.8 Parking Survey – Road Sections and Sites



Source: JICA Study Team

Figure 1.2.9 Road Network Inventory Survey – Coverage Area



Source: JICA Study Team

1.2.10 Willingness to Pay Survey

Willingness to pay survey aimed to collect information on travel behaviour and travel budget. The objective was to estimate value of time of different transport mode users, and their willingness to pay for transport services improvement. Interviews were conducted with different transport mode users include: Car (31 %), Rickshaw (31 %), Qingqi (6 %), Wagon (8 %), Bus (18 %), and AC Bus (6 %) of a total sample about 2,100 respondents. This survey was conducted at a number of locations in the Study Area like: fuel stations, educational institutions, shopping malls, intra-city bus terminal, to avoid sampling bias. Location map of interview sites is given in Figure 1.2.10, and details are described in Table 1.2.14.

Table 1.2.14 Willingness to Pay Survey Sample Details

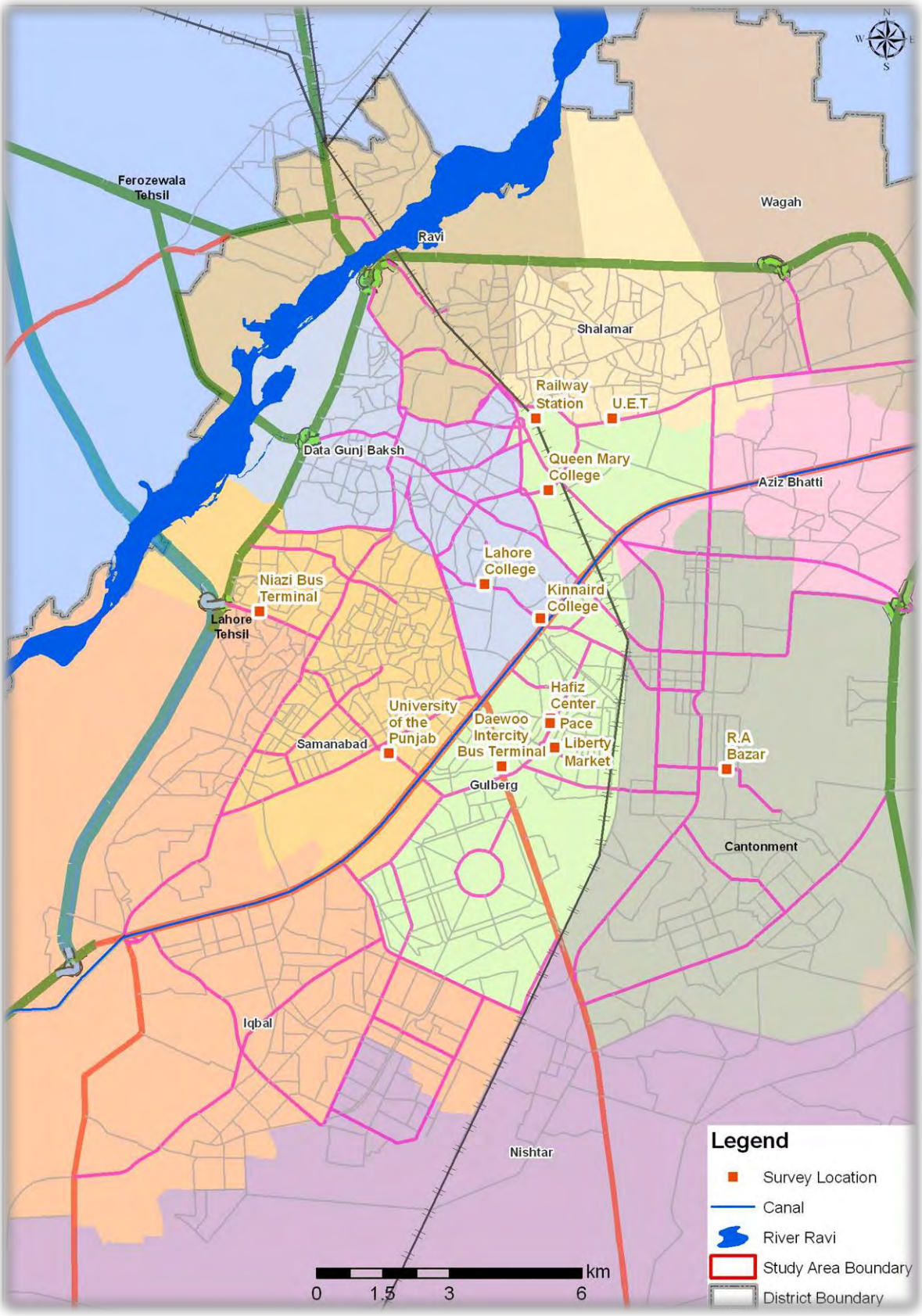
Transport Mode Used	Sample	Questionnaire Type	Percent Sample
Car	645	3	31%
Rickshaw	647	3	31%
Qingqi	125	3	6%
Wagon	175	3	8%
Bus	385	3	18%
AC - Bus	115	3	5%
Total	**2,092**	**-**	**100%**

Source: JICA Study Team

1.2.11 Road Junction and Traffic Signal Survey

Road junction and traffic signal survey focused to collect data in the Central Business District (CBD) area of Lahore, south, and south east of the Walled City. The survey collected broad junction layout, junction geometric design, traffic circulation, and signal phasing information. In total 26 junctions were surveyed: out of which three (3) were Roundabouts, eighteen (18) were signalized, including six (6) three arms, and the rest were 4 to 6 arms; and five (5) junctions were uncontrolled. Location map of junctions is given in Figure 1.2.11 and details are summarized in Table 1.2.15.

Figure 1.2.10 Locations of Willingness to Pay Survey Sites



Source: JICA Study Team

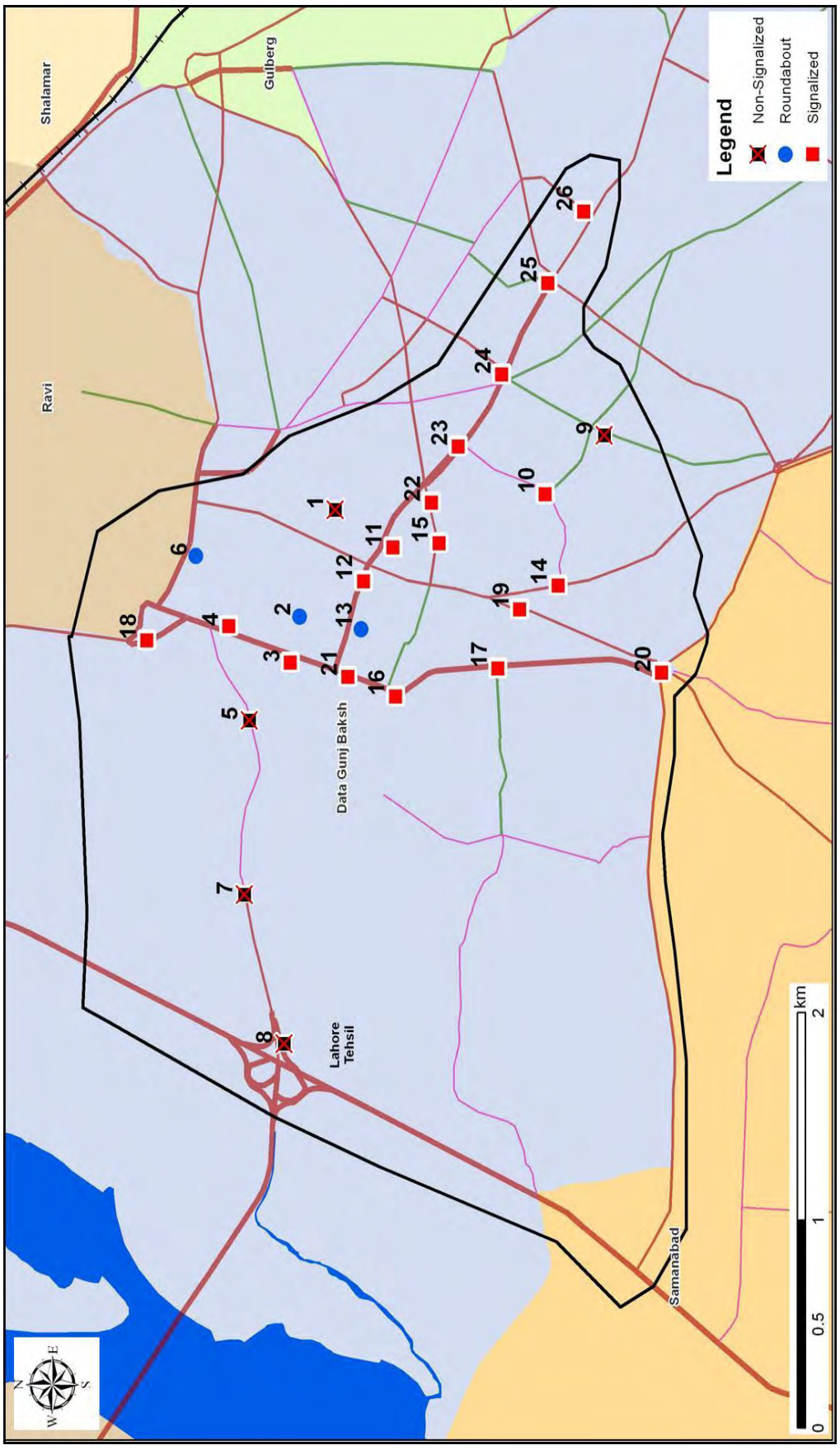


Figure 1.2.11 Locations of Junctions Surveyed for Road Junctions and Traffic Signal Survey

Source: JICA Study Team

Table 1.2.15 Details of Road Junctions Survey

No.	Junction Name and Description	Type of Junction
1	Neela Gumbad Chowk	Unsignalized
2	Government College Chowk	Roundabout
3	Outfall Road and Lower Mall	Pre-Timed
4	Rettigan Road and Lower Mall Road	Pre-Timed
5	Rettigan Road and Outfall Road	Unsignalized
6	Lohari Gate Chowk	Roundabout
7	Rettigan Road and Abdul Qadir Jillani Road	Unsignalized
8	Saggian Bypass and Outfall Road	Unsignalized
9	Mozang Road and Temple Road	Unsignalized
10	Mozang Road and Begum Road	Pre-Timed
11	Mcload Road and Mall Road	Pre-Timed
12	Anarkali Road and Mall Road	Pre-Timed
13	Town Hall Chowk	Roundabout
14	Lytton Road and Begum Road	Pre-Timed
15	Mclean Road and Bank Road	Pre-Timed
16	Lower Mall Road and Mall Road	Pre-Timed
17	MAO College Chowk	Pre-Timed
18	Bhatti Chowk	Pre-Timed
19	Babri Chowk	Pre-Timed
20	Chauburji	Pre-Timed
21	Post Master General Chowk	Pre-Timed
22	YMCA Chowk – Mall Road	Pre-Timed
23	Fane Road and Mall Road	Pre-Timed
24	Regal Chowk	Pre-Timed
25	Chairing Cross	Pre-Timed
26	Awari Chowk	Pre-Timed

Source: JICA Study Team

1.3 HIS Survey Implementation

Implementation of Household Interview Survey (HIS) includes the following steps;

i. Questionnaire Design

ii. Sampling

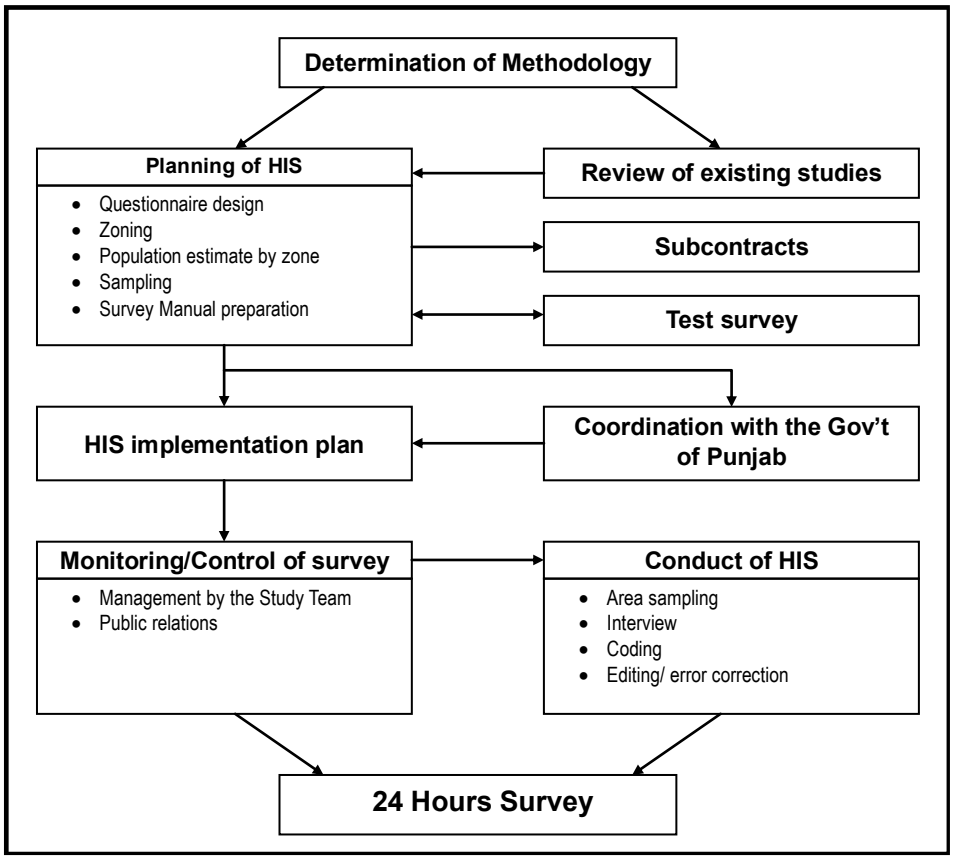
iii. Preparation of Field Survey

iv. Conduct of Field Survey

v. Data Processing

However, for all other types of survey; steps include; define survey locations, design survey form, training of survey staff with respect to each survey type, field supervision for quality assurance, data coding, data encoding, and simultaneous range and logic checks to minimize error in data entry. HIS survey control procedure designed for successful implementation of filed survey is presented in Figure 1.3.1. Steps involved for the preparation, and conduct of HIS survey are described next.

Figure 1.3.1 Household Interview Survey – Quality Control Procedure



Source: JICA Study Team

1.3.1 HIS Questionnaire Design

Questionnaire design is a very complex process; which needs local cultural knowledge in order to define questions in a context; so that to enhance acceptance by general public and avoid any cultural or societal conflict. Some questions are highly unacceptable by certain societies around the world which could not be incorporated directly to every culture and may result in local public grievances, as an impediment in the implementation of HIS surveys.

Questionnaire was designed for its requirement to be used for the specific purpose of travel demand model development, calibration, and validation, and also for the alternative socio-economic development analysis. Basic contents covered information regarding the socio-economic condition of each household and its members, travel log of each household member 5 years or above, their trip details, and each household assessment of present traffic, transport situation and the environment in the Study Area.

Questions included were defined according to maximum interview time of 30 minutes per household with 3-5 members, social constraints and interview response time. A short (HIS) pilot survey was conducted in different parts of the Study Area to cover most classes of people to check responses. Later questionnaire was modified as necessary.

An Urdu (direct translation of English) version of questionnaire was also tested in the small pilot. It was found to be not acceptable in the field as people started reading the questionnaire, and argued unnecessarily. This was time consuming and a constraint to complete the survey within the scheduled time.

For simplicity and ease of handling; questionnaire was divided into five parts, and each part was printed on a different colour paper;

Part-0 – Survey Control Page – **White**
Part-A – Household Information – **Off White**
Part-B – Household Member Information – **Blue**
Part-C – Daily Travel Log – **Pink**
Part-D – People's opinion on Transport and Environment – **Green**

Detail contents of the Household Interview Survey are given in Table 1.3.1.

Table 1.3.1 Household Interview Survey – Contents

Item		Content
Socio-Economic Information	**PART A**: Household Information	• Accommodation Information • Household Composition • Household Income • Vehicle Ownership • Other Household Socio-economic Features
	PART B: Household Member Information	• Age, Sex, Education, Occupation, Income • Vehicle Availability
Trip Information	**PART C**: Daily Travel Activity Information	• Trip Purpose (including pick-up/ drop-off) • Origin / Destination, Departure/ Arrival time/ Transfer Point • Travel Mode • Travel Time, Cost, Fare, Tolls, Parking
Assessment of Trip	**PART C**: Assessment of Daily Travel Activity Information	• Reason of mode choice (Time, Comfort, Convenience, Cost, Safety, Other choices etc.) • Assessment of Trip (Time, Convenience, Safety, Other)
Assessment on Present Traffic Conditions and Transport System	**PART D**: People's Opinion of Transport and Environment	• Traffic Congestion • Traffic Safety (accident experience and opinions for traffic safety) • Public Transport (Bus and other Modes) • Transport Measures

Source: JICA Study Team

1.3.2 Sampling

Sampling is concerned with selection of subset of individual households within a population. The main advantages of sampling are that; the cost is lower, data collection is faster, and since the data set is smaller, it is possible to ensure homogeneity and to improve the accuracy, and the quality of data. Sample calculation and its statistical reliability are discussed in detail in Section 1.2.1.

1.3.3 Preparation of Field Survey

1) Organization Set-up

The survey was conducted under the supervision of JICA Study Team. Following organization setup was maintained during the Survey. Organization set up of one survey group is given in Figure 1.3.2:

a) Chief Supervisor: chief supervisor was responsible for overall survey activities and reporting works. Therefore, he/ she was in direct contact with JICA Study Team during the course of the surveys;

b) Area Coordinators: area coordinator to assist chief supervisor in the course of the field survey and be responsible for survey activities in specific area, training of

their allocated teams, monitoring and control of overall progress of his/ her survey group;

c) Supervisors: supervisors to assist area coordinator during the course of survey and mainly responsible for field reconnaissance, deployment of allocated teams, field survey supervision, and quality assurance;

d) Group Leaders: group leaders of specific teams to assist their supervisors in the course of field survey, and be mainly responsible for logistics, sample control of his/ her teams, to ensure timely completion of field survey, quality checking of survey forms, handing over completed survey forms with short report to supervisor, and safe return of survey teams;

e) Surveyors: surveyors were responsible for field work;

f) Coders: coders were employed for the data coding. HIS Surveyors were preferred for the basic coding of HIS Survey Forms after the completion of HIS field survey. Whereas, for Zone Coding; Shortlisted Supervisors and Surveyors having better understanding and familiarity of the Study Area were employed.

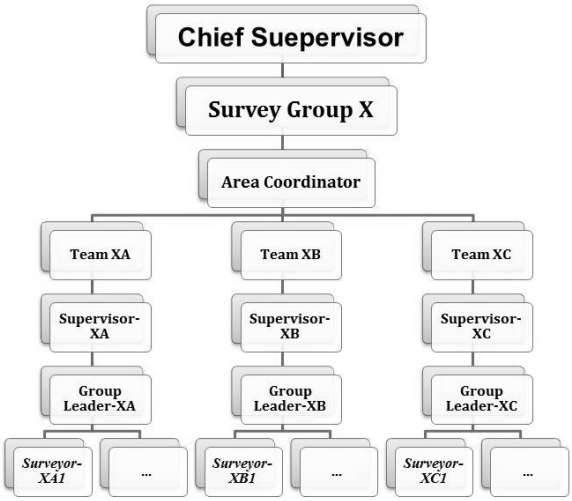
g) Chief Encoder: chief encoder was deployed to assist Chief Supervisor in the course of the data processing, and to ensure the quality of encoded data through different range and logic checks during data entry;

h) Encoders: encoders were employed for data entry in a database using specially designed software.

The survey company has arranged insurance to secure the safety of the survey team. During the survey, members of the JICA Study Team and the staffs of the Transport Planning Unit, Transport Department visited the sites to oversee and monitor the conduct of the surveys at locations and often at random.

Completed survey forms and coded results were sent weekly to the JICA Study Team for inspection and additional quality checks. An office for the survey staff and the JICA Study Team working together on daily basis was arranged for close cooperation.

Figure 1.3.2 Organizational Setup of One Survey Group



Source: JICA Study Team

2) Preparation of HIS Survey Manuals

JICA Study Team prepared detail Household Interview Survey manual; which explained each individual question with its objective, and brief explanation through practical interview examples.

Coding manual was prepared separately to give instructions to coding staff; so as to bring the consistency in all survey form coding and to avoid any type of systematic or random errors.

3) Preliminary/ HIS Pilot Survey

In order to get conformity of survey form in local context, and training core team of survey expert, a pilot survey was conducted with selected number of HIS Surveyors. They were trained before sending them to the field. This team was then used to further train the additional survey staff through properly organized, training workshops, and on the job training in the field with experienced surveyors.

HIS survey form was finalized based on the pilot survey analysis and recommendations field staff experience. The pilot survey was conducted in five different parts of the Study Area, representing mostly different societies. Those survey zones were Deenanath (Kasur District), Sharaqpur (Sheikhupura District), DHA Phase-8, Sabzazar, and Maraka (Lahore District).

4) Training of Surveyors

A temporary Human Resource Management (HRM) section was established to look after the recruitment and training of the survey staff. Rate of absentees were reduced by employing well educated staff at good wage rate.

At the start of each survey training session, briefing was given by the Study Team on the key objectives of the Study, relevance of data to the future of the city; and for the motivation of survey staff. Training was conducted using actual survey forms and manuals by dividing the Staff into groups with each supervisor training the allocated staff.

First day of survey for new staff, after short training from HRM section; they have been sent to the field with experienced staff to get familiarity with the task at hand, understand respondent behaviour and responses. Later on; to cover small absentees in the staff, HRM section was continuously recruiting and training new survey staff.

5) Management of the Field Survey

The following system was established for the field survey management.

- **a)** Field reconnaissance and sampling system;
- **b)** Surveyor assignment system;
- **c)** Check system for surveyors' dishonest activities;
- **d)** Schedule of management system;
- **e)** Progress control of HIS;

6) Coordination with GoPb

JICA Study Team requested various stakeholder public authorities/ agencies through Transport Department, GoPb for issue of Authority Letters, Public Notices, in their jurisdiction and Staff I.D. Cards to develop public confidence to avoid any misunderstanding between general public and survey staff.

Transport Department, and City District Government of Lahore, Sheikhupura and Kasur had issued authority letters and public notices; whereas for Lahore Cantonment area, Lahore Cantonment Board (LCB) issued Authority Letter for the conduct of HIS survey in the vicinity. However, Askari-X housing society refused to acknowledge LCB authority and demanded for GHQ permission for sample interview survey.

HIS survey teams have to carry the copies of all such Authority Letters and Public Notices with them as proof of the Study and their own I.D. Cards for identification.

7) Publicity Campaign for Surveys

There were many robbery cases reported, where persons entered the households in Lahore impersonating the surveyor of Pakistan Government's Income Support Program for verification of Household's eligibility for Income Support; as this program was advertised in Print and Electronic media.

In this regard, Survey Company recommended to JICA Study Team for avoiding advertising LUTMP Survey to circumvent any conflict or confusion with general public which might adversely affect the Surveys.

1.3.4 Conduct of HIS Field Surveys

1) Field Reconnaissance

Supervisors were specially trained in each group to do the field reconnaissance. They visited survey area one day in advance accompanied with detailed survey zones maps containing all landmarks, major/ minor roads, and to divide survey zone into equal parts for random household sampling.

Each team consisted of two persons preferably male/ female. But this paring depended upon the field reconnaissance of the area to be surveyed. In some areas like Walled City, outskirts or rural areas of Sheikhupura and Kasur, and Lahore only male pairs were sent to avoid discrimination and safety reasons.

2) Survey Teams Deployment

Supervisors discussed plans with their team group leaders for their survey teams to the field one day in advance of reconnaissance survey, and deployment of selected marked sub-areas.

3) Field Supervision

Supervisor to deploy teams and also check in field or vehicle or walk to check the forms completed by Surveyors. In case of suspicion of incomplete information, they have to go to specific Household for verification or completion of survey forms.

4) Field Accomplishment

At the end of field survey, each team group leader had to ensure the completion of the sample allocated to that team, ensure quality, and prepare short summary table of households samples completed. Supervisor to cross check the forms, transport to survey office and to submit to databank in-charge.

5) Field Dispatching

Supervisor and surveyors were instructed together at the drop – location of field, and once the survey is complete, they should immediately returned to same location. Supervisors then dispatch the teams from the field after successful completion of sampled households by each team.

6) Quality Check

Supervisors have to submit accomplished survey forms to Quality Assurance team for checking, in case of discrepancies and incomplete forms were rejected and referred to Tail Team for re-survey. Each surveyor was instructed to take mobile/ or home phone number of the interviewed household; because in case of any member missing information it could be later pursued by the Tail Team over the phone for recovery of data.

7) Tail Team

Tail Team to verify the missing information of the survey forms by dedicated Phone-Calls in the evening time; when most of the respondents were likely to be at home. In case of incompletion, tail team had to re-survey the rejected samples, to complete sample size for that zone.

1.3.5 Data Processing

Data from complete coded survey forms were entered in excel format by the following procedures:

(i) Editing:

Accomplished survey forms were checked again and corrected by editors, where possible.

(ii) Coding:

Coding was divided into two categories, basic coding for all fields and special coding for O/D Zones;

a) Basic Coding

Basic coding was done for the HIS form except, addresses;

b) Zone Coding

Selecting a zone code for different addresses itself was a very laborious task and depended on the understanding and familiarity of a person with the Study Area. Selected HIS Surveyors and Supervisors were recruited for this assignment. They were given special training provided with mapping and GIS System to assist with zone coding.

(iii) Encoding:

a) Software Development

Data Entry software was specifically developed for encoding of HIS data due to large volume. This was to minimize data entry discrepancies, and perform range and logic checks simultaneously. All possible logic checks were applied at this stage of

data processing which limited the entry of incorrect information into the database.

(iv) Data Check:

a) Printing and Manual Checking

Completed sample data of each survey zone was printed and 10 % was checked by different supervisors for verification against original survey forms.

b) Complete Data Check and Data Merging

Each Data File was checked by a specially developed program to check the integrity of complete data set of a sample zone. Completely checked data files were then merged using a specially developed program to form the HIS database without introducing further errors.

Volume-II – Chapter-2

TRANSPORT DEMAND FORECAST

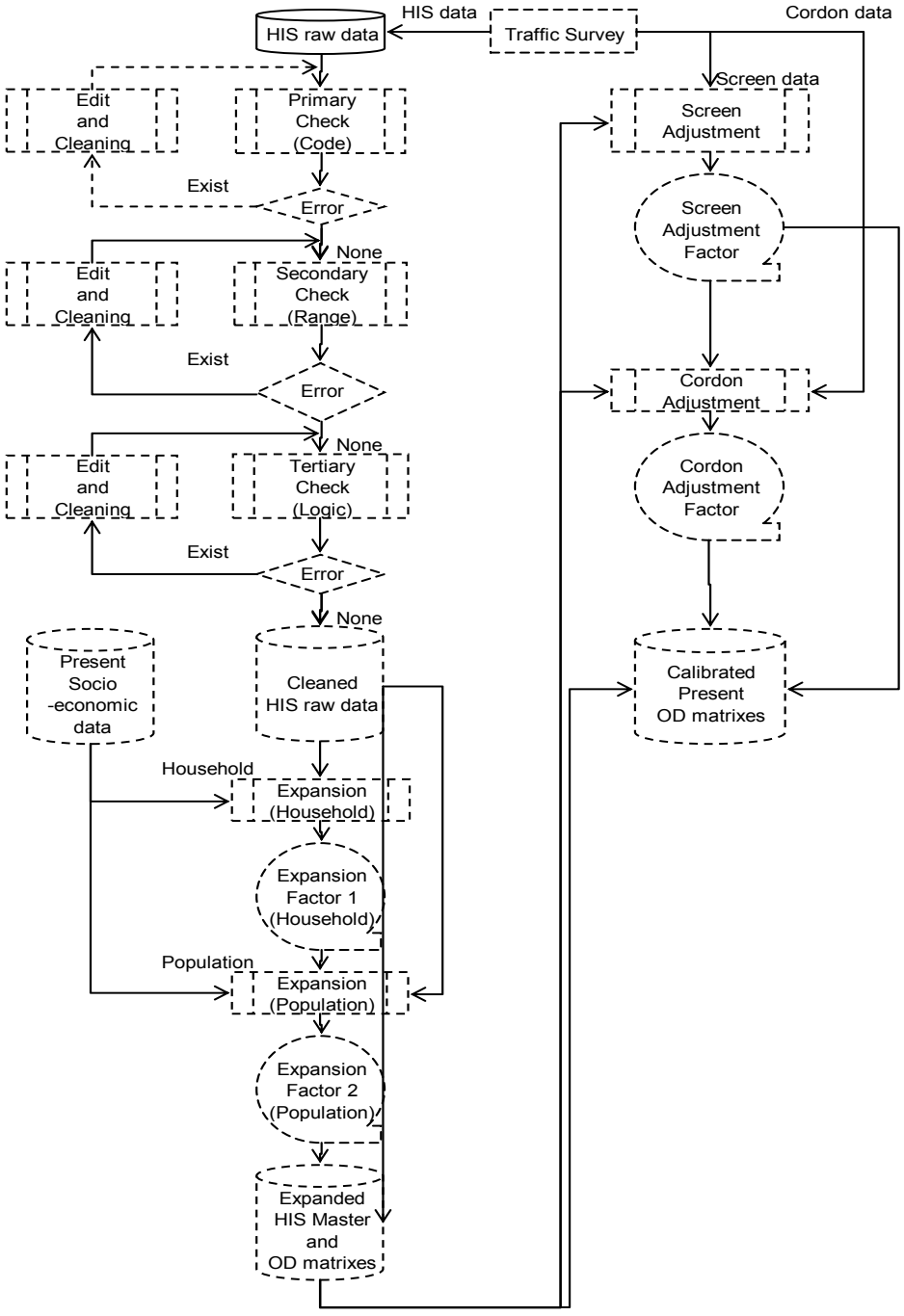
FINAL REPORT

2. TRANSPORT DEMAND FORECAST

2.1 Preparation of Present (2010) O/D Trip Matrices

The master file of HIS and present O/D (Origin/ Destination) trip matrices are prepared, and validated based on a series of transport/traffic surveys. The process is complex and iterative. The complete process and the use of various transport and traffic surveys at various stages of the trip matrices development is given in Figure 2.1.1.

Figure 2.1.1 Procedure of Creating Present OD Matrices



Source: JICA Study Team

2.2 Study Area Zone System

The basis of any transport model development for travel demand analysis and forecast is the division of the Study Area in to homogenous sub-areas, collectively called a Zone System. The travel patterns are then represented as travel within or between zones. The size of zones usually determines the level of detail and accuracy of demand analysis/ forecasts. However, it is constrained by the level of accuracy of planning data and network detail available for each zone. Therefore a compromise is reached on how many traffic zones the Study Area could be divided into, to be able to achieve the demand forecast accuracy for the desired level of detail for the Study. The Study Area was divided into 228 internal zones, boundaries of which were mostly based on the Union Councils in each Town, Tehsil and District. In addition special areas such as bus and freight termini, railway stations and airport were given special zone numbers (229-290). The rest of the world outside the Study Area is given external zones 291-320.The structure of LUTMP zone system has three main categories of zones; Internal Zones, Special Generator Zones and External Zones.

2.2.1 Internal Zones

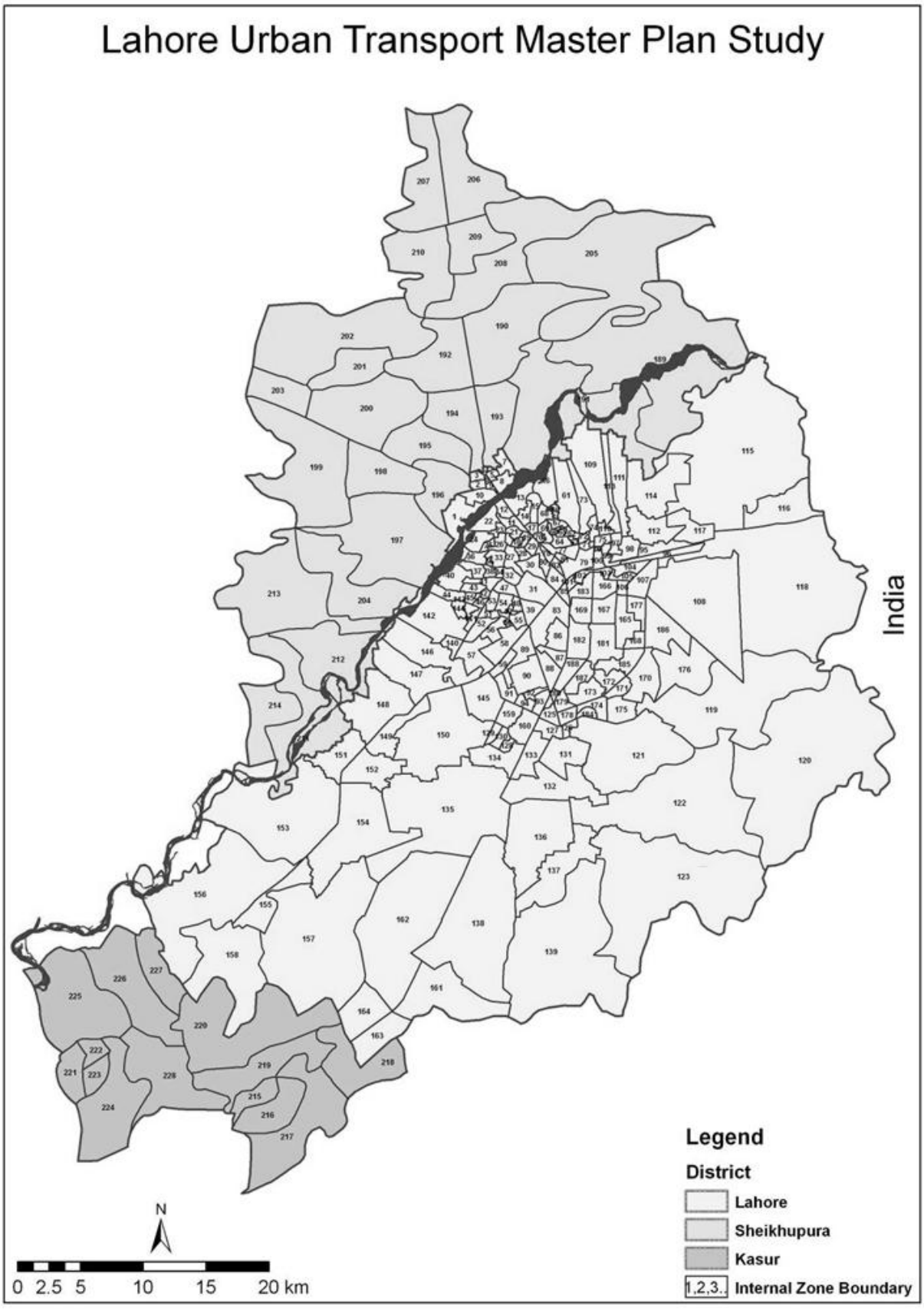
Zones inside the Study Area are termed as Internal Zones. Lahore district has a total of 188 zones. Parts of Sheikhupura and Kasur Districts areas included in the Study have 26, and 14 zones respectively. Internal Zones are shown in Figure 2.2.1. Summary of internal zones is given in Table 2.2.1 and complete description of zone system is presented in **Annex-I**, **Volume-II**.

Table 2.2.1 The Study Area - Internal Zones

No	District	Tehsil	Town	No of Zones
1	Lahore (188)	Lahore City (164)	Ravi	21
2			Data Gunj Baksh	18
3			Samanabad	20
4			Shalamar	17
5			Gulberg	18
6			Aziz Bhatti	14
7			Wagah	12
8			Nishtar	19
9			Iqbal	25
10		Cantonment	Cantonment	24
11	Sheikhupura (26)	Ferozewala	Ferozewala	16
12		Muridke	Muridke	6
13		Sharaqpur Sharif	Sharaqpur Sharif	4
14	Kasur (14)	Kasur	Kasur	6
15		Pattoki	Pattoki	8
1-15	**The Study Area**	**All**	**All**	**228**

Source: JICA Study Team

Figure 2.2.1 The Study Area Internal Zone System



Source: JICA Study Team

2.2.2 Special Generator Zones

Zones which have facilities for mode change are termed as Special Generator Zones like bus termini, airport, railway stations, and truck terminals. The Study Area has 62 Special Generator zones, as summarized below by the type of activity:

a) 1 Airport – Domestic Pax

b) 10 Intercity and Intra-city Bus Termini;

c) 25 Railway Stations

d) 10 Freight Terminals

e) 16 Other current and proposed future facilities.

2.2.3 External Zones

Zones outside the Study Area are termed as External Zones. External zones are defined to capture people's travel to and from the Study Area. Areas adjacent to the Study Area are aggregated into expanding level of detail according to the distance from the Study Area, zone size of areas nearby are kept small, while areas father away are aggregated. There are 30 external zones, including one representing international travel by air. A complete list is given in Annex-I, Volume-II.

2.3 Transport Demand Models

2.3.1 Introduction

LUTMP master plan study required a strategic travel demand model capable of forecasting implications of changes in future socio-economic framework, and to determine an optimal/ near optimal transport network which best serves the city's travel demand. A well used and internationally acceptable approach of using conventional 4-stage model was adopted. CUBE software package is a well known, state-of-the-art and internationally acclaimed was used to calibrate, develop and apply the demand forecast models. The remaining parts of this section document the components of the LUTMP travel demand model and broad forecast results.

2.3.2 Trip Production/ Generations Models

Household by Vehicle Ownership Category

This step of the four stage model aims to estimate the total travel demand (by all modes) by the Study Area zone, by household category and trip purpose. For this estimation trip rates are estimated from HIS for each category of household by trip purpose. For this purpose household were divided into three main categories: No-vehicle or Bicycle,

Motorcycle and car owning household. Household having multiple motorcycles are included in the motorcycle category, and those owing mixture of motorcycle(s) and car(s) are included in the car category. As there were insufficient number of households with just bicycles, and their income levels and other characteristics were analyzed, and found to be similar to the households owning no-vehicles these were therefore included in the No-vehicle owning category of household.

Trip Purpose Category

A number of trip purposes were observed and analysed and later aggregated to a level of detail which could be statistically significant to calibrate the models. For the final demand analysis only four trip purposes were adopted: to-work, to-school, to-home and all the remainder in 'Other' category

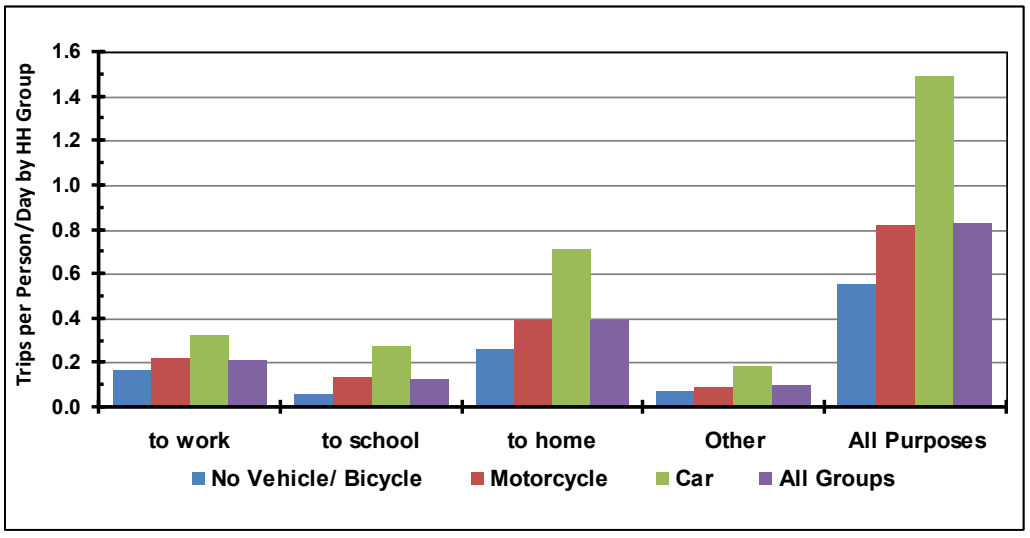
Trip production rates generally increase with vehicle ownership category, and differ by trip purpose. The estimated trip rates by household vehicle ownership category and trip purpose are give in Table 2.3.1 and compared in Figure 2.3.1.

Table 2.3.1 Person Trip Rates by Household Vehicle Ownership Group and by Trip Purpose, 2010

Household Vehicle Ownership Group	Trip Purpose				
	To-Work	**To-School**	**To-Home**	**Other**	**All Purposes**
No Vehicle/ Bicycle	0.163	0.058	0.259	0.071	0.552
Motorcycle	0.219	0.129	0.390	0.085	0.823
Car	0.323	0.273	0.714	0.182	1.492
All Groups	0.214	0.124	0.391	0.095	0.824

Source: JICA Study Team

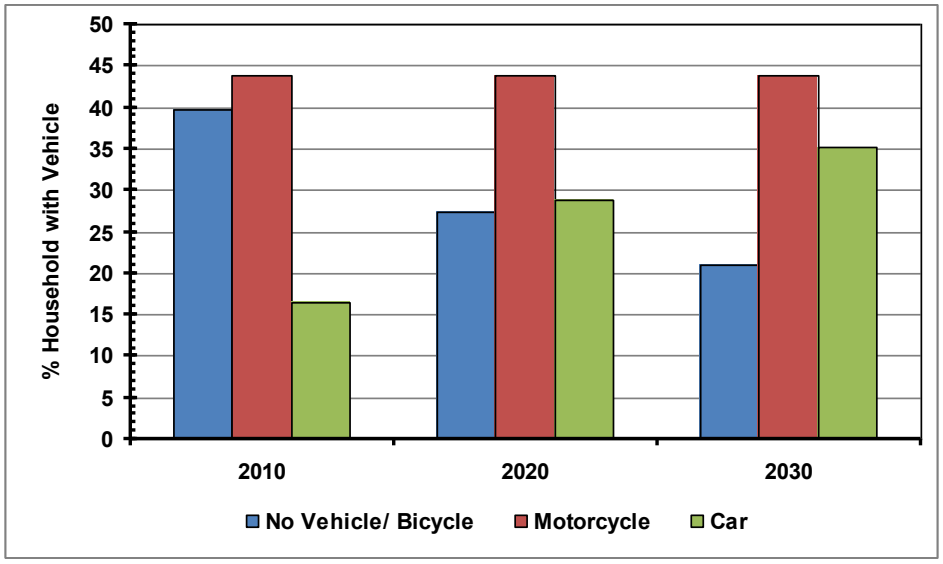
Figure 2.3.1 Person Trip Rates by Household Vehicle Ownership Group, and by Trip Purpose, 2010



Source: JICA Study Team

In future the car ownership is forecast to grow from 18 % in 2010 to 29 % and 43 % by 2020 and 2030, respectively. This is detailed in Socio-economic framework chapter. Share of motorcycle ownership is forecast to remain at almost similar levels as at present. Judging from the current correlation between household income and motorcycle ownership it can be seen that as the household incomes goes above certain threshold, then the households move from motorcycle ownership to car ownership. Therefore the forecast, that the proportion of motorcycle owning households in the Study Area would be similar to that in 2010. These trends are illustrated in Figure 2.3.2.

Figure 2.3.2 Forecast Changes in Household Vehicle Ownership



Note; The Values for 2020 and 2030 represent development Scenarios-2 and are similar to those for Scenarios 1 and 3, as at the Study Area level the population and income growth is same between all three scenarios.
Source: JICA Study Team

The zonal trip productions/ generations are estimated using separate equations for each household group and trip purpose using statistically significant independent variables, and then are controlled to zonal level control using aggregate zonal equations. The individual and zonal control total equations are calibrated using 2010 trips and using only statistically significant independent variables. These trip production equations are given Table 2.3.2. There is one equation for each the 12 household vehicle ownership category and trip purpose.

The observed and modelled numbers of trips by each household vehicle ownership group and by trip purpose are compared in Table 2.3.3. The table reflects the errors in modelling, in most cases it is under 5%. In the forecast process the ratios of modelled to observed was carried forward as calibration factors in order to minimise error of over estimation of trips by each household group for each trip purpose. These trip control totals represent trips made by the Study Area residents within the Study Area. Trips made between the Study Area and the outside world is estimated separately and are not included here, and detailed elsewhere, under External Trip Models.

Table 2.3.2 Calibrated Trip Production/ Generation Models

Purpose	Regression	Ownership	Variable	Coeffcient	t-value	R^2
Home to Work	by Each Group	CAR	Night Time Car Owning Workers	1.1138	28.7	0.78
		Motorcycle	Night Time M/Cycle Owning Workers	0.8141	38.6	0.87
		None/ Bicycle	Night Time No-Veh Owning Workers	0.5823	22.0	0.68
	Zonal Aggregate	CAR	Night Time Car Owning Workers	1.0287	7.5	0.84
		Motorcycle	Night Time M/Cycle Owning Workers	0.9964	9.0	
		None/ Bicycle	Night Time No-Veh Owning Workers	0.4253	3.9	
Home to School	by Each Group	CAR	Night Time Car Owning Students	2.3450	31.6	0.81
		M/Cycle	Night Time M/Cycle Owning Students	1.3843	33.6	0.83
		None/ Bicycle	Night TimeNo-Veh Owning Students	0.6710	13.7	0.45
	Zonal Aggregate	CAR	Night Time Car Owning Students	2.2686	12.2	0.84
		Motorcycle	Night Time M/Cycle Owning Students	1.2310	6.2	
		None/ Bicycle	Night Time No-Veh Owning Students	1.0586	4.4	
Return to Home	by Each Group	CAR	Students Day Time - Total	0.6081	10.7	0.78
			Employment Day Time - Total	0.3372	13.0	
		Motorcycle	Students Day Time - Total	0.4898	11.4	0.92
			Employment Day Time - Total	0.5639	28.8	
		None/ Bicycle	Students Day Time - Total	0.0651	1.9	0.82
			Employment Day Time - Total	0.3624	23.2	
	Zonal Aggregate	ALL	Students Day Time - Total	1.1629	11.9	0.92
			Employment Day Time - Total	1.2635	28.4	
Other	by each Group	CAR	Night Time Car Owning Population	0.1629	17.0	0.56
		Motorcycle	Night Time M/Cycle Owning Population	0.0818	29.7	0.80
		None/ Bicycle	Night Time No-Veh Owning Population	0.0616	12.0	0.39
	Zonal Aggregate	CAR	Night Time Car Owning Population	0.1946	7.5	0.67
		Motorcycle	Night Time M/Cycle Owning Population	0.0784	3.7	
		None/ Bicycle	Night Time No-Veh Owning Population	0.0621	3.1	

Source: JICA Study Team

Table 2.3.3 2010 Observed and Modelled Trips by Household Group and by Trip Purpose

Purpose	Ownership	Observed	Modelled	M/O
Home to Work	CAR	525,900	493,200	0.94
	Motorcycle	951,600	979,800	1.03
	None/ Bicycle	646,200	613,900	0.95
	Total	2,123,700	2,086,900	0.98
Home to School	CAR	444,600	407,700	0.92
	M/Cycle	558,000	555,500	1.00
	None/ Bicycle	230,800	218,200	0.95
	Total	1,233,400	1,181,400	0.96
Return to Home	CAR	1,162,800	1,432,400	1.23
	M/Cycle	1,694,800	1,944,600	1.15
	None/ Bicycle	1,024,500	1,036,200	1.01
	Total	3,882,100	4,413,200	1.14
Other	CAR	296,400	285,800	0.96
	Motorcycle	368,100	366,800	1.00
	None/ Bicycle	281,700	250,200	0.89
	Total	946,200	902,800	0.95
All Purposes	CAR	2,429,700	2,619,100	1.08
	Motorcycle	3,572,500	3,846,700	1.08
	None/ Bicycle	2,183,200	2,118,500	0.97
	Total	8,185,400	8,584,300	1.05

Source: JICA Study Team

2.3.3 Trip Attractions

Zonal trip attraction models are even more complex to calibrate. In case of Lahore no land use data in the form of employment by category (primary, secondary and tertiary or by Industrial classification), school places data or other similar variables, like industrial / shopping floor space is available. Therefore, day/ night population from HIS as a proxy for above variables was estimated to derive trip attraction rates. These rates were used to estimate to get trip attractions by zone and then these totals are controlled to Trip productions estimated above. The trip attraction models are summarised below in Table 2.3.4.

Table 2.3.4 Trip Attraction Model Calibration

Purpose	Regression	Ownership	Variable	Coeffcient	t-value	R^2
Home to Work	for each Group	CAR	Employment Day	0.27390	24.7	0.73
		Motorcycle	Employment Day	0.44561	41.7	0.88
		None/ Bicycle	Employment Day	0.24567	32.9	0.83
	Aggregate	All	Employment Day	0.96519	45.1	0.90
Home to School	for each Group	CAR	Student Day	0.54393	28.6	0.78
		Motorcycle	Student Day	0.54555	40.7	0.88
		None/ Bicycle	Student Day	0.18142	16.8	0.56
	Aggregate	ALL	Student Day	1.27090	43.5	0.89
Return to Home	for each Group	CAR	Population Night	0.11035	13.4	0.44
		Motorcycle	Population Night	0.17237	30.0	0.80
		None/ Bicycle	Population Night	0.09996	14.8	0.49
	Aggregate	ALL	Population Night	0.38269	30.6	0.80
Other	for each Group	CAR	Employment Day	0.12026	21.5	0.67
		Motorcycle	Employment Day	0.13744	34.3	0.84
		None/ Bicycle	Employment Day	0.08711	11.7	0.38
	Aggregate	ALL	Employment Day	0.34481	28.6	0.78

Source: JICA Study Team

As the zonal trips are controlled to trip production, the lower accuracy of trip attraction models does not affect the over demand levels.

2.3.4 Trip Distribution Models

Twelve doubly constrained Gravity Models were calibrated, one for each of the three household vehicle ownership groups, and by for four trip purposes. The general form of the model may be described as:

Tij= ai * bj * **α** * EXP (**-β***(Cij)*); where:

Tij = trips between Zone i and Zone j;
Cij= Generalised cost of travel between Zone i and Zone j;
α & β is the calibrated parameter; Separate **β** values were calibrated for Inter-zonal trips i.e. Tij for i#j and for Intra-zonal trips i.e. for all i=j.

ai & bj are the balancing factors estimated through iterative process, with the following constraints:

i) ΣTij = Gi (sum overall j; and ii) ΣTij = Aj (sum over all i); and Gi and Aj are production and attractions estimated at trip production and attraction stage of the models.

Table 2.3.5 details the model calibration parameters and simplified comparisons of observed and modeled values.

Table 2.3.5 Gravity Model Calibrated Parameters by Household Group and by Trip Purpose

Trip Purpose	Household Vehicle Ownership Group	Intra-zonal Trips I=j		Inter-zonal Trips (i#j)	Av. Trip Length (km)	
		α	β	β	Observed	Modelled
To Work	No Vehicle + Bicycle	5.6	0.026	0.015	14.3	14.3
	Motorcycle	5.2	0.035	0.006	10.5	10.3
	Car	7.8	0.0060	0.004	14.4	14.2
To School	No Vehicle + Bicycle	3.3	0.052	0.003	9.9	9.9
	Motorcycle	4.2	0.058	0.003	7.6	7.5
	Car	6.4	0.0192	0.012	10.2	10.2
To Home	No Vehicle + Bicycle	7.6	0.032	0.022	14.1	14.2
	Motorcycle	5.8	0.040	0.007	9.5	9.2
	Car	9.5	0.0080	0.007	13.3	13.0
Other	No Vehicle + Bicycle	5.5	0.026	0.030	17.4	17.1
	Motorcycle	6.0	0.035	0.006	10.3	9.8
	Car	9.0	0.0055	0.007	15.4	15.1

Source: JICA Study Team

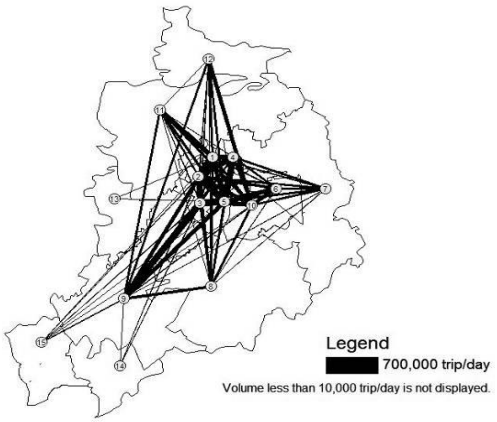
Table 2.3.6 Forecast Average Trip Length by Trip Purpose

Trip Purpose	Trip Length (km)(2010 Network)						
	2010	2020 Scenario 1	2030 Scenario 1	2020 Scenario 2	2030 Scenario 2	2020 Scenario 3	2030 Scenario 3
To Work	11.8	12.8	13.5	13.0	13.9	14.6	14.5
To School	8.4	9.1	8.3	10.0	8.6	9.3	7.6
To Home	10.6	11.4	11.8	11.8	12.1	12.9	12.8
Other	13.5	13.9	13.8	13.9	14.2	15.0	15.7

Source: JICA Study Team

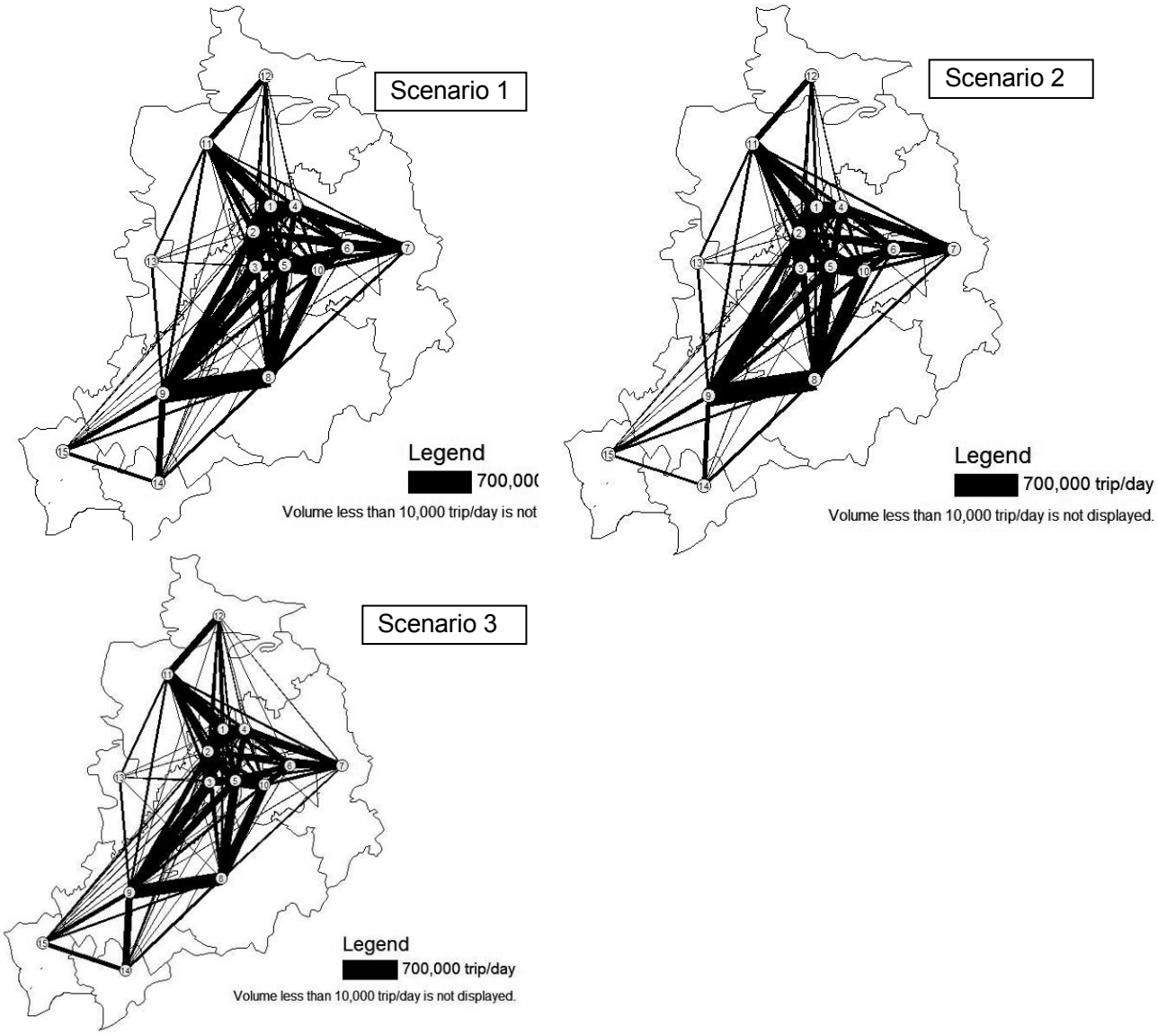
Figures 2.3.3, 2.3.4 and 2.3.5 show estimated trip distribution patterns for total trips for 2010, 2020 and 2030 for all three scenarios. Although the pattern of trip distribution seems similar among urban development scenarios, the details show considerable changes, e.g. by trip purpose and by traffic zone pair.

Figure 2.3.3 Trip Distribution, All Purpose, 2010



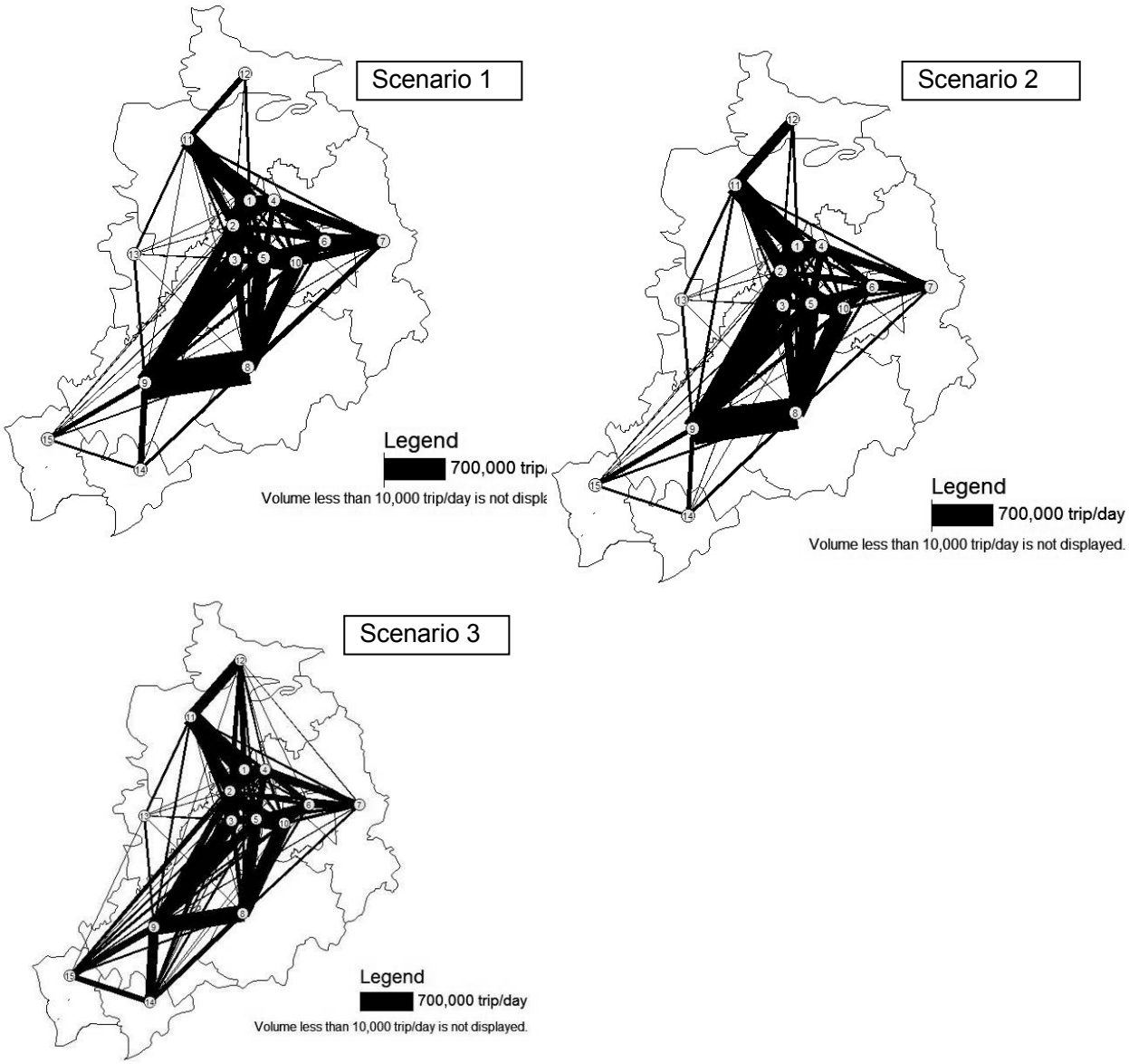
Source: JICA Study Team

Figure 2.3.4 Trip Distribution, All Purpose, 2020



Source: JICA Study Team

Figure 2.3.5 Trip Distribution, All Purpose, 2030



Source: JICA Study Team

2.3.5 Modal Split Models

Modal split models were developed and calibrated for each of the three household vehicle ownership groups, i.e. No vehicle/ bicycle, motorcycle and car ownership for all trip purposes combined and for Inter-zonal trips only. It should be noted that at this stage of the modelling all intra-zonal trips are removed and only Inter-zonal trips are subjected to mode-choice models. Walk trips have been extracted at the outset. These are dealt with in separate walk model and are no longer part of the general modal split models.

1) Modal Split Models for Trips by Households with No Vehicle/ Bicycle

Regression models were developed for this group to extract trips by (travel mode) Bicycle, Motorcycle, and Car. These trips were then subtracted from the total trips, and remainder trips are deemed to use public transport (i.e. Bus or paratransit modes like Rickshaws/ Qingqi). Model developed, calibrated and used were based on distance travelled between zone i and j. (i.e. Dij)

a) % Share of Bicycle Trips = 0.23 – 0.0559 Ln(Dij) (R^2=0.70)
b) % Share of Motorcycle Trips = 0.127 – 0.0287 Ln(Dij) (R^2=0.60)
c) % Share of Car Trips = 0.144 – 0.0372 Ln(Dij) (R^2=0.40)
d) Bus Share is the remainder of the trips in the trip matrix after extraction of above three modes. Split between bus and paratransit is carried out in the trip assignment model.

All three models (a, b and c) may not appear statistically very strong, but in all cases the sign of the constants and coefficients are sensible, and do show that as the distance increases the % trips decreases by that mode. Table 2.3.7 below presents the calibration results and trips for 2020 and 2030 Scenario 2.

Table 2.3.7 Non-Vehicle/ Bicycle Owning Household Modal Split Model Calibration Results

Trip Type	No-vehicle/ Bicycle Owning Household Trips by Mode of Travel				
	Bicycle	Motorcycle	Car	Bus and Para	Total
Observed (Inter+Intra) Zonal	279,000	129,200	49,200	1,725,800	2,183,200
Observed Intra-zonal	114,000	32,500	6,600	249,100	402,200
Observed Inter-zonal	**165,000**	**96,700**	**42,600**	**1,476,700**	**1,781,000**
Observed % by Mode Share	***9.3***	***5.4***	***2.4***	***82.9***	***100.***
Modelled Inter-Zonal	**177,100**	**107,800**	**31,400**	**1,465,300**	**1,781,600**
Modelled % by Mode Share	***9.9***	***6.0***	***1.8***	***82.3***	***100.***
Trips (Modelled– Observed)	**+13,100**	**+11,100**	**-11,200**	**-7,400**	**0.**
% Difference	+7.9	+11,.4	-26.3	-0.5	0.

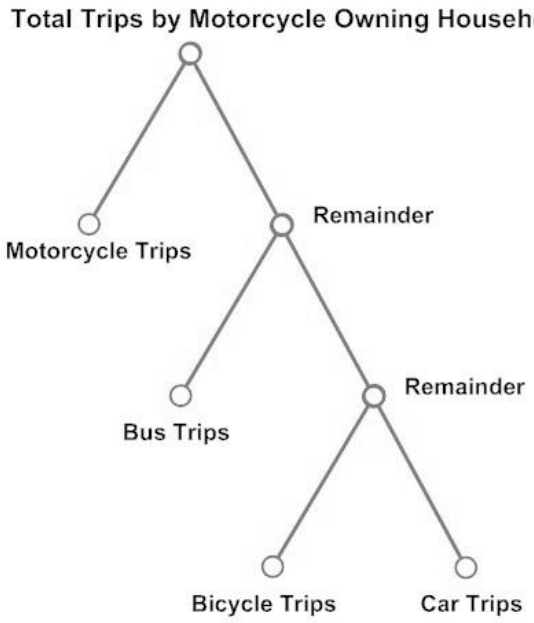
Source: JICA Study Team

It can be seen that model performs well for the Bus/ Para share, which is by far the largest share. Hence the model was considered to be suitable for use in the forecast years. In case of modes other than bus are relatively very small, and as compared with the observed (rather 'lumpy') matrices, it would be very difficult to get better calibration results.

2) Modal Split Models for Trips for Motorcycle Owning Households

In the case of Motorcycle owing households the situation is more complex, and the cost of travel by alternative mode affects the mode choice. Therefore, a hierarchical logit mode choice model was developed. Note that the mode choice at each stage is based on the relative generalised cost differences between the selected mode and the difference of the next mode of choice in the hierarchy. The general form of the logit model is schematically shown in Figure 2.3.7.

Figure 2.3.6 Structure of Hierarchical Logit Model (Motorcycle Owning Households)



Source: JICA Study Team

The calibrated parameters are tabulated below, and in all cases the 't' statistics for both parameters were statistically significant.

Motorcycle Owning Household Hierarchical Logit Mode Choice Models

Mode Choice Extracted	Remainder	Constant	Coefficient
Motorcycle Trips	Bus+Bicycle+Car	-0.4437	0.6546
Bus Trips	Bicycle+Car	-1.3383	0.4985
Bicycle Trips	Car as remainder	-0.6639	-0.8158

Table 2.3.8 Motorcycle Owning Household Modal Split Model Calibration Results

Trip Type	Motorcycle Owning Household Trips by Mode of Travel				
	Bicycle	Motorcycle	Car	Bus and Para	Total
Observed (Inter+Intra) Zonal	172,600	2,190,000	93,400	1,116,400	3,572,400
Observed Intra-zonal	74,800	473,300	15,100	174,500	737,700
Observed Inter-zonal	**97,800**	**1,716,700**	**78,300**	**941,900**	**2,834,700**
Observed % by Mode Share	***3.5***	***60.5***	***2.7***	***33.3***	***100.***
Modelled Inter-Zonal	**96,100**	**1,716,900**	**75,100**	**946,600**	**2,834,700**
Modelled % by Mode Share	***3.4***	***60.6***	***2.6***	***33.4***	***100.***
Trips (Modelled – Observed)	**-1,100**	**+200**	**-3,200**	**+4,100**	**0.**
% Difference	-1.1%	0.0%	-4.1%	4.4%	0.

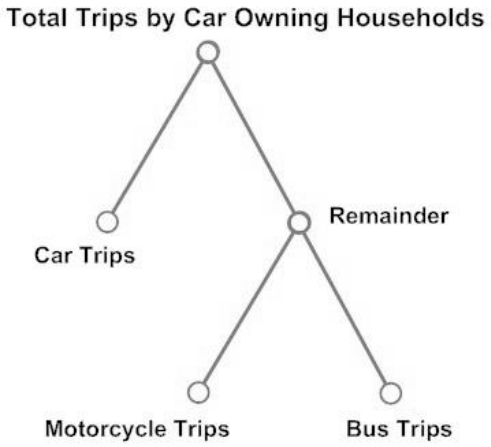
Source: JICA Study Team

Table 2.3.8 demonstrates that the synthesised models perform well and reproduces the observed models almost exactly. In cases, where there is larger % difference, the absolute number of trips is small.

3) Modal Split Models for Car Owning Household Trips

Car owing households generally tend to travel by car and make maximum use of their investment in vehicle. The usage of car is also higher as occupancy can be higher than motorcycle. Therefore the number of trips made by modes other than car, by car owning households tends to be small. Here it should be noted that if a household owns one or more cars, or one or more motorcycles as well, such household is treated as a car owning household. The trips made by motorcycle may be using the motorcycle the household owns. Therefore, same as for motorcycle owing households a hierarchical logit mode choice model was developed. However, in this case the choice of Bicycle was so small that it was considered as not a realist choice of mode by the Car Owning household, with the exception of few leisure trips on Sunday afternoon! Note that the mode choice at each stage is based on the relative generalised cost differences between the selected mode and the next choice of mode of the remaining modes in the hierarchy. The general form of the logit model is schematically shown in Figure 2.3.8.

Figure 2.3.7 Structure of Hierarchical Logit Model (Car Owning Households)



Source: JICA Study Team

The calibrated parameters are tabulated below, and in all cases the 't' statistics for both parameters were statistically significant. Modal calibration results are summarized in Table 2.3.9.

Car Owning Household Hierarchical Logit Mode Choice Models

Mode Choice Extracted	Remainder	Constant	Coefficient
Car Trips	Motorcycle + Bus	0.0973	-0.3157
Motorcycle Trips	Bus as remainder	-0.0200	1.0365

Table 2.3.9 Car Owning Household Modal Split Model Calibration Results

Trip Type	Car Owning Household Trips by Mode of Travel				
	Bicycle	Motorcycle	Car	Bus and Para	Total
Observed (Inter+Intra) Zonal	31,500	538,100	1,397,900	462,100	2,429,600
Observed Intra-zonal	15,200	99,900	140,300	71,700	327,100
Observed Inter-zonal	**16,300**	**438,200**	**1,257,600**	**390,400**	**2,102,500**
Observed % by Mode Share	***0.8***	***20.8***	***59.8***	***18.6***	***100.***
Modelled Inter-Zonal	**Add to bus**	**438,300**	**1,257,600**	**406,600**	**2,102,500**
Modelled % by Mode Share	***n/a***	***20.8***	***59.8***	***19.3***	***99.9.***
Trips (Modelled – Observed)	**n/a**	**+100**	**0**	**+16,200**	**0.**
% Difference	n/a	0.0%	0.0%	4.1%	0.

Source: JICA Study Team

It can be seen that model fits well and reproduces the observed models almost exactly. In cases, where there is somewhat larger % difference, the absolute number of trips is small.

The result of model application is shown in Tables2.3.10, 2.3.11 and 2.3.12 for 2010, 2020 and 2030, respectively.

Table 2.3.10 Modelled Number of Trips by Mode ('000) and Mode Share, 2010

Mode of Travel	Inter-Zonal Trips by Household Vehicle Ownership Group				
	No Vehicle / Bicycle	M/cycle	Car	Total Trips	Mode Share
Bicycle	177,100	96,100	0	273,200	4.1%
Motorcycle	107,800	1,716,900	438,300	2,263,000	33.7%
Car	31,400	75,100	1,257,600	1,364,100	20.3%
Bus and Para transit	1,465,300	946,000	406,600	2,817,900	41.9%
Total	**1781,600**	**2,2834,700**	**2,102,500**	**6,718,200**	**100.%**

Source: JICA Study Team

Table 2.3.11 Modelled Number of Trips by Mode ('000) and Mode Share, 2020

Mode of Travel	2010		Inter-zonal Trips by Development Scenario, 2020					
			Scenario-I		Scenario-II		Scenario-III	
	Total Trips	Mode Share	Total Trips	Mode Share	Total Trips	Mode Share	Total Trips	Mode Share
Bicycle	273,200	4.1 %	239,600	2.4 %	239,700	2.4 %	233,000	2.3 %
Motorcycle	2,263,000	33.7 %	3,133,000	31.9 %	3,126,500	31.6 %	3,147,500	31.1 %
Car	1,364,100	20.3 %	3,032,700	30.9 %	3,074,400	31.1 %	3,259,200	32.2 %
Bus and Paratransit	2,817,900	41.9 %	3,415,000	34.8 %	3,455,600	34.9 %	3,474,500	34.4 %
Total	**6,718,200**	**100. %**	**9,820,300**	**100. %**	**9,896,200**	**100. %**	**10,114,200**	**100. %**

Source: JICA Study Team

Table 2.3.12 Modelled Number of Trips by Mode ('000) and Mode Share, 2030

Mode of Travel	2010		Inter-Zonal Trips by Development Scenario, 2030					
			Scenario-I		Scenario-II		Scenario-III	
	Total Trips	Mode Share	Total Trips	Mode Share	Total Trips	Mode Share	Total Trips	Mode Share
Bicycle	273,200	4.1 %	188,600	1.3 %	184,200	1.3 %	192,600	1.4 %
Motorcycle	2,263,000	33.7 %	3,860,300	27.5 %	3,886,700	27.0 %	3,595,700	25.8 %
Car	1,364,100	20.3 %	6,162,700	43.9 %	6,478,800	45.0 %	6,583,600	47.2 %
Bus and Para transit	2,817,900	41.9 %	3,833,300	27.3 %	3,847,500	26.7 %	3,580,800	25.7 %
Total	**6,718,200**	**100. %**	**14,044,900**	**100. %**	**14,397,200**	**100. %**	**13,952,700**	**100. %**

Source: JICA Study Team

It can be seen that in do-nothing scenario the mode share of bicycle would decline by a percentage point on average under all scenarios to just over 1% by 2030. In other developed cities cycling is encouraged and mode share of cycle is on the increase particularly with increase in the provision of cycle lanes and priority to cyclists at crossroads.

As far motorized trips are concerned, in case of do nothing scenario, the trend shows a declining use of motorcycles and a considerable decline in the share of public transport in favour of car. During scenario development stage these facts will be addressed further.

2.3.6 Walk Trips

The above modelling covered the Study Area mechanized/ motorized mode trips. Walk trips were also observed, recorded, and analyzed. It was noticed that in outer areas there are some exceptionally long walk trips. It was considered that it is impossible for anyone to walk such distances on regular basis. Hence all inter-zonal trips above 10km were deemed to be made by the same mode vehicle as owned by that household owns. In case No-vehicle owning households these trips (105,000) were included in the public transport (Bus/ paratransit) mode, 60,400 trips by motorcycle, and 7,200 trips by Car.

Based on the changes in socio-economic framework from 2010 to 2020 and 2030 the walk trips transferred to motorized mode were forecast. Table 2.3.13 below summarizes the walk trips for 2010 and 2020 and 2030 in Table 2.3.14.

Table 2.3.13 2010 Observed Walk Trips

Description	2010			
HH Group	Total Trips	Intra-Zonal Trips	Inter-zonal Trips	Inter-zonal Trips>10km
No vehicle/ Bicycle	2,012,400	1,673,600	338,800	105,000
Motorcycle	1,528,100	1,250,900	277,200	60,400
Car	286,200	240,400	45,800	7,200
Total	**3,826,700**	**3,164,900**	**661,800**	**172,600**

Source: JICA Study Team

Table 2.3.14 2010 Inter-Zonal Observed Walk Trips and Forecasts for 2020, 2030

HH Group	Observed Walk Trips and Forecast for 2020 and 2030						
	2010	2020 Scenario 1	2030 Scenario 1	2020 Scenario 2	2030 Scenario 2	2020 Scenario 3	2030 Scenario 3
No Vehicle/ Bicycle	338,800	249,200	150,700	252,300	154,100	249,500	160,700
Motorcycle	277,200	295,500	304,700	298,100	304,700	300,000	308,000
Car	45,800	100,500	170,800	102,000	170,800	100,000	163,000
Total	**661,800**	**645,200**	**626,200**	**652,400**	**629,600**	**649,500**	**631,700**

Source: JICA Study Team

2.3.7 External Trips

The above modelling covered internal the Study Area trips – i.e. those trips with both ends in the Study Area zones (1~228). Trips with one or both end outside the Study were modelled using the observed trips (from the LUTMP cordon surveys) as seed. The forecast methodology differed from internal trips. The methodology adopted for the external trip distribution was:

For Internal-to-external and external-to-internal trips 'Fratar' technique was used to get the relative growth in trips in the internal to the Study Area. For external-external (through) trips straight growth factoring based on growth in the Study Area GDP and trip type elasticity was used. The resultant forecast trip totals are shown in Table 2.3.15.

Table 2.3.15 2010 Observed and 2020 and 2030 Forecast External Person Trips

Mode	2010	2020	Growth over 2010	2030	Growth over 2010
M/Cycle	37,100	45,100	21.6 %	45,300	22.1 %
Car	216,900	367,500	69.4 %	575,600	165.4 %
Bus	586,900	647,000	10.2 %	760,100	29.5 %
Total	**840,900**	**1,059,600**	**26.0 %**	**1,381,000**	**64.2 %**

Source: JICA Study Team

2.3.8 Goods Vehicle Trips

All non-passenger carrying vehicles were separately classified. After initial analysis these were aggregated to three groups:

i) Pick-up Trucks – these are open back 2-axle vehicles or closed back delivery trucks, used mostly for small goods delivery and distribution, ambulances, etc

ii) 2 Axle Trucks – this is the most common type of trucks used in Pakistan.

iii) All other Vehicles (these include large trucks, construction vehicles, Tractors, tractor trolleys, other agriculture vehicles, animal drawn carts etc)

It is known to the Study Team that trucks are not allowed on most city roads during the day. However, delivery pick-up vans/ trucks are used mostly during along with animal drawn

carts etc. These vehicles are included in the modeling process. Their forecast was dependent on changes in GDP. Demand elasticity was estimated and the forecast was made using the growth in GDP and the demand elasticity. The observed 2010 and forecast number of trips are summarized in Table 2.3.16 below.

Table 2.3.16 2010 Observed and 2020 and 2030 Forecast Goods Vehicle Trips

Vehicle Type	2010	2020	Growth over 2010	2030	Growth over 2010
Pickup	49,600	65,700	32.5 %	71,600	44.4 %
Trucks	44,100	83,400	89.1 %	149,400	238.8 %
Other	58,100	68,000	11.0 %	87,700	50.9 %
Total Vehicles	**152,800**	**217,100**	**42.1 %**	**308,700**	**102.0 %**

Source: JICA Study Team

2.4 Study Area Transport Network

2.4.1 Overall Traffic Assignment

Travel demand matrices from modal split mode, walk model, and external models are aggregated to common unit called Passenger Car Unit (PCU) for highway assignment. Public Trips are directly assigned as person trips to Public Transport network, which in addition to the same highway network as for private mode includes bus/ wagon routes with headways, and the Pakistan Rail network. PT network is assigned first, the person trip volumes on bus routes are converted to Bus PCU's and the remainder paratransit mode passengers are converted to Rickshaw/ Qingqi (paratransit PCU's) modes. These Public mode PCU's are then added to Highway assignment process as pre-loads as the bus routes are fixed, and paratransit loads wherever these are take up road capacity not available to private mode users.

The vehicle occupancy and PCU conversation factors used to convert all trips to PCU's are given below in Table 2.4.1.Vehicle occupancy factors are average of several traffic surveys carried out in the Study Area, whereas the PCU factors are universal, and commonly used. The same factors were also applied for the forecast year assignment models.

Table 2.4.1 Applied Observed and Forecast Goods Vehicle Trips

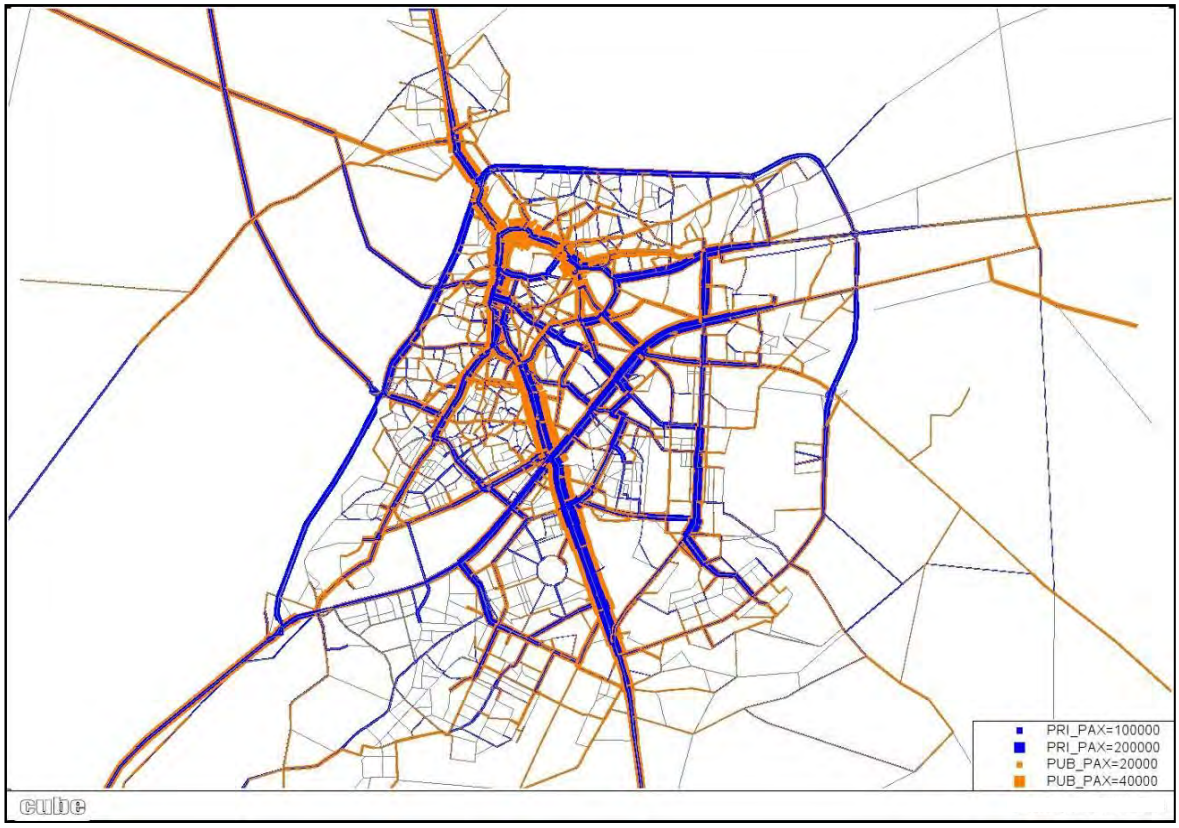
Vehicle	Occupancy	PCU Factor
Bicycle	1.0	0.20
Motorcycle	1.65	0.30
Rickshaw	1.7	0.50
Qingqi	5.0	0.50
Average for Rickshaw and Qingqi	3.28	0.50
Car	2.43	1.00
Wagon	10.5	1.50
Coaster	20.0	1.75
Mini-Bus (Mazda)	35.0	2.00
Bus	50.0	2.50
Articulated Bus (Future)	90.0	3.50
Average Bus	15.58	2.00
Pick-up	1.0	1.25
2 Axle Truck	1.0	2.0
3 Axle Truck	1.0	2.5
Tractor	1.0	3.5
Other Motorized	1.0	3.0
Animal Drawn	1.0	4.5

Source: JICA Study Team

The results are shown in Figures 2.4.1, 2.4.2 and 2.4.3. In these figures the thickness of the line represents the person trips along that section of the road, and colour indicates the mode of travel (Blue: Private – Includes Cycle, motorcycle and car, where as Orange shows public transport i.e. Rickshaw, Qingqi, Wagon Bus and Pakistan Rail). The person trip volumes are well spread out in the Study Area. Busy corridors are obvious, such as Ferozepur road, Canal Bank road, Western section of LRR, GT road, Allama Iqbal road, around the wall city area and the Ravi Bridge. Only limited person travel is notice able on the northern and particularly on eastern section of the LRR.

However the pictures changes rather rapidly by 2020 and more dramatically by 2030. The person trips assignment for these forecast years 2020 and 2030 for all three scenarios are presented in Figures 2.4.2 and 2.4.3 respectively. This exercise implies the necessity to take strong countermeasures to enhance the transport network capacity and its systems in Lahore. Further discussion on demand supply analysis is given in Volume 1, Chapter 4.

Figure 2.4.1 2010 Modelled Traffic Assignment – Private and Public Person Trips

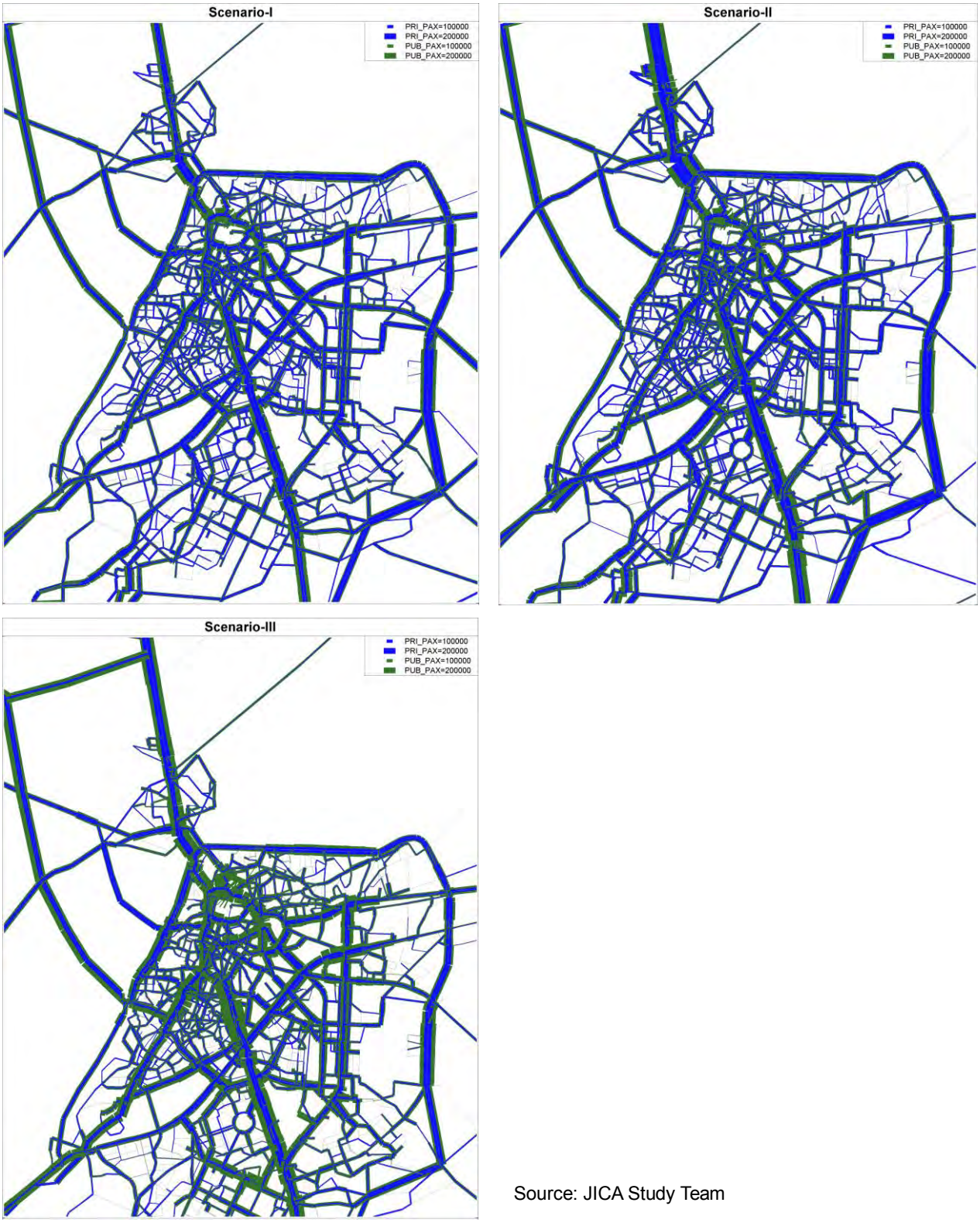


Source: JICA Study Team

Figure 2.4.2 2020 Modelled Traffic Assignment – Private and Public Person Trips

Source: JICA Study Team

Figure 2.4.3 2030 Modelled Traffic Assignment – Private and Public Person Trips



Source: JICA Study Team

2.4.2 Demand/ Supply Analysis

The forecast presented in this Chapter detailed the methodology adopted and affects of application of such models on the overall transport demand in 2020 and 2030 under the three development scenarios and same network condition. These forecasts did not take account of supply side development. This was intentional to understand the behaviour of the demand models.

Comparison of demand forecast in terms impact on highway and public transport supply have been discussed in Chapter-4 Volume-1 of this report.