MINISTRY OF PHYSICAL INFRASTRUCTURE AND TRANSPORT
FEDERAL DEMOCRATIC REPUBLIC OF NEPAL

FEDERAL DEMOCRATIC REPUBLIC OF NEPAL

DATA COLLECTION SURVEY ON URBAN TRANSPORT IN KATHMANDU VALLEY

FINAL REPORT

JULY 2019

JAPAN INTERNATIONAL COOPERATION AGENCY

ORIENTAL CONSULTANTS GLOBAL CO., LTD.
PADECO CO., LTD.

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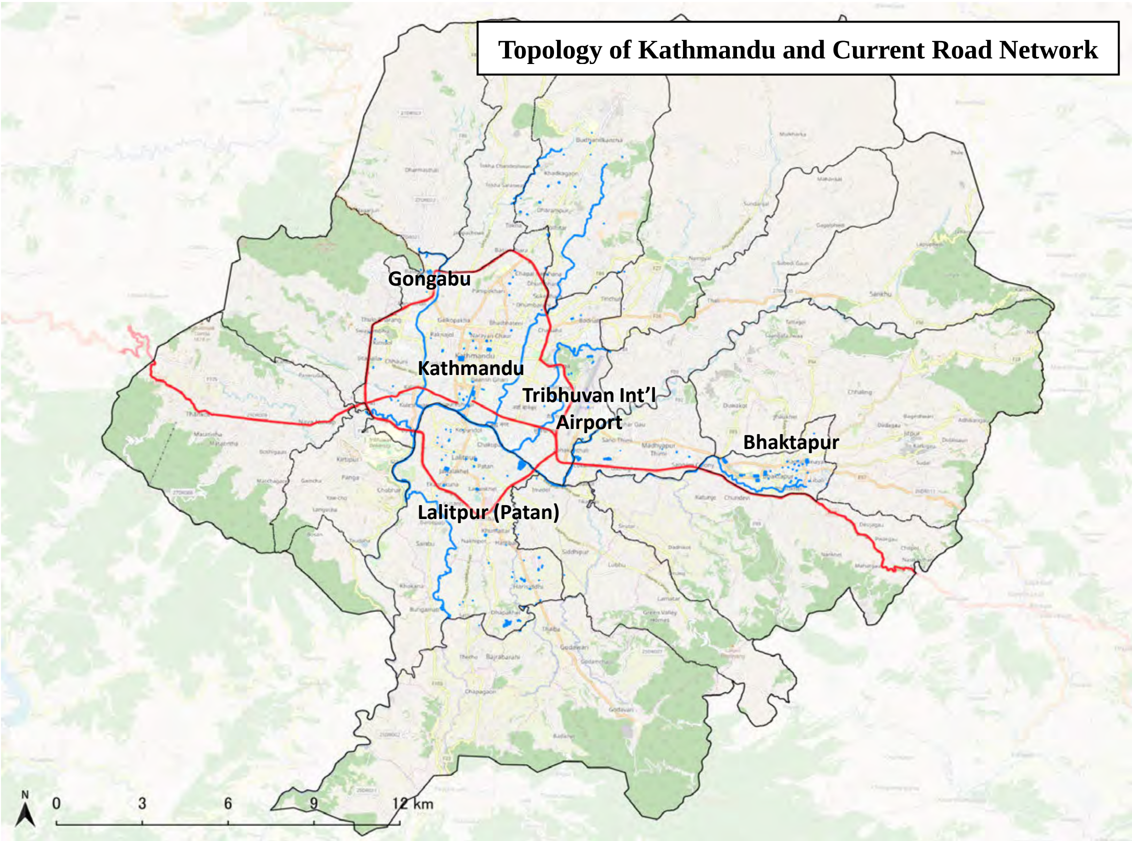
Project Area: Kathmandu Valley



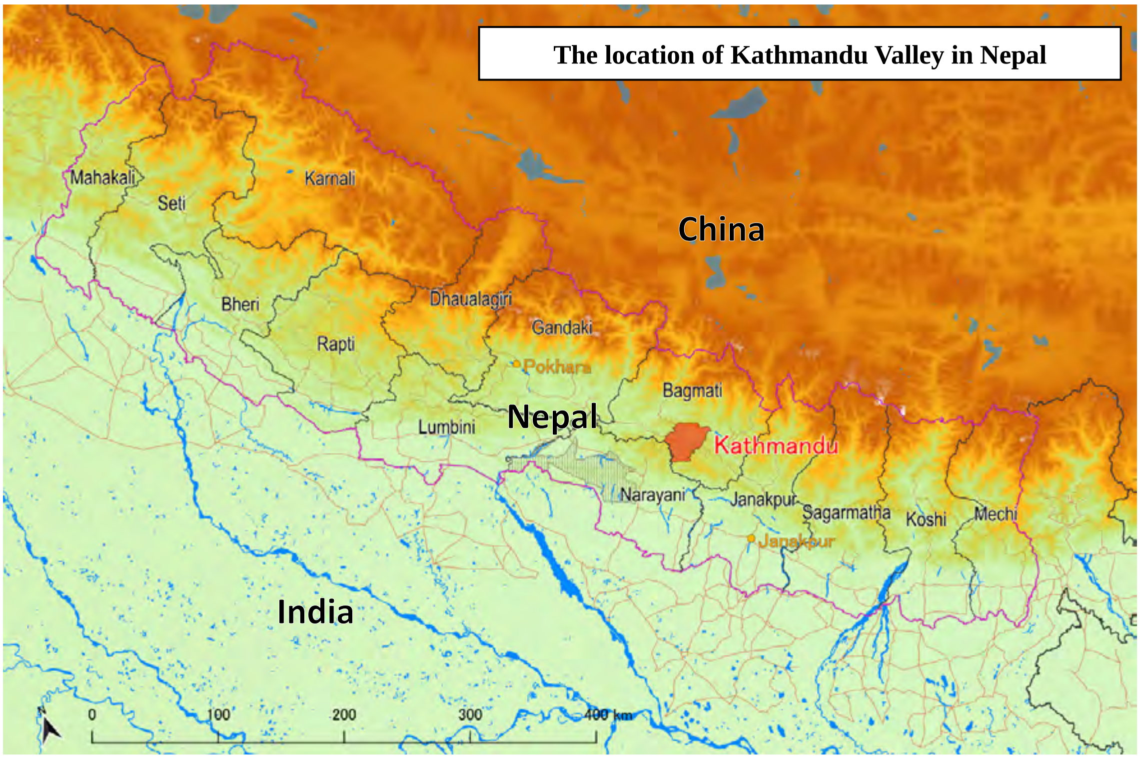


TABLE OF CONTENTS

Appendices

LIST OF FIGURES

LIST OF TABLES

Page

LIST OF ABBREVIATIONS

Abbreviation	Name
A/G	At Grade
AC	Alternating Current
ACEM	Advanced College of Engineering and Management
ADB	Asian Development Bank
ADT	Average Daily Traffic
AGT	Automated Guideway Transit
Alt	Alternative
AP	Airport
B.P	Beginning Point
B-B	Private Business to Private Business
BOOT	Build Own Operate and Transfer
BP	Bypass
BRT	Bus Rapid Transit
C/P	Counterpart
CAAN	Civil Aviation Authority of Nepal
CAD	Computer-Aided Design
CBD	Central Business District
CDC	Compensation Determination Committee
CO_2	Carbon Dioxide
CPI	Consumer Price Index
D	Diameter
DBST	Double Bituminous Surface Treatment
DC	Direct Current
DD	Detail Design
DDC	District Development Committee
DFR	Draft Final Report
DG	Director General
DOLIDAR	Department of Local Infrastructure Development and Agricultural Roads
DOLRM	Department of Land Reform and Management
DOR	Department of Roads
DORW	Department of Railways
DOTM	Department of Transport Management
DPR	Detailed Project Report
DUDBC	Department of Urban Development and Building Construction

Abbreviation	Name
DWSS	Department of Water Supply and Sewerage
E	East
E&M	Electrical and Mechanical
e.g.	exempli gratia
EB	East Bound
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EL	Elevation
EOI	Expression of Interest
etc.	et cetera
EV	Electric Vehicle
E-W	East-West
F.R.M.O	Federal Road Monitoring Organization
FCAN	Federation of Contractors' Associations of Nepal
FNNTE	Federation of Nepalese National Transport Entrepreneurs
FR	Final Report
FS	Feasibility Study
ft	feet
FUG	Forest User Groups
FY	Fiscal Year
G/S	Grade Separation
GDP	Gross Domestic Product
GEF	Global Environment Facility
GESU	Geo-Environment and Social Unit
GFS	Government Finance Statistics
GGGI	Global Green Growth Institute
GHG	Greenhouse Gas
GL	Ground Level
GPS	Global Positioning System
GTFS	General Transit Feed Specification
h	hour
HCM	Highway Capacity Manual
HCMC	Ho Chi Minh City
HEP	High Speed Element Pull
HP	Home Page
HQ	Head Quarters

Abbreviation	Name
HR	Human Resources
Hwy	Highway
i.e.	id est
I/S	Intersection
IBN	Investment Board Nepal
IC	Integrated Circuit
ICAO	International Civil Aviation Organization
ICR	Inception Report
ICT	Information and Communication Technology
ID	Identity Document
IEE	Initial Environmental Examination
IMF	International Monetary Fund
IOE	Institute of Engineering
IOT	Internet of Things
IRR	Internal Rate of Return
IT	Information Technology
ITS	Intelligent Transport Systems
JBIC	Japan Bank for International Cooperation
JES	Jointed Element Structure
JICA	Japan International Cooperation Agency
JOCV	Japan Overseas Cooperation Volunteers
JST	JICA Study Team
JSTE	Japan Society of Traffic Engineers
JV	Joint Venture
km	kilometer
KMC	Kathmandu Metropolitan City
KMC-CIMEX	Kathmandu Metropolitan City - Cimex Inc Pvt Ltd
KMC-CRCC	Kathmandu Metropolitan City - China Railway 25th Bureau Group Co., Ltd
KMPD	Kathmandu Metropolitan Police Division
kN	kilo newton
KSUTP	Kathmandu Sustainable Urban Transport Project
KSUTP-MTOPS	Kathmandu Sustainable Urban Transport Project Mass Transit Options and Prioritization Study
K-T	Koteshwor - Tinkune
KTM	Kathmandu
KUTMP	Kathmandu Valley Urban Transport Master Plan

Abbreviation	Name
KV	Kathmandu Valley
KVDA	Kathmandu Valley Development Authority
L	Length
LAP	Lumbini International Airport Project
LDC	Least Developed Country
LIC-DSF	Debt Sustainability Analysis Framework for Low Income Countries
LOS	Level of Service
LRN	Local Road Network
LRT	Light Rail Transit
m	meter
MaaS	Mobility as a Service
min	minimum
MLIT	Ministry of Land, Infrastructure, Transport and Tourism
MOCTCA	Ministry of Culture, Tourism and Civil Aviation
MOF	Ministry of Finance
MOFALD	Ministry of Federal Affairs and Local Development
MOFE	Ministry of Forests and Environment
MOHA	Ministry of Home Affairs
MOLMCPA	Ministry of Land Management, Cooperatives and Poverty Alleviation
MOPIT	Ministry of Physical Infrastructure and Transport
MOU	Memorandum Of Understanding
MOUD	Ministry of Urban Development
MOWS	Ministry of Water Supply
MP	Master Plan
MRT	Mass Rapid Transit
MTOPS	Mass Transit Options and Prioritization Study
MTP	Metropolitan Traffic Police
MTPO	Metropolitan Traffic Police Office
Mun	Municipalities
N	North
N/A	Not Applicable
NATM	New Austrian Tunnel Method
NB	North Bound
NDC	Nationally Determined Contribution
NFC	Near Field Communication
NH	National Highway

Abbreviation	Name
NLC	Nepal Law Commission
NMT	Non-Motorized Transport
NMTEA	Nepal Meter Taxi Entrepreneurs' Association
NP	Nepal Police
NPC	National Planning Commission
NPR	Nepalese Rupee
NRS	Nepal Road Standards
N-S	North-South
NTMS	National Transport Management Strategy
O&M	Operation and Maintenance
OCG	Oriental Consultants Global Co., Ltd.
OD	Origin-Destination
ODA	Official Development Assistance
OECF	Overseas Economic Cooperation Fund
Opt	Option
pax	Passenger
PC	Prestressed Concrete
PCU	Passenger Car Unit
PDM	Project Design Matrix
PFI	Private Finance Initiative
PPHPD	Passengers Per Hour Per Direction
PPP	Public Private Partnership
PU	Pokhara University
Q'ty	Quantity
QR	Quick Response
R	Radius
R&D	Research & Development
RAP	Resettlement Action Plan
RBN	Roads Board Nepal
RC	Reinforced Concrete
RD	Regional Division
Rd	Road
RFT	Revolving Fund for Transport
ROW	Right of Way
RR	Ring Road
Rur. Mun.	Rural Municipalities

Abbreviation	Name
S	South
SB	South Bound
SCAEF	Society of Consulting and Architectural & Engineering Firms
SD	Scoping Document
SDGs	Sustainable Development Goals
SDMP	Strategic Development Master Plan
sec.	Seconds
SME	Small and Medium-sized Enterprise
sq	Square
SRN	Strategic Road Network
St	Station
STEP	Special Terms for Economic Partnership
STRADA	System for Traffic Demand Analysis
SV	Senior Volunteer
T	Heavy Vehicle Ratio
TA	Technical Assistance
TAZ	Traffic Analysis Zone
TBM	Tunnel Boring Machine
TDF	Town Development Fund
TL	Team Leader
T-M	Tripureswor – Maitighar
TOD	Transit Oriented Development
TOR	Terms of Reference
TRB	Transportation Research Board
TTC	Travel Time Cost
TU	Tribhuvan University
UK	United Kingdom
US	United States
USA	United States of America
USD	United States Dollar
UTMG	Urban Traffic Management Guidelines
UTMP	Urban Traffic Management Plan
V	Volt
V/C	Volume/Capacity
VCR	Volume/Capacity Ratio
VDC	Village Development Committee

Abbreviation	Name
veh.	vehicle
VOC	Vehicle Operating Costs
Vs	Design Speed
w	width
W	West
WB	West Bound
WG	Working Group

Summary

1.	**Country: Federal Democratic Republic of Nepal**
2.	**Survey Name: Data Collection Survey on Urban Transport in Kathmandu Valley**
3.	**Executing Agency:** **Ministry of Physical Infrastructure and Transport (MOPIT),**
4.	**Survey Background and Objectives:** Due to severe traffic congestion in Kathmandu Valley caused by rapidly increasing number of inhabitants and underdeveloped road network, the introduction of efficient and effective interventions for alleviating traffic congestion, together with sustainable urban development, has become urgently necessary. Japan International Cooperation Agency (JICA) conducted a road development plan study in 1993 entitled "The Study on Kathmandu Valley Urban Road Development" (1993 Road development plan), and the urban transport master plan study in 2017 entitled "The Project on Urban Transport Improvement for Kathmandu Valley" (JICA MP) to establish a comprehensive urban transport master plan with implementation target year of 2030 for the long term, 2025 for the middle term, and 2020 for the short term. In pursuit of the JICA MP, JICA has commenced the "Data Collection Survey on Urban Transport in Kathmandu" (hereinafter referred to as "the Survey") since January 2019 to develop the technical/ financial assistance programs for the improvement of the urban transport sector in Kathmandu Valley. This survey aims to identify future potential projects to be discussed for JICA technical/financial assistance which include the following: • Short-term: Traffic management schemes suitable for JICA technical assistance, small and medium-sized enterprise (SME) supporting scheme and Grant Aid scheme • Medium-term: Flyover/underpass suitable for prompt Japanese ODA loan in the near future • Long-term: Urban railway system for ensuring the compatibility with flyover/underpass
5.	**Survey Contents/Components:** The following items had been conducted during the survey to meet the above objectives: • Information on current activities and issues on urban transport sector were collected through a series of discussions with various stakeholders during the 1st mission period (17th Jan. to 19th Feb.) • An interim Working Group (WG) meeting was held on 11th Feb. to share and discuss the general findings on present issues and tentative proposal for short-term, mid-term and long-term solutions • High ranked government officials from MOPIT and the Ministry of Finance were invited to Japan to see and experience various types of urban transport services available in Japan together with Japanese technologies • A networking seminar with Japanese companies having technologies with potentials to be applied to support the urban transport sector in Kathmandu Valley was held in Japan • Proposal preparation for potential short/mid/long-term solutions • Necessary surveys for future technical considerations (e.g. traffic survey and geological survey)
6.	**Findings and Proposals:** **(1) Findings** • To establish an efficient and effective administrative structure for urban transport planning and management under the current institutional reform, it is expected that comprehensive and integrated decision making procedures will be established. Also, the Kathmandu Valley Public Transport Authority will play an essential role and start initiatives to provide guidance for the management of public transport services. • Urban transport-related service industries are envisioned and led by the private sector with challenges to develop innovative ICT solutions without government subsidies. These private initiatives, such as "open market with quality licensing scheme", shall be kept and backed by proper government support and management. It would encourage and create new urban transport services by digital platform such as MaaS (Mobility-as-a-Service) to enrich the quality of urban transport services. • The southern part of the Ring Road widening project, completed in the summer of 2018, made a significant impact on the valley transport environment. It may divert heavy traffic from major focal

points in the city, but traffic accidents increased and air pollution is at a serious level. The ongoing river road and affiliated bridge development will form the proper road network structure within the Ring Road; however, the present approach shows high dependency on road-based transport.

- There are several plans, studies and offers for mass transit development, but feasibility studies are merely arranged and started without any strong commitments for funding.
- Envisioned urban development outside of the Ring Road will increase the traffic demands, especially in the eastern area of Kathmandu Valley. Due to the presence of the international airport from Eastern area for crossing the Ring Road and insufficient road network, Koteshwor junction will be faced with serious traffic congestion in the near future.
- Based on the macroscopic transport demand analysis (JICA-STRADA) developed by the JICA MP and fine-tuned by ADB's KSUTP-MTOPS, the Study Team suggests the following interventions:
  - Urban railway system development is essential to absorb the future transport demand for east-west passengers in 2030. It is proposed to be a long-term project.
  - Even with the urban railway system installed, the Koteshwor junction still requires physical improvements (e.g. separation of the overlapping Ring Road and national trunk road). This intervention should be started as soon as possible as a mid-term project, which takes more time for construction. Note that several new bypass roads for this junction (e.g. Manohara River corridor) are also required to be examined. It is proposed to be mid-term solution for junction improvement.
  - Since the Ring Road can support the diversion of unnecessary trips through the city center as well as the distribution of entering points from the Ring Road, the improvement of traffic management at each intersection becomes highly important. It is possible to start immediately as short-term project. In addition, the enhancement of road network within the Ring Road is also important such as increasing traffic capacity for crossing the Bagmati River.

(2) Mid-Term Solution: Intersection Improvement for Immediate Action Towards Japanese ODA Loan

- Based on the macroscopic analysis of traffic demand versus road network capacity development plan, the sections of Koteshwor junction and Tinkune junction will incur serious congestion even with the urban railway system installed. This is because the national trunk road (Araniko Highway. and National Highway No.2 (NH-2)) and the Ring Road merge between these junctions, forming an overlapping section. Also, the intersection of Koteshwor has a large number of turning traffic volume. As a result, intersection improvement is essential.
- The intersection improvement at Koteshwor junction alone will not solve the problem caused by the overlapping section. Therefore, grade-separation needs to be included until the Tinkune intersection due to the short length (approximately 500m) between these two intersections.
- With the considerations of geometrical conditions, height clearance and estimated traffic volume, possible alternatives for grade separation with different civil structures are examined. For the result, the Study Team recommends the alternatives listed as follows:
  - Alt. 4-1: Underpass connecting Ring Road (North) and Ring Road (South)
  - Alt. 4-2: Flyover (viaduct) connecting Ring Road (North) and Ring Road (South)
  - Alt.5: Underpass connecting Araniko Highway to two separate directions, one for NH-2 bound for the city center and the other for the Ring Road (North)
- During this survey, the Study Team conducted the preliminary design for the above alternatives and found several pros and cons for each of the alternatives.
- Since this section is already congested and does not have enough space for traffic, in addition to construction costs and periods, several other items need to be jointly considered for further selection of alternatives. The proposed items for consideration are as follows:
  - Adverse effects by traffic closure/restrictions during the construction (affected numbers of vehicles and peoples)
  - Required land acquisition area/costs
  - Flexibility on traffic management such as buses, pedestrians and future BRT on ground level
  - Coordination with future urban railway system structures, multi-modal transport hub (bus terminals and urban railway station as interchange points)

- Risks of the alternatives against earthquakes and flooding
- Operation and maintenance costs, rehabilitation costs
- Applicability of new construction technologies to other places in the future
- Urban aesthetics, sustainability of modern structure to the surrounding buildings

- Manohara River corridor will be effective to alleviate traffic congestion at Koteshwor intersection. It can be used to divert several vehicles to/from Araniko Highway and Ring Road (South). It should be enhanced to install good connection and capacity together with the above solution.
- The present result of the economic analysis does not show the positive impact of the intervention. Therefore, it is necessary to consider another approach to calculate the net, accurate and specific traffic improvement; microscopic simulation; revision of population growth scenario; and an integrated assessment of Manohara bypass installation.
- Regarding congestions at Maitighar, Thapathali, Tripureshor and New Baneshwor intersections, based on the preliminary analysis of traffic flow/capacity under signal control, congestions will be manageable if the lane width for urban area in Nepal will be reduced in accordance with other countries' proven width such as 2.8-3.25m. The Study Team suggests physical changes from roundabout to signal control intersection in these areas.
- ROW of 50m or more was thought to be secured throughout Ring Road, but upon reviewing the legal documents, it was found that there are sections where ROW has been reduced. In case of Alt. 4-2 (Flyover along Ring Road), land acquisition is likely to be required at Koteshwor intersection.
- According to the laws of Nepal, an Environmental Impact Assessment will be required for any of the proposed road improvement projects. A Resettlement Action Plan may also be required depending on the scale of resettlement (if any). The process is expected to take about 2.5 months for preparations (scoping) and 3.5 months for EIA study/approval.

(3) Short-Term Solution: Traffic Management Project and Facilitation of Private Initiatives

- Based on the data collected for identifying issues on the current traffic environment, the Study Team identified the potential projects for the improvement of urban transport in Kathmandu Valley which may be supported by the JICA's schemes such as Technical Assistance, SDGs/SME supporting and Grant Aid.
- As for the JICA Technical Assistance (TA) scheme, the enhancement of capacity for traffic management and control is the one of the candidates with the following outputs/activities;
  - Engineering: improvement of design capacity at intersections (design guidelines (e.g. lane width in urban area, motor cycle box, lane and bus-bay arrangements and geometrical improvements), traffic signal control and safety devices for traffic management/control)
  - Education: raising awareness to observe manner/discipline and safety for vehicle driving and pedestrian crossing
  - Enforcement: regulating driving rules including bus-stop operation, parking policy, dissemination of information on traffic conditions and instructions
- TA can include experienced experts working with Nepalese officers, the budget of pilot projects for trial installations and geometrical improvements, and trainings in Japan/3rd countries for capacity development of Nepalese officers. Grant Aid is supposed to be discussed when the pilot project is evaluated as an effective solution for wide installation stage.
- As for SDGs/SME supporting scheme, EV tempos and buses are among the candidates under the EV modernization program. The program aims to develop efficient battery and charging system with proper operation and management system in collaboration with Japanese companies with practical experiences in this field. Also, payment modernization program with IC card is one of the potential candidates for future JICA assistance if private companies are supported and recognized by the government entities.

(4) Long-Term Solution: Urban Railway System Development

- The Study Team reviewed previous discussions, proposals and plans for urban railway system in Kathmandu Valley and proposed several route options for supporting an envisioned new urban development in the eastern area.

	• The Study team suggested the following development principles for urban railway system: - Urban electrical railway system aims to provide fast, comfortable riding, improved mass transit capacity and well-connection with feeder public service. - It is noted that urban railway system can create a large number of employment and various types of service industries linked to urban railway transport services. • It is essential to describe the key technical parameters, secure the land for depot (maintenance workshop and stabling yard; more than 6 - 7 ha) and select the appropriate size of rolling stocks (2.8-3.0m width, 18-20m long) to meet the development principles above. • Based on the field survey and new urban development plan, the Study Team proposed two alternative routes from the city center to Bhaktapur, (1) the North route (14.7km) and (2) the Araniko Highway route (14.3km). In the case of North route, the Study Team recommended KVDA to integrate the urban railway route into its new development plan. In addition, since this route runs along the Manohara River, it will be a good chance to utilize the river-side space with appropriate flood control for urban land use development. • In terms of the financial situation of the Government of Nepal, having a strong 7.9% GDP growth rate in 2017, combined with the government's efforts in decreasing the debt balance to 26.4% of GDP in 2017 (vs 60% in 2003), the risk of debt distress remains low. Although currently, the railway sector currently accounts for only a minor portion of the overall budget for the transport sector, the Nepal Government has exceeded its neighboring countries' GDP per capita of the years they have received their first ODA railway sector funding from Japan (Bangladesh: US$541 in 2007, Nepal: US$ 849 in 2018), which could be one indicator of the timing of the railway development. • In order to realize the smooth development and implementation of the project, several challenges exist which have been listed as follows: - Institutional arrangements, such as coordination and cooperation for urban railway system development and urban development (e.g. MOPIT-DORW, DOR and KVDA) - Integrating public transport mode exchanging point (to be proposed at Tinkune area) which will benefit all the public transport users - Tunnel Boring Machine (TBM) needs to be applied below the airport runway if the shortest route is required. The TBM method was applied for the installation of the railway line under the Haneda Airport runway in Japan during its operation. - Property ownership for underground private land/buildings should be discussed and utilized. - Transporting components of the railway system (e.g. rolling stock (20m long), rail (25m long)) should be secured from the border of Nepal to Kathmandu from the logistics point of view. • It is recommended to set the "Road Map" describing the necessary actions and required time frame for smooth implementation of the urban railway system development. • As of now, no regulations exist in Nepal regarding underground property rights. Following the case of the ongoing Nagdhunga Tunnel project, a draft concept note suggesting the establishment of appropriate legal guidelines related to tunnel works was submitted to the Government, but no action has been taken as of March 2019.
7.	**Recommendations:** • Mid.-term solution for intersection improvement from Koteshwor - Tinkune shall proceed to the Feasibility Study (FS) with the multi-criteria evaluation to select the civil structure type, in consideration of the applicability of advanced construction technologies. In addition to this solution, the Manohara River corridor development shall be discussed to enhance its capacity for diverting the traffic from Araniko Highway to Ring Road (South). • The Government of Nepal shall consider conducting the enhancement of capacity for traffic management and control for short-term solution. Also, SDGs/SME supporting scheme will be applicable if private companies, both in Nepal and Japan, are interested in developing the EV modernization program. • For long-term solution, urban railway system development needs to be integrated with the new urban development plan led by KVDA to secure the land for route and depot.

CHAPTER 1 BACKGROUND AND OBJECTIVES OF THE SURVEY

1.1 Survey Background

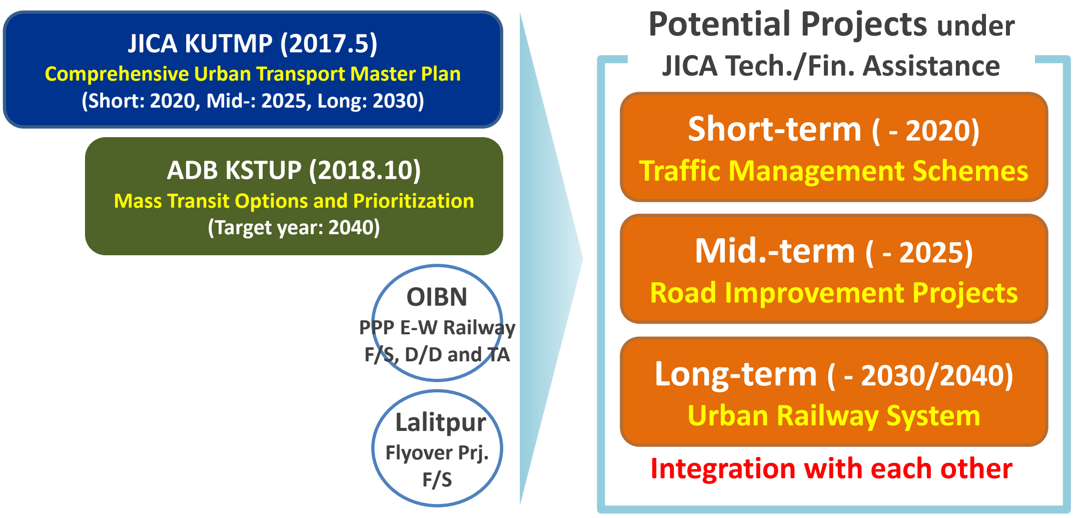
Kathmandu and its surrounding areas are called Kathmandu Valley and are the most important political, economic and social centers in Nepal. The population of Kathmandu Valley accounts for 9.3% of the total population of Nepal and its proportion is increasing year by year. The population in Kathmandu Valley is 2.5 million in 2011 and is projected to increase to over 4 million by 2035[1].

The rapid increase of inhabitants and their mobility needs against the underdeveloped road network has caused severe traffic congestion in Kathmandu Valley. The introduction of efficient and effective interventions for alleviating the traffic congestion, together with sustainable urban development, has become urgently necessary.

Japan International Cooperation Agency (JICA) conducted a road development plan study in 1993 called "The Study on Kathmandu Valley Urban Road Development" (1993 Road Development Plan) and carried out the urban transport master plan study in 2017 called "The Project on Urban Transport Improvement for Kathmandu Valley" (JICA MP). The aim of the study is to establish a comprehensive urban transport master plan with a target year 2030 for long-term, 2025 for mid-term, and 2020 for short-term.

In addition, Asian Development Bank (ADB) carried out a series of studies under "Kathmandu Sustainable Urban Transport Project" which included public transport restructuring (2014), review and update of bus route restructuring (2017), and mass transit options and prioritization study (2018).

In pursuit of the JICA MP and taking into consideration ADB's mass transit options and prioritization study, JICA commenced the "Data Collection Survey on Urban Transport in Kathmandu" (hereinafter referred to as "the Survey") to develop the technical/financial assistance programs for the improvement of urban transport sector in Kathmandu Valley beginning January 2019.



Note: JICA KUTMP: Kathmandu Valley Urban Transport Master Plan (The Project on Urban Transport Improvement for Kathmandu Valley) (2017.5); ADB KSUTP: Kathmandu Sustainable Urban Transport Project, Mass Transit Options and Prioritization Study (2018.10)

Source: JICA Study Team

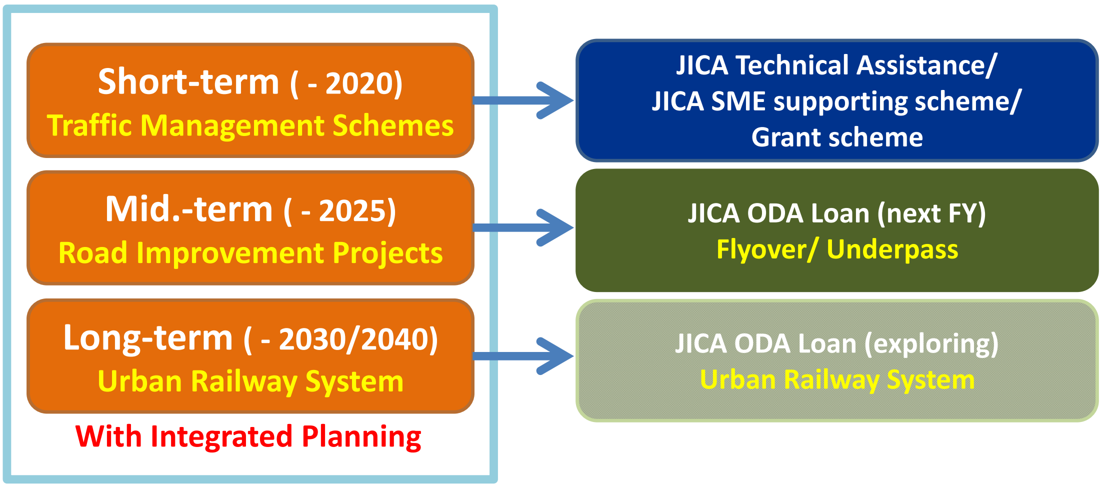
Figure 1.1.1 Potential Projects for JICA Technical/ Financial Assistance Programs

[1] Source: TOR of "Data Collection Survey on Urban Transport in Kathmandu Valley"

1.2 Survey Objectives

This survey aims to explore the future potential projects to be discussed for JICA technical/financial assistance in the short-term, medium-term and long-term. As Figure 1.2.1 shows, the potential projects under the survey objectives include the following:

- Short-term: traffic management schemes which are suitable for JICA technical assistance, small and medium-sized enterprises (SMEs) supporting scheme and Grant Aid scheme;
- Medium-term: flyover/underpass which are suitable for prompt implementation of Japanese ODA loan in the near future;
- Long-term: urban railway system and ensuring its compatibility with the flyover/underpass.



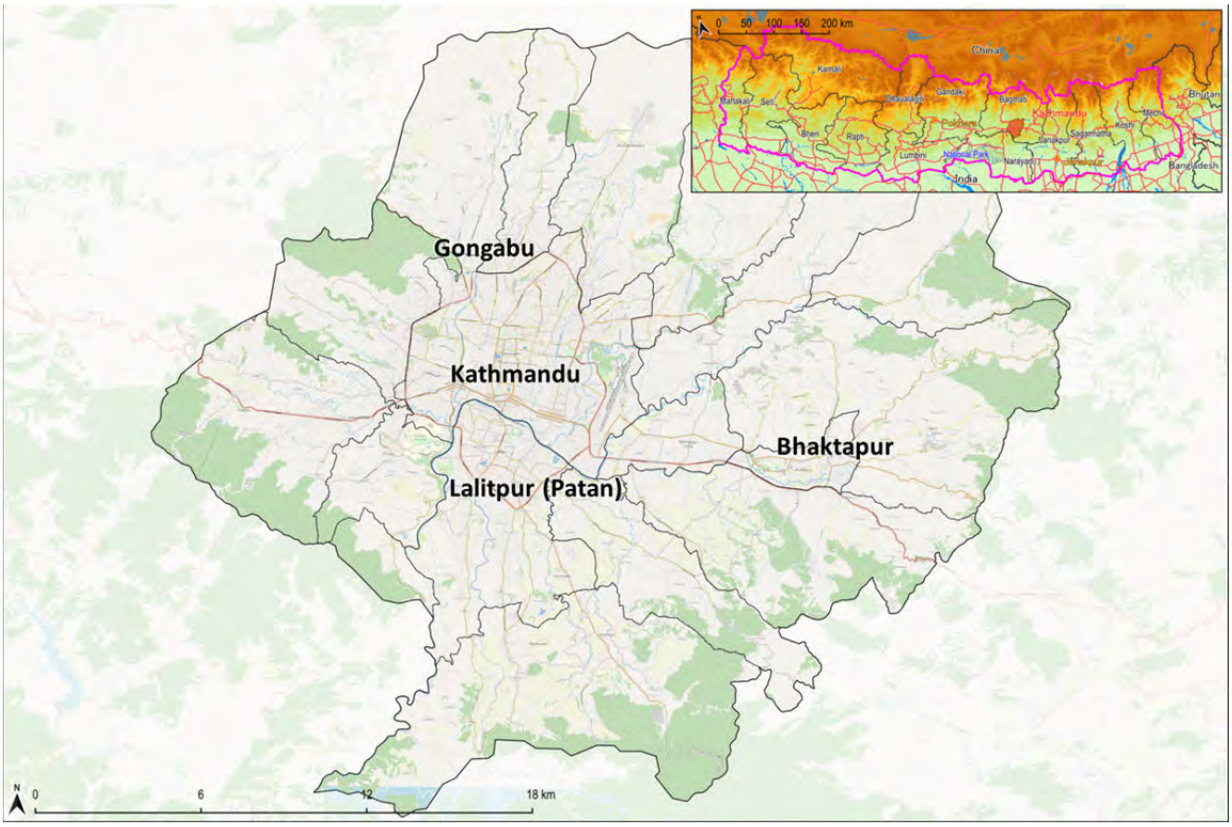
Note: JICA ODA Loan: Loan agreement between the Government of Japan and Nepal with 1.45% of 30 years repayment period and a 10-year grace period; JICA Technical Assistance (grant): Capacity development program dispatching experts to government agency/institution

Source: JICA Study Team

Figure 1.2.1 Survey Objectives for Short-Term, Mid-Term and Long-Term

1.3 Survey Area

The survey area is in the same extent of the JICA MP coverage as shown in Figure 1.3.1 below.



Source: JICA Study Team

Figure 1.3.1 Location Map of the Survey Area

1.4 Schedule, Organization, Major Events during the Survey

1.4.1 Survey Schedule

As shown in Figure 1.4.1, the survey was conducted from January 2019 to June 2019 during which JICA Study Team accomplished two missions in Nepal, one in January-February and another in March-April.

To wrap up the first mission, an Interim Working Group (WG) meeting was conducted on February 11th, 2019 to present the general findings and discuss the directions for the short-term, mid-term and long-term based on the findings.

An invitation program in Japan was conducted between February 23rd and March 2nd, 2019 for the decision-makers of relevant agencies to deepen their understanding on urban transport planning concept and advanced construction technology.

During the second mission, a Dissemination Seminar will be held in April, from which feedbacks and inputs from relevant agencies will be reflected in the Final Report to be delivered in May 2019.

Traffic survey at nine intersections and geological survey at five locations were conducted to collect the necessary supporting data for the survey.

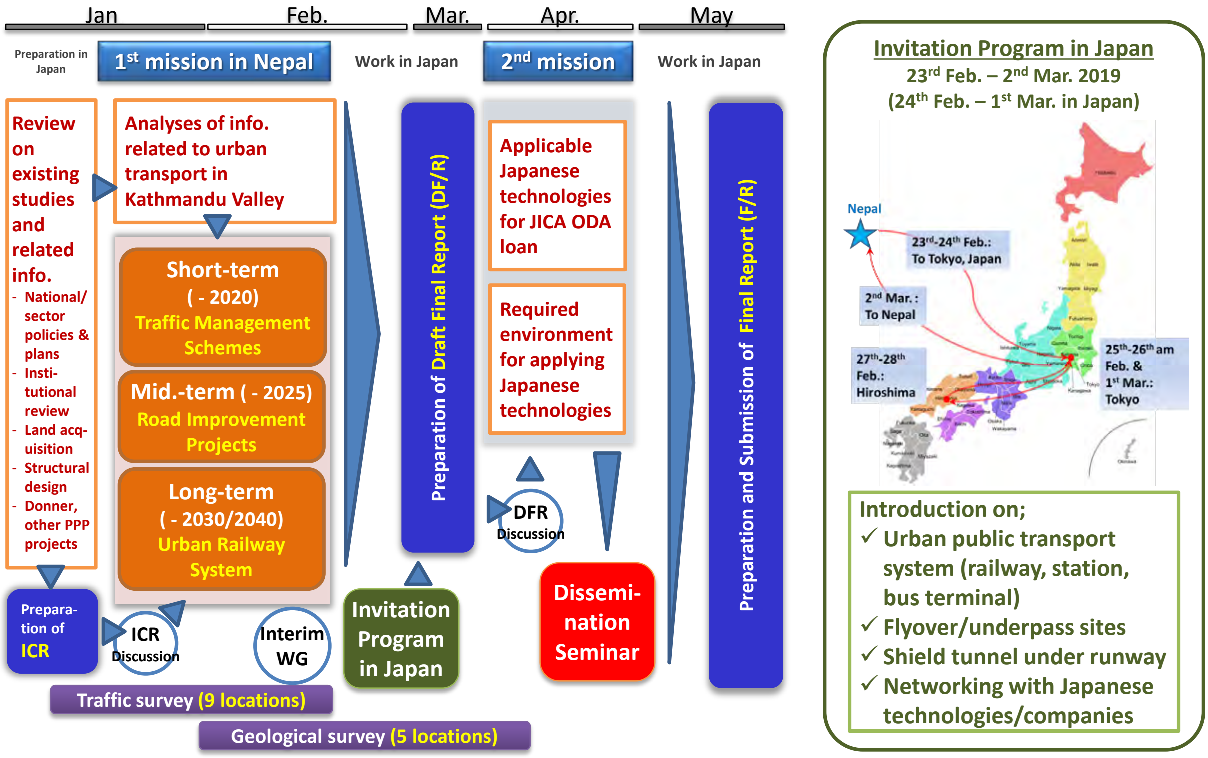


Figure 1.4.1 Survey Schedule

1.4.2 Survey Organization

The organization of the JICA Study Team is presented in Figure 1.4.2. There are 12 international consultants, including engineers and planners dispatched from Oriental Consultants Global Co., Ltd. and PADECO Co., Ltd.

In addition, experienced engineers of OCG in Nepal and advisors are supporting the JICA Study Team.

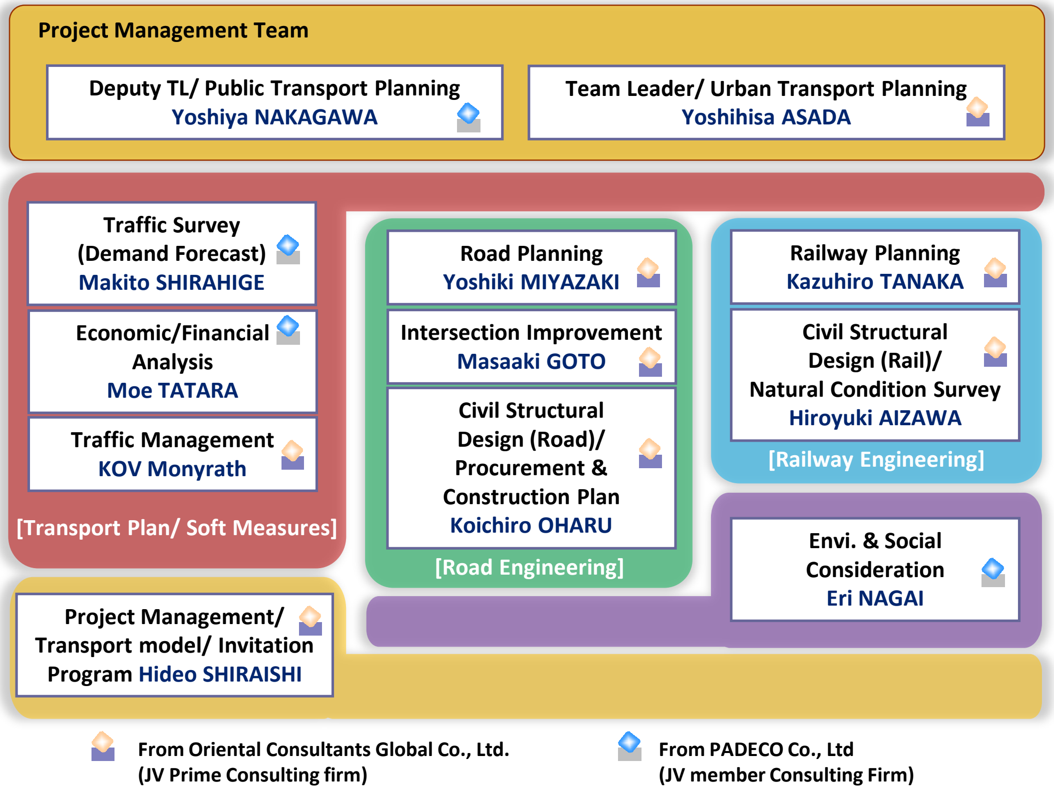


Figure 1.4.2 Organization of the JICA Study Team

1.4.3 Major Events during the Survey

(1) Interim Working Group Meeting

To wrap up the first mission, an Interim Working Group (WG) meeting was conducted on February 11th, 2019 to present the general findings and discuss the directions for the short-term, mid-term, and long-term based on the findings.

Further information related to the WG meeting is shown in Appendix 1.

(2) Invitation Program to Japan

It is desired that the short-term, mid-term and long-term potential projects require proper integration during the planning stage and advanced technologies in the construction stage. Therefore, the invitation program aims to deepen the understanding among the decision-makers of relevant agencies about the planning concepts and importance of those technologies.

The delegation from the Nepalese side was led by the Joint Secretary of MOPIT, and seven other members from MOPIT, DOR, and MOF were invited to Japan from February 23rd to March 2nd, 2019.

The detailed objectives of the invitation program are as follows:

- To deepen understanding of Urban Transport Policy in Japan for smooth implementation of this project.
- To experience various urban railway systems in Japan and to deepen understanding of the differences of each system.
- To understand the cooperation between public transport policy and urban development as well as the importance of public transport-integrated urban development through presentations from local governments.

- To understand civil engineering/ construction technology in Japan on road and railway structures (with video etc.) and explore their applicability in Nepal.
- To establish an opportunity to exchange dialogues with Japanese companies possessing knowledge and skills related to this project, to build networks with Japanese companies.
- To deepen understanding of Japanese assistance and interest in future urban transport policy.

Further details of the invitation program can be found in Appendix 2.

(3) Dissemination Seminar

During the 2nd mission, the dissemination seminar chaired by Joint Secretary of MOPIT was held on 12th April, 2019 after submitting the draft of DFR to MOPIT. In the seminar, findings and recommendations of the Survey were presented to and discussed with various stakeholders from urban transport sectors in Nepal. In addition, advanced technologies and challenges were introduced by 15 companies from Japan and Nepal in the exhibition room. The objectives of the seminar are as follows:

- To share the outputs of the Survey to stakeholders both from government and private sectors
- To introduce solutions and technologies applied to Short, Medium- and Long-term development for urban transport sector
- To exchange opinions among stakeholders and networking for supporting of urban transport sector development.

There were 97 candidates from government officers, development partners, academics and private sectors. The record of the seminar is summarized in Appendix 3.

(4) Traffic Survey

Traffic surveys were conducted at nine (9) intersections between January 24th and February 11th, 2019. The traffic survey includes the directional traffic count of classified vehicle, queue length and signal control survey.

The details of the traffic survey are provided in Appendix 4.

(5) Geological Survey

Geological surveys were conducted at five (5) sites with the desirable depth of borehole of 50 meters. Three (3) sites are for the candidates of the road intersection improvement, and two (2) sites are for the candidates of the future urban railway track.

The details of the geological survey are provided in Appendix 5.

1.5 Outline of the Report

This report is divided into six chapters, which explicitly explain the steps taken to achieve the survey objectives. The report structure in the following chapters is described as follows.

Chapter 2 provides an overall summary of the current urban transport situation in Kathmandu Valley, reviews of the existing studies and development plans, looks into institutional organization, enlists the key findings on urban transport in Kathmandu Valley, and suggests transport model review.

Chapter 3 concentrates on the traffic demand forecast, in which network analysis is done to provide the rationale for the grade separation, to assess infrastructure development impact on the proposed grade separation, and to forecast how the new city development will affect the traffic in the valley.

Chapter 4 discusses the mid-term solutions and highlights the importance of intersection improvement for immediate action in regard to the Japanese ODA loan. The rationale for suggesting Koteshwor intersection to be grade-separated is discussed, and preliminary designs of desirable alternatives are presented in this chapter.

Chapter 5 focuses on the short-term solutions by listing up the candidate traffic management projects suitable for JICA's assistance schemes such as Technical Assistance, SDGs/SME support, and Grant Aid.

Chapter 6 envisions the long-term solutions with urban railway system. Based on review and confirmation of previous discussions, proposals, plans for urban railway system in the valley, as well as the new urban development plan, two alternatives routes for urban railway were proposed.

Finally, Chapter 7 wraps up the survey report with conclusions and recommendations in short-term, medium-term, and long-term perspectives based on the survey's findings.

CHAPTER 2 REVIEW OF EXISTING PLANS AND ONGOING DEVELOPMENT PROJECTS

2.1 Introduction

This chapter presents a holistic review of existing transport plans and projects, as well as an institutional assessment of key stakeholders in the urban transport sector.

Firstly, Section 2.2 provides an overarching comprehensive review of the existing transport plan, ongoing major studies, projects and activities. They are classified according to the transport sector, major plan and studies, road development project, rail/MRT project, bus restructuring, IT innovations, and land use development project which will influence the transport market.

Secondly, Section 2.3 provides a brief explanation of institutional analyses and the roles of institutions in the transport market and their activities – from public agencies with direct roles in transport, those with indirect roles, private institutions, and others. It is possible that the explanation of activities has minimal overlaps with Section 2.2 to enhance the understanding of the institutional roles and activities.

2.2 Existing Studies and Major Development Projects

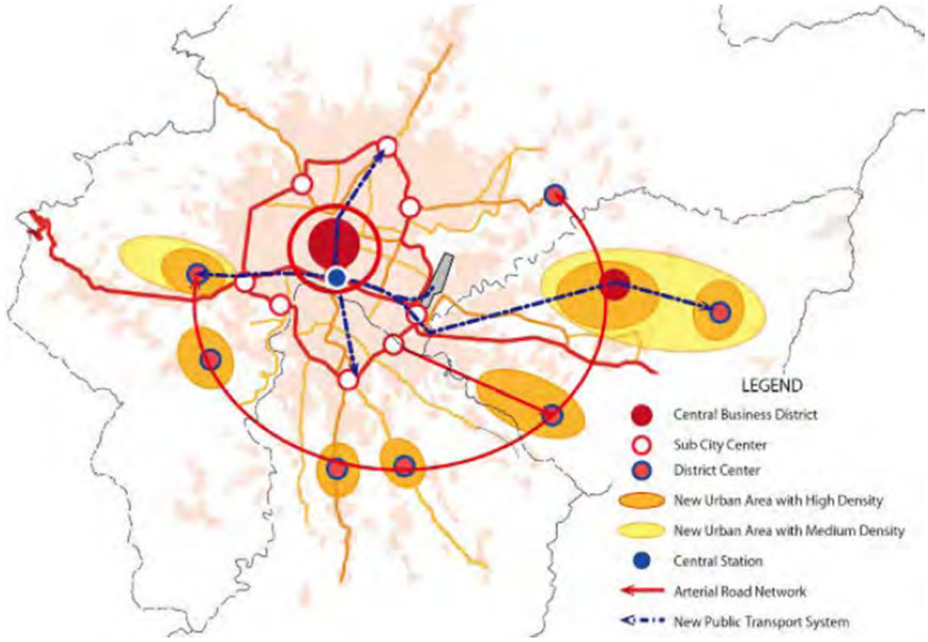
2.2.1 Existing Studies and Superior Plans

This section introduces two major studies for comprehensive urban transport development and two superior national plans for Kathmandu transport development.

(1) 2017 Comprehensive Urban Transport Master Plan (JICA MP)

In May 2017, JICA formulated the Comprehensive Urban Transport Master Plan under the *Project on Urban Transport Improvement for the Kathmandu Valley*, with a target year of 2020 for the short-term, 2025 for the middle-term, and 2030 for the long-term. The JICA MP envisions to establish "sustainable transport with high mobility, safety and comfort" through six strategic pillars: (i) transit-oriented development (TOD); (ii) sustainable economy through improved travel experiences; (iii) impartiality and universal public transport design; (iv) traffic safety; (v) protection from air pollution; and (vi) preservation of cultural heritage.

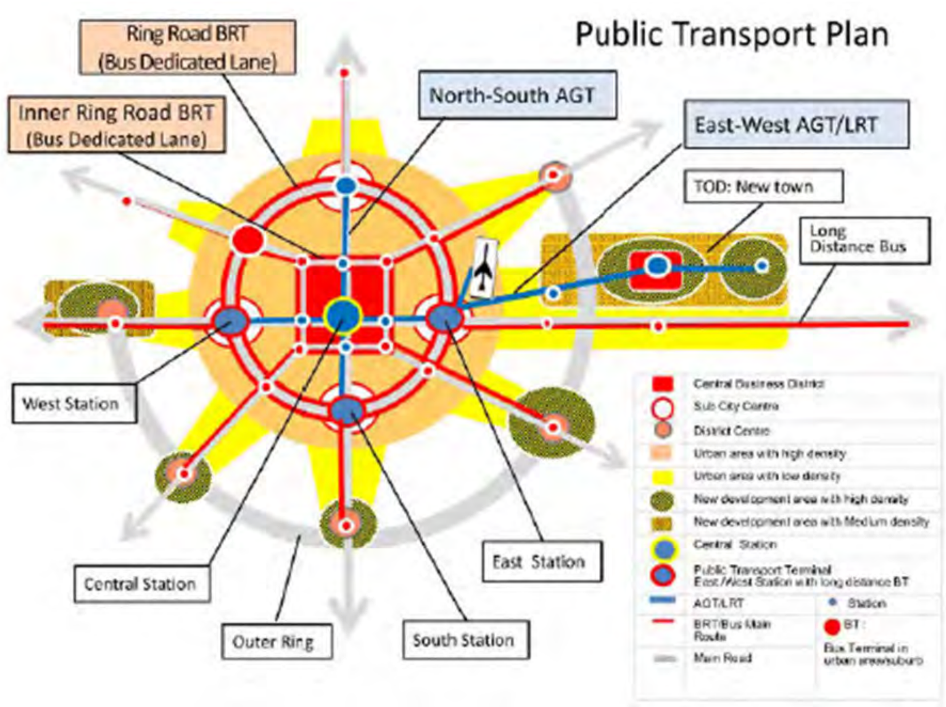
Major issues pertaining to urban transport are identified, such as monocentric urban structures with traffic concentrated in the city center; high population concentration inside the Ring Road; disorderly and uncontrolled urban sprawl; serious inroads to conservation areas; and unorganized and inefficient public transport system. The Master Plan adopted the concept of polycentric development with two central business districts as a preferred urban structure for the city as shown in Figure 2.2.1.



Source: JICA, Project on Urban Transport Improvement for Kathmandu Valley (2017)

Figure 2.2.1 Proposed Urban Structure in JICA MP

In line with this spatial plan, the 2017 Master Plan formulated a conceptual plan for future public transport network, including 2 lines of AGT and BRT along the Ring Road and three sets of the Ring Road (Inner, Mid and Outer) as shown in Figure 2.2.2.



Source: JICA, Project on Urban Transport Improvement for Kathmandu Valley (2017)

Figure 2.2.2 Future Public Transport Network

In its pre-feasibility section, road grade-separated interventions were assessed for three intersections: Tripureshwor - Maitighar (T-M), New Baneshwor and Kalimati. The details are explained in Section 2.2.2.

(2) Kathmandu Sustainable Urban Transport Project (KSUTP) – ADB

The Government of Nepal received financing from the Asian Development Bank (ADB) as well as from the Global Environment Facility (GEF) to produce a series of KSUTP studies to improve urban public transport.

1) Public Transport Restructuring (2014)

This study focuses on a plan to rationalize and upgrade the existing public transport network by introducing a three-tier route hierarchy with 8 primary, 16 secondary, and 42 tertiary routes (66 routes in total). The plan envisions to create a combination of feeder-trunk and direct services as an integrated network of all public transport services. The proposed route hierarchy requires a radical transition from the existing transport system comprised of small vehicles operating in over 250 direct routes, to consolidation of individual operators in a formal bus company. This requires institutional strengthening of the Department of Transport and Management (DOTM) by creating a public transport division within DOTM and ultimately establishing a Kathmandu Valley Bus or Transit Agency[1]. However, no institutional arrangement was established as of September 2016, resulting in the delay of implementation.

2) Review and Update of Bus Route Restructuring (2017)

This updated version of the above study revised the original routes (primary, secondary and tertiary) to provide an interim system of bus routes that can be implemented within the current framework of the public transport industry and government institution[2]. A pilot consolidation project was launched on two secondary routes, S5 and S3. However, S3 route was never implemented due to limited timeline. More details will be covered in Section 2.2.2.

3) Mass Transit Options and Prioritization Study (MTOPS) (2018)

The MTOPS aims to identify a preferred mass transit option for Kathmandu Valley. The objectives include the following: (i) compare various mass transit modes (e.g. MRT, LRT, BRT) to identify a preferred option for mass transit in Kathmandu Valley; (ii) select a priority corridor or corridors for the initial implementation of the preferred mass transit option; (iii) undertake a pre-feasibility assessment; and (iv) propose an appropriate institutional structure capable of effective and efficient regulation, planning and management of mass transit. The results of the MTOPS are explained in details in Section 2.2.2 along with other railway plans.

(3) 20-year Strategic Development Master Plan (SDMP) (2035)

The Kathmandu Valley Development Authority (KVDA), which is mandated to prepare and implement an integrated physical development plan for the Valley, drafted a 20-year Strategic Development Master Plan in 2016, or SDMP (2035). The SDMP takes into consideration the existing and emerging trends of urbanization, environment and the current socio-political and economical situations within the framework of the JICA MP. The SDMP focuses on 11 strategic areas: two-level planning (valley and municipal level); constraints/sensitivity-based zoning and risk-sensitive land use planning; risk-resilient urban infrastructure; environment-friendly and resilient planning approach; urban regeneration of historic city core; identification of economic opportunities and growth areas; gender equity and social inclusion; safety and security in urban development; private sector involvement in urban development activities; information, communication and advocacy; and youth mobilization and participation in urban decision-making processes and development activities.

[1] Asian Development Bank, KSUTP PMCBC Report, Public Transport Restructuring, February 2014.
[2] At the onset of the 2017 study, it was apparent that there would be no government capacity for implementation of the three-tier hierarchy.

(4) 15th Five-Year Plan

The 15th Five-Year Plan, prepared by the National Planning Commission, draws out the country's development goals and growth targets for the next five years (fiscal year 2019/20 – 2023/24). The five-year periodic plan – the first of its kind since 2006 – aims to achieve a minimum average economic growth of 9.4% per annual during the period[3]. At the core of the 15th Five-Year Plan is the national slogan of creating a "Prosperous Nepal and Happy Nepali." The 15th Plan Concept Paper is currently being drafted.

2.2.2 Development Projects by Sector

This section covers the current situation and development plans around railway, road and traffic management, BRT/trolleybus, bus system, ITS and signals, urban development and land use.

(1) Railway

As shown in Table 2.2.1, there are currently five railway development plans proposed by various countries and entities in Kathmandu Valley. Note that some of these plans were undertaken without referring to the Comprehensive Transport Master Plan prepared by JICA in 2017.

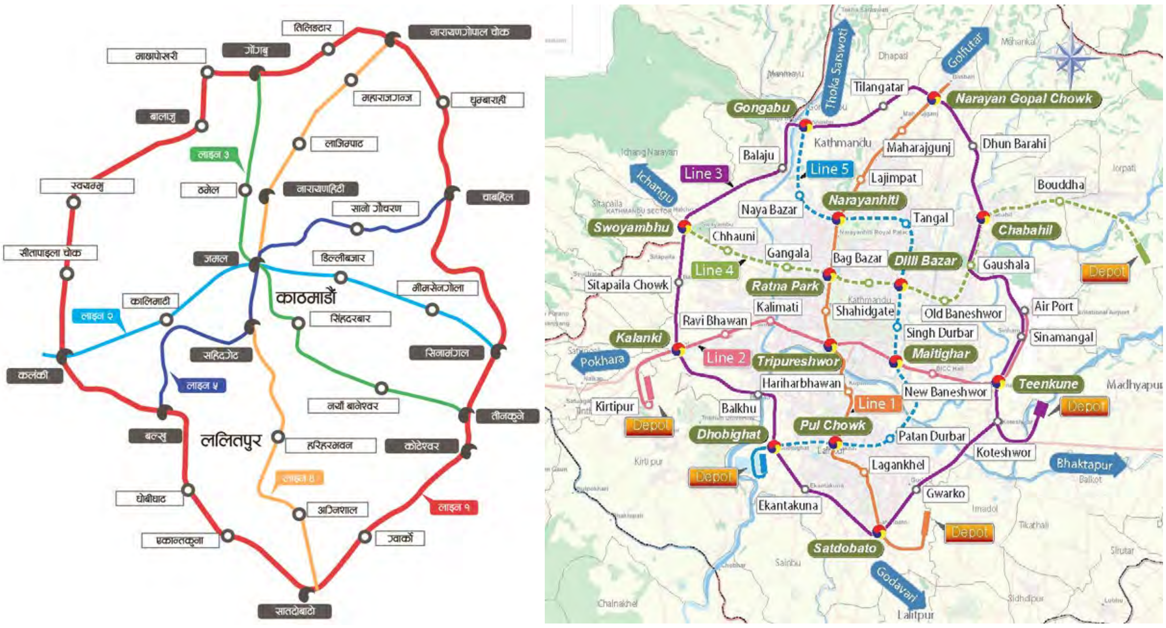
Table 2.2.1 Railway Development Plans

Railway plans	Description
Metrorail 5 Lines: Department of Railways (DORW)	DORW revealed a FS of metro with five lines in 2012 (prepared by Korean contractors). Government decided to proceed with feasibility study in 2017.
East-West Metrorail: Investment Board Nepal (IBN)	PPP scheme based on a decision of the National Planning Commission. Detailed FS and DD were announced in Sep 2018. Technical evaluation is in process. Awarding is expected very soon.
AGT: JICA (Comprehensive Transport Master Plan)	AGT (Automated Guideway Transit) with a viaduct type structure along the road. Proposed East-West and North-South Corridors in 2017.
East-West MRT: ADB/KSUTP	Steel rail-based mass transit systems (MRT). Selected East-West Corridor (Bhaktapur to Gongabu) as a Priority Corridor after assessing 5 options. Pre-FS conducted in 2018.
Monorail along Ring Road: Kathmandu Metropolitan City (KMC) and China	Monorail along the 27-km Ring Road. Signed a MOU with China Railway Construction Corporation to conduct the Detailed Project Report in 2018.
Kathmandu City Urban Cable Car	The French Embassy submitted a feasibility study report in May 2018.

Source: JICA Study Team

3 https://thehimalayantimes.com/business/15th-five-year-plan-targets-minimum-9-4pc-annual-growth/

1) Metrorail 5 Lines by the Department of Railways (DORW)



Source: Mr. Deepak K C, Project Director, DOR

Figure 2.2.3 Metrorail 5 Lines Route Map

In 2012, a feasibility study of five metro lines covering the entire valley was conducted by a Korean contractor (the left map in Figure 2.2.3). The plan entails four lines operating diagonally across the city, all of which are linked with the circle line running in parallel with the Ring Road. A high-level discussion took place in 2017 led by the Investment Board; the outcome of this was a new map (the right map in Figure 2.2.3) though no major change was made. The Nepal Investment Summit in March 2019 unveiled the latest outline of Kathmandu Valley Metrorail Project, with salient features summarized as below:

Table 2.2.2 Kathmandu Valley Metrorail Project (5 Lines)

Line	Location	Length (km)	Type	Stations
1	Satdobato – Ratnapark – Narayan - Gopalchowk	12.1	Elevated	11
2	Kirtipur – Kalimati - New Baneshwor - Airport	11.5	Elevated	9
3	Koteshwor – Chabahil – Swoyambhunath - Koteshwor	28.35	Elevated	17
4	Swayambhunath – Dillibajar- Bouddha	11.7	Underground	10
5	Dhobighat – Singhadurbar – Naksal - Gongabu	13.8	Underground	10

Source: Nepal Investment Summit (2019)

Other key features include:

- Intelligent Transport Component: Use of state-of-art technology, Real Time Information display at Stations, Automated Fare collection and verification
- Lines: 2 Two-way Railway lines
- Modern Terminal and Stations: The project will have 57 modern stations and 2 Terminals

It should be noted that the DORW has announced a set of tender announcements for the Feasibility Study and Detailed Project Design of the Line 1 (North-South Direction) in February 2019. The Detailed Project Report (DPR) is expected to be ready by the end of 2019.

2) East-West Corridor by Investment Board Nepal (IBN)

In January 2018, the IBN concluded that the East-West Corridor would be developed based on a BOOT (Build Own Operate and Transfer) scheme, which was approved by members of the National Planning

Commission and DORW, while the North-South Corridor will use government funding[4]. Following this decision, in September 2018, IBN invited six foreign firms (including two Chinese, one Japanese, one Turkish, one Indian and one South Korea-Japan JV) to submit proposals for a detailed FS and detailed design on East-West Corridor (from Dhulikhel to Nagdhunga, via Kalanki and Koteshwor). The technical evaluation is being processed as of March 2019.

It should be noted that the idea of the East-West Corridor was referred to the DORW's Metrorail Line 2, but the terminals of the corridor, Dhulikhel and Nagdhunga, are revised from the original Line 2.

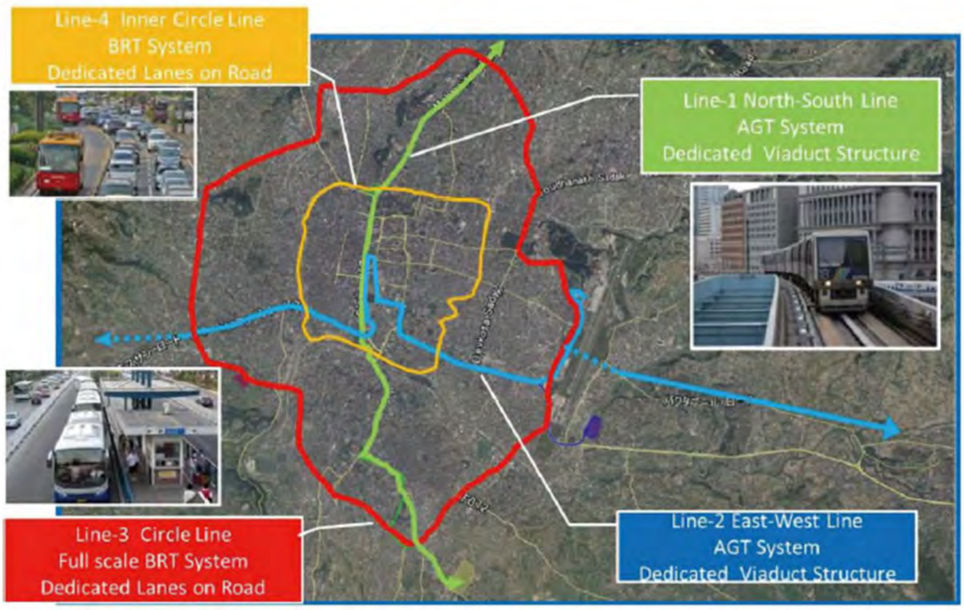
3) AGT by JICA MP

The mass rapid transit plan based on Automated Guideway Transit (AGT) system was proposed in the JICA MP, though the plan remains at the conceptual stage (see Figure 2.2.4 and Table 2.2.3). The AGT system is planned to be aligned along the north-south and east-west urban axis, whereas Bus Rapid Transit (BRT) system will serve as feeder routes along the existing/planned Ring Roads and the river corridor. The alignment of the east-west AGT, which will be extended eastward to Bhaktapur, will go along the Bhaktapur Road and not along the existing Araniko Highway; rather, it will be integrated with the surrounding new urban developments. In the city center, the alignment takes advantage of AGT (i.e. at sharp curves and sections with steep slopes). The alignment will run underground beneath the Tribhuvan International Airport and the runway.

Table 2.2.3 Proposed AGT Routing – JICA MP

No	Structure	Length (km)	Station	Description
Line 1: North-South	Viaduct	11.9	12	Narayan Gopal Chowk - Lainchaur - Thamel - KTM Central Station - Trispreswar - Thapathali - Jawarkhel - Satdobato
Line 2: East-West Airport Link	Viaduct	13.8	13	Kalanki - Kalimati - Tripureshwor - KTM Central Station – New Baneshwor - Tinkune - Tribhuvan International Airport

Source: JICA MP (2017)



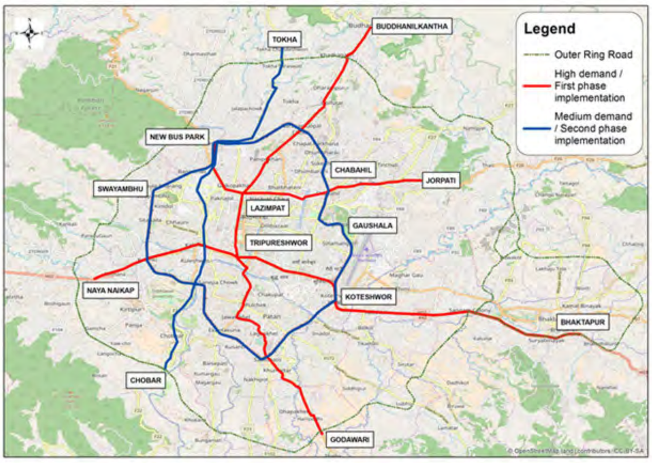
Source: JICA MP (2017)

Figure 2.2.4 Proposed AGT Routing – JICA MP

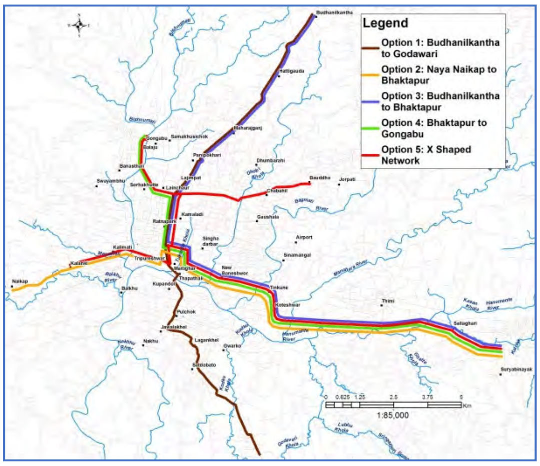
4 Meeting with Mr Sunil Poudel (senior divisional engineer), IBN. This approval also mentioned that the Line 1 of the Metrorail should be implemented by the DORW and MOPIT.

4) East-West Corridor (MRT) by ADB under KSUTP

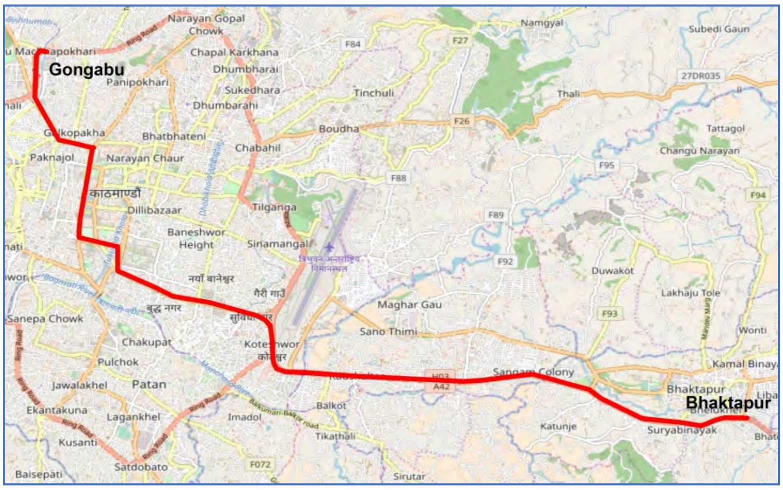
The KSUTP (Mass Transit Options and Prioritization Study - MTOPS) reviewed several mass transit plans and proposals. After which, it assessed a suitable mass transit option and recommended a steel rail-based mass transit systems (MRT) as a preferred option. Regarding the alignment, the study considered three high-demand corridors (red) for MRT and two medium-demand corridors (blue) for bus rapid transit (BRT) as shown in Figure 2.2.5 (a). The red corridors are forecast to support between 20,000 and 40,000 passengers per hour per direction (PPHPD), while the blue corridors can accommodate between 10,000 and 20,000 PPHPD by year 2040. The MRT on the "segregated" red corridors will run completely independent of mixed traffic in their own right-of-way (ROW), whereas the BRT on the "dedicated" blue corridors will run at-grade in their own ROW. Furthermore, as shown in Figure 2.2.5 (b), the five corridor options were comparatively assessed to select a Priority Corridor for first implementation. Based on multi-criteria evaluation, it was recommended that Option 4: "Bhaktapur to Gongabu" be selected as the Priority Corridor (Figure 2.2.5 (c)). The study also did a feasibility analysis and suggested the hybrid alignment viaduct in suburban and underground inside the Ring Road. The study results were shared and discussed with the stakeholders (Figure 2.2.5 (d)).



(a) High/Medium Demand Mass Transit Corridors



(b) Mass Transit Corridor Options



(c) Recommendation on the Priority Corridor

(d) Consultation Meeting on the Assessment of the Priority Corridor, July 2018

Source: ADB, MTOPS (2018)

Figure 2.2.5 KSUTP Mass Transit Corridor Analysis

5) Monorail along the Ring Road by the Kathmandu Metropolitan City (KMC) and China

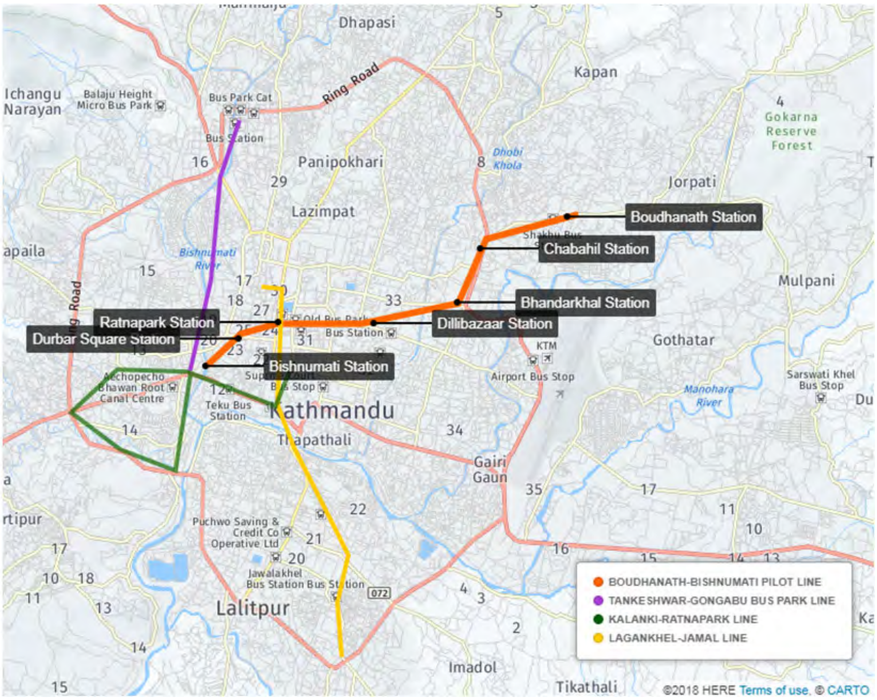
In December 2018[5], the KMC signed a memorandum of understanding (MOU) with China Railway Construction Corporation to conduct the DPR for the construction of proposed monorail along the 27-km Ring Road. Prior to this, the Chinese state-owned firm submitted a feasibility study report in September

[5] Kathmandu Post. *Kathmandu Metropolitan City, Chinese Company sign MoU for DPR on monorail*, dated 19 Dec. 2018. http://kathmandupost.ekantipur.com/news/2018-12-19/kathmandu-metropolitan-city-chinese-company-sign-mou-for-dpr-on-monorail.html

2018. The project cost is estimated at NPR 116 billion. The DPR will be completed by end of 2019. The Mayor of KMC is very keen to materialize the project and asked for government support. However, the Office of Investment Board Nepal, though respecting the local government's decision, considered the project not viable due to the low carrying capacity of the monorail[6].

6) Kathmandu City Urban Cable Car

In May 2018, the French Embassy submitted a feasibility study report on the cable car project7. According to its statement, the objective of the study was to put into perspective the feasibility and relevance of a cable transport system in Kathmandu, as fast to implement, a cost-effective and sustainable solution to tackle traffic congestion, reduce air pollution and ease mobility of the city. The cable car envisions to become a relevant part of the public transportation system in the Valley. The report proposed a 7-km pilot line with four lines and seven stations between Boudhanath and Bishunumati in Kalimati. Various operational and financial models such as the public-private-partnership and design-build-operate for the project are proposed in the report.



Source: Carto.

Figure 2.2.6 Kathmandu City Urban Cable Car Project

7) Comments by Study Team

The Metrorail plan was initiated and coordinated by the DORW and MOPIT only. However, it has now moved to the DPR for the preparation stage, and MOPIT should coordinate with DOR for the physical development as it will be constructed in the urban road right-of-way (ROW) area.

(2) Road and Traffic Management

Various plans are formulated or already implemented across the valley in the area of road expansion, traffic management (e.g. signals) and intersection improvement. These include the Outer Ring Road, river corridor, signal ITS, ongoing road expansion, intersection improvement and traffic management.

6 Meeting with Mr. Sunil Poudel (senior divisional engineer), IBN.
7 https://in.ambafrance.org/Kathmandu-City-Urban-Cable-Car-Project

1) Ring Road Development

There are two Ring Road projects currently underway. The Inner Ring Road (the blue circle) is a 27km four-lane two-way circular road, which is currently being built in three phases. In 2011, China agreed to provide the grant assistance worth US$40 million for the first phase in upgrading and widening the Kathmandu Ring Road[8]. A Chinese company completed the 10.5km road expansion between Kalanki and Koteshwor in December 2018 in the first phase of the Kathmandu Ring Road Improvement Project. The second phase of the project includes an 8.2km section between Kalanki and Maharajgunji, is due to start this year under Chinese funding. The third phase includes the remaining section from Maharajgunji to Koteshwor.

The Outer Ring Road (the red circle) is a 72km spreading across three districts of the valley, with 35.08 km falling in Kathmandu, 15.80 km in Lalitpur and 21.05 km in Bhaktapur district. At the Nepal Investment Summit held in March 2019, the government unveiled the Kathmandu Outer Ring Road Development Project, featuring eight-lane road with 50m of Right of Way, together with the commercial hub development along the road. The objective is twofold: (i) interconnect isolated three cities through a single road network to manage urbanization and improve urban-rural mobility; and (ii) create a new and planned settlement for the valley[9]. For the second objective, land acquisition along the corridor – 250m on either side from the center line of the road – will offer vast opportunity to accelerate planned urbanization (e.g., business centers, high-rise apartments). Development will be led by private investment, with the public and private each playing different roles. Key features of the project are summarized in the following table. Four firms submitted the detailed proposal in May 2019 in response to the announcement of the open bidding.

Table 2.2.4 Overview of Kathmandu Outer Ring Road Development Project

<table>
<tr><th>Project Name</th><td>Kathmandu Outer Ring Road Development Project</td></tr>
<tr><th>Funding modality</th><td>Private Investment</td></tr>
<tr><th>Indicative financials</th><td><table><tr><td>Total Cost (Road Development)</td><td>USD 1,871 million</td></tr><tr><td>• Land acquisition</td><td>USD 1,544 million</td></tr><tr><td>• Road construction</td><td>USD 327 million</td></tr></table></td></tr>
<tr><th rowspan="2">Roles</th><td>Government of Nepal:
• Facilitation of various legal approvals
• Government permits and approvals
• Facilitation of land acquisition to provide Right-of-Way and required land for the project</td></tr>
<tr><td>Private Sector:
• Plan, design, finance, construct and develop the envisioned facilities and other components of the project (Road and other physical infrastructure)
• Handover the road project to the government after completion
• Business development along corridor</td></tr>
<tr><th>Timeline</th><td>• Feasibility study – 1 year
• Detailed project report (Financial closure) – 1 year
• Construction – 5 years</td></tr>
</table>

Source: Nepal Investment Summit (2019)

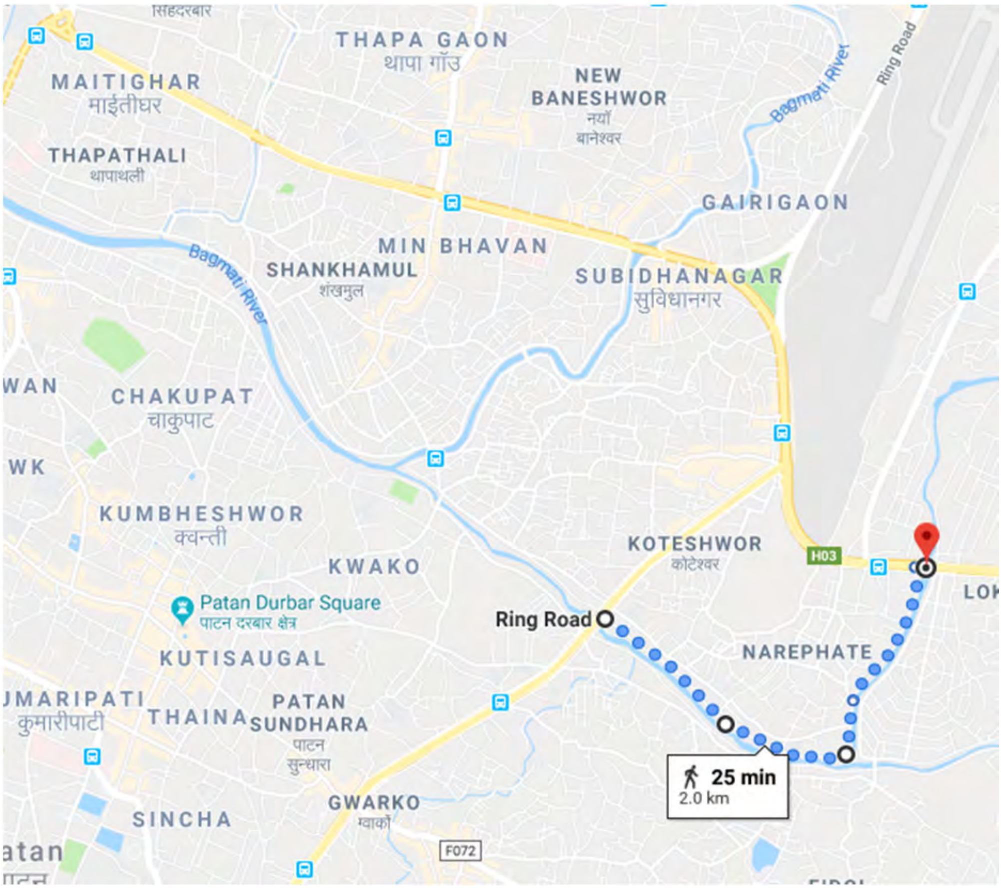
8 https://china.aiddata.org/projects/34420
9 https://investmentsummitnepal.com/transport-infrastructure/#KTMORR

Source: KVDA

Figure 2.2.7 Proposed Alignment of Ring Road

2) River Corridor

The Department of Roads (DOR) plans to develop the River Corridor parallel to the Manohara River from Jadibuti to Balkumari. The objective of this corridor is to minimize the traffic congestion at Koteshwor by providing a viable alternative route. The project will include upgrading of the 2 km existing roads and building a bridge across the river.



Source: Google Map

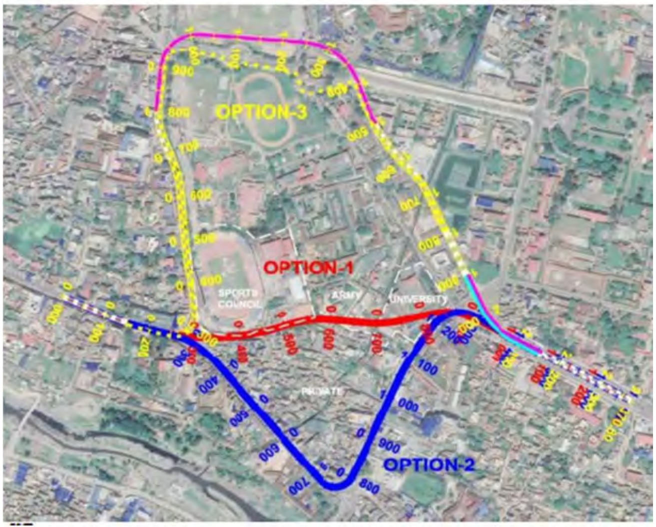
Figure 2.2.8 Proposed Alignment of River Corridor

3) Araniko Highway (Project for the Improvement of Kathmandu-Bhaktapur Road)

The main objective of the project is to widen the existing road between Kathmandu (Tinkune Intersection) and Bhaktapur (Suryabinayak Intersection) from 2 lanes to 4 lanes for 9.1km; improvement of 5 intersections; and provision of lay-bys for 14 bus stops. The project cost was granted by the Government of Japan, and it was opened in November 2011. Later, some sections were damaged by the earthquake in 2015 and were rehabilitated.

4) Flyover at T-M Intersection under JICA MP

JICA conducted a Pre-FS for the installation of a flyover at the Tripureshwor – Maitighar Intersection (T-M Intersection, Figure 2.2.9) as a priority project for intersection improvement in the 2017 Master Plan. The Pre-FS considered three options including a flyover alignment proposed in the "Basic Configuration Design Report" issued by DOR in 2011. The Pre-FS carried out a multi-criteria assessment and concluded that Option 1, the shortest alignment, should be proposed as the most feasible option.



Source: JICA MP (2017)

Figure 2.2.9 Flyover Options for T-M Intersection

5) Underpass at New Baneshwor Intersection under JICA MP

In JICA MP, an underpass at New Baneshwor utilizing the existing landscape was also identified as a priority project as shown in Figure 2.2.10. A Pre-FS concluded that the project is feasible and that an overall development effect would be very large if the project was developed together with the T-M Flyover.

Source: JICA MP (2017)

Figure 2.2.10 Underpass at New Baneshwor Intersection

6) Flyover and At-Grade Intersection at Kalimati Intersection under JICA MP

A Pre-FS was undertaken in the JICA MP to assess the feasibility of a flyover and at-grade intersection at Kalimati as shown in Figure 2.2.11. It was concluded that at-grade intersection improvement such as intersection capacity enlargement by arranging existing lanes is enough to accommodate more traffic volumes.

Source: JICA MP (2017)

Figure 2.2.11 Kalimati Intersection

7) Elevated Pedestrian Walkways at Shahid Gate / Sundhara Intersection (completed)

DOR built two elevated walkways for pedestrians on the north and south side of the Shahid Gate / Sundhara Intersection as shown in Figure 2.2.12. From the traffic management perspective, this well-designed urban roundabout facilitates traffic movements for both vehicles and pedestrians.

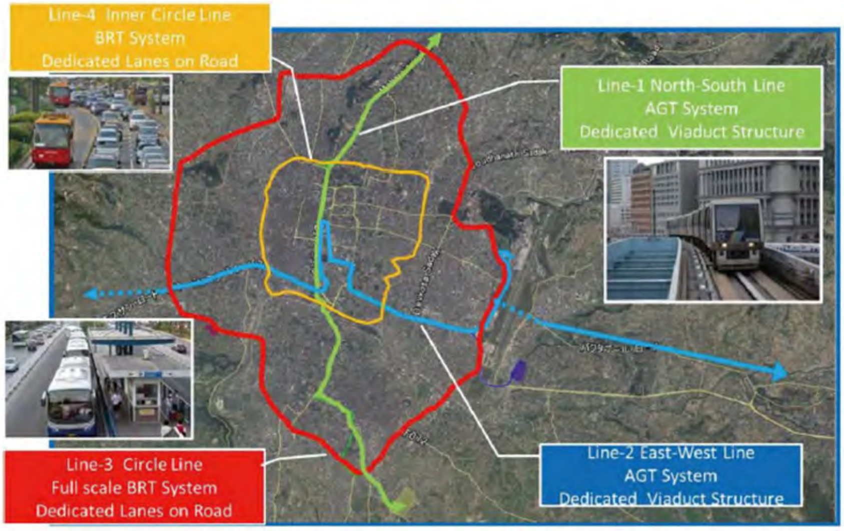
Source: JICA Study Team

Figure 2.2.12 Shahid Gate / Sundhara Intersection

(3) BRT / Trolleybus

1) BRT

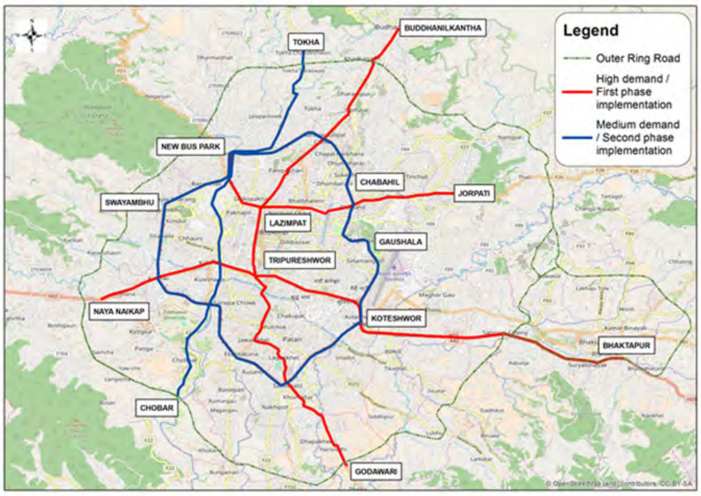
The JICA MP proposed two BRT routes along the Inner Ring Road and the Outer Ring Road, with a target year of 2025. These BRT plans were assumed to be realized under the existing organizational structure and relevant laws and regulations. The routes were selected taking into consideration the urban development plans to provide a reliable, connected public transport network in Kathmandu Valley as shown in Figure 2.2.13.



Source: JICA MP (2017)

Figure 2.2.13 Proposed Public Transport Network

In addition, the MTOPS (2018), under the KSUTP, identified the two corridors for the development of BRT to support up to an estimated 20,000 passengers per hour per direction as shown in Figure 2.2.14. While the proposed Ring Road Corridor overlaps with the JICA MP, the other routing takes the Bishnumati River Corridor instead of the Inner Ring Road proposed in the JICA MP.



Source: ADB KSUTP (2018)

Figure 2.2.14 High and Medium Demand Potential Mass Transit Corridors

In addition, according to the Town Development Fund[10], there is another proposal to build an electric BRT along Bhaktapur – New Baneshwor – Maitighar in alignment with a new road plan along Araniko Highway. It is estimated that 30% of the current traffic can be shifted to BRT. TDF plans to apply a funding proposal to Green Climate Fund in 2019.

In short, all plans conclude that the BRT system only provides a short-term solution to the existing traffic problems and serves as feeders to the planned mass transit system (e.g. AGT, MRT).

10 Meeting with Mr. Suman Maher Shrestha on 31 January 2019.

2) Trolleybus

The trolleybus system opened to the public in 1975 and ceased its operation in 2008. To re-introduce the modernized trolleybus system to Kathmandu, the Global Green Growth Institute (GGGI) prepared a basic project concept[11] of the trolleybus system. GGGI proposed to use four feeder lines from four cardinal directions of the Ring Road towards CBD to facilitate the movement of passengers from segment to segment (different from the concept of BRT which circulates passengers along the Ring Road).

(4) Bus

1) Current Situation

Road-based transport system is the only available way to travel in Kathmandu. Under all likely mass transit strategies as reviewed in the previous sections, buses will continue to carry more passengers than the mass transit system for the foreseeable future, and thus the bus sector warrants policy and funding support. Table 2.2.5 shows the estimated number of public transport routes and vehicles operating in the Kathmandu Valley in 2012[12].

Table 2.2.5 Number of Public Transport Routes and Vehicles

Vehicle Type	No of Route	No of Vehicles	Passengers Capacity
Bus	9	320	26-56
Minibus	93	2,036	Max 25
Microbus	73	2,036	10-16
Tempo	12	750	12
Total	187	5,142	-

Source: ADB KSUTP (2018)

Reforms in three key areas are necessary to improve mobility and alleviate congestion and pollution from vehicles. The following are essential pre-requisites to support mass transit:

- Consolidation of the fragmented paratransit industry into a manageable number of corporate entities
- Deployment of large buses on primary and secondary routes
- Development of an effective agency to plan, monitor, procure and regulate public transport

The Kathmandu Sustainable Urban Transport Project (KSUTP) implemented a pilot project to replace small paratransit vehicles with larger buses which will be explained in the next section.

2) S5 Pilot Project – A Successful Case of Bus Route Restructuring

The KSUTP public transport restructuring project is a pilot consolidation initiative on two routes, S5 and S3. However, S3 was never implemented due to limited time. The main objective of the KSUTP is to improve the overall quality of urban transport in Kathmandu Valley. The capital for corporatization was provided by Town Development Fund (TDF) with funding sourced from Asian Development Bank (ADB) – Global Environmental Facility (GEF) grant. The total funding for two pilot routes was USD 3.8 million[13], and it can be estimated that the actual amount spent for Route S5 is approximately 80 Million NRPs (need to be confirmed). The funding was utilized for project design consulting services, bus facilities development (including USD 80,000 for a bus depot), new bus fleets, equipment (e.g. ITS and automated ticketing, GPS, communication devices), and compensation for the affected individual owners/operators, among others.

[11] Meeting with Mr. Rowan Fraser, GGGI on 5 February 2019.

[12] There is no official figure of fleet size. Tempo statistics are based on meeting with SAFA Tempo in February 2019. Source: JICA, *Data Collection Survey on Traffic Improvement in Kathmandu Valley*, October 2012.

[13] USD 2 million from GEF grant and USD 1.8 million from ADB grant.
Source: Town Development Fund, *2016-17 Annual Report: 30th Anniversary Publication 2018*, February 2018.

3) S5 Pilot Project

Route S5 (New Bus Park – Gongabu – CBD – Sinamangal – Airport, 12.1 km) was proposed in 2014 in the Review and Update of Bus Route Restructuring as shown in Figure 2.2.15. Route S5 was originally comprised of two routes (west and east) operated by two groups of individual owners/operators[14]. These individual groups were merged into one company, Digo Sarbajanik Yatayat Pvt. Ltd. As a result, 61 operators on route S5 became the shareholders in Digo which now operates 17 medium-size diesel buses. Unlike other countries' experience, there was little (violent) conflict in the process of negotiation.

TDF provided several incentives to facilitate the transition from paratransit to formal bus services: (i) 80% low interest loan for new vehicle purchase (with 5% low interest rate over 8 years); (ii) 20% equity for the new company (as "recapitalizing amount" with 15% from the national government); and (iii) 5% from the decongestion fund. In addition, if they scrap over 50% of existing vehicles, they are eligible for supplemental incentives.

The Introduction of a service contract was one of the key elements of the project. In the previous informal paratransit system, the individual operators obtained the route permit to operate on a particular route, but without any service obligations and penalties. The service level agreement signed between Digo and DOTM defines the route, service frequencies, operating hours, fares and liability. The operator has little influence over these conditions as these are defined by DOTM.

Source: ADB KSUTP (2018)

Figure 2.2.15 Proposed Secondary Routes / S5 Route

4) Current Operation

Bus operation by Digo started in August 2018. All local stakeholders including TDF, a project consultant and Digo operators agreed that route S5 route rationalization was successful (after 5 months of project implementation). Digo operates solely based on farebox revenue without any subsidy. They are currently in the process of acquiring 10-20 large buses to optimize their business operation as shown in Figure 2.2.16. New bus equipment, such as on-board announcement system, GPS monitoring system,

[14] Meeting with Mr. Madhab Raj Ghimire from PSM Global Consultants, who was involved in KSUTP bus restructuring. The actual figures may be different, as the SMEC study estimated existing public vehicle volumes on route S5 as follows: 5 associations; 27 buses; 234 microbuses; and 84 tempos.

ITS ticketing, has not been introduced as of February 2019. Local IT manufacturers, such as RamLaxman Pvt and n.Cloud Pvt, are still testing and improving the systems for better bus operation.

(a) On-board announcement system

(b) Digo bus

(c) Bus depot

Source: JICA Study Team

Figure 2.2.16 Digo Bus Facilities (KSUTP)

(5) Information Technology

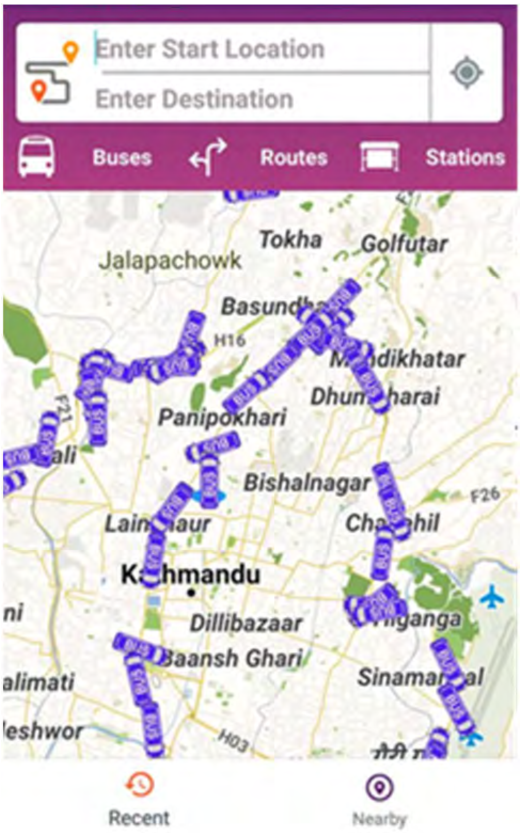
1) LetzGo and On-board GPS Equipment and Business Model for MaaS Service

LetzGo, developed by RamLaxman Pvt. Ltd.[15], is a smart phone application featuring real-time shortest bus route search (see Figure 2.2.14). Compared to other publicly available apps such as Mera Sajah[16] and GPS Nepal[17], LetzGo has more comprehensive functions for public transport services. One is a real-time route search function covering 108 routes and 845 stops in Kathmandu Valley. The data charge is free for LetzGo users, as the company bears all the users' data cost under its cooperation with NCell[18].

The company envisions to be a MaaS (mobility as a service[19]) platform of Nepal not only for transport

[15] RamLaxman Pvt is the company for software development. There is another company named Technology Sales Pvt for promotion or business development.
[16] Exclusive for showing real-time tracking of the Sajah Bus
[17] A basic viewer location tracking functions for ambulance calling, taxi booking, school bus tracking, private vehicle tracking, developed by the RamLaxman
[18] In Nepal, NCell has 45% share, NTC has 30% share, but most users have two different sims.
[19] A digital platform that integrates end-to-end trip planning, booking, electronic ticketing and payment services across all modes of public and private transport.

services in Kathmandu, but across intercity transport. To date, it has invested to install on-board GPS equipment, information boards and mobile modems to 800 buses in Kathmandu. The company also aims to develop a business model with advertisement revenues to sustain the MaaS platform with minimum passenger charge. The application will be free to download up to 3 million times (target achievement); one third of which, or 1 million users, are expected to use its services on a daily basis. Once the company hits this milestone, they plan to charge 1 NRP per day to sustain their business. More functions will be added, including LetzGo Parking (for online parking reservation) and LetzGo Traffic (to monitor real-time traffic conditions).



Source: JICA Study Team

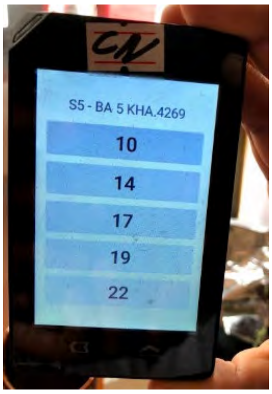
Figure 2.2.17 LetzGo Mobile App

2) IC Card Payment System

n.Cloud Pvt Ltd, an ICT private company, is currently developing and testing a new ICT card payment system in Nepal for Sajha and Digo bus routes, supported by the two bus companies and Nepal Bank Ltd. This ICT card is a MIFARE type (or Type A) and costs approximately USD 0.50 per card media during the development stage (see Figure 2.2.18). n.Cloud plans to provide a small portable device to conductors. Customers can pay either by cash or through a smart card. Fares are charged based on the distance traveled, therefore the two bus companies consider that conductors on-board should remain to confirm the passenger charge. It should be noted that the rationalization process of the S5 route include the installation of the IC card payment, which was approved by the Board of Kathumandu Municipality Council, and n.Cloud was awarded as the contractor for the IC card payment installation.

The motivation of the IC card payment installation is to minimize the miscollection of fare. According to the Digo, 20% of fares is lost due to mishandling of conductors, as well as misapplication of discount fares for students or elders to ordinary passengers.

NFC Card



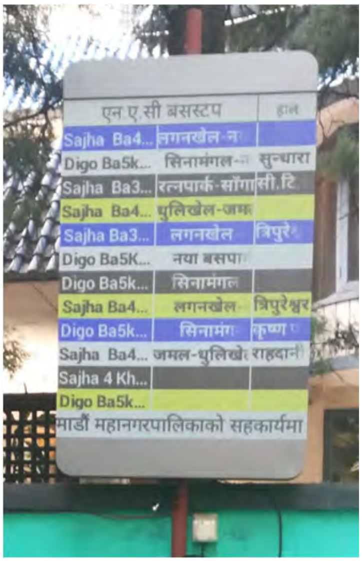
A Handheld Device for Conductors

Source: JICA Study Team

Figure 2.2.18 IC Card Payment Prototype

3) Digital Information Board

As aforementioned, RamLaxman has a vision to provide the MaaS platform. To mitigate the digital divide for non-smartphone users, the company developed a prototype of the digital information board (see Figure 2.2.19) that shows the real-time bus location information and time schedules of buses in Kathmandu. In a discussion with Kathmandu Metropolitan City, RamLaxman proposed to install 100 boards at bus terminals and major bus stops under the condition that 25% of the display time can be used for their advertisement on a PPP basis. RamLaxman plans to install the boards with their own money and recover the cost through revenues generated from the advertisement. The Board of Kathmandu Metropolitan City (KMC) is currently reviewing its proposal. According to KMC[20], the Mayor sees it as positive.



Source: JICA Study Team

Figure 2.2.19 Prototype of the Digital Information Board

(6) Signals

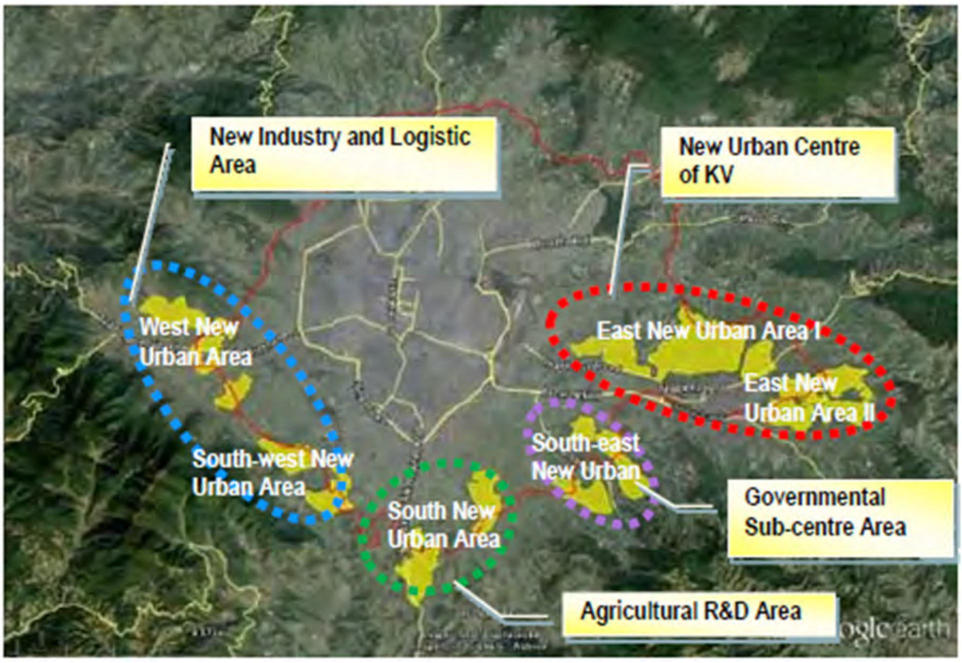
In early 2000s, traffic signals were installed at 10 intersections in Kathmandu under Japan's grant assistance[21]. All but two intersections (New Baneshwor and Maharajgunj) are under maintenance as of

[20] Meeting with Mr. Ram Thapa, Department Chief.
[21] https://www.np.emb-japan.go.jp/oda/grant2001.html#10

February 2019. The maintenance of traffic signals at New Baneshwor and Maharajgunj is done by local engineers and funded by DOR and Kathmandu Municipality, respectively. Seeing the lack of traffic lights (including pedestrian lights) at main intersections as a major bottleneck, the Metropolitan Traffic Police (MTP) prepared a list of intersections where traffic lights are necessary for more efficient traffic management. The list includes: 52 traffic lights and 26 pedestrian lights[22]. MTP has requested DOR many times to install them, but no action has been taken yet.

(7) New Urban Development Areas in the East of Kathmandu

The JICA MP identified four new urban development areas based on the following policies: (i) Layout new municipality offices at each new urban area; (ii) Conserve water course and buffer area; (iii) Create large-scale green parks; (iv) Arrange commercial and business areas and high-density residential areas along main road; and (v) Adopt the Transit Oriented Development (TOD) concept for the development of AGT and BRT.



Source: JICA MP (2017)

Figure 2.2.20 New Urban Development Areas

Partly in line with the JICA MP, KVDA plans to develop four urban areas designated for new town development: two in Bhaktapur, one in Lalitpur, and one in the north of Kathmandu as shown in Figure 2.2.20. These satellite cities outside of Kathmandu Valley will function as government administrative and commercial hubs and will be connected to the Outer Ring Road. For Bhaktapur, JST obtained two project plans from KVDA in February 2019. This new urban development will cover an area equivalent to 10% of the total land area of Kathmandu Valley (722 km^2).

KVDA considers utilizing a land pooling policy, though 90% of the land is owned by private entities[23] (KVDA will acquire land parcels before private development). This policy has been practiced by KVDA for a number of small-scale developments.[24] KVDA expects to receive 8-10% of the value of the total developed land. This development plan is expected to be a model applicable to the capital of seven provinces across the nation.

22 The JICA Study Team requested a copy of the list from MTP, but was unable to receive it in a timely manner.
23 Nepali may express those private individual owners as "general public"
24 Including Thimi District (between Araniko Highway and Bhaktapur Road), North of Airport, Jadhibuti District, East of Airport).

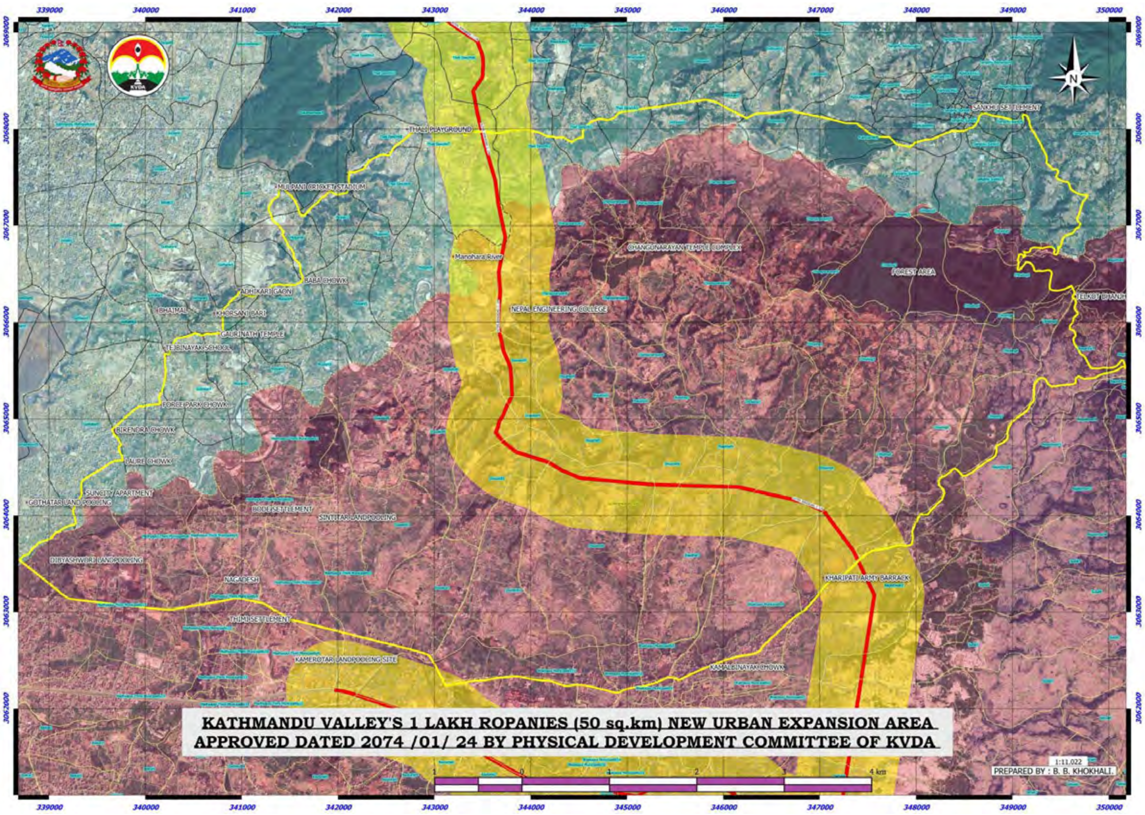
1) The New Development Area in the North of Araniko Highway

The new urban expansion area of 50 sq. km (1.0 lakh ropani[25]) with over 1 million inhabitants is planned for the area in the North of Araniko Highway. Helenko architect, a Finnish firm hired by KVDA, developed the conceptual land use map. The land use plan is divided into the natural resources area (45%) and the settlement promoted area such as commercial, residential and heritage developments (55%). The transport plan, in line with the JICA Comprehensive Transport Master Plan, proposes two transport systems: AGT and BRT. The timeline of the new town development is shown in Table 2.2.6. Figure 2.2.21 shows the target area of the new urban development highlighted in a yellow line boundary. The red line with the yellow buffer represents the planned Outer Ring Road. Figure 2.2.22 shows the conceptual land use map in the north of Araniko Highway.

Table 2.2.6 Timeline of New Town Development in the North of Araniko Highway

Target year	Activities
1st Quarter 2019	Finalize the project after stakeholder consultation
2nd Quarter 2019	Official announcement of the project
3rd Quarter 2019	Start infrastructure development, including land acquisition
1st Quarter 2020	Components development and construction stage
1st Quarter 2022	Completion of tourism component; completion of the first model of residential community

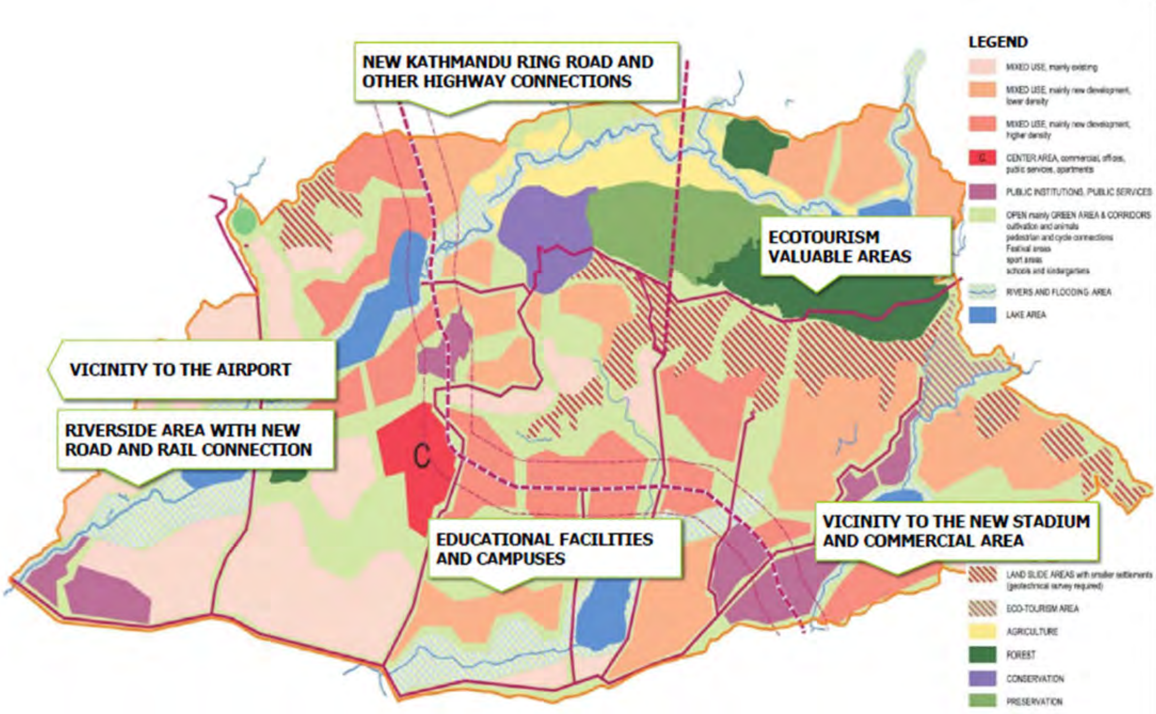
Source: KVDA (2019)



Source: KVDA (2019)

Figure 2.2.21 Target Area of New Urban Development in North of Araniko Highway

25 1 lakh/lac = 100,000, 1 Ropani = 508.74 m2 = 5,476 ft2,



Source: KVDA (2019)

Figure 2.2.22 Conceptual Land Use Map in North of Araniko Highway

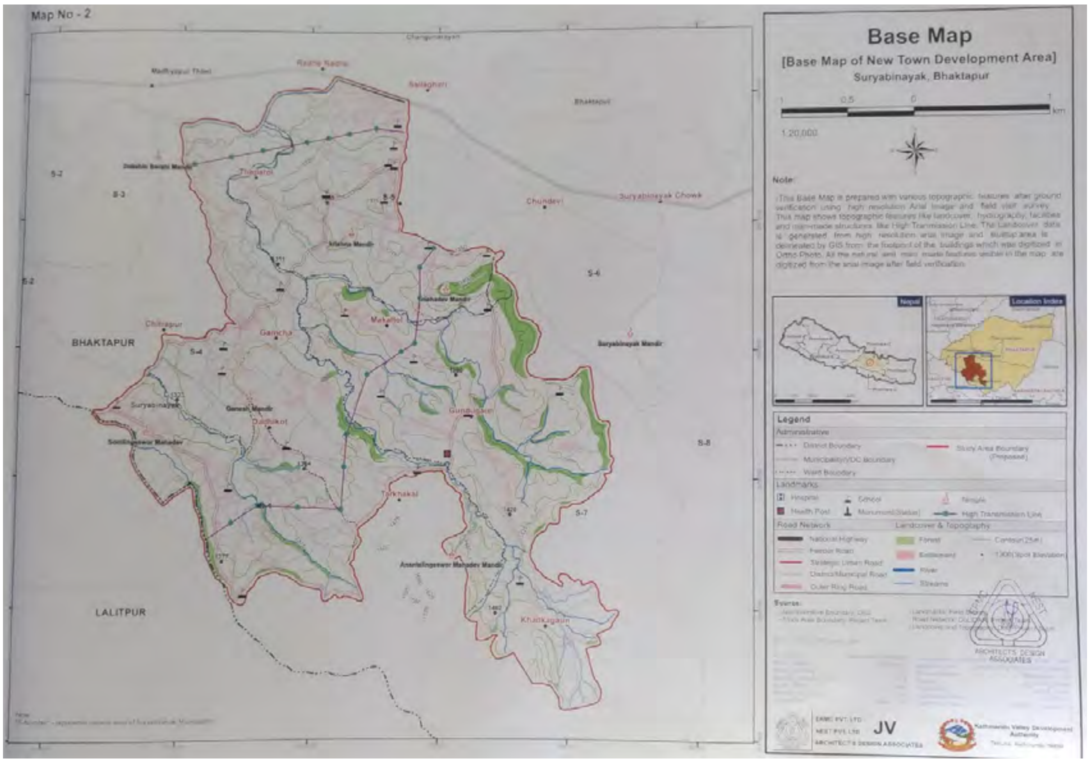
Regarding the river road construction along the Manohara River, the land use plan will specify necessary land as 50-meter width for river basin, and 20-meter ROW on both sides. Transport infrastructure planned in these new town developments will incorporate the JICA MP. KVDA supports the idea of integrated land use with transport plans proposed by the JICA Survey Team. The new town development will adopt Japan's land re-adjustment approach. Up to 10% of land will be sold, and revenue will be allocated for the development. Even with the minimum land value, the project will be feasible. In line with the new town development, KVDA plans to relocate the brick factories in Bhaktapur to further east, out of Kathmandu Valley.

2) Proposed New Development in the South of Araniko Highway

The proposed plan covers an area of 25 sq. km (0.5 lakh ropani) in the south of Araniko Highway, roughly half the size of the land in north. The concept plan is prepared by national consultants (ERMC and NEST JV). Figure 2.2.23 shows the target area of the proposed new development – a boundary is highlighted in red. Figure 2.2.24 is the base map prepared with various topographic features after ground verification using high resolution aerial imagery and field visit surveys. The map contains topographic features including land cover, hydrography, facilities and man-made structures like high transmission line.

Source: KVDA (2019)

Figure 2.2.23 Proposed New Development Area in the South



Source: KVDA (2019)

Figure 2.2.24 Base Map in South of Araniko Highway

2.3 Institutional Organization

2.3.1 Public Sector

The public sector has limited or insufficient roles in planning, monitoring and regulating urban transport services. As reviewed in the previous section, the inefficient public institutional structures resulted in uncoordinated patchwork of plans and projects. The public sector can be largely classified into two groups: (i) road and traffic sector and (ii) public transport sector.

(1) Road and Traffic Sector

Generally, the road network in Kathmandu Valley is classified into two categories: SRN (Strategic Road Network) and LRN (Local Road Network) depending on the jurisdiction of administration bodies. The Department of Roads (DOR) under the Ministry of Physical Infrastructure and Transport (MOPIT) is responsible for SRN. The Department of Local Infrastructure Development and Agricultural Roads (DOLIDAR) and the local bodies (DDCs, VDCs and Municipalities) under the Ministry of Federal Affairs and Local Development (MOFALD) have the overall responsibility for LRN. This study focuses on SRN or a network of national highways and feeder roads.

1) Ministry of Physical Infrastructure and Transport (MOPIT)

The MOPIT has three departments, namely DOR, Department of Transport Management (DOTM) and Department of Railways (DORW). The jurisdiction of transport infrastructure is limited to land transport. In 2017/18, the budget allocated to MOPIT was NPR 96.6 billion[26], which is about 7.6% of national total budget. MOPIT aims to promote “infrastructure development for national integration, socio-economic development and peace”. The mission of MOPIT is to enhance the economic and social development of the whole country through the development of infrastructure and to promote the evolution of Nepal.

2) Department of Road (DOR) under MOPIT

The DOR is the responsible authority of SRN which consists of national highways and feeder roads including primary, secondary, and strategic urban roads. To develop, expand and strengthen the road network in a sustainable way for enhancing the nationwide socio-economic development, DOR sets its objectives as below:

- To maintain road network effectively and efficiently;
- To provide access to all District Headquarters to strengthen social, economic and administrative linkages;
- To improve existing access to District Headquarters for safe, reliable and cost-effective travel;
- To develop roads to supplement the Poverty Reduction Program;
- To develop and expand the existing SRN to facilitate effective and efficient movement of goods and services and to foster economic growth;
- To develop and adopt cost-effective measures by initiating innovativeness in road pavement and bridge design;
- To develop roads to support other infrastructure development and to link areas of significant social and economic importance; and
- To encourage private sector participation in the development, maintenance and management of roads

[26] https://mof.gov.np/uploads/document/file/Budget_Speech_207475_20170530011441.pdf

3) Department of Traffic and Transport Management (DOTM) under MOPIT

The DOTM was established in 1984 to manage vehicles plying the road network. The functions of DOTM are specified in the Vehicle and Transport Management Act (1992) and Regulation (1997). Based on the act and the regulation, DOTM issues road permit for public vehicles (passenger/goods), registers new vehicles, issues driving licenses, renews and cancels driving licenses, and regulates tariff on public vehicles together with introducing many other safety measures for safe travel. DOTM has 14 zonal offices (3 offices in Bagmati Zone) throughout the country. DOTM has failed to manage the transport operation effectively due to lack of knowledge and enforcement which has led to increased ownership of private vehicles thus increasing traffic congestion in Kathmandu Valley.

4) Roads Board Nepal (RBN)

The RBN was founded in 2001 with the objective of providing a sustainable fund for the planned maintenance of the road network in Nepal. It is a self-governing, self-sustaining and organized institution based on Public Private Partnership model. RBN mobilizes resources for maintenance directly from road tariff and indirectly from fuel levy, and vehicle registration fee from the government together with donor and government fund for road maintenance based on the agreement. The objective of the planned maintenance of road is to preserve the road asset and keep the existing maintainable road in serviceable condition, reduce vehicle operating cost and provide comfort to road users to facilitate the socioeconomic growth of Nepal. The main functions of RBN are to collect the fund from the Roads Board Act and manage the fund for maintenance; allocate the fund to road agencies (DOR, DDCs, VDCs, Municipalities) for maintenance of road; and monitor and improve the system for better management of the road network.

5) Metropolitan Traffic Police (MTP) under MOHA

The MTP is a branch of Nepal Police (NP) under the Ministry of Home Affairs (MOHA), which is responsible for traffic management by enforcing the traffic rules and regulations, in coordination with the Department of Traffic Management (DOTM). There are 1,420 traffic police officers in Kathmandu Valley. MTP is divided into 13 sections comprising of 40 units. Each unit is specifically appointed to a police station.

Manual traffic control is the MTP's key task to alleviate congestion and facilitate the flow of traffic. On average, five police officers are deployed at each intersection. Their duty starts at 6am and ends at 8pm, and hours are allocated by three shifts. With the increasing number of vehicles and motorcycles, traffic management has become a challenging task. As the implementing agency of traffic control, MTP has identified three priority areas to alleviate traffic problems described under Section 2.2.2.

- Pedestrian traffic management by installing traffic lights
- Junction (intersection) management by road construction/expansion.
- Parking management through P&R.

(2) Public Transport Sector

There are two organizations related to public transport, namely the Department of Traffic and Transport Management (DOTM) and the Department of Railway (DORW). Both organizations are under the Ministry of Physical Infrastructure and Transport (MOPIT).

1) Department of Traffic and Transport Management (DOTM) under MOPIT

The functions of DOTM are specified in the Motor Vehicles and Transport Management Act (1993). Based on the Act, DOTM is responsible for the overall management of transport services, transport policy formulation, transport planning, management and regulations. The main functions of DOTM are:

- To determine the policies and to give necessary direction to persons, firms, companies or organization related to transport services;

- To determine routes and fares for public motor vehicles;
- To determine speed and weight of motor vehicle and the number of passengers to be seated;
- To issue driver and conductor license;
- To implement transport security system;
- To implement road safety audit; and
- To plan electric transport system.

2) Department of Railway (DORW) under MOPIT

The DORW under the Ministry of Physical Infrastructure and Transport (MOPIT) was established in 2012 for the planning of the development of the railway network in the country to meet the growing passenger and freight transport demand. There are no railway engineers, and most of the engineers came from DOR (yet there is still a significant shortage of engineers). DORW functions as a regulatory and oversight body for each stage of planning, construction and operation, with its scope clarified as Railway, Metrorail and Monorail. The supervising authority of urban railway lies in DORW.

DORW's vision is the development and construction of rail network within the country as well as connecting with international networks to contribute to the overall socio-economic development by ensuring safe, affordable, accessible, and reliable rail transportation system. DORW's objectives are:

- To develop, extend and manage railway network effectively and efficiently;
- To enhance socio-economic, cultural and administrative relations between trading center, industrial areas, places of religious values and tourism with the national capital as well neighboring nations with railway networks;
- To provide safe, affordable and reliable passenger rail and freight transport system;
- To encourage Public Private Partnership in the development, extension, operation and management of the railway network;
- To enhance international trade connecting the national railway network to the Trans-Asian railway network;
- To develop, extend and manage ropeway services; and
- To develop, extend and manage cable car services.

2.3.2 Other Institutions in Transport Sector

(1) National Planning Commission (NPC)

The NPC is the advisory body for formulating development plans and policies of the country under the directives of the National Development Council of the government of Nepal. NPC issues periodic plans every three or five years. It serves as the only organization formulating the infrastructure plan even under the changing political system. Currently, the 15th Five-Year Planning Concept Paper is being prepared for the fiscal year 2076/77 (2018/19) – 2080/81 (2022/23). In addition, the NPC is also preparing a 25-year Long-Term Vision of Nepal, with a vision to graduate to a middle-income economy by 2030 and transform the country into a developed nation by 2043[27].

(2) Investment Board Nepal (IBN)

The IBN, established in 2011, is a high-level government body chaired by the Prime Minister. It functions as a central fast-track government agency established to facilitate economic development in Nepal by creating an investment-friendly environment, mobilizing and managing domestic as well as foreign investments. Alongside Prime Minister (Chairman), six permanent members sit in the board, including the following: Minister of Finance, Minister of Industry, Minister of Forest, Vice Chairman of National Planning Commission, Chief Secretary of Government of Nepal, and Governor of Nepal Rastra Bank.

[27] Kathmandu Post. *25-year vision to transform nation in sight*, dated 17 October 2018. http://kathmandupost.ekantipur.com/news/2018-10-17/25-year-vision-to-transform-nation-in-sight.html

The mandates of the IBN focus on medium- and large-scale projects in service industries, including construction (e.g. railways, highways, mega bridges), mines and minerals, tourism and aviation industry. The IBN, based on a decision made by the National Planning Commission, plans to develop a Metrorail system along the East-West Corridor on a PPP scheme. See Section 2.2.2 for more information.

(3) Town Development Fund (TDF) under MOF

TDF is the intermediary financial institution under the Ministry of Finance, first established as TDF Board in 1988 and made as an autonomous entity in 1997. Its primary function is to mobilize resources and finance basic infrastructures for municipalities using blended finance options available locally and internationally. TDF's annual capital investment – combining inter-governmental fiscal transfers, municipal own revenue and TDF financing (e.g. World Bank, ADB) – amounts to NPR 32 billion.[28] TDF has shifted an investment focus from rural to urban due to ongoing rapid urbanization and the influx of population. However, funding is not sufficient to keep up with the demand; about 1.9 trillion is needed annually to meet 60% of urban infrastructure needs.

TDF's specialty lies in procurement management[29], on/off lending to municipalities and project management. In this regard, TDF can be an intermediate funding institution for JICA two-step loan for developing basic infrastructures of municipalities, such as a small-scale intersection improvement packaged loan. In addition, TDF also undertakes project appraisal process to assess the project in terms of its technical soundness, economic viability, financial feasibility, etc. TDF also supervises the procurement and implementation process, but most are done by hired consultants.

TDF has a special fund called the Revolving Fund for Transport (RFT). TDF aims to expand the fund by investing the recovery of KSUTP's S5 in other projects. Though the current share of RFT consists of loans (80%) and grant (20%), TDF is requesting the federal government to access other sources. The current available amount is USD 7 million (USD 1.1 million in grant) as of February 2019.

For the KSUTP project, TDF provided USD 3.8 million in the form of loan and grant funded by ADB and Green Environmental Facility[30]. The funding was provided for project design, bus facilities and equipment[31] and bus fleets. For the first procurement of 17 new vehicles (EURO 4, medium-size diesel vehicles), TDF gave a low interest rate with a 5% interest for 8 years. See section 2.2.2 for more details about KSUTP.

(4) Provincial Government

In line with local governance restructuring, the state level government (Province No. 3 in Kathmandu Valley) is due to be established around mid-2019, according to the Kathmandu Valley Development Authority[32]. Full details are not yet known, though some 17,000 public servants will be allocated from the central government to Province No. 3.

(5) Kathmandu Valley Development Authority (KVDA), MOUD

KVDA was established in 2012 under the Ministry of Urban Development (MOUD) in accordance with the Kathmandu Valley Development Act, 1988. KVDA is mandated to prepare and implement an integrated physical development plan for Kathmandu Valley. Neither government agencies nor donor partners are necessarily well-coordinated in urban planning, resulting in the duplication of projects and roles as well as inefficient use of limited resources. The creation of KVDA was intended to integrate fragmented development and control development as one administrative system in Kathmandu Valley.

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28 Town Development Fund, *2016-17 Annual Report: 30th Anniversary Publication 2018*, February 2018.
29 TDF's funding process is as follows: municipalities submit proposals to TDF; TDF seek technical advice to (international) consultants; after reviewing with municipalities, TDF decide on funding modalities
30 A partial amount was not used as S3 route didn't take place.
31 Regarding procurement of bus facilities/equipment, e-payment system was provided by N Clouds; GPS system by Technology Sales (RamLaxman); Communication equipment by Decade International Pvt. Ltd.; and Bus fleets by TATA. TDF and its PM
32 Meeting with Mr. Bhagawat B. Khokhali, KVDA on 3 February 2019.

The newly created organization still needs capacity development both in terms of human resource and technical capacity. Currently, KVDA has three internal structures: (i) Head Office chaired by a politically-appointed Development Commissioner; (ii) Deputy Commissioner; and (iii) District Offices for Kathmandu, Lalitpur, and Bhaktapur, each chaired by a District Commissioner. KVDA covers a total area of 720 sq. km across 18 municipalities.

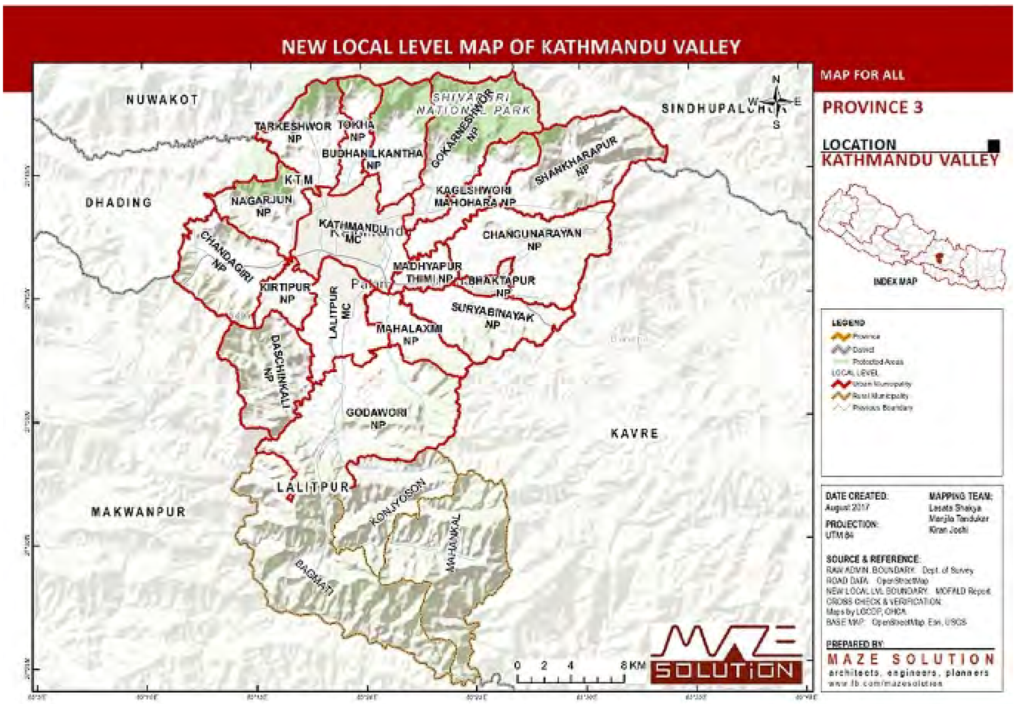
The KVDA is responsible for the land acquisition of the road widening program in the Valley in cooperation with DOR. For instance, the implementation of the Outer Ring Road applied the land pooling system. However, the capacity for planning and designing of the road facility is limited to KVDA and a strong support from DOR might be required.

(6) 18 Urban Municipalities in KV

There are 18 municipalities in Kathmandu Valley, which has the autonomous administration for public services. The largest is Kathmandu Metropolitan Council (KMC) with more than 1 million population in its boundary. There are two neighboring cities adjacent to Kathmandu: Lalitpur to the southeast, and Bhaktapur to the east. The basic role of municipalities in road transport is to develop and maintain the district road, which is specified as less than 7 meters in width. KMC is involved in the following activities related to traffic management:

- Management of roadside parking: identification of installation site, management of parking space, collection of parking fee
- Penalty and control illegal parking (in cooperation with the Traffic Police)
- Installation of traffic signals
- Cooperation with Traffic Police and DOTM

It should be noted that there are three districts, another administrative level between the Province and Municipality, but it is not important in urban and transport planning.



Source: JICA Study Team

Figure 2.3.1 18 Urban Municipalities in KV and its Boundary

1) New Mayors and Mayor's Forum in KV

After the federalization process and election in 2017, 18 new mayors – who presented strong interests in transport facilitations in their manifesto – were elected through the public voting. The Mayor's Forum, comprised of 18 urban municipalities in Kathmandu Valley, are held regularly to discuss mutual interests such as transport, heritage, cultural activities, environment. The Mayor's Forum suggested the BRT installation along the Ring Road Corridor in KV, and Town Development Fund is also supporting its activities.

2.3.3 Private Sector

Due to the absence of an effective agency for planning, monitoring and regulating transport services, the private sector has played a key role in providing transport services. Yet the transport industry is highly fragmented, marked by dominance of paratransit operators[33]. Operators are trapped in a minimum-cost, minimum-quality equilibrium of poorly maintained small vehicles, fragmented ownership, with access to routes and terminals controlled by illicit groups. Despite the challenging operating environment, there are positive signs of transport development driven by the private sector, particularly in the area of information and communication technologies (ICT).

(1) Transport Operators

1) Sajha Yatayat (Bus Operator, Semi-Public Cooperative)

Sajha Yatayat is a hybrid public cooperative (semi-public company) established in 1960s, but regenerated and reorganized in 2010s. It is owned by public shareholders comprised of Kathmandu Metropolitan City (30%), government agencies (69%) and the remaining 1% by its members, including drivers and conductors. All shareholders are equal, each with one vote for decision-making on the board. There are 7 board members at present, with two from government. Sajha suffered institutional turbulence and restarted its bus operation in 2013/14 with 16 buses. It now owns 51 diesel buses with 8 routes (trunk) in operation and plans to get 20 more diesel buses from India and 20 electric vehicle (EV) buses.

The company's vision is to become the most innovative player and leader in the bus industry to set bus standards (e.g. operating system, staff benefits, specification, facilities for persons with disability). Institutional management has been a weakness due to various factors including fare rates set by the government, night-time operation, provision of standard benefits such as salary for its employees/drivers in accordance with laws (unlike other operators). It still faces difficulty to sustain its operation. Sajha has requested municipalities to invest in its operation/maintenance (therefore, KMC has 30% share).

Sajha has several plans to modernize the bus business through the following: (i) install IC card payment system (e.g. n.Cloud); (ii) integrate the GPS location system with the IC fare collection system; and (iii) replace existing diesel vehicles with EV buses. These will make the bus operation more efficient and cost-effective such as by cutting 40-50% of the operation cost coming from diesel cost.

2) Digo Sarbajanik Yatayat (Bus Operator, New Private Company)

Digo Sarbajanik Yatayat is a newly established bus operating company after the consolidation of 66 individual transport operators as part of the KSUTP's bus restricting project[34]. Digo considers the company establishment as "not bad", partly because drivers used to receive payment on a daily basis (now monthly salary). On the other hand, the public gave positive feedback for better services, spacious fleet and comfortable ride experience. Digo operates along S5 route with 17 medium-sized diesel buses. There are 20 drivers paid by monthly salary. There are no competitors (except several individual

[33] small vehicles, owned by individuals, loosely organized into route associations, permissive licensing with no service obligations.
[34] The Mayor of Kathmandu Metropolitan City was directly involved in its establishment. The Mayor, together with DOTM, promoted the consolidation and modernization of the bus system.

operators) and thus Digo is able to operate on farebox revenue (without any subsidies). Diesel fuel costs weigh about 30% of the total cost. The company plans to procure more (bigger) buses to optimize its operation and reduce cost.

3) Transport Associations (Groups of Individual Bus/Tempo Operators)

The Federation of Nepalese National Transport Entrepreneurs (FNNTE) estimates that it has 100 affiliate associations in Kathmandu Valley and represents the operators of 300,000 vehicles in Nepal. These associations effectively manage access to route permits and terminal space. Since DOTM only endorses agreements reached at operator level enabling cartels to develop, no vehicle could be granted a route permit without the approval of the associations.

Following a militant action by some route associations to obstruct competition from other operators, most recently from big buses, the government announced in 2018 that the route associations would be abolished and all operators would need to form and register companies or cooperatives within the current fiscal year (i.e. Company Act). However, with the exception of the Public Transport Restructuring project on route S5 in KSUTP, the government has not taken measures to impose effective regulation to replace the functions carried out by the associations such as scheduling departures and managing the numbers of vehicles on a route.

4) Taxi

There are 10,465 registered taxis plying in Kathmandu Valley which belong to Nepal Meter Taxi Entrepreneurs' Association (NMTEA). Taxis operate based on the routes and fare structures administered by DOTM. The taxis industry currently faces several issues in the midst of changes in urban transport sector.

Passengers complaining of drivers overcharging is common along major roads. According to NMTEA Chairperson Arjun Gautam, overcharging is a result of non-operating meters[35] and unrealistic fare structures. Fare machines with receipt printing capabilities were installed on 8,500 taxis in 2017, most of which were currently out of function. NMTEA blamed the quality of machines, while the government (i.e. Nepal Bureau of Standards and Metrology) sees it as the driver's negligence to fix nonfunctional machines.

The setting of taxi fares is a contested issue between the taxi drivers and the government. An alliance of taxi drivers is demanding a fixed fare for routes less than three kilometers to rationalize the taxi businesses. The government (i.e. MOPIT) has not considered this possibility, but is working on fare adjustments that are incremental based on components including consumer price index, fuel prices, growing maintenance expenses and staff salary[36].

The entire taxi business is also affected by the emerging ride-sharing services offered by Tootle and Pathao. NMTEA Chairperson sees these transport services as illegal. The DOTM is currently deliberating whether or not to allow motorcycles to function as public transport[37].

5) SAFA Tempo

Background

SAFA Tempo is the term for three-wheeled electric vehicles (EV) made in Nepal, which were converted from the conventional diesel-powered vehicles under the support of USAID in the 1990s. SAFA Tempo

35 https://kathmandupost.ekantipur.com/news/2018-07-26/forum-chairman-blames-mediocre-printers-for-taxis-not-giving -receipts .html

36 https://thehimalayantimes.com/business/govt-preparing-to-hike-taxi-fare/ http://kathmandupost.ekantipur.com/printedition/news/2019-03-07/kathmandus-taxi-drivers-say-the-meter-fare-is-killing-them .html

37 http://kathmandupost.ekantipur.com/news/2019-01-15/in-cracking-down-on-ride-sharing-apps-nepals-government-sides -with-taxi-operators.html

is suitable for Kathmandu Valley where the road is narrow and inconveniently crowded. More than 100,000 passengers use SAFA Tempo daily. It uses electricity to power a motor, thus it achieves "zero carbon dioxide emissions". While being environmentally friendly and a sustainable means of transport, it also contributes to generating local employment and plays a major role in the social advancement of women's drivers and promotion of gender equality. Table 2.3.1 shows an overview of its operation.

Table 2.3.1 Overview of SAFA Tempo

Number of Tempo EVs	700
Routes	12
Charging stations	32
Female employees	1,500 (500)
Maximum carrying capacity	12

Source: JICA Study Team

<u>Technology</u>

Battery: SAFA Tempo is equipped with a DC motor with variable speed and power, powered by a 72 V battery pack made up of 12 batteries. The DC motor is controlled by a simple electronic control device. On a full charge, it can cover up to 65 km. The battery uses lead batteries manufactured by Trojan of USA. A set with 12 batteries costs USD 1,300, and the battery life is about 3 years. The battery quality has deteriorated in recent years, although the price has not changed. In effect, the battery life has been shortened to less than one year, which raises the operational cost. Currently, the SAFA Tempo organization is considering changing to lithium batteries. Ongoing discussions with Trojan and Chinese companies have not seen fruitful results yet.

Vehicle: Nepali manufacturers assembles imported parts from India (car body) and USA (electric parts) and produces e-vehicles in Kathmandu. The average life expectancy of existing vehicles is older than 20 years. The government recently increased the ban time of tempo vehicles from 20 to 30 years. SAFA Tempo organization is considering upgrading from three-wheeled vehicles to four-wheeled vehicles.

GPS Technology: RamLaxman is promoting GPS installation on bus for the purpose of GPS bus management and location system construction. SAFA Tempo also installed a GPS device as a trial for five units for the purpose of monitoring the number of operations.

<u>Organization structure</u>

There are three associations in the tempo industry: Route Association (12 in total, 1 for each route); Entrepreneur Association (12 in total, 1 for each route); and Charging Association (32 in total). A representative for the Entrepreneur Association (only tempo owners are eligible) is elected every 3 years by tempo owners. Following the recent change on the Company Act, those general associations are required to terminate and be corporatized.

(2) IT Entrepreneurs

1) RamLaxman Pvt Ltd (MaaS Provider)

RamLaxman is a R&D hardware development company (with about 40 staff) owned by two brothers, Ram and Laxman Rimal. It started in late 1990s when the brothers started electronic hardware development and IOT focusing on security. The company owns RamLaxman Innovative and provides the GPS tracking services for buses including Sajha Yatayat. In addition, RamLaxman provides several transport mobile apps in Nepal (e.g. LetzGo, Mera Sajah, GPS Nepal).

The company has been active in the transport sector since 2005 when it launched the GPS tracking service for private vehicle users. In 2015, it extended the service to public vehicle operators. Currently, the GPS is installed on 700 buses, 20 school buses, and 7 ambulances (Dhulikhel Hospital) free of charge (to spread the services to wider users). In addition to GPS, Ramlaxman developed a prototype of bus location and on-board announcement system, which was installed on 46 Mahanagar buses, as well as a special bus location app for Sajha Yatayat. For the return on investment, Ramlaxman is negotiating with other bus operators to install an on-board announcement system (on which Ramlaxman can place advertisements) and a cash collection machine (from which Ramlaxman can receive commission fees). Furthermore, Ramlaxman is currently discussing with municipalities in Kathmandu and Patan to install more than 100 sets of real-time digital information board at bus terminals and major bus stops. If the negotiations turn out well, this will be a PPP project.

Leveraging its technology, Ramlaxman aims to contribute to traffic accident reduction (though speed monitoring system). The company is also keen on changing the travel behaviors of the public by promoting social awareness programs using on-board advertisements. With its unparalleled technology and considering all of its investments, the company envisions becoming a major player in Nepal's public transport sector in the next few years.

2) n.Cloud Pvt Ltd (Bus Fare Collection Solutions Provider)

n.Cloud is a pioneer in the development of the IC card payment system in Nepal. The company developed the first prototype devices with limited functions (i.e. in comparison to the IC card) on Sajha Yatayat buses. Digo Sarbajanik Yatayat will be n.Cloud's second client. At present, daily cash transaction and ticketing is handled by conductors before boarding which is a common practice in Nepal. This conventional payment transaction raises concerns regarding fare evasion. According to the CEO of n.Cloud as well as Digo, daily fare losses amount to 20% of the total fare revenue. The IC card payment system is expected to minimize fare evasion, though there is no target date for the official launch of IC card payment services. Kathmandu Metropolitan City is also pushing this initiative into practice.

3) Ride-hailing services: Tootle and Pathao

Tootle and Pathao are motorbike ride-hailing service providers using their smartphone-based apps in Nepal. Tootle, operated by Hyperloop Nepal Pvt. Ltd, is solely Nepali-based and started its services in 2017. The other one, Pathao, is headquartered in Bangladesh with US investors and joined the market in 2018. They have a user base of 450,000 active clients in Kathmandu. Together, they have 26,500 registered motorcycle drivers, and 8,000 trips are made daily (average NPR 100 per ride).

According to local news[38], these companies have recently come under scrutiny for lack of regulations, tax filing issues, privacy and security compliance, and road safety and insurance. In response to their popularity among the public users, DOTM will not ban the services; instead, DOTM plans to introduce the new law with provisions for ride-sharing and directives to regulate the services, which will be effective on April 14.

2.3.4 Development Partners

(1) Japan International Cooperation Agency (JICA)

Since 1990s, JICA has conducted various urban transport studies, including road and bridge construction and intersection improvement. Intersection improvement has been a core JICA activity for the last three decades.

- Project for the Reconstruction of Bridges in Kathmandu (1989-93)
  - Bridges in the city were constructed between 1993-95 under the grant. Further improvements were made to the north-south corridor in 1995-97, including the construction of a new Bagmati bridge and geological design adjustments to Thapathali intersection.

[38] http://kathmandupost.ekantipur.com/news/2019-02-01/ride-sharing-services-ridden-with-issuesfrom-safety-and-insurance-to-privacy-compliance.html

- Project for the Improvement of Intersection in Kathmandu (2000-02)
  - JICA provided the grant to improve 10 intersections in the city and carried out the basic design study and implementation of intersection improvements, including traffic lights.
- Project for the Improvement of Kathmandu-Bhaktapur Road (2006)
  - JICA provided the grant to expand the width of a 10km road between Tinkune and Jadibuti intersections. The 2015 earthquake caused critical damages to this road section.
- Project on Urban Transport Improvement for Kathmandu Valley (2012-2017)
  - This basic study was conducted in 2012 to collect a large-scale transport data (including households surveys), which was used as the basis of the 2017 Comprehensive Transport Master Plan.

Until 2012, JICA studies were mainly focused on a single intersection improvement. However, the Comprehensive Urban Transport Master Plan, formulated in 2017, shifted the focus to an integration of public and private passenger transport, as envisioned in the key strategies of the JICA MP, such as continuous-flow intersection improvements, corridor developments and integration with AGT plans.

1) Cooperation Volunteers and Senior Volunteers (JOCV and SV)

Under its scheme for Japan Overseas Cooperation Volunteers (JOCV) and Senior Volunteer (SV), JICA dispatches traffic control advisors to Kathmandu and Pokhara municipality. It is expected that JICA is going to dispatch a SV to Kathmandu Traffic Police.

(2) Asian Development Bank (ADB)

Since 2010, ADB has been involved in urban public transport improvement and produced a series of KSUTP studies (see Section 2.2.1). The objectives are twofold. The first is to identify an appropriate mass transit system on a selected corridor for first implementation (2025). The second is to restructure the fragmented bus industry by implementing a pilot project to replace small paratransit vehicles with large buses on Route S5. The latter is perceived to be a success as it eliminated the syndicates and benefited the public in terms of service levels and better transport vehicles.

(3) World Bank (WB)

The World Bank published the Country Partnership Framework[39] covering the five-year period of 2019-2023. In the transport sector, much of its financing focuses on road and air transport connectivity, particularly for cross-border movement of people and goods with neighboring countries like India and China. The World Bank recognizes inefficient and low public investment as a major constraint in the sector. The Nepal Development Update[40], published in November 2018, noted that: “The transport sector is characterized by a lack of prioritization and planning of projects, inefficiency created by the problematic relationships between the private and public sector, and an overall lack of capacity.” Institutional and policy reforms to improve investment efficiency in the sector is a key challenge for all development partners, according to the World Bank.

2.3.5 Others (International Organization, Academic and Civil Organizations)

(1) Global Green Growth Institute (GGGI)

GGGI (HQ: South Korea; Chairman: Ban Ki-moon) is a treaty-based international organization that focuses on research and project preparation to promote green growth plans such as electric vehicles (EV).

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39 World Bank. *Country Partnership Framework*. July 2018. http://documents.worldbank.org/curated/en/998361534181363354/pdf/Nepal-CPF-v08-07-18-Master-Copy-08092018.pdf
40 World Bank. *Nepal Development Update*. November 2018. https://openknowledge.worldbank.org/bitstream/handle/10986/30617/NepalDevUpdate-Nov2018.pdf?sequence=1&isAllowed=y

It functions as a think tank on EV promotion in Nepal. Working under the overall direction of the Ministry of Forests and Environment and in partnership with MOPIT, GGGI has been active in Nepal since 2017 when the company launched the National Action Plan for Electric Mobility[41] to support the transition towards clean and sustainable transport.

GGGI's EV promotion activities focus on four outputs: (i) provide technical assistance (simple cost-benefit analysis) for bus operators to convince the government to fund EV buses; (ii) establish National Electric Mobility Fund with GIZ, supported by Swedish and German government; (iii) establish a dedicated electric mobility unit at federal level; and (iv) establish a national program for electric mobility.

(2) Academics

In Nepal, there are two universities offering graduate courses in transport planning and engineering: Tribhuvan University (TU) and Pokhara University (PU). TU accepts up to 20 students per year, and PU accepts about 30 students. Most graduates from these courses are employed by the DOR.

(3) Volunteer Groups for Traffic Safety

About 40 individual volunteers carry out traffic safety activities at major intersections during peak hours, in collaboration with the Traffic Police. Activities are left to the discretion of individual volunteers (not as a group). Some have worked for four days a week since 2007. The traffic volunteer system was established in 2015 and an ID is now issued to them by the Traffic Police.

During the data collection study, a number of senior Metropolitan Traffic Police (MTP) officers brought up the name of a senior JICA traffic volunteer, Kiyoshi Baba. He is considered as the father of traffic management and safety in Kathmandu when he introduced the Japanese experience to MTP in 2000s. His contributions include the establishment of median on busy roads and the handing out of white gloves to traffic police officers on the ground (provided by Mr. Baba out of his own pocket money). Since his departure, JICA has continuously sent senior and young volunteers for traffic management and safety assistance.

[41] This program was initially launched by Prime Minister with a cabinet support and policy decision to get 300 EV buses.

CHAPTER 3 CHALLENGES AND STRATEGIES

3.1 Introduction

Section 3.2 identified five major challenges through data collection in Sections 2.2 and 2.3 in the previous chapter. The Section 3.3 reviewed the present status of project holistically and revealed viable approaches to tackle the challenges in the short, medium, and long time period.

Section 3.4 explained the macroscopic network analysis on traffic congestion, a long-standing urban transport issue which is increasingly posing a serious threat to people in Kathmandu Valley. The analysis identified traffic bottlenecks in the road network of the valley, as well as viable improvement measures to achieve smooth and seamless urban transport in the near future.

3.2 Development Challenges

During the first field visit in January/February 2019, the JICA Study Team had more than 20 interviews with various stakeholders, including public and private, as well as development partners and local institutions. The Team identified five core challenges in the urban transport sector in Kathmandu Valley.

(1) Traffic Congestion

According to the JICA MP (2017), with rising population growth, the number of registered vehicles including motorcycles increased from 150,000 to 570,000 in the last 10 years (2001-2011), resulting into traffic congestion in the city. Although the latest data was not available for this study, with the increasing population, traffic congestion will pose a serious threat to the livelihood of people in the Valley, if left unattended. The government of Nepal is striving to relieve traffic congestion through improvement of the road network including widening of the Ring Road, the traffic infrastructure is still insufficient to cope with the ever-increasing traffic volume.

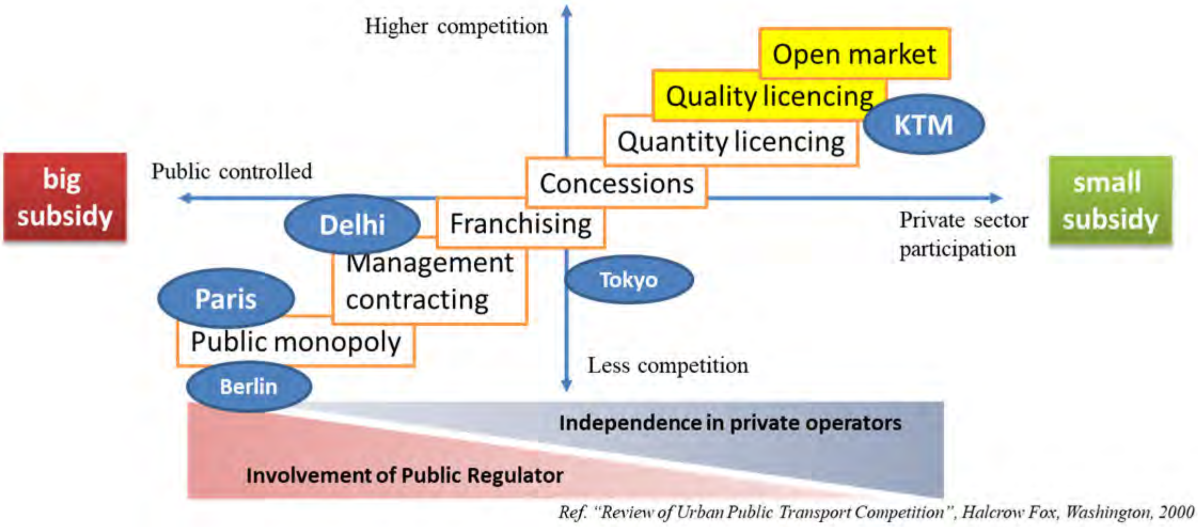
1) Population Growth and Transport Demand in East of Kathmandu

As reviewed in Section 2.2.2. (7), the planned urban developments will generate an influx of population to the eastern side of Kathmandu. Bhaktapur, where two conceptual plans are being formulated, will have a population increase of over 2 million by 2030. This will result in the increase of transport demand and the resulting traffic congestion within the planned sites as well as between the East region and Kathmandu. However, the Araniko Highway is the only available transport option between the East region and Kathmandu, creating many congestion points along the highway, especially at Koteshwor intersection. To accommodate future demand for transport and alleviate traffic congestion, there is an urgent need to make physical intersection improvements (e.g. Koteshwor) coupled with development of urban railway system.

(2) Inefficient and Unreliable Public Transport

1) Unregulated Competition in the Market

The transport market and the existing services in Kathmandu are generally driven and served by the private sector, including major bus operators (e.g. Sajha Yatayat) and minor transport syndicates. This results in unregulated competition in the market. Figure 3.2.1 shows a diagram of the characteristics of the bus operating environment measured by competition and governance. Regulation on bus services in Kathmandu is weak. DOTM’s functions are limited to the regulation of safety requirement and fare structure. In other words, Kathmandu’s operating environment sits between “Open Market” and “Quality Licensing” in the diagram. Other cities tend to have a stronger involvement of the public sector (less independence of private operators) with more subsidy[1]. The private bus operators in Kathmandu can sustain their business without any subsidy despite operational issues such as fare evasion, high diesel cost and low fares.



Source: *Review of Urban Public Transport Competition*, Halcrow Fox, 2000, modified by JICA Study Team

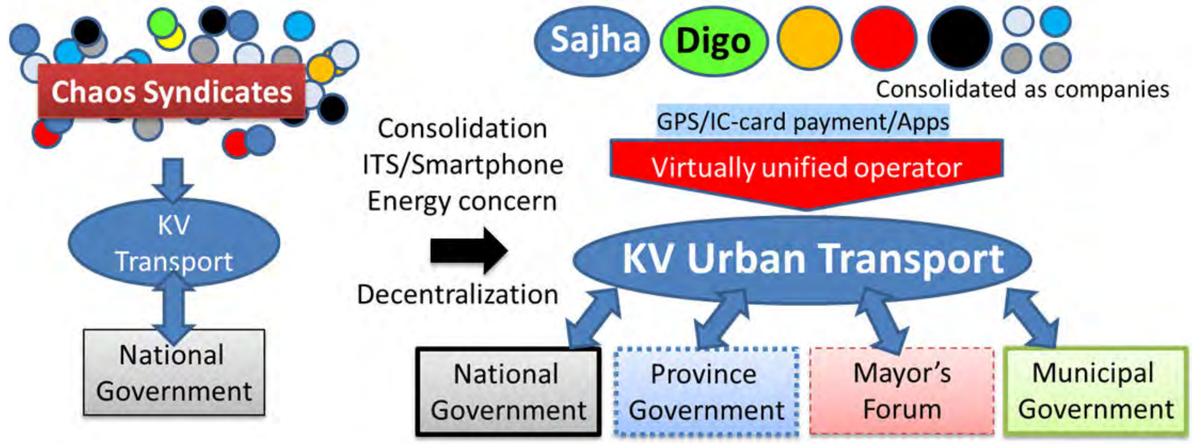
Figure 3.2.1 Urban Public Transport Competition and Regulation

2) Gap between Private Consolidation and Governance Decentralization

Figure 3.2.2 summarizes both trends of transport service market and governance in Kathmandu Valley. Before the restructuring of local bodies, the transport market was supported by the national government with little regulation, and private individual operators under syndicates provided chaotic services.

After the federalization and restructuring, dozens of unorganized, individual syndicates were consolidated into several companies such as Digo and Sajiha. This consolidation came along with the modernization of vehicle fleets and the installment of new IT system such as GPS services. Private sectors are increasingly playing a vital role in the transport market as they are in the stage of developing a digital platform, e.g. MaaS applications, that will provide efficient IT tools with optimized transport services to the public. In contrast, the newly established federal government still takes a top-down approach and is fragmented, with little coordination between ministries. In effect, local governments do not have adequate authority and resources over the decision-making process regarding transport provision.

[1] European cities like Paris and Berlin have a regional transport authority that operates metro/tram/bus services. This tends to be an affiliated entity of municipal government or a group of regional governments. Strong regulations exclude private operators from the market, and the service quality are also regulated by a service contract. This business model requires a large subsidy to sustain operation. The operating environment in Delhi and Tokyo sits between those in European cities and Kathmandu. Bus operation in Delhi has a transport authority, DTC. However, half of the operations are undertaken by private subcontractors. Tokyo does not have a transport authority similar to those in European cities, and this creates a corridor-wise monopoly in which several private operators is common.

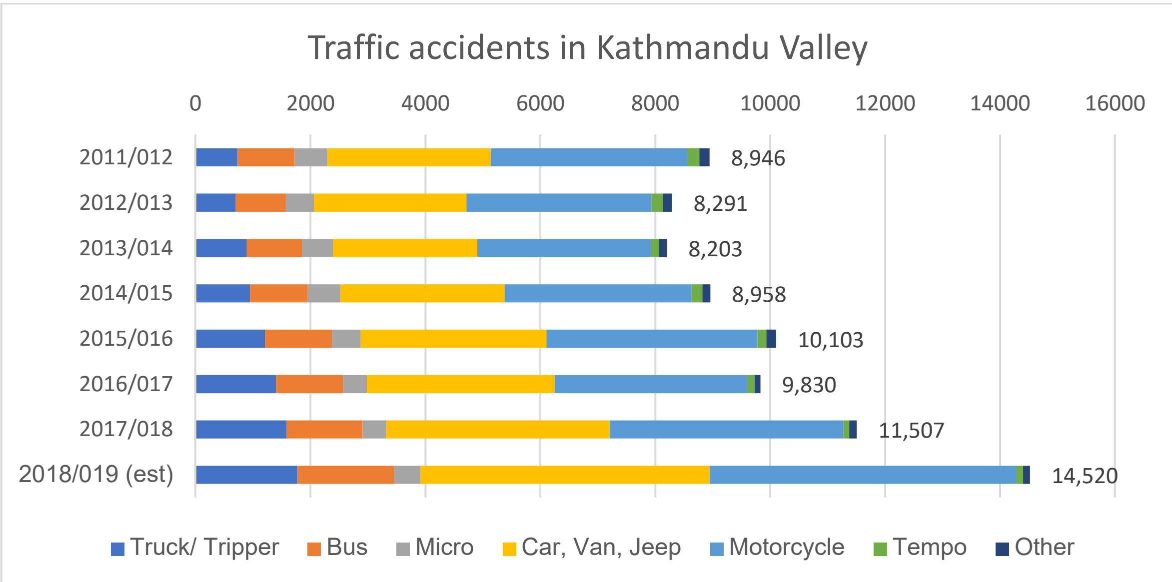


Source: JICA Study Team

Figure 3.2.2 Private Consolidation and Public Fragmentation

(3) Traffic Accidents

Road accidents are on the rise (see Figure 3.2.3). The first six months of the current fiscal year (2018/19) already has a record of over 7,000 accidents in Kathmandu Valley. This indicates that the estimated number of road accidents by the end of July 2019 will reach 14,520. A local newspaper[2] reported a 36% increase in the number of fatal road accidents this year as compared to the previous record. The total number of road fatalities also sees a sharp rise, with a record of 133 deaths in six months, whereas there were 194 victims in fiscal year 2017/18. It is plausible to assume that this fiscal year will record the highest number of road accidents in the latest data.



Source: Metropolitan Traffic Police

Figure 3.2.3 Traffic Accidents in Kathmandu Valley

A reason behind the increasing number of road accidents is the opening of the southern part of the Ring Road, or the newly widened Koteshwor-Kalanki road section constructed by China in late 2018. The Metropolitan Traffic Police Office (MTPO) claimed the roads were built without much attention to safety features, thus is they are considered "dangerous roads".[3] Most accidents in this section occur due to

2 https://myrepublica.nagariknetwork.com/news/valley-roads-claimed-132-lives-in-six-months/
3 https://myrepublica.nagariknetwork.com/news/valley-roads-claimed-132-lives-in-six-months/

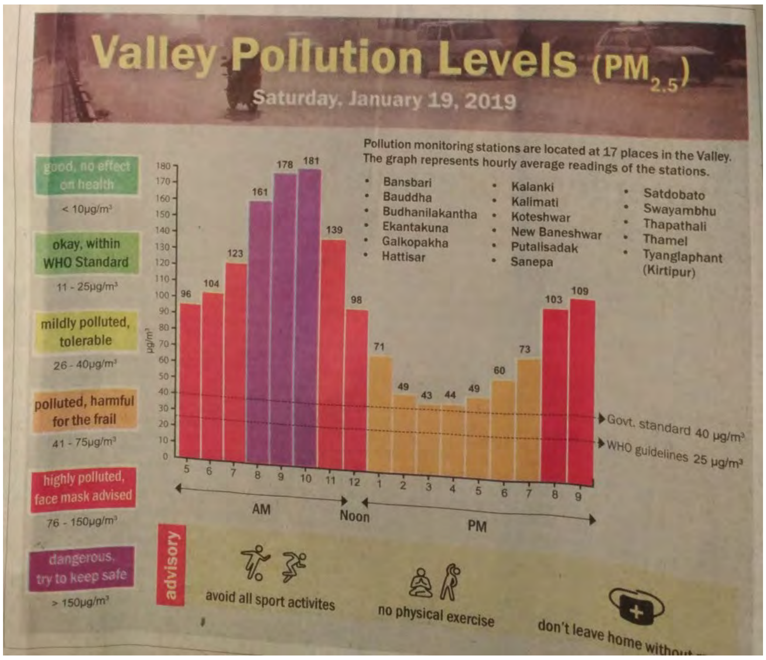
overspeeding. There are no safety measures to control this at present. The road signals are not easy to understand. Overspeeding is often unchecked in this section, highlighting poor traffic control on the ground. In addition, there is lack of safety awareness among the drivers. To address this issue, the MTPO is currently considering introducing a new program to control road accidents.

Road accidents are a major public concern, especially for pedestrians. A local newspaper[4] stated that, according to the MTPO, 40% of the road accidents last year involved pedestrians, mostly fatal accidents. Of the 624 people killed in road accidents, almost half (296) were pedestrians. It highlights that 60% of zebra crossings in Kathmandu Valley are faded and almost invisible, posing a threat to pedestrians crossing the road. Moreover, where there are no zebra crossings, people tend to cross the roads in undesignated areas, which can easily lead to accidents (e.g. Ring Road).

(4) Deteriorating Air Pollution

According to the National Action Plan for Electric Mobility (2018) published by the Global Green Growth Institute, the rapid growth in numbers of automobiles and motorbikes increased greenhouse gas (GHG) emissions, which grew by 22% during the period of 2007-13. Deteriorating air quality causes over 9,000 deaths per year in Nepal. There is also an adverse impact on the economy, amounting to a loss of welfare of USD 2.8 billion. In a bid to solve this acute problem, the government is committed to "decrease the rate of air pollution through proper monitoring of sources of air pollutants like wastes, old and unmaintained vehicles, and industries" as declared in Nepal's Nationally Determined Contribution (NDC) Target 4.

Figure 3.2.4 shows a graph with pollution levels data published in a daily local newspaper. The morning period from 8-10am is the most polluted or "dangerous" time of the day, as the newspaper advised the public to wear a mask outside and refrain from doing any outdoor activities. It is alarming that the pollution levels exceed the national standard, let alone the WHO guidelines, at all hours of the day.



Source: Kathmandu Post

Figure 3.2.4 Pollution Levels in Kathmandu Valley Published by a Local Newspaper

4 http://kathmandupost.ekantipur.com/news/2019-01-20/with-60-percent-zebra-crossings-faded-pedestrians-at-risk-of-being-run-over.html (This link has been expired)

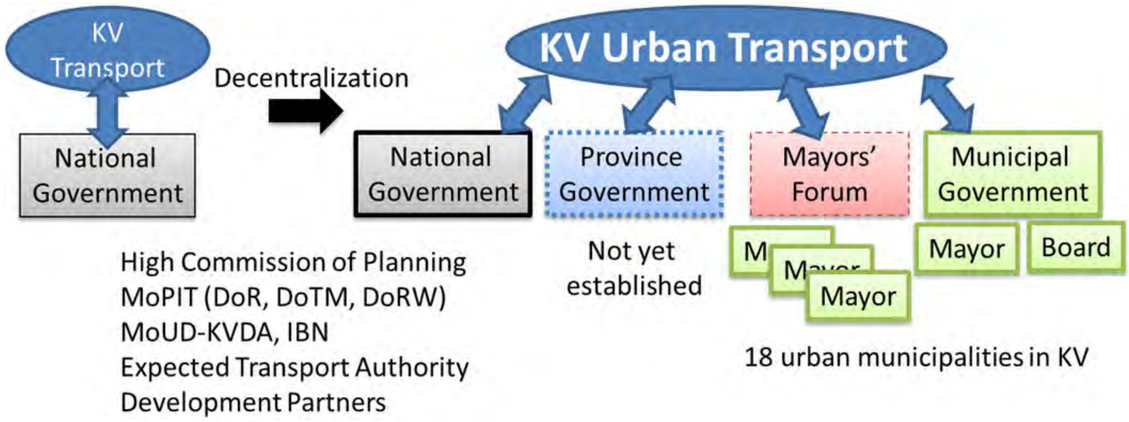
1) Promotion of Electric Vehicles

In response to this urgent challenge, the Prime Minister of Nepal, with support from the cabinet, launched the National Action Plan for Electric Mobility in 2017 to accelerate the transition towards clean and sustainable transport using electric vehicles (EV). In NDC, the government targets to increase the share of electric vehicles up to 20% by 2020. Driven by this target, the government announced to introduce 300 EV buses for public transport[5]. Both public and private sectors plan to install charging stations across Kathmandu.

Also, as part of the Lumbini International Airport Project (LAP) with funding from ADB, ADB procured 5 EV buses for airport transit which were to be operated by Sajha Yatayat. Since the LAP was not ready upon arrival of buses, Sajha agreed to operate them through a memorandum of agreement with Lumbini Development Trust. However, due to the delay in government decision-making, the procured EV buses and a ready-to-use charging station are still not in operation as of February 2019.

(5) Institutional Restructuring toward Multi-level Governance

Institutional restructuring for better transport governance is underway. Until 2017, the national government was the single authority to plan, manage and monitor all infrastructure projects in Kathmandu, headed by the National Planning Commission. However, after the 2017 restructuring, the government transitioned itself from a single-tier authority to a new three-tier government structure, comprising the federal government, province[6] and municipality. For Kathmandu Valley, Province No. 3 will function at province level, while 18 urban municipality governments have the authority over their municipal areas[7] as illustrated in Figure 3.2.5.



Source: JICA Study Team

Figure 3.2.5 Institutional Movements for Kathmandu Valley Urban Transport

However, the recent institutional reform has not yet resulted in the envisaged establishment of an efficient and effective administrative structure. A gap in policy and investment decisions under the new government structure is clear in the planning process of railway proposals. In other words, existing various railway plans underline a weak institutional framework, coupled with poor and ineffective coordination. Some plans, such as MOPIT and IBN, originated from high-level government decisions in coordination with development partners, while the municipality's monorail proposal is largely supply-driven without reflecting the actual needs and demands of the local conditions.

5 http://kathmandupost.ekantipur.com/news/2018-12-27/government-to-purchase-300-electric-buses.html
6 Province-level government will be established in May/June 2019. A minister in each state will be appointed.
7 There is an administrative level of "district" between the province and the municipality level, but it is not empowered.

1) Proposals of New Authorities for KV Public Transport Sector

According to DOTM[8], the government is currently drafting a bill to create a law to establish the Kathmandu Valley Public Transport Authority. Full details are not yet known.

The National Transport Management Strategy (NTMS) 2013/2070 proposed that local transport issues should be addressed by the Kathmandu Valley Coordination Committee, chaired by the Chief of Kathmandu Valley Development Authority (under the Ministry of Urban Development, not MOPIT) to support the National Transport Authority and to prepare and maintain a Kathmandu Valley Transport Master Plan. Each municipality and district would also have a transport coordinating committee.

The case for transport administration to be carried out at the local level has been strengthened by the enactment of the Local Government Operation Act 2017 which confers responsibility for mass transit policy on local government.

It is widely accepted that the transport network in Kathmandu Valley should be managed as a whole, rather than separately, by the three metropolitan city districts and 18 municipalities which have little capability in public transport management. The Valley includes Kathmandu District, Lalitpur District and Bhaktapur District covering an area of 570 square km, with a total population of about 4 million.

3.3 Strategies for the Kathmandu Valley

Table 3.3.1 summaries the existing development plans and projects across all transport sectors. These are expected to address the core challenges identified in the previous section. However, traffic congestion, one of the most significant problems, still requires further improvement measures to create smooth and seamless road transport network. The next section assesses the existing and future road network using the JICA STRADA Model to identify major bottlenecks in the network.

8 Meeting with Dr. Padma Shahi from DOTM on 20 January 2019

Table 3.3.1 Review of Existing Transport/Traffic Management Approach in Kathmandu Valley

PLANS AND PROJECTS	Status	Time Frame
0. Public Transport Improvement Plan		
0.1 Bus Service Improvement Plan	ADB/KSUTP prepared	--
0.2 Metro Development Plans	FS are under preparation	Long-term
0.3 Trunk and Feeder Public Transport Network	ADB/KSUTP prepared but restructuring scheme can be expanded	Short term
0.4 ITS Application	With private initiatives	Short term
1. Road Network Development Plan		
1.1 Hierarchical Road Network	DOR has initiative of implementation for River road and bridges.	--
1.2 Arterial Road Construction/Improvement		--
1.3 Secondary Road Construction/Improvement		--
1.4 Intersections and Flyovers	Flyover for Koteshwor Jct, but minor improvement are needed	Mid-term and Short term
1.5 Railway Crossing and Underpass	No railway service	--
2. NMT Facility Improvement Plan		
2.1 Strategy for NMT Facility Improvement	Not yet planned, but motorcycles are popular than NMT and difficult to promote	--
2.2 Pedestrian Facility Improvement		--
2.3 NMV Facility Improvement (bicycles, rickshaws)		--
2.4 Electric Vehicles promotion	Government plans to electrify 20% of all vehicles by 2020	
3 Intermodal Facilities		
3.1 Bus Terminals	ADB/KSUTP prepared	--
3.2 Bus-Rail Interchange	Coordinate with Rail project	Long-term
3.3 Park and Ride Facilities	ADB/KSUTP prepared	--
3.4 Freight Terminals	Not yet	Short term
4. Regulatory and Institutional Measures		
4.1 Unified Metropolitan Transport Authority	MOPIT has prepared draft legal document and on-going	--
4.2 Traffic Impact Assessment Mechanism	Not yet	--
4.3 Regulatory Changes Required for the Introduction of TDM Measures	Transport authority with strong implementation capacity is required	--
4.4 Traffic Safety Regulations		--
4.5 Parking Regulations		--
5. Fiscal Measures		
5.1 Fare Policy for Public Transportation, and Parking	Transport authority with strong implementation capacity is required	--
5.2 Subsidy Policy for Public Transport Operators		--
5.3 Taxation on Private Vehicles and Public Transport Vehicles		--
5.4 Potential for Road Congestion Charging		--

Source: Guidelines and Toolkits for Urban Transport Development in Medium Sized Cities in India Module 1: Comprehensive Mobility Plans (CMPs), 2008, ADB/PADECO, and modified by JICA Study Team

Below is a brief overview of plans and projects in each subsector:

- [0] Bus network improvement plans was composed by the KSUTP study but it implementation of restructuring has not yet completed. Similar scopes can be expanded based on the experience of S5, and this should be classified as short term scheme.
  - [0.4] ITS approaches has been initiated by private investors, without any assistance of public sector. This should be enhanced as short term, and involvement of private technology companies is preferable approach.

- [1] Road network improvement has still difficulties but the DOR strongly promote the river road development to create new bypass in the city district. Instead, the significance of the intersection improvement will come larger, and most intersection should be controlled and improved as short term schemes as grade separation measures can be applied in a limited number of intersections.
- [2] NMT is not popular in the KTM as the utility of motorcycle is higher than NMT. As environment friendly transport mode, Instead, EV-tempo promotions could be considered as alternative idea.
- [3] Bus facilities development are proposed by the KSUTP study, and Bus-rail intermodal station could be suggested as rail program. This study has also suggested intermodal station among bus and metro at the Tinkune junction. Freight terminal development could be considered as short-term.
- [4&5] TDM, parking control, fiscal control measures which will regulate the passenger behavior are not yet implemented in Kathmandu, but the present market will face on the strong motorization. It is necessary to wait the establishment proper transport authority, and coordination bodies among several levels of governments.

3.4 Macroscopic Transport Demand Analysis

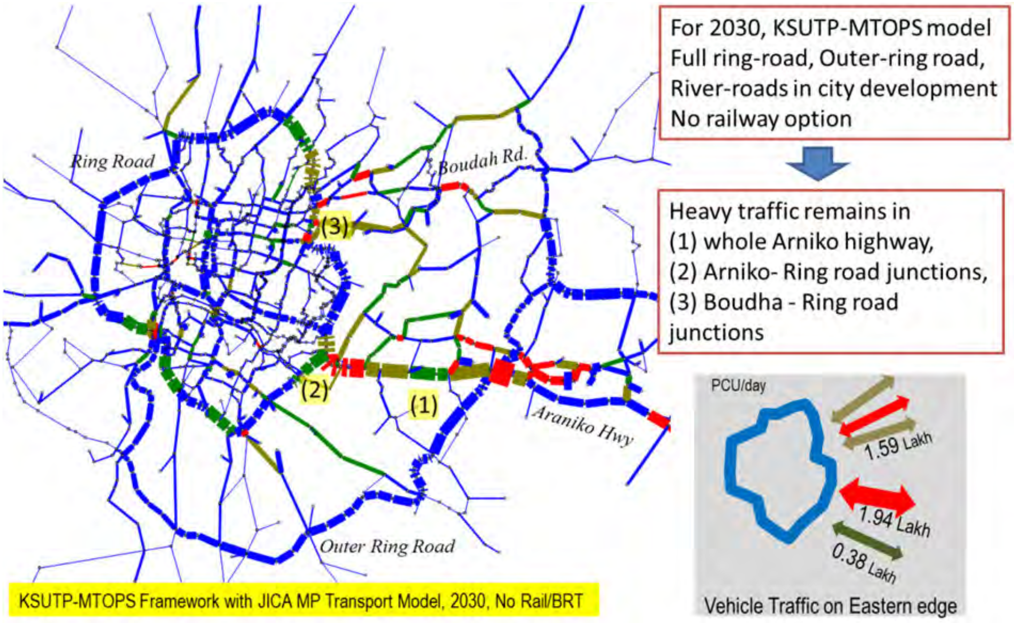
This section will assess traffic demand and flows to identify major bottlenecks in the road network and formulate viable road improvement schemes to alleviate existing and future traffic congestion. The JICA Study Team applied macroscopic transport demand analysis using the JICA STRADA Model considering the following transport development conditions in the valley:

- How the expected large infrastructure development until 2030 including ring roads, river roads, and railway development influence the necessity of flyovers (see 3.4.1)
- How the new city developments and expected increase in traffic volumes affect the traffic situation in the valley (see 3.4.1)
- Rationale for building a flyover or underpass (grade separation) at major intersections along the target corridor including T-M junction and Koteshwor-Tinkne junction, in future scenarios (see 3.4.2 for Koteshwor-Tinkne, see 3.4.3 for T-M junction)

3.4.1 Necessity of the Rail Development and Weakness in the Network

(1) Traffic Condition in 2030 without E-W rail

Figure 3.4.1 shows the road traffic assignment result for 2030, with improvement of full ring road development, half outer ring road development, and several river road developments. The color of the link shows the forecasted traffic volume per capacity ratio in a day. The blue links present the ratio is less than 1.0 (i.e. normal traffic), while the red sections present more than 1.5 (i.e. heavy traffic). It should be noted that the traffic within the Inner Ring Road is classified as blue, because the major traffic were diverted to the ring road (see the other analysis Section 3.4.3(1)). The major congestion remains in (1) Araniko Highway, (2) Araniko-Ring Road junctions, and (3) Bouda-Ring Road sections. Also, this result will not suggest flyovers inside the ring road because the Ring Road will absorb the traverse traffic from the center, and alleviate the traffic demands at the flyovers in the center.

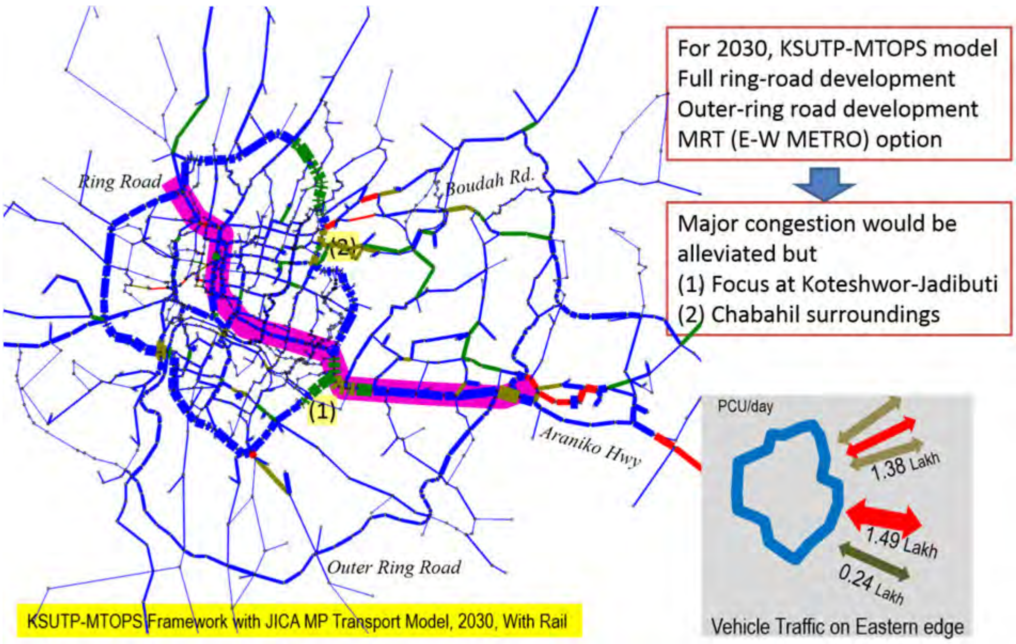


Source: JICA Study Team

Figure 3.4.1 Road Network Improvement Result in 2030

(2) Traffic Condition in 2030 with E-W rail

Figure 3.4.2 shows the expected traffic flows with the development of the urban railway along the Gongabu-Koteshwor-Bhaktapur alignment (highlighted in pink), which was recommended as the priority corridor in the KSUTP-MTOPS study in 2018. Compared with the previous case (Figure 3.4.1), there will be less congestion along the Araniko Highway. However, (1) the Koteshwor, and (2) Chabahil will remain as bottlenecks in traffic network.

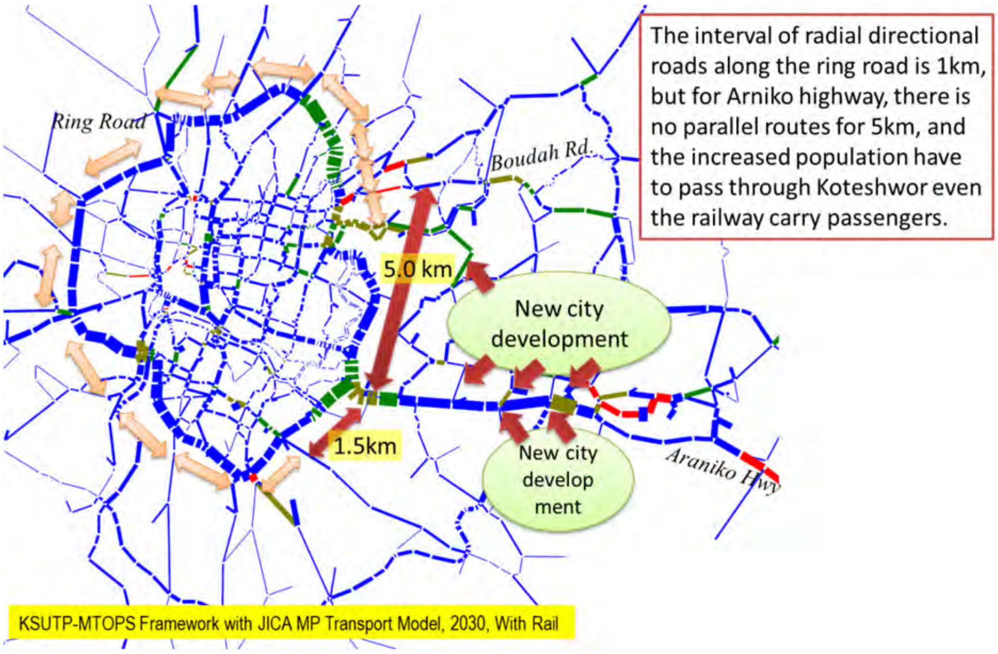


Source: JICA Study Team

Figure 3.4.2 Railway Scenario for 2030

(3) Road Network Weakness in Eastern Face for New City Development

As KVDA proposed in their new urban development plans, the eastern area of the valley will accommodate 1 million populations by 2030 and create a huge transport demand between Kathmandu and the Eastern area. Figure 3.4.3 shows the network characteristics of the radial routes around the Ring Road.



Source: JICA Study Team

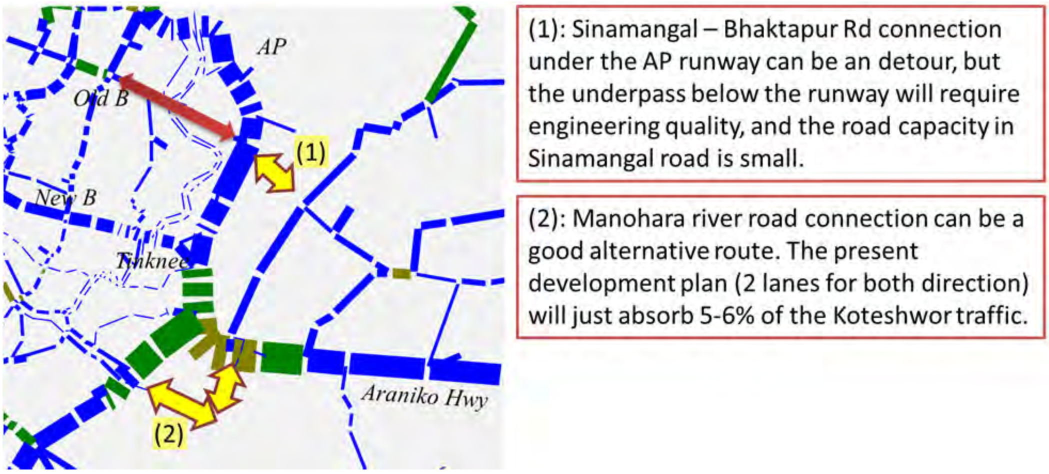
Figure 3.4.3 Network Weakness and New City Development

The average interval between the radial directional roads surrounding the Ring Road is around 500m to 1km, except two sections. The interval between the Araniko Highway and the Boudah Road is 5 km because of the International Airport. Also, Manohara river impedes development in the southern side of the Araniko highway, creating a 1.5km of interval between two adjacent roads. Lack of road infrastructure and access from/to new development areas in the Eastern side will generate an increase in traffic demand along the Araniko Highway, especially at the Koteshwor Junction. The planned railway development alone will not alleviate expected traffic volumes. Physical improvement on the road surface including grade separation should be considered.

3.4.2 Grade Separation Necessities

(1) Options for Koteshwor Junction Improvement

Other than grade separation at the Koteshwor junction, there are two options for physical improvement at Koteshwor: (1) Sinamangal – Bhaktapur underground tunnel beneath the airport runway, and (2) Manohara river corridor development, as shown in Figure 3.4.4.



Source: JICA Study Team

Figure 3.4.4 Options for Koteshwor Junction Improvement

The study team prepared two scenarios to compare the degree of influence of building a bypass at Koteshwor: (1) underpass beneath the airport runway connecting Sinamangal to Bhaktapur, with 2-lane road, and (2) bypass along the Manohara river with 2 lane (each way) road, in order to assess the necessity of physical improvement at the Koteshwor intersection. It should be noted that the underpass beneath the airport runway require cost and careful engineering application to secure continuous operation of the runway.

Table 3.4.1 shows the cross sectional PCU/ day volumes at the major locations of those interventions. Based on the comparison of assignment results in Figure 3.4.5, it is clear that building the bypass along the Manohara River brings more positive effects than the airport underpass. The Manohara river road can divert the more traffic and ease the congestion on the Ring Road. The Airport (AP) Bypass option can attract larger volumes of traffic from the eastern region but its impact on traffic handling capacity at Koteshwor is limited. It seems this result will not justify its high cost. The "with both Bypass (BP)" case can improve the traffic situation at Koteshwor, but the target junction will still have traffic more than its capacity, which can justify the needs of grade separation. The whole comparison will justify the requirement of Manohara River Bypass for Koteshwor, and also necessity of the grade separation at Koteshwor.

Table 3.4.1 Traffic Volume at the Major Locations for the Bypass Options

PCU/day (x100)	Koteshwor on Araniko Highway	Manohara Bypass	AP Bypass
I) With Manohara BP	1,250	285	--
II) With AP BP	1,281	--	349
III) With Both BP	1,109	213	342

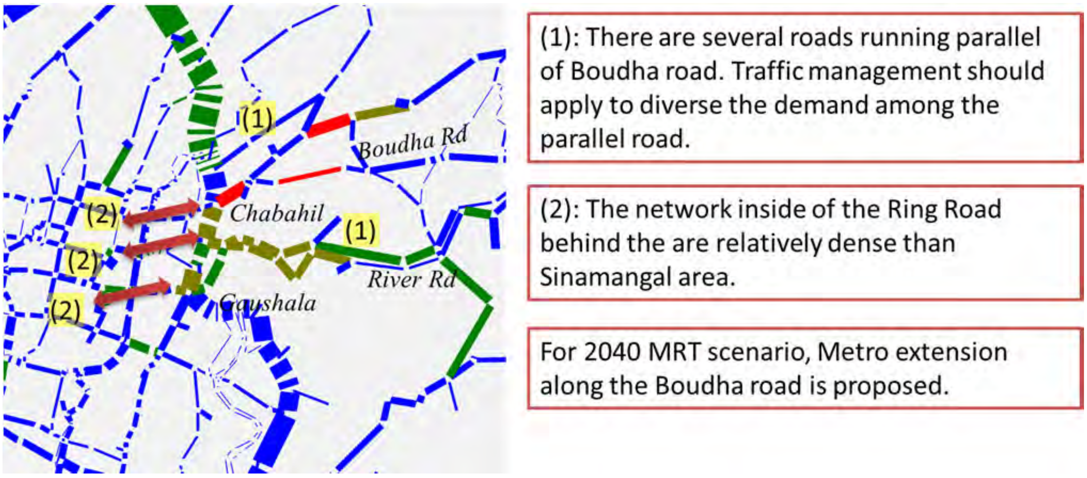
Source: JICA Study Team

Source: JICA Study Team

Figure 3.4.5 Comparative Analysis of Bypass Options for Koteshwor

(2) Further Actions in Chabahil

Chabahil is the other traffic bottleneck – alongside Koteshwor – in the forecast year of 2030, after the ring road development. Figure 3.4.6 shows the traffic analysis at Chabahil and its surroundings. This area will receive traffic from the Northeastern corridors but there are several parallel roads other than major Boudha road, including the river road development. The road network inside the Ring Road is more dense than other areas, which can accommodate the increased traffic from outside in 2030. This result suggests this area requires re-designing of the ring road and parallel roads, but traffic can be managed without physical improvement. It should be noted that the KSUTP-MTOPS study suggested the metro development along the Boudha road corridor in 2040.



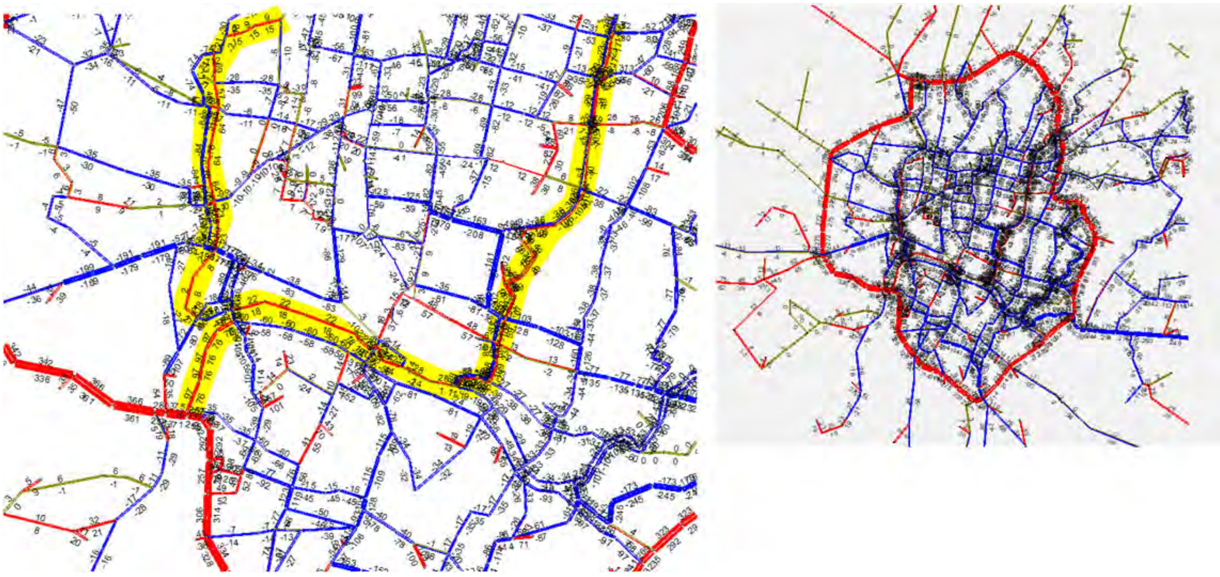
Source: JICA Study Team

Figure 3.4.6 Situation in Chabahil in 2030, with Railway

3.4.3 Necessity of Grade Separation at T-M junction

(1) Impact of the Ring Road Development and T-M junction

The previous section mentioned about the impact of the railway development on the vehicle traffic demand. However, the ring road development will also give a huge impact on the traffic situation. Figure 3.4.7 gives a comparative analysis between the 2030 and 2020 scenario, showing which section has larger or lesser traffic by color. Red sections have larger traffic in 2030 than 2020, and traffic on the blue sections will be decreased.



Source: JICA Study Team

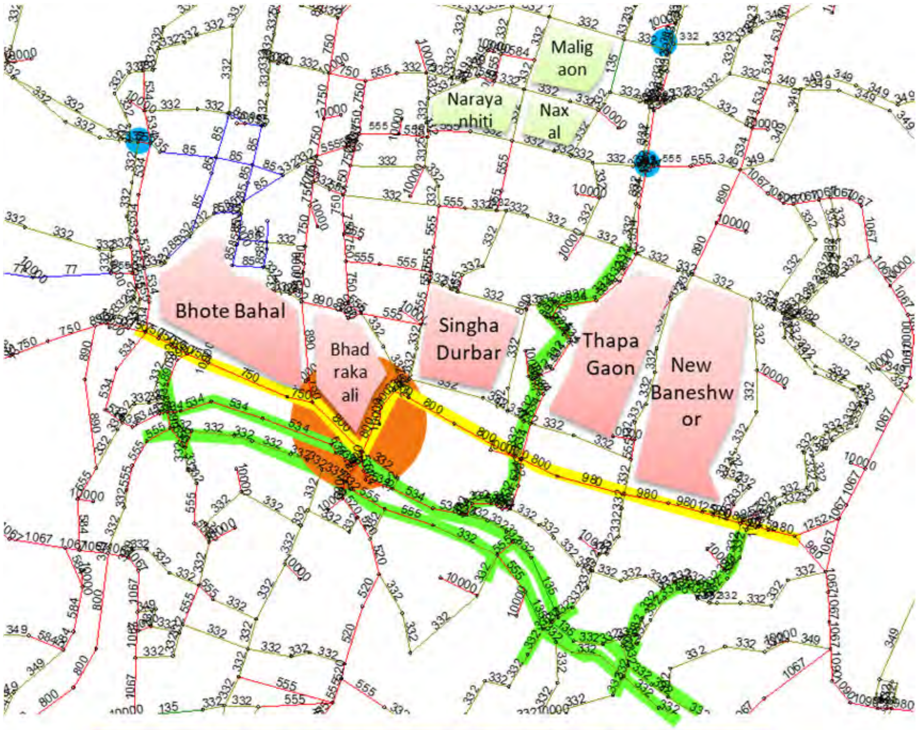
Figure 3.4.7 Comparative Analysis among 2020 to 2030 in Expected Traffic Volume

The diversion to Ring Road from city center have a large impact on vehicle traffic demand. Most road sections inside the Ring Road reduce its traffic from 2020. The increased sections are mainly newly capacity added River roads along Dhobi Kola River, Bishnumati River, and Bagmati River (highlighted in yellow), however, the traffic increase is minimum, as the Ring road absorbs major traffic demands.

This result suggests that the situation of Tripreshor will be eased, Thapathali will be medium, and Maitighar will receive more traffic.

(2) Further Analysis for T-M Junction – Poor Network in the City Center

The following analysis will give a reason why the Maitighar junction still attract the larger traffic. Figure 3.4.8 shows the road network setting in the center of the city in 2030 scenario, including river road and several improvements. The figure also identifies large urban blocks without internal road connections close to the T-M junction (Orange circle highlighted) and Araniko-NH2 corridor (yellow highlighted).



Base: KSUTP-MTOPS / Optimized by JST, The Figure on the roads show road capacity (Q-Max, with100 units), varies from 8,500 pcu/day in both directions (single track narrow roads) to 106,700 pcu/day (6-8 lanes, Ring road)

Source: JICA Study Team

Figure 3.4.8 Network Setting and Large Blocks Surrounding the T-M Junctions

Particularly, the block of the new Baneshwor does not have internal road in the network simulation for 1.5km, which attract the traffic along the Araniko Highway and Maitighar. (Actually, there are several internal roads in those blocks, but they are not enough widths as major roads for simulation, on the other hands, Singha Durbar is the gated city for national administrative function, and there is no public passage inside). The large blocks in Bhadrakaali and Bhote Bahal also bring traffic to Tripreshwor and Kalimati.

The river corridors and N-S directional bridges in parallel to the Bagmati Bridge (highlighted in light green) will divert the demand from T-M junction.

Compared to those large blocks in the center, the northern areas in the CBD (e.g., Maligaon, Naxal, Naraaynhiti) have relatively smaller blocks and dense road network, which can diverse the traffic demand. It should be noted that the richness of the network in the northern area is attributed to the JICA's bridge development grant[9] in 1992, which constructed two minor bridges (identified by blue dots) along the Dhobi Khola river which formed proper network in the end.

(3) Further Analysis for T-M Junction : 1 – Route Assignment in T-M

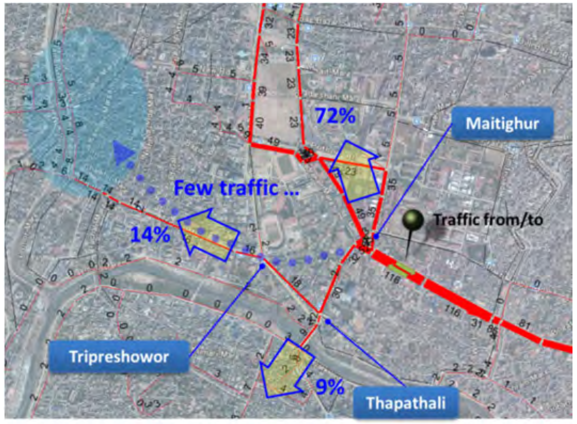
The following figures show the traffic flow patterns using specific 6 links in and surrounding the T-M Junction, under situation of 2030, without railway option. Those figures present how the traffic on the specific section comes from which route, or goes to which route. These analyses will show the connectivity of traffic at the junction as shown in Figure 3.4.9.

(a) Maitighar East on Araniko Hwy, shows large connection between Araniko Highway and Ratna park section.
(b) Maitighar East on Singha Durbar Rd. shows northeast - south connection. The major movement are between Ghattekulo and Lalitpur.

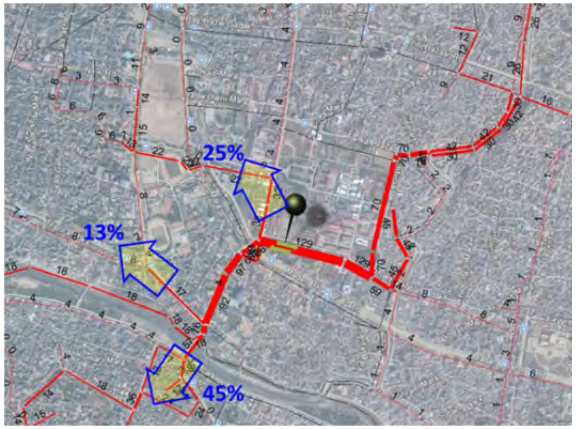
[9] Project for the Bridge Reconstruction in Kathmandu Valley

(c) Maitighar North and
(d) Maitighar South: shows strong North-South connection
(e) Thapathali South (Bagmati Bridge): shows strong North-South connection
(f) Tripreshwor West: major traffic goes into the west-North direction.

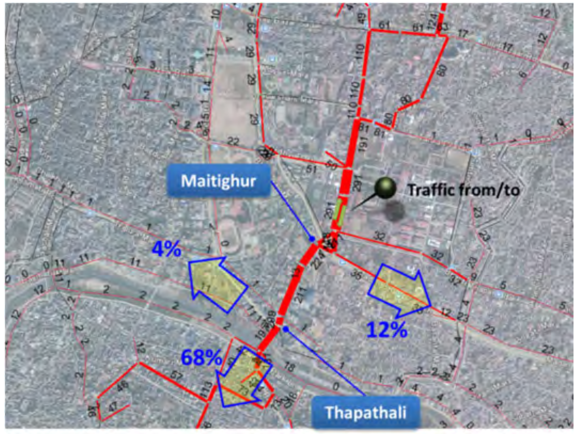
In summary, the traffic patterns connecting East – West direction is very small in the future situation in 2030, as the whole ring road and parallel river road development will have been completed. In other word, the flyovers for East – West direction will not contribute to future traffic patterns in Kathmandu.



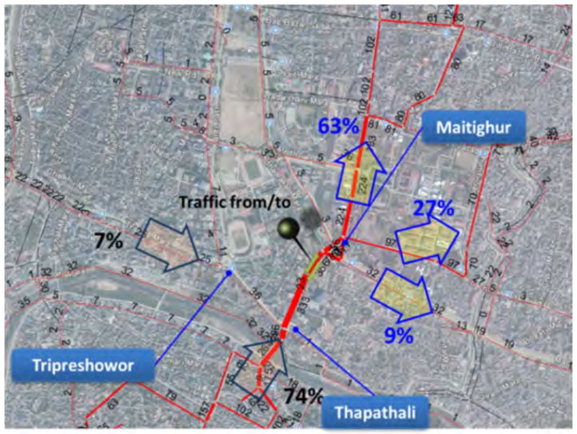
(a) Maitighar East on Araniko Hwy



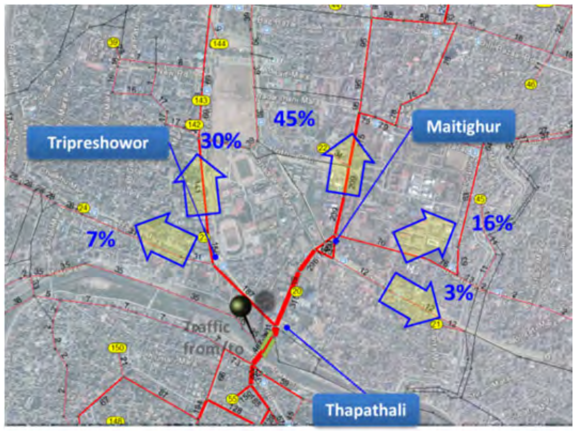
(b) Maitighar East on Singha Durbar Rd.



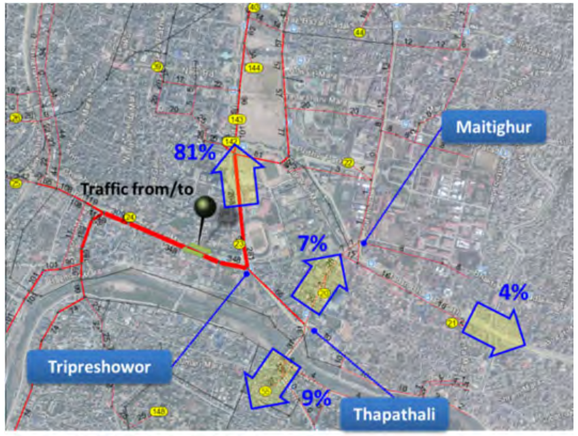
(c) Maitighar North



(d) Maitighar South



(e) Thapathali South (Bhagmati Bridge)



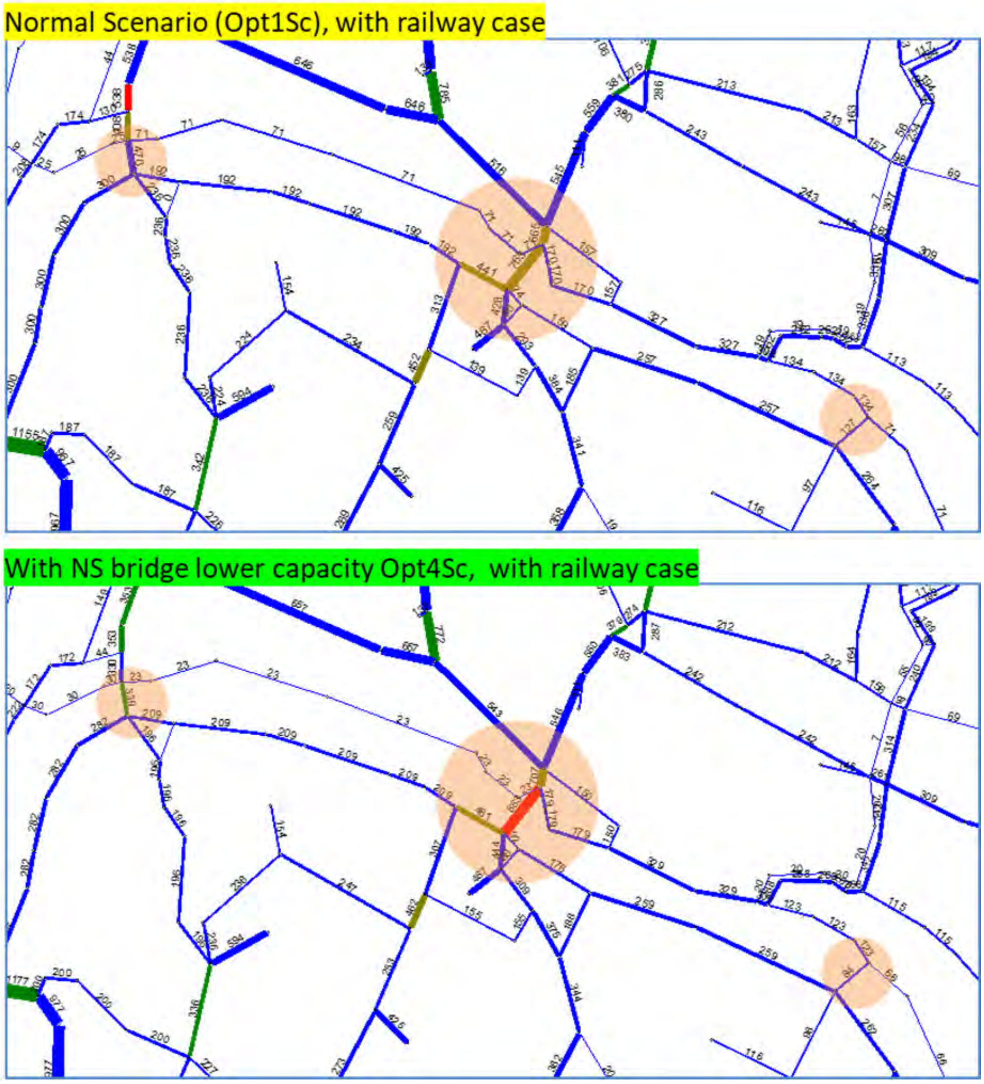
(f) Tripreshwor West

Source: JICA Study Team

Figure 3.4.9 Route Assignment Results of the Specific Links in and Surrounding the T-M Junction

(4) Further Analysis for T-M Junction : 2 – Importance of N-S Bridge Improvement

The study team prepared another scenario for assessing the importance of further network development, particularly for T-M junction management.



Source: JICA Study Team

Figure 3.4.10 Comparison Analysis: Less Capacity of Bridges in N-S direction

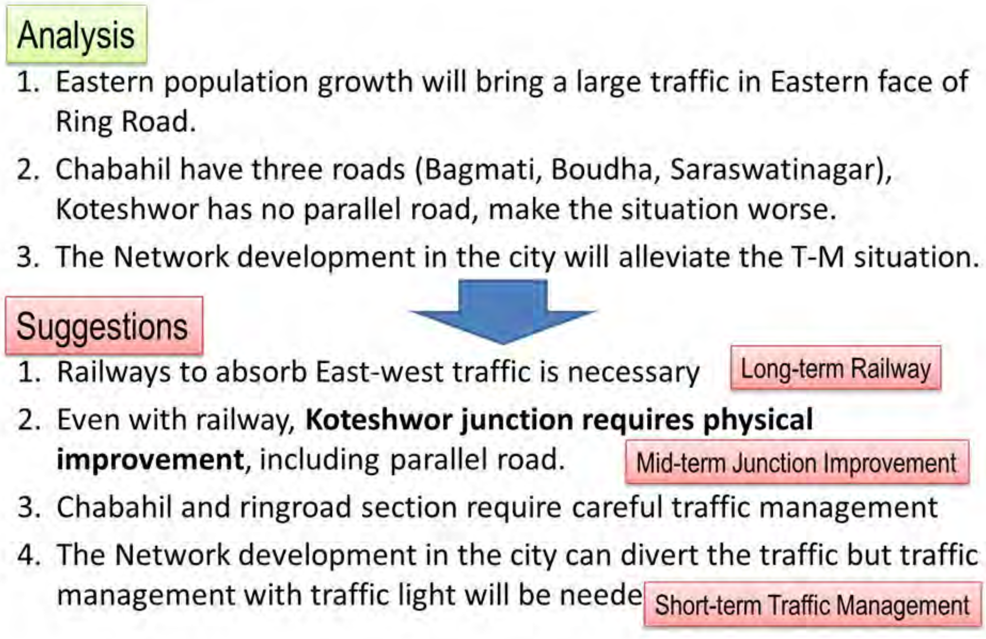
There are 3 bridges on the Bagmati river, including Bagmati bridge (identified by large dot in the map, Figure 3.4.10), but the other 2 bridges and its connections are not developed since the present situation. For the future scenario, 1x2 lanes (32K PCU, 32km/h) for the other 2 bridges, but for the present scenario 32K PCU, 20km/h were applied. The lower figure in the drawing shows the result.

When compared both cases, the N-S movements will be attracted to Bagmati bridge, due to lower LOS in other bridges, however, the road VCR at the T-M junctions still remains lower than its capacity. The scenario suggests the following:

- Delay of bridge development will bring more traffic to Bagmati Bridge and Thapathali junction.
- The T-M junction has large traffic, but there is still capacity to accommodate traffic, as surrounding river road and ring road diverted traffic.

3.4.4 Summary

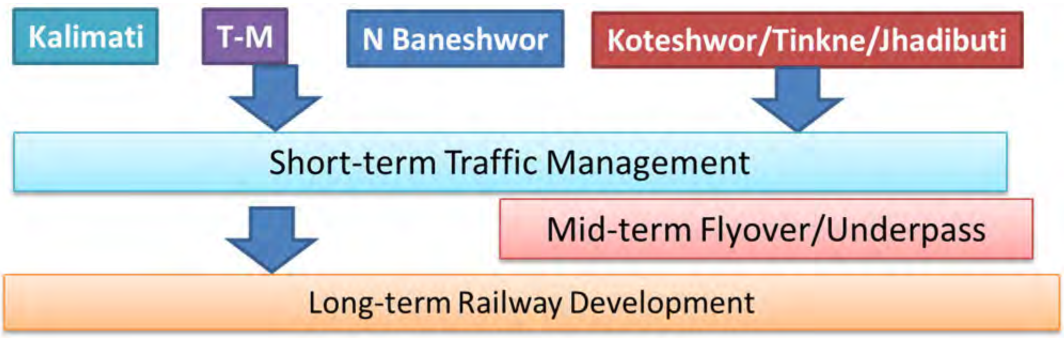
The Macro-scopic analysis can be summarized and will give the following suggestions, as shown in Figure 3.4.11.



Source: JICA Study Team

Figure 3.4.11 Analysis and Suggestions

For the target corridor, it is clarified that the Koteshwor junction with its neighboring junctions will require grade separation approaches, therefore it will be targeted for the mid-term intervention and further study will be discussed in Chapter 4 (Mid-term interventions). The other junctions, T-M, New Baneshwor, and Kalimati can be managed without a flyover, but require proper traffic management. Therefore, general traffic management application shall be discussed and planned in the Chapter 5 (short-term interventions). Even with those interventions, the large traffic due to the new city development in the Eastern area will require the railway development, therefore Chapter 6 (long-term interventions) will give further analysis for railway development. Those idea can be illustrated as shown in Figure 3.4.12.



Source: JICA Study Team

Figure 3.4.12 Strategy for Target Corridors

CHAPTER 4 MID-TERM SOLUTION

4.1 Introduction

Chapter 3 identified the road section from Koteshwor intersection to Kalimati as an important corridor to be improved for the alleviation of traffic congestion with a strategic approach, such as adopting the necessary solution/intervention method based on the present and future road network plans, and the current and future traffic demand in Kathmandu Valley.

Based on the output in Chapter 3, this chapter will proceed to further study the proposals for the improvement method of the intersections on the said road corridor, namely: Koteshwor – Tinkune intersection, New Baneshwor One and Tripureshwor – Thapathali – Maitighar One as a mid-term intervention plan.

This further study mainly focuses on a detailed improvement plan for alleviating the traffic congestion at Koteshwor – Tinkune intersection as a major mid-term intervention project. It will focus on i) improvement of the area/range, ii) improvement of the alternatives considering the current and future traffic flow, iii) structural options for the improvement of the intersection while introducing the latest technology for both flyover and underpass, and provision of the recommendable improvement alternative and structural option for the future study.

On the one hand, for the New Baneshwor and Tripureshwor – Thapathali – Maitighar intersections, this chapter will provide only the proposal for the improvement of the direction.

4.2 Proposed Interventions for Mid-Term Project

Table 4.2.1 summarizes the improvement direction/policy for the identified bottleneck intersections on the targeted road corridor. Further details shall be described in the following sub-chapter.

Table 4.2.1 Improvement Direction/Policy for the Identified Congested Intersections/ Intersections to be Congested

Name of Intersection/ Road Section	Improvement Direction/Policy in Med-term or Long-term
Maitighar - Thapathali - Tripureshwor Intersections (T-M Intersections)	- Large urban blocks without internal road connections close to the T-M intersections are one of the causes of traffic congestions in the T-M junction. - The Ring Road improvement will give a huge impact on the traffic situation on T-M Intersections. - The river corridors and N-S directional bridges parallel to the Bagmati Bridge will divert the traffic demand from T-M intersections - To summarize, physical improvement at this junction may not be required because of the improvement and development of the surrounding road/bridge for the time being. However, the study team examines the intersection analysis and proposes the necessary countermeasures in the following chapter.
New Baneshwor Intersection	- No internal roads in the block of New Baneshwor causes attracting the traffic along the road section from Tinkune to Maitighar. - The river corridors and N-S directional bridges parallel to Bagmati Bridge will divert the traffic demand from the road section between Tinkune to Maitighar. - To summarize, this intersection can be managed without grade separation but requires proper traffic management.
Koteshwor-Tinkune Intersection	- Physical improvement on the road surface including **grade separation should be considered.** - In addition to the above, the Manohara River corridor development should be considered, which is more effective for easing the traffic congestion at the intersection, than the Sinamangal-Bhaktapur road connection by underpass above the airport runway.

Source: JICA Study Team

4.3 Improvement Plan for the Intersections

4.3.1 Study of the New Baneshwor Intersection

The New Baneshwor intersection is located at the meeting point of NH.2 (Madan Bhandari Road) and Devkota Sadak Road (north) / Shankhamul Marg Road (south), with the International Convention Center in the northeast corner. The traffic control of the intersection has been carried out by traffic police officers in peak hours, although there are signalized devices installed at the intersection.

Based on traffic demand forecast data in year 2030, an intersection analysis – which examines the appropriate option of having a signalized intersection design to enable smooth traffic flow within the intersection – is carried out for the New Baneshwor intersection.

1) Traffic Flow in Year 2030

The major features of the traffic flow at this intersection are as follows;

- East-West bound traffic is a dominant movement at the intersection; in particular, a traffic volume from east to west is double than that in the opposite direction.
- There is less right-turn or left-turn traffic and straight movement is dominant in E-W bound movement.
- There is a heavy vehicle ratio of 10.4% at New Baneshwor intersection.

From the West

From the East

From the North

From the South

Unit: [veh./day]

Source: JICA Study Team

Figure 4.3.1 Traffic Flow by 2030 for Small Vehicles at New Baneshwor Intersection (with rail)

From the West

From the East

From the North

From the South

Unit: [veh./day]

Source: JICA Study Team

Figure 4.3.2 Traffic Flow by 2030 for Heavy Vehicles at New Baneshwor Intersection (with rail)

2) Result of the Intersection Analysis (2030)

In order to assess the congestion level within the intersection, the intersection analysis shall be conducted in the study using both "Japan Society of Traffic Engineers (JSTE), 1977" for signalized intersection and "HCM: Highway Capacity Manual (TRB), 2010" for roundabout intersection.

The results of the intersection analysis for New Baneshwor intersection are shown in Table 4.3.1. According to the analysis, it is found that physical grade separation is not required up to year 2030 because the assessment result indicates “Good” – which means the saturation degree is lower or equal to 0.90 – by year 2030. In addition, this intersection analysis is carried out based on the existing lane arrangement. Thus, any physical improvement of this analysis will not be necessary.

However, it is recommended to apply traffic management measure described in Chapter 5 for the achievement of a smoother traffic at the intersection.

Table 4.3.1 Result of New Baneshwor Signalized Intersection Analysis (Year 2030)

<table>
<tr><th rowspan="2">Name of Intersection</th><th rowspan="2">Name of Option</th><th colspan="3">Result/Evaluation of Signalized Intersection Analysis</th><th rowspan="2">Remarks</th></tr>
<tr><th>Cycle Time (sec.)</th><th>Saturation Degree</th><th>Evaluation</th></tr>
<tr><td rowspan="2">New Baneshwor</td><td rowspan="2">Current lane arrangement</td><td>70</td><td>0.81</td><td>Good</td><td rowspan="2">In 2030, the necessity for grade separation will be not high in this section.</td></tr>
<tr><td colspan="3">SB: 2-lanes, EB: 4-lanes, NB: 2 and WB: 4 lanes
Total of inflow lanes: 10 lanes</td></tr>
</table>

Source: JICA Study Team

4.3.2 Study in Tripureshwor - Thapathali - Maitighar (T-M) Intersections

(1) Introduction

T-M Intersections can be regarded as interlocking intersections, in which a series of intersections, namely Maitighar (North), Maitighar (South), Thapathali and Tripureshwor, are located on the same corridor within short distances of each other. Therefore, in the case of the application of the signalized system to the said intersections, it is desirable that the cycle time (seconds) should be in the same length or at multiple length relation.

(2) Current Condition of T-M Intersections

1) Maitighar (North) Intersection

It is located just north of the Maitighar (South) intersection, having a 3-leg intersection. If this intersection is operated as a signal intersection, it is desirable that the setting of the cycle time / plan of traffic signal synchronizes with the traffic signal of the Maitighar (South) intersection.

2) Maitighar (South) Intersection

Maitighar (South) intersection is a roundabout type that is sandwiched between Singha Durbar's 3-leg intersection (Maitighar (North)) to the north and Thapathali’s 4-leg intersections to the south.

3) Thapathali Intersection

Thapathali intersection is operated by signalized system between the 4 (3)-leg roundabout type intersection of Maitighar (south) to the north and the 4-leg Tripreshwor intersection signalized to the west. In addition, there are two bridges nearby across Bagmati River; one for 6-span and 2-lane new bridge to the west side (w = 14.07m, L = 145.5m) for north bound traffic, and another for a 2-lane and 6-span old bridge (w = 10.5m, L = 120.0m) with foot path for the south bound traffic.

4) Tripureshwor Intersection

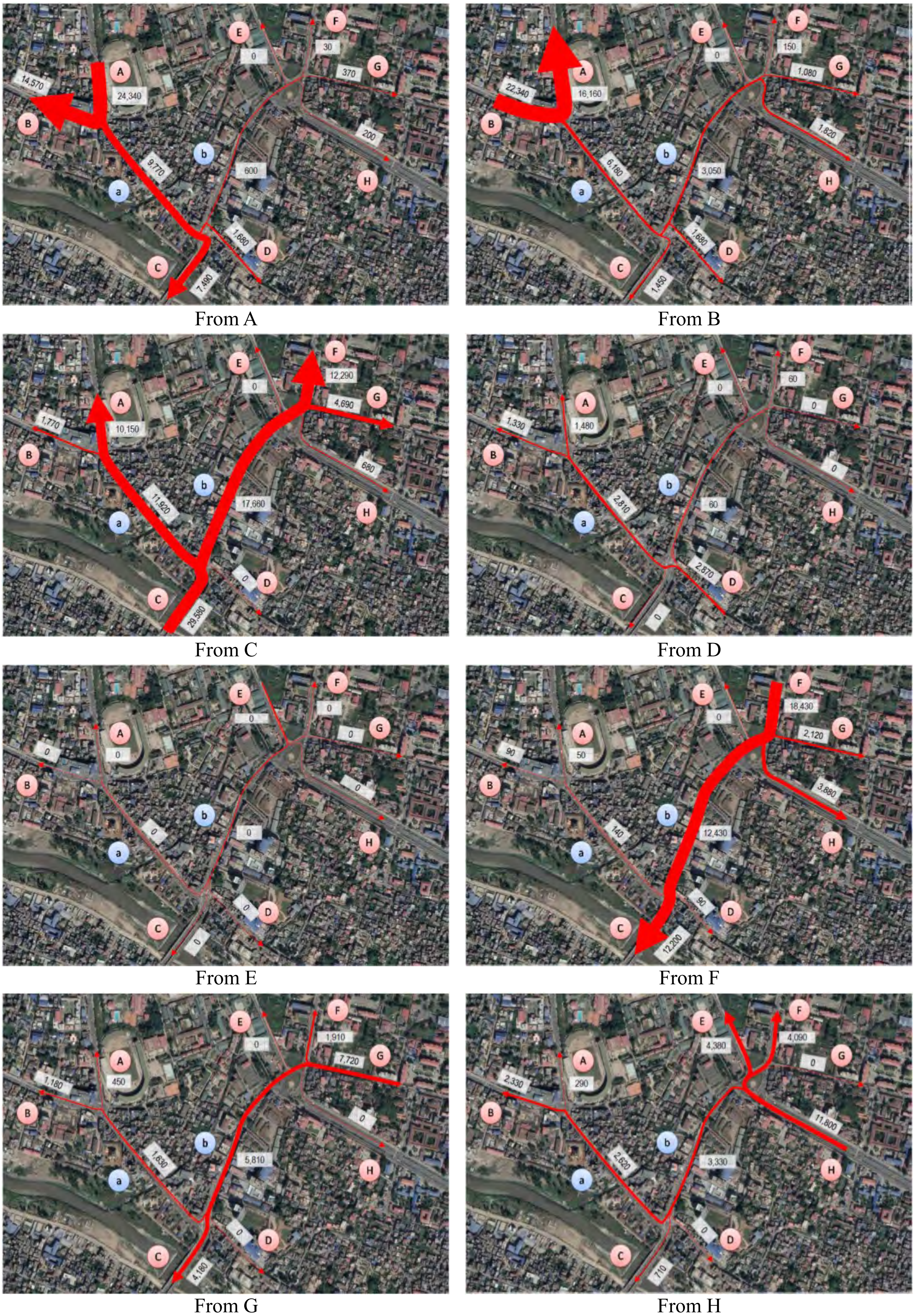
Tripureshwor intersection has a roundabout type located in the south (east) of Thapathali intersection, having Dasarath Stadium on the north side, and Bishnumati River bridge on the west side. In the center of the roundabout, there is a statue of the former king Tribhuvan Shah.

Source: JICA Study Team

Figure 4.3.3 Photo of Dasarath Studium and the Statue of King Tribhuvan Shah

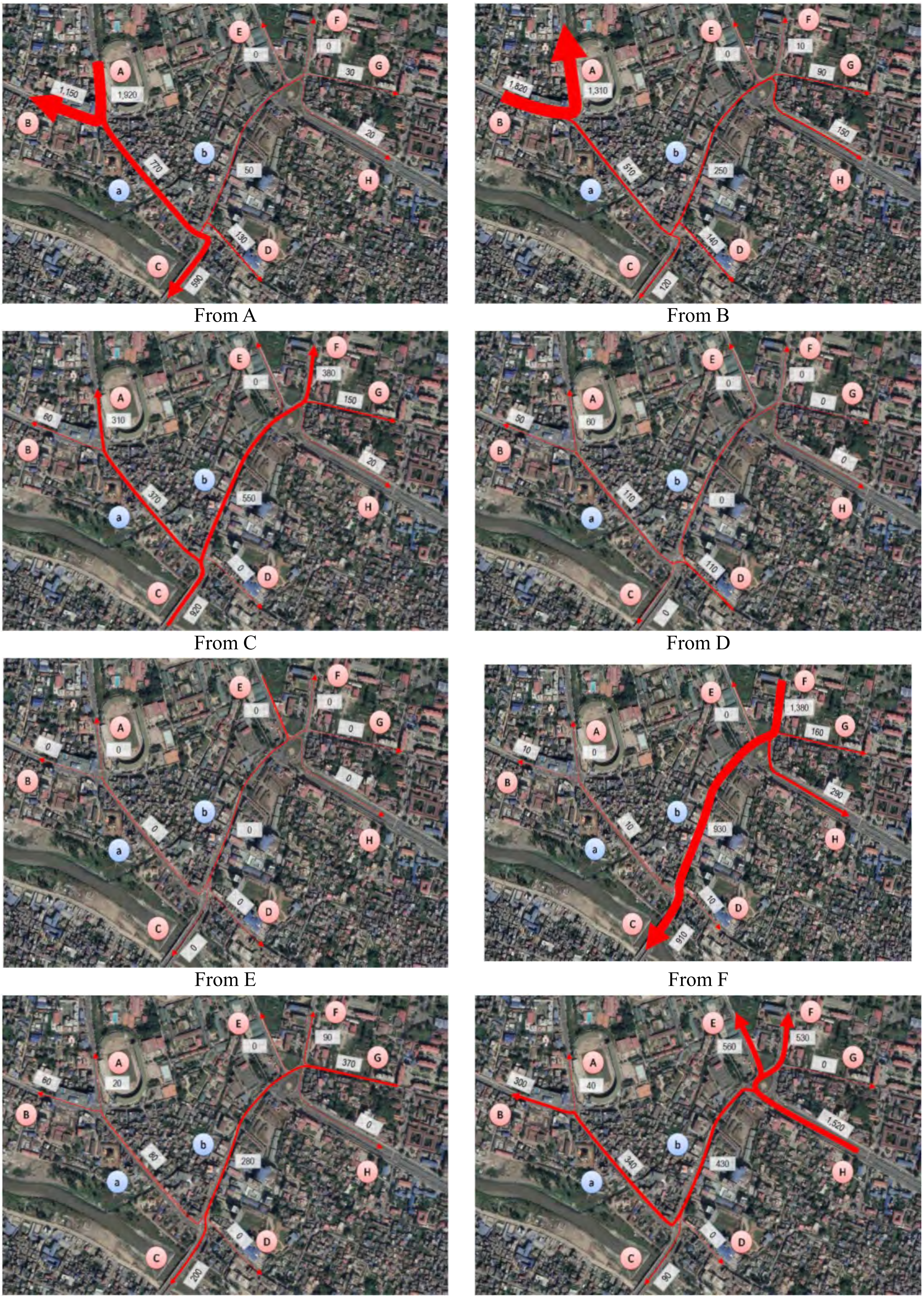
(3) Intersection Analysis at T-M Intersections

The T-M intersections are a combination of 4 intersections, and the traffic movement flow over the intersections should be clarified for further analysis. Figure 4.3.4 and Figure 4.3.5 show the flows of the T-M intersections – bounded to specific road links of the T-M intersections – for small vehicles and heavy vehicles (using JICA STRADA Network Analysis) by year 2030 with rail scenario. Figure 4.3.6 shows the turning movements for major directions in T-M intersections.



Unit: [veh./day]
Source: JICA Study Team

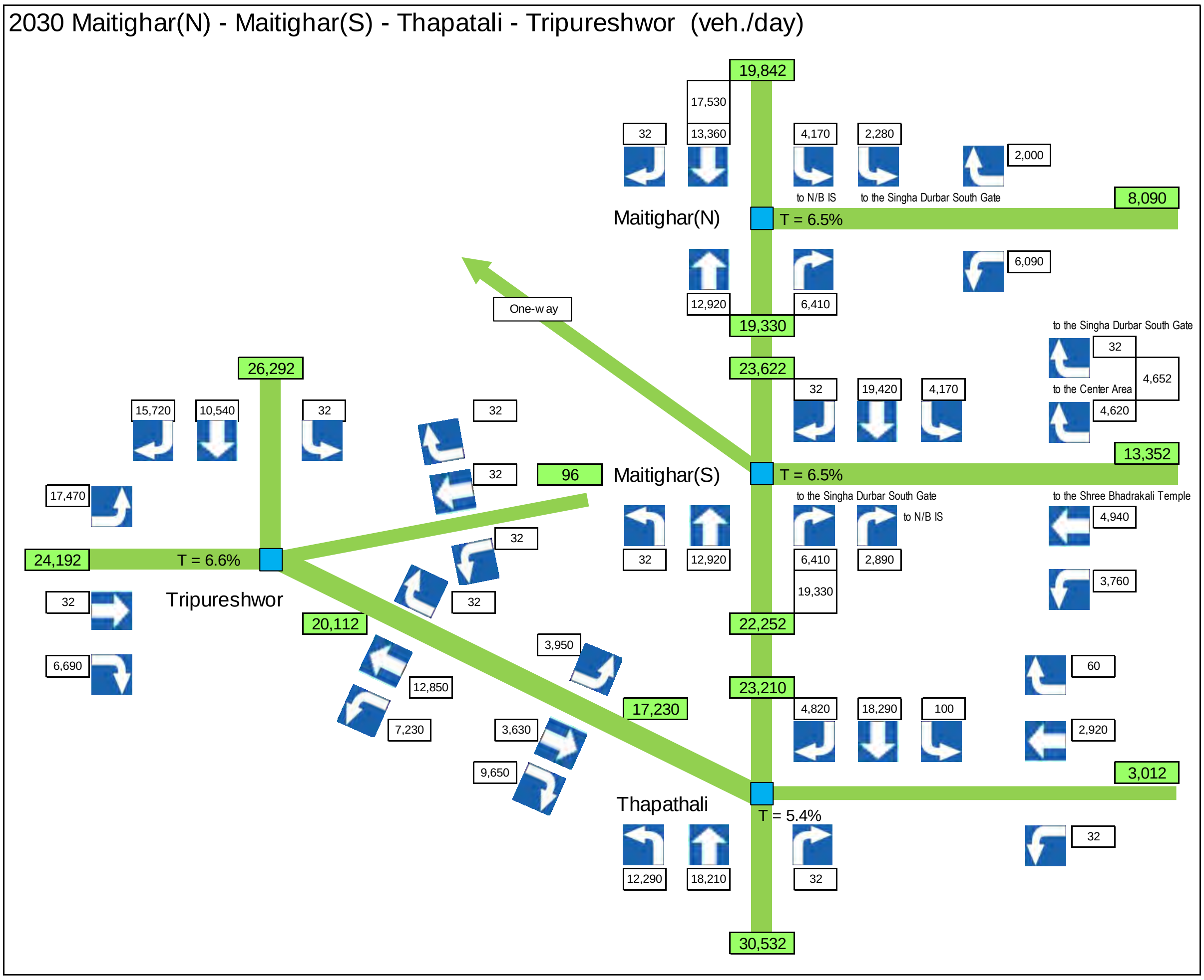
Figure 4.3.4 Traffic Flow at T-M Intersections for Small Vehicles by Year 2030



From A | From B
From C | From D
From E | From F
From G | From H

Unit: [veh./day]
Source: JICA Study Team

Figure 4.3.5 Traffic Flow at T-M Intersections for Heavy Vehicles by Year 2030



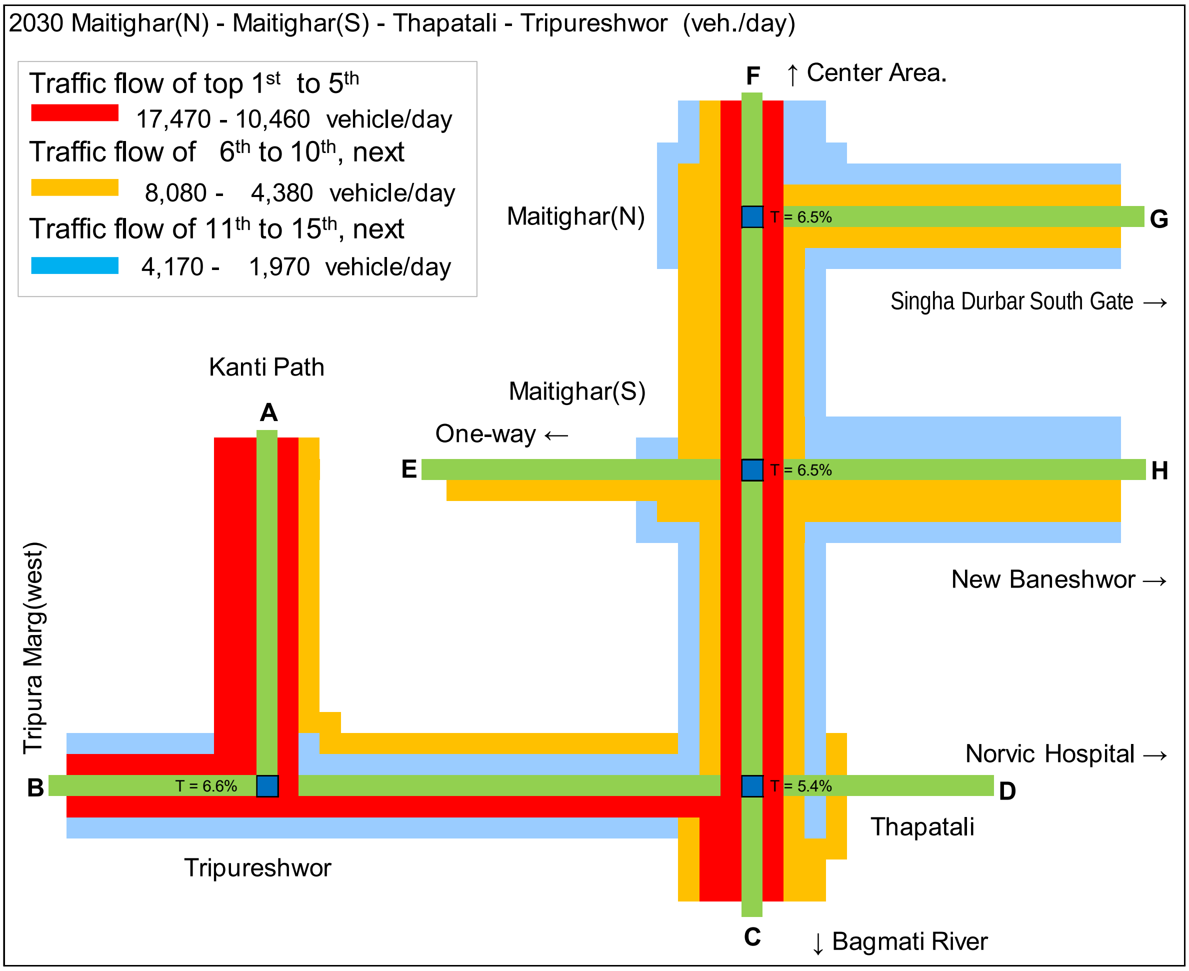
Note: "T": Heavy Vehicle Ratio
Source: JICA Study Team

Figure 4.3.6 Traffic Flow with H/V Ratio Around T-M Intersections by Year 2030 (With Rail)

The major features of traffic flow at T-M intersections by year 2030 are as follows:

- Dominant traffic movements at the intersections are:
  - i) Both direction between the city center (A) and western (B) at Tripureshwor
  - ii) South-North bound traffic (Lalitpur (C) from/to the city center (F or A))
- The heavy vehicle ratio is low as it is in the city center, and the ring road diversion is affected.

This movement can be visualized and tabulated as an OD table as shown in the following charts.



OD Table of T-M Intersections

O \ D	A	B	C	D	E	F	G	H	Σ	Point/Location
A		15,720	8,080	1,810	0	30	400	220	26,040	Kanti Path
B	17,470		1,570	1,820	0	160	1,170	1,970	22,190	Tripura Marg(west)
C	10,460	1,830		0	0	12,670	4,840	700	29,800	Bagamati Bridge
D	1,540	1,380	0		0	60	0	0	2,980	Norvic Hospital
E	0	0	0	0		0	0	0	0	One-way
F	50	100	13,110	100	0		2,280	4,170	15,640	Center Area
G	470	1,240	4,380	0	0	2,000		0	8,090	Singha Durbar South Gate
H	330	2,630	800	0	4,940	4,620	0		13,320	New Baneshiwor
Σ	30,320	22,900	27,940	3,730	4,940	19,540	8,690	7,060		

Source: JICA Study Team

Figure 4.3.7 Distinguished Traffic Flow and OD Table Around T-M Intersections by Year 2030

1) Assessment of previous proposal by JICA MP

The Study Team attempts to examine the effectiveness of the proposed East-West bound viaduct/flyover as part of the T-M intersections improvement plan in the JICA MP, referring to the traffic analysis above . The traffic flow from/to Tripura Marg and New Baneshwor (B↔H in OD table) in Figure 4.3.7 shows (H→B: 2,630 vehicles/day) and (B→H: 1,970 vehicles/day), both of which account for lower ratio in the total traffic volume within intersections. Accordingly, it can be judged that the proposed E-W bound viaduct/flyover is less effective as an intersection improvement option. On the one hand, it can be said that additional left and right turn lanes at Tripureshwor intersection are highly effective options to improve the intersection.

2) Results of the Intersection Analysis of T-M Intersections (2030)

The results of the intersection analysis at T-M Intersections are shown in Table 4.3.2. This table shows the saturation degree or the level of service (LOS) by several conditions for each intersection. For Maitighar (North), it is estimated the current lane arrangement with proper signalization cannot process the forecasted traffic as the north-bounded right turning lane, and will be fully saturated. However, it would be an acceptable condition if three lanes were added in the intersection. For Maitighar (south), the current condition is worse than that of Maitighar (north). However, it is estimated that adding two lanes would achieve an acceptable condition. It should be noted that the operation with roundabout arrangement will bring an unacceptable condition, which means that LOS will be "F".

For Thapathali, similarly to the above two, adding three lanes can ease the situation. For Tripureshwor, it is estimated that the signalizing under the current lane arrangement would be the worst condition. However, the condition would be alleviated in case three lanes were added to the specified links.

Table 4.3.2 Results of T-M Signalized Intersection Analysis (Year 2030)

<table>
<tr><th rowspan="2">Name of Intersection</th><th rowspan="2">Number of Legs</th><th rowspan="2">Type of Intersection</th><th rowspan="2">Lane Arrangement</th><th colspan="4">Result/Evaluation of Signalized Intersection Analysis</th><th rowspan="2">Remarks</th></tr>
<tr><th colspan="2">Cycle Time (sec.)</th><th colspan="2">Saturation Degree/LOS</th></tr>
<tr><td rowspan="3">Maitighar (North)</td><td rowspan="3">3 legs</td><td rowspan="3">Signalized</td><td>Current condition</td><td colspan="2">120</td><td colspan="2">1.04
No good
(> 0.90)</td><td>Cannot process the traffic volume of NB right turn lane</td></tr>
<tr><td>Additional +3 lanes</td><td colspan="2">120</td><td colspan="2">0.62</td><td rowspan="2">Can process the traffic volume of NB right turn lane</td></tr>
<tr><td colspan="5">Additional Lanes: SB+1, WB+1 and NB+1</td></tr>
<tr><td rowspan="6">Maitighar (South)</td><td rowspan="6">4 legs
EB: only outflow</td><td rowspan="3">Signalized</td><td>Current condition</td><td colspan="2">120</td><td colspan="2">1.27
No good
(> 0.90)</td><td rowspan="3">Can process the traffic volume of NB right turn lane</td></tr>
<tr><td>Additional +2 lanes</td><td colspan="2">120</td><td colspan="2">0.76</td></tr>
<tr><td colspan="5">Additional Lanes: SB+1 and NB+1</td></tr>
<tr><td rowspan="3">Roundabout</td><td>Inflow</td><td>WB</td><td>SB</td><td>EB</td><td>NB</td><td>LOS intersection</td></tr>
<tr><td>Average Control Delay (second/veh.)</td><td>506</td><td>103</td><td>-</td><td>735</td><td>532</td></tr>
<tr><td>LOS</td><td>F</td><td>F</td><td>-</td><td>F</td><td>F</td></tr>
<tr><td rowspan="3">Thapathali</td><td rowspan="3">4 legs</td><td rowspan="3">Signalized</td><td>Current condition</td><td colspan="2">120</td><td colspan="2">1.12
No good
(> 0.90)</td><td>Cannot process the traffic volume of NB left turn and EB right turn lanes</td></tr>
<tr><td>Additional +3 lanes</td><td colspan="2">120</td><td colspan="2">0.61</td><td rowspan="2">Can process the entire traffic volume</td></tr>
<tr><td colspan="5">Additional Lanes: SB+1, NB+1 and EB+1</td></tr>
<tr><td rowspan="6">Tripureshwor</td><td rowspan="6">4 legs</td><td rowspan="3">Signalized</td><td>Current condition</td><td colspan="2">120</td><td colspan="2">1.32
No good
(> 0.90)</td><td>Cannot process the traffic volume of SB right turn lane</td></tr>
<tr><td>Additional +3 lanes</td><td colspan="2">120</td><td colspan="2">0.90</td><td rowspan="2">Can process the traffic volume of SB right turn lane</td></tr>
<tr><td colspan="5">Additional Lanes: SB+1, NB+1 and EB+1</td></tr>
<tr><td rowspan="3">Roundabout</td><td>Inflow</td><td>WB</td><td>SB</td><td>EB</td><td>NB</td><td>LOS intersection</td></tr>
<tr><td>Average Control Delay (second/veh.)</td><td>33</td><td>656</td><td>84</td><td>311</td><td>427</td></tr>
<tr><td>LOS</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td></tr>
</table>

Source: JICA Study Team

(4) Image of T-M Intersections for Physical Improvement

1) Approaches

The intersection analysis in Table 4.3.2 suggested that adding lanes can ease the saturated traffic condition. However, it seems difficult to install additional lanes in small intersections. The study team proposes to apply geometric improvement, channeling rearrangement and setback of footpath, particularly by applying a narrower lane width than the present conditions. Those proposals are shown on the aerial photos; however, it seems applicable without proper land surveys and CAD design.

Referring to the Nepali road design standard, it is specified that the road width in the multilane roads should be designed with 3.50 meters. However, from an international perspective, it is too strict. For example, according to “Road Construction Ordinance” issued by Japan Road Association, the applicable lane width is 2.75 to 3.50 meters under an urban condition, and many applications can be seen in Tokyo and congested cities to secure the capacity of urban roads. A similar application can be seen in London.

It should be noted that such geometric improvement in the intersections in an urban area have various approaches, and the study team proposes a package of technical assistance to prepare a detailed design with experienced planners, designers and engineers (see Section 5.2 for further proposals of the technical assistance). Also, signalization should be applied, but proper geometric improvement should also be applied and harmonized with the signal phasing. Therefore, the institutional harmonization would be necessary between the road designers and traffic management bodies.

The application of narrow width lanes would be influenced to traffic flows, which would be more controlled and calmed. The T-M intersections are located in the city center with many pedestrian, and the traffic flow should be harmonized under urban conditions. This application would contribute to better urban conditions.

2) Maitighar Intersections

It is necessary to add one lane each for inflows at south bound of Putalisadak Road, west bound of Tanka Prasad Ghumti Sadak Road and north bound of Putalisadak Road. In addition, it is proposed to reduce the current lane widths from w = 3.5 m to 3.0 m for straight lane and 2.75 m for bending lane, and acquire additional lands of 0.75m (14.75m - 14.0m) or reduction of a sidewalk width to secure the land for the necessary number of lanes.

Source: JICA Study Team

Figure 4.3.8 Image of Maitighar Intersections

Table 4.3.3 Lane Arrangement Plan for Maitighar Intersections

	1. Current lane arrangement		2. Lane arrangement plan		2. - 1. (increased number of lanes)	
	Inflow (In)	Outflow (In)	Inflow (In)	Outflow (In)	Inflow (In)	Outflow (In)
SB	2	2	3	2	+1	-
WB (North)	1	1	2	1	+1	-
WB (South)	3	3	3	2+1	-	-
NB	2	2	3	2	+1	-
EB	-	2	-	2	-	-
Total					+3	

Source: JICA Study Team

3) Thapathali Intersections

It is necessary to add one or two lane(s) each for inflows at south bound of Putalisadak Road, north bound of Teku Bagamati Bridge Road and east bound of Tripura Marg Road. In the case of east bound of Tripura Marg Road, it is proposed to reduce the current lane width from w = 3.5 m to 3.0 m for straight lane and 2.75 m for bending lane, and acquire an additional land of 2.75m (16.75m - 14.0m) or a reduction of the width of sidewalk to secure the necessary number of lanes.

Source: JICA Study Team

Figure 4.3.9 Image of Thapathali Intersections

Table 4.3.4 Lane Arrangement Plan for Thapathali Intersections

	1. Current lane arrangement		2. Lane arrangement plan		2. - 1. (increased number of lanes)	
	Inflow (In)	Outflow (In)	Inflow (In)	Outflow (In)	Inflow (In)	Outflow (In)
SB	2	2	3	2	+1	-
WB	1	1	1	1	-	-
NB	3	3	4	3	+1	^
EB	2	2	4	2	+2	-
Total					+4	

Source: JICA Study Team

4) Tripureshwor Intersections

It is necessary to add one lane each of inflows at the south bound of Kanti Path, north bound of Tripura Marg Road and east bound of Tripura Marg Road. It is proposed to reduce the current lane width from w = 3.5 m to 3.0 m for straight lane and 2.75 m for bending lane), and acquire additional land of 0.75m (14.75m - 14.0m = 0.75 m) or reduction of sidewalk width to secure the necessary number of lanes.

Source: JICA Study Team

Figure 4.3.10 Image of Tripureshwor Intersections

Table 4.3.5 Lane Arrangement Plan for Tripureshwor Intersections

	1. Current lane arrangement		2. Lane arrangement plan		2. - 1. (increased number of lanes)	
	Inflow (In)	Outflow (In)	Inflow (In)	Outflow (In)	Inflow (In)	Outflow (In)
SB	2	2	3	2	+1	-
WB	1	1	1	1	-	-
NB	2	2	3	2	+1	^
EB	2	2	4	3	+1	-
Total					+3	

Source: JICA Study Team

4.4 Improvement of Koteshwor – Tinkune Intersection

4.4.1 Introduction

Firstly, this sub-chapter will conduct further analysis of the traffic situation both at present and in the future (year 2030) in order to grasp the traffic flow at both Koteshwor and Tinkune intersections. Based on the analysis on the traffic flow and situation, the Study Team will further study the alternatives for improvement of two intersections to realize the most appropriate solution against the traffic congestion. Finally, the structural option shall be examined considering the latest technology and site situation according to the selected improvement alternative for two intersections.

4.4.2 Current Status of Koteshwor – Tinkune Intersection

Near the Koteshwor and Tinkune intersections, especially for the Koteshwor intersection, there are many stops/bays for middle to long distance buses within and near the intersections. The intersections are congested with such buses and other vehicles throughout the day.

Based on the traffic survey result in February 2019, when the intersection analysis was carried out (with the result shown in Table 4.4.1), it is found that Koteshwor intersection is very congested at present, but traffic flow at Tinkune intersection is in good condition.

Regarding a route connecting Koteshwor with Tinkune intersections, traffic volume was at 12,200 [PCU/Day] which results in V/C Ratio of 2.22.

Source: JICA Study Team

Figure 4.4.1 Photographs at Koteshwor Intersection Area

Table 4.4.1 Result of Intersection Analysis of Koteshwor and Tinkune Intersections (Year 2020)

Name of Intersection		Result/Evaluation of Signalized Intersection Analysis		
		Cycle Time (sec.)	Saturation Degree	Evaluation
Koteshwor		120	1.78	No Good (> 0.90)
Tinkune	North	-	0.07	Good
	West	-	0.55	Good
	South	-	0.82	Good

Source: JICA Study Team

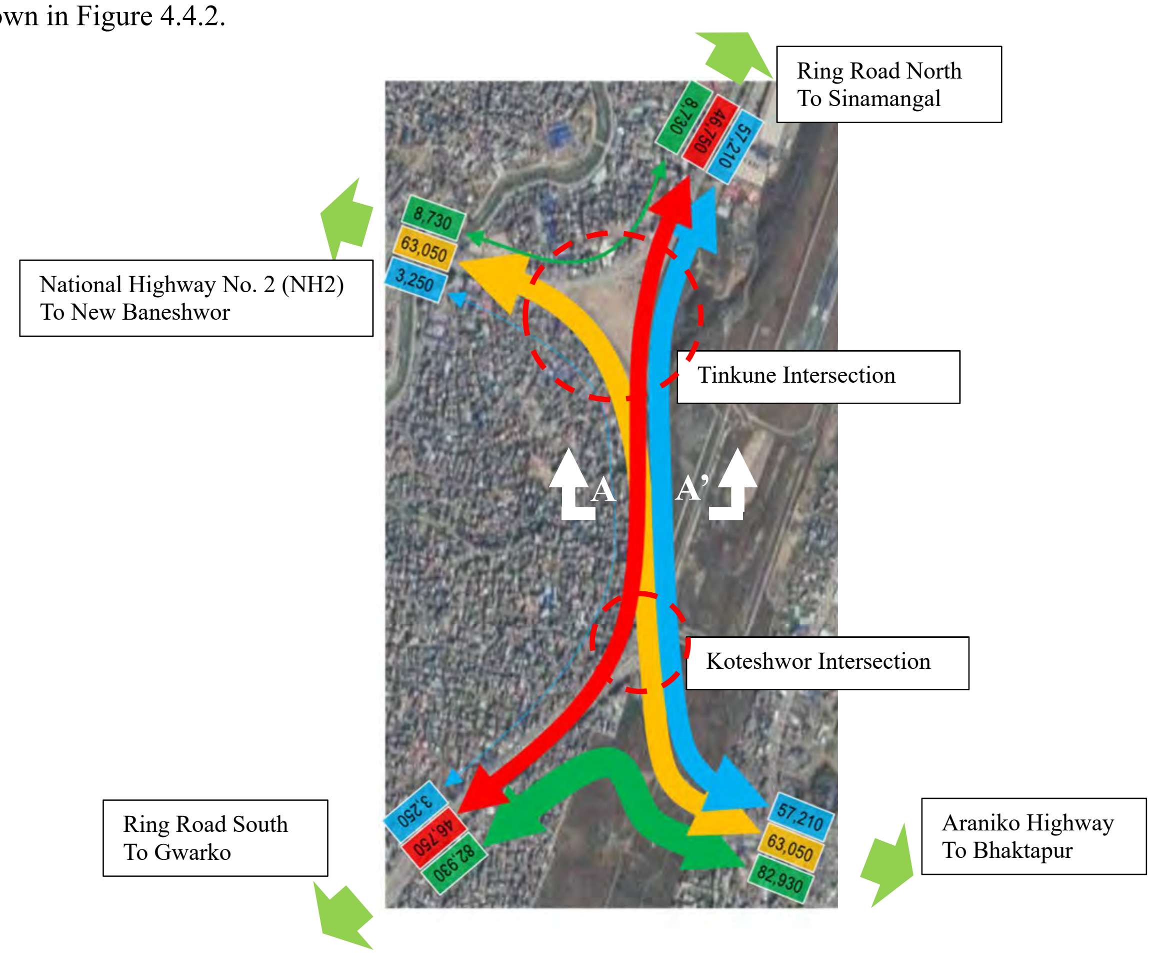
4.4.3 Preliminary Study of Improvement Method

(1) Traffic Demand Forecast Result

An intersection improvement method shall be studied based on traffic demand forecasted by the model prepared by Kathmandu Sustainable Urban Transport Project (KSUTP) (ADB, 2017). According to KSUTP, the following traffic cases were estimated:

- Year 2020
- Year 2030
- Year 2030 with Railway (East-West Line) and BRT

Based on the traffic forecast demand in year 2030, the estimated traffic flows within the study area are shown in Figure 4.4.2.

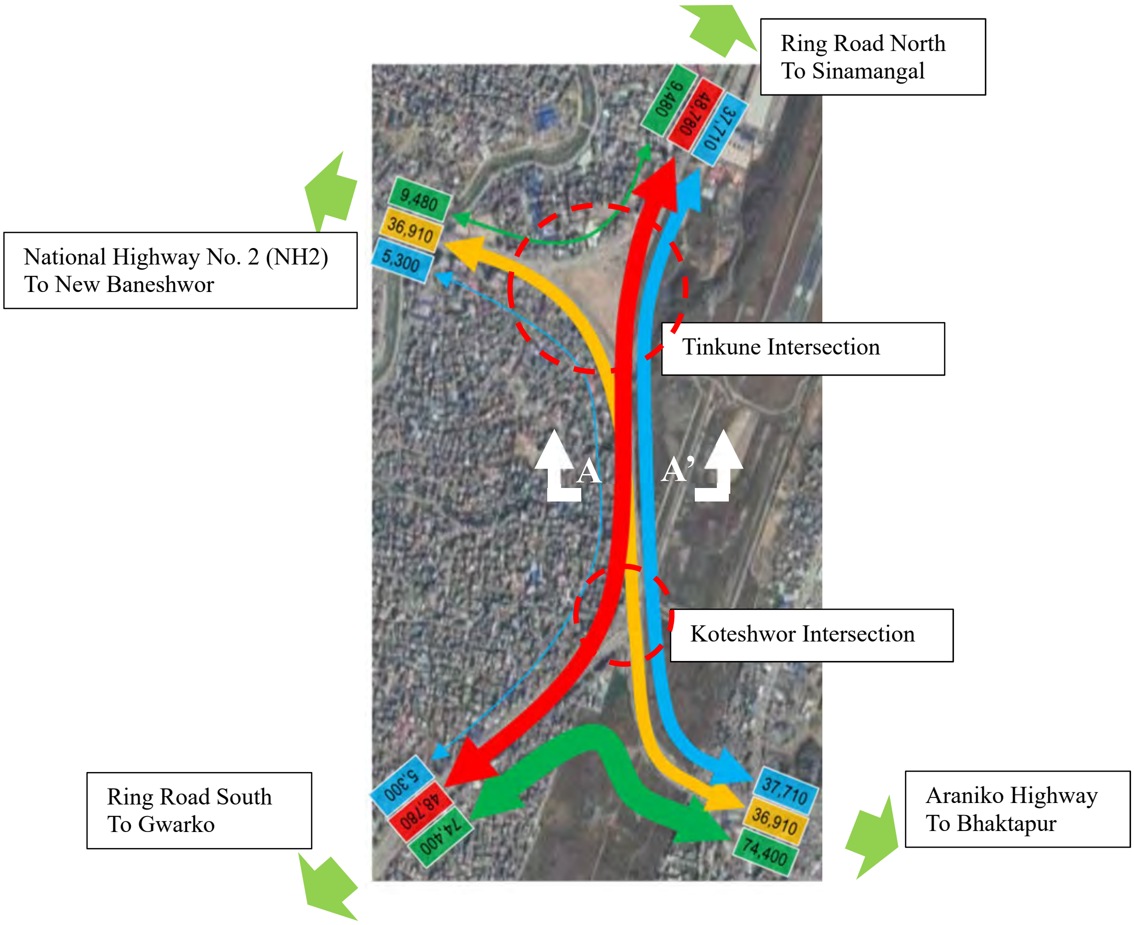


Unit: [PCU/day]
Source: JICA Study Team

Figure 4.4.2 Traffic Flow (Year 2030 Without Railway and BRT)

According to the traffic demand forecast by year 2030, the traffic volume at Throughway Link (A-A' Cross Section) – which is an overlapped road section between the Ring Road and Araniko Highway-NH2 Highway – becomes 170,260 [PCU/Day]. Currently, the Throughway Link has 4 lanes, of which the V/C ratio by year 2030 without railway and BRT is about 3.07. This means that 3 times of the lane number (i.e. 12 lanes) shall be required to alleviate the traffic congestion at the Link. It should be noted that the traffic generation due to the eastern new city development proposed by KVDA has influenced the high traffic demand from Bhaktapur.

Currently, whereas the introduction of Railway (East-West Line) is proposed by KSUTP by year 2030, a plan of introducing BRT is raised during the Mayor's Forum. The necessary number of lanes at Throughway Link will be reduced after both traffic systems are implemented. The estimated traffic flow with Railway and BRT at the studied area by year 2030 is shown in Figure 4.4.3.



Unit: [PCU/day]
Source: JICA Study Team

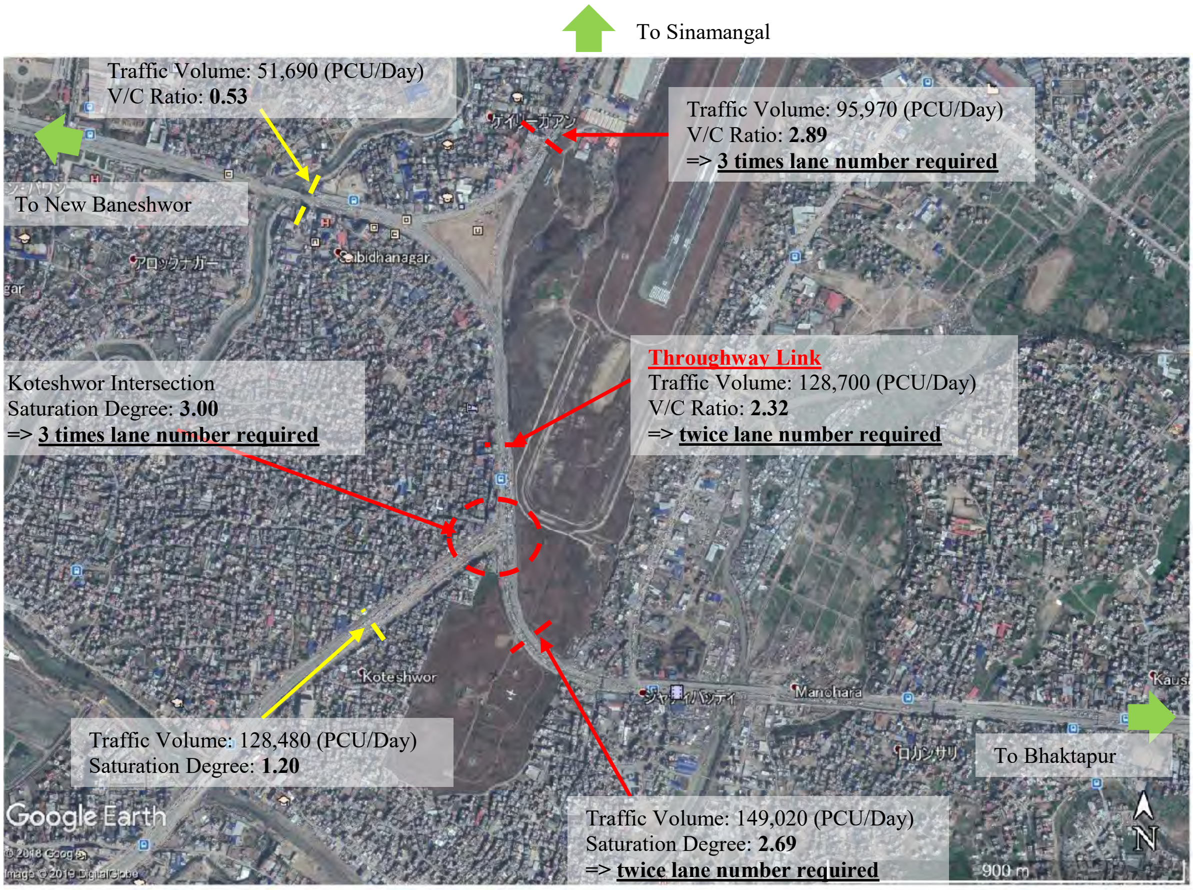
Figure 4.4.3 Traffic Flow (Year 2030 with Railway and BRT)

In the case of "with Railway and BRT" scenario, the traffic volume at Throughway Link (A-A' Cross Section) becomes 128,700 [PCU/Day], which results in V/C ratio of 2.32. This means that additional 4 lanes with grade separation are required to alleviate traffic congestion along Throughway Link. Since the grade separation with 4 lanes shall be considered as feasible and adequate scale of a road improvement project, the further study shall proceed based on traffic demand forecast by year 2030 with Railway and BRT.

(2) Issues of Koteshwor – Tinkune Intersection

Based on the traffic demand forecast by year 2030 with railway and BRT, both V/C ratio at each connecting roads and saturation degree of intersections are summarized in Figure 4.4.4. The analysis shows that the expected saturation degree at Koteshwor and Tinkune intersections will be 2.89 to 3.00, which are much higher than that in T-M intersections (see Table 4.3.2), and it is apparent that a geometric re-design is not suitable.

As a result, it can be said that an envisioned issue at Koteshwor – Tinkune intersection has an insufficient traffic flow capacity at both Throughway Link and Koteshwor intersection. Accordingly, a grade separated structure is essential covering both Throughway Link and Koteshwor intersection in order to increase the traffic link capacity.



Source: JICA Study Team

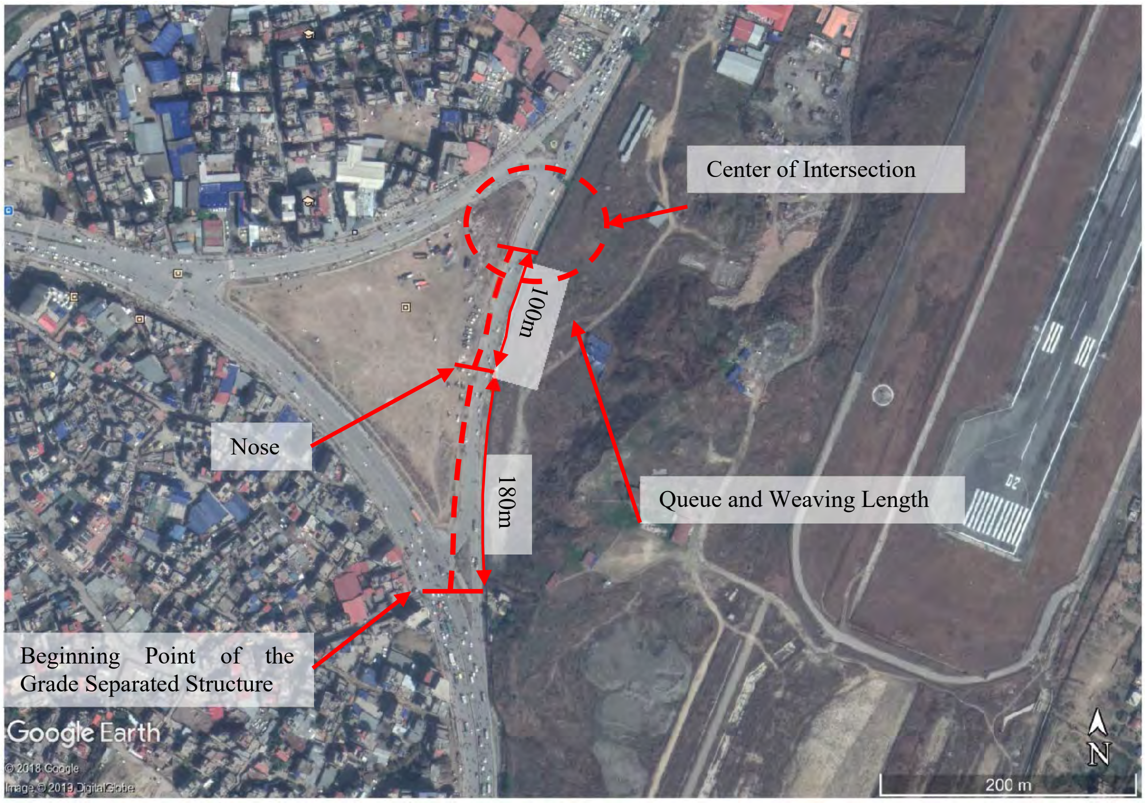
Figure 4.4.4 Envisioned Issues at Koteshwor – Tinkune Intersection by Traffic Demand Forecast (Year 2030 with Railway and BRT)

Regarding to the Tinkune intersection, although there is enough space to increase traffic lanes and the saturation ratio of the intersection keeps a satisfactory level, the grade separated structure needs to be covered up to the end of Throughway Link in order to increase the road capacity of Throughway Link. Accordingly, the following 2 options can be considered.

Option 1 : Application of the grade separated structure from the north/west end of Tinkune Intersection – Throughway Link – Koteshwor Intersection

Option 2 : Application of the grade separated structure from Throughway Link – Koteshwor Intersection

In the case of Option 2, the Study Team attempted to formulate a plan for a new Tinkune intersection shown in Figure 4.4.5. It is found that setting a new intersection with NH 2 along the existing road section from the end of the grade separated section to the beginning of the Ring Road North would be impossible. Although it is necessary to secure a geometrically necessary distance for both nose-entrance of the grade separated structure and queue and weaving section before the center of the intersection, this would result in making it impossible to set the intersection in the middle of the said road section. Thus, Option 1, or a continuous grade separated structure from north/west end of Tinkune intersection to Throughway Link – Koteshwor Intersection, can be an applicable improvement option.



Source: JICA Study Team

Figure 4.4.5 Plan View of Tinkune Intersection with Option 2 Applied

(3) Improvement Policy

Based on the traffic demand forecast with railway and BRT by year 2030, it is confirmed that increments of traffic capacity for both Throughway Link and Koteshwor intersection are required in order to avoid traffic congestion. Therefore, the application of a grade separated structure for both Throughway Link and Koteshwor intersection is required.

In addition, it is also confirmed that it will be difficult to formulate an appropriate intersection plan/design if the grade separated structure is applied for Throughway Link until the south end of Koteshwor Intersection (as explained in the previous section).

Therefore, it can be judged that a continuous grade separated structure is required from the north/west end of Tinkune intersection to Koteshwor intersection via Throughway Link.

(4) Preliminary Study Result

Based on the improvement policy mentioned above, an alignment study for the grade separated structure is conducted. According to traffic demand forecast by year 2030 with railway and BRT as shown in Figure 4.4.3, the following issues are confirmed.

- From Araniko Highway, where approximately 50% of the traffic flow goes to the Ring Road South, approximately 25% of the traffic flow goes to NH No. 2 and the Ring Road North, respectively.

- From the Ring Road South, where approximately 58% of the traffic flow goes to Araniko Highway, approximately 38% of the traffic flow goes to the Ring Road North.

Thus, traffic volume passing through the grate separated structure varies greatly depending on the route alternative. Therefore, a preliminary study of route alternative for the grade separated structure is carried out, focusing on how much traffic volume can use the grade separated structure. A comparison table is shown in Table 4.4.2.

Table 4.4.2 shows that Alternative 4 and 5 indicate a relatively good balance of traffic volumes between one of the grade separated routes and one at grade.

Table 4.4.2 Preliminary Study of the Alignment of Grade Separated Structures

Item	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Image of Alignment					
	NH2-Araniko	NH2-RR South	RR North -Araniko	RR North -RR South	NH2 and RR North-Araniko
Total Volume	128,700	128,700	128,700	128,700	128,700
Traffic at G/S	36,910 (0.67)	5,300 (0.10)	37,710 (0.68)	48,780 (0.88)	74,610 (1.34)
Traffic at A/G	91,790 (1.65)	123,400 (2.22)	90,990 (1.64)	79,920 (1.44)	54,080 (0.97)
Evaluation Based on V/C Ratio	G/S: Middle A/G: Low	G/S: Low A/G: Low	G/S: Middle A/G: Low	G/S: Very High A/G: High	G/S: High A/G: Very High
Recommendation				Recommended	Recommended

Note: G/S="Grade Separation", A/G="At Grade", Unit of Traffic Volume: PCU/Day and Number in Bracket shows V/C Ratio
Source: JICA Study Team

4.4.4 Preliminary Design on Highway/Intersection

(1) Design Condition

1) Highway Design

a) Geometric design standard

"Nepal Road Standard 2070 (July 2013)" is applied in this preliminary study.

b) Administrative Classification of Road

Based on the administrative classification of NH.2, the Ring Road and Araniko Highway can be regarded as "National Highway and Class I and / or II".

Table 4.4.3 Approximate Correlation Between Administrative and Functional Classifications

	Plain and Rolling Terrain	Mountainous and Steep Terrain
National Highways	**Class I, II**	Class II, III
Feeder Roads	Class II, III	Class III, IV

Source: Nepal Road Standard 2070

Table 4.4.4 Road Classification

Road Classification	Description	Remarks
National Highways	National Highways are the main roads connecting the east to west and the north to south of the nation. These highways directly serve the greater portion of the longer distance travel, provide consistently higher level of service in terms of travel speeds, and bear the inter-community mobility. These roads shall be the main arterial routes passing through the length and breadth of the country as a whole.	Araniko Highway, Ring Road and NH.2

Source: Nepal Road Standard 2070

Table 4.4.5 Road Specification

Road Specification	Description	Remarks
Class I	Class I roads are the highest standard roads with divided carriageway and access control (i.e. expressways) and with ADT of 20,000 PCU* or more in a 20-year perspective period. The design speed adopted for the design of this class of roads in plain terrain is120 km/h.	Araniko Highway, Ring Road and NH.2
Class II	Class II roads are those with ADT of 5,000-20,000 PCU in a 20-year perspective period. The design speed adopted for the design of this class of roads in plain terrain is 100 km/h.	

Note: *PCU: Passenger Car Unit (Passenger Car Equivalent)
Source: Nepal Road Standard 2070

c) Dimensions of the vehicle for the design of roads

The maximum dimensions of vehicles considered for the design of roads in Nepal are as follows:

- Maximum Width = 2.50m; Maximum Height = 4.75m; Maximum Length = 18.00m
- Maximum single axle load = 100kN

d) Design speed

The design speed of Vs = 60km per hour on the grade separate section is adopted as shown in Table 4.4.6.

Table 4.4.6 Design Speed

Road Specification	Plain	Rolling	Mountainous Grade separation section	Steep	Remarks
Class I	120	100	80	60	It will be Class I based on the future traffic volume by year 2030. However, in consideration of economic efficiency, a design speed of 60 km/hr would be desirable.
Class II	100	80	60	40	

Source: Nepal Road Standard 2070

e) Horizontal alignment (Minimum radius of horizontal curves)

The minimum curve radius at the design speed of 60 km/hr is 200m as a standard, and R = 110m as an exceptional value. In this design, R = 200m will be secured in principle. However, R=160m is applied for the grade separate section of the Koteshwor intersection in order to avoid land acquisition of the existing buildings along the roadside.

Table 4.4.7 Radius of Horizontal Curves

Road Specification		Design Speed V_s km/hour	Minimum Recommended Radius R_{min} m			Remarks
			When no super-elevation is provided 2.5% camber i.e. negative super-elevation	When a maximum of super-elevation of 10% is provided	From the comfort criteria of passengers Max lateral force 15% of vertical force	
Class I		120	1,730	600	760	It is also possible to adopt the R = 110m (exceptional minimum value) for the radius of curvature of the Koteshwor bend point, but it has been found to be disadvantageous in extra-widening of the carriageway and widening for the setback distance.
Class I	Class II	100	870	370	530	
Class I	Class II	80	440	210	340	
Class I	Class II	**60**	**200**	**110**	**190**	
	Class II	40	70	40	90	

Source: Nepal Road Standard 2070

f) Vertical Alignment (Maximum Gradient)

The maximum longitudinal gradient is 7% as shown in Table 4.4.8. In this design, 6% will be adopted in anticipation of the 1% margin. In addition, the minimum longitudinal gradient for longitudinal drainage purpose is 0.5%.

Table 4.4.8 Maximum Gradients

Design Speed	km/hr	40	60	80	100	120
Maximum Gradient	%	9	7	6	5	4

Source: Nepal Road Standard 2070

g) Width of Carriageway

The lane width of the carriageway on both at grade and grade separation section is 3.5m. However, the lane width of the inflow/outflow section for intersection will be flexibly set in consideration of widening improvement.

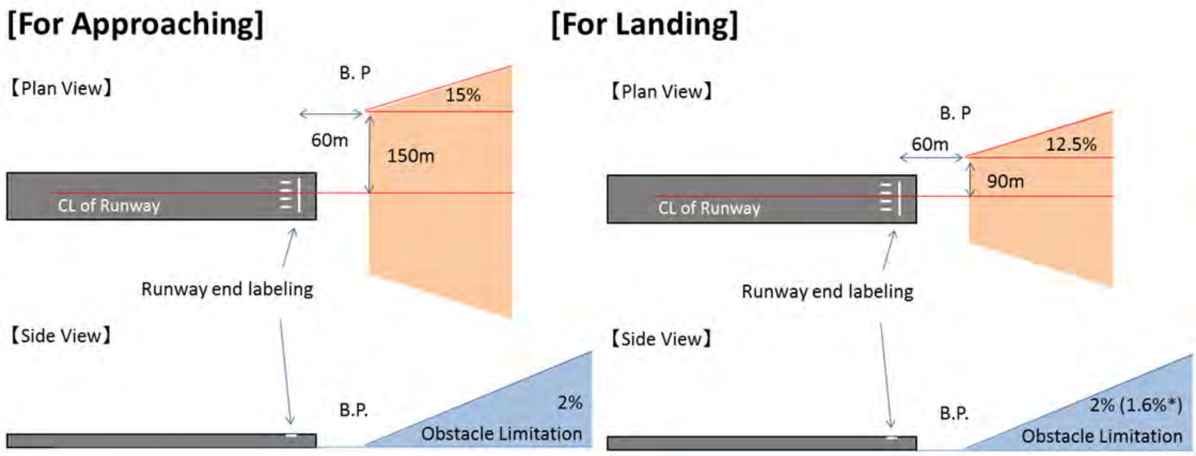
Table 4.4.9 Width of Carriageway

Multilane Pavements Width per Lane (m)	Intermediate Lane (m)	Carriageway Width of Single Lane Road (m)
3.5	5.5	3.75

Source: Nepal Road Standard 2070

2) Aviation Requirements

Since Koteshwor intersection is located near the Tribhuvan International Airport, aviation requirement may create a limitation of the structure location or height. According to an interview with CAAN, the aviation requirements of Tribhuvan International Airport follow the International Civil Aviation Organization (ICAO) specifications. The obstacle limitation is considered as shown in Figure 4.4.6.

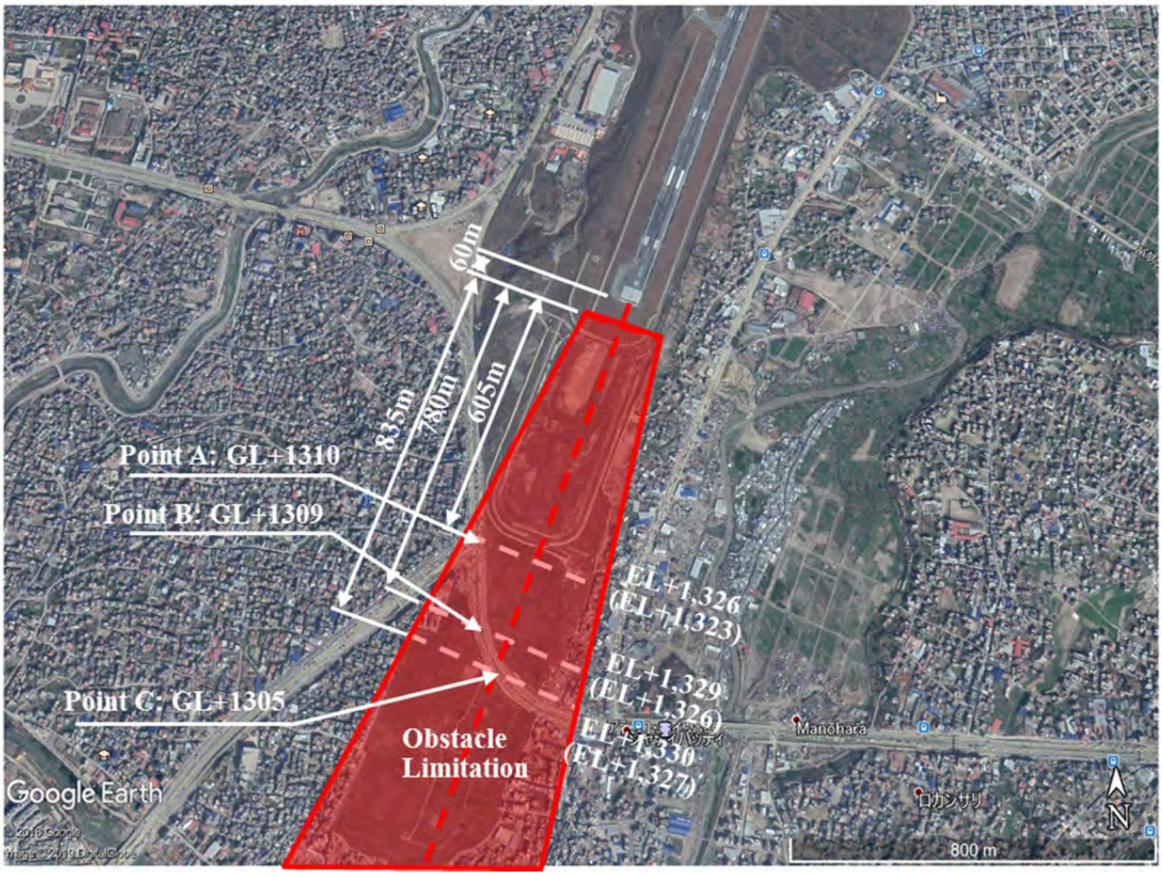


Note: *: ICAO recommends applying 1.6% for the newly constructed structure

Source: JICA Study Team

Figure 4.4.6 Sketch of the Obstacle Limitation based on ICAO Specifications

According to an interview with CAAN, the base elevation of the airport runway is set at EL+1314. Based on this elevation and requirements mentioned above, the actual elevation of the obstacle limitation is calculated as shown in Figure 4.4.7 and Table 4.4.10.



Source: JICA Study Team

Figure 4.4.7 Plan View of Obstacle Limitation

Table 4.4.10 List of Obstacle Limitation Elevation and Clearance

Point	Elevation of Obstacle Limitation	Ground Elevation	Clearance [m]
Point A	+1,326 (+1,323)	+1,310	16 (13)
Point B	+1,329 (+1,326)	+1,309	20 (17)
Point C	+1,330 (+1,327)	+1,305	25 (22)

Note: Number in bracket is calculated by 1.6% gradient.
Source: JICA Study Team

Although, there is enough clearance for the viaduct structure at Point C, the viaduct (with expected elevation of +1320~+1323) will obstruct the view of navigation light (+1308). Therefore, a viaduct structure cannot be deemed applicable along the Araniko Highway.

(2) Plan and Profile

A preliminary design is performed on the two alternatives based on the comparison results shown in Table 4.4.2. Due to the aviation requirements as explained in the previous section, it is found that a flyover structure type cannot be applied to Alternative 5. Accordingly, the following structural options shall be preliminary examined.

- Alternative 4-1 by Underpass
- Alternative 4-2 by Flyover
- Alternative 5 by Underpass

(3) Intersection Analysis Results at K-T Intersections

1) Traffic Flow by Year 2030

From South-West | From South-East | From North-West | From North-East

Small Vehicle Unit: veh./day

from South-West | from South-East | from North-West | from North-East

Heavy Vehicle Unit: veh./day

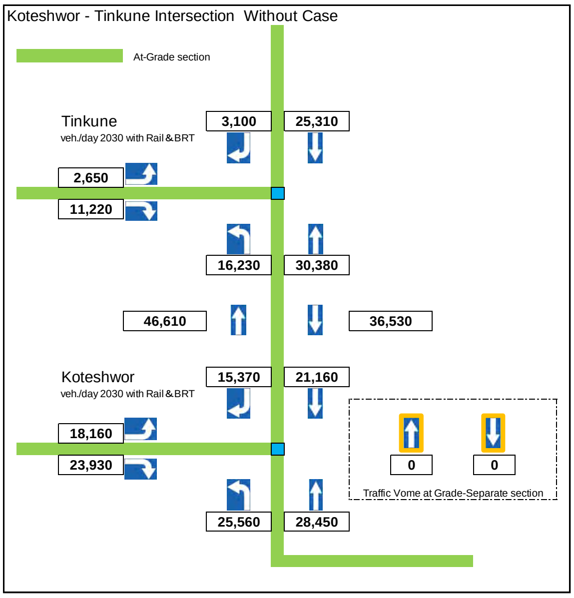
Source: JICA Study Team

Figure 4.4.8 Traffic Flow by Year 2030

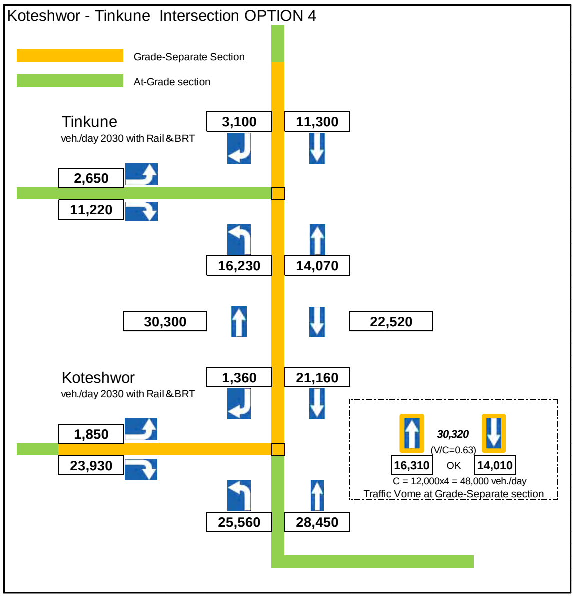
The ratios of heavy vehicles at both Koteshwor intersection and Tinkune intersection are at 11.6% and 12.3%, respectively.

2) Traffic Flow by Year 2030 for Each Option

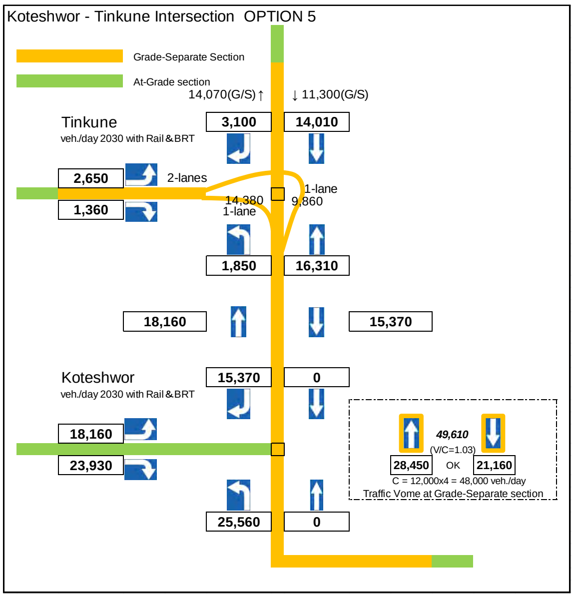
The traffic flow from Koteshwor intersection to Tinkune intersection for each alternative is shown in Figure 4.4.9, and an intersection analysis is carried out by using the obtained traffic flow.



Without Case



Alternative 4



Alternative 5

Source: JICA Study Team

Figure 4.4.9 Traffic Flow by Year 2030 for Each Alternative

3) Results of Intersection Analysis of Koteshwor and Tinkune Intersections (Year 2030)

The results of the intersection analysis of both Koteshwor and Tinkune intersections are shown in Table 4.4.11.

Regarding the at grade portion of Koteshwor intersection, since traffic volume between Araniko Highway and the Ring Road South is too huge, the required lane number for the at grade road section connecting Araniko Highway and Ring Road South also become large. As a result, land acquisition is required especially for Alternatives 4-1 and 4-2.

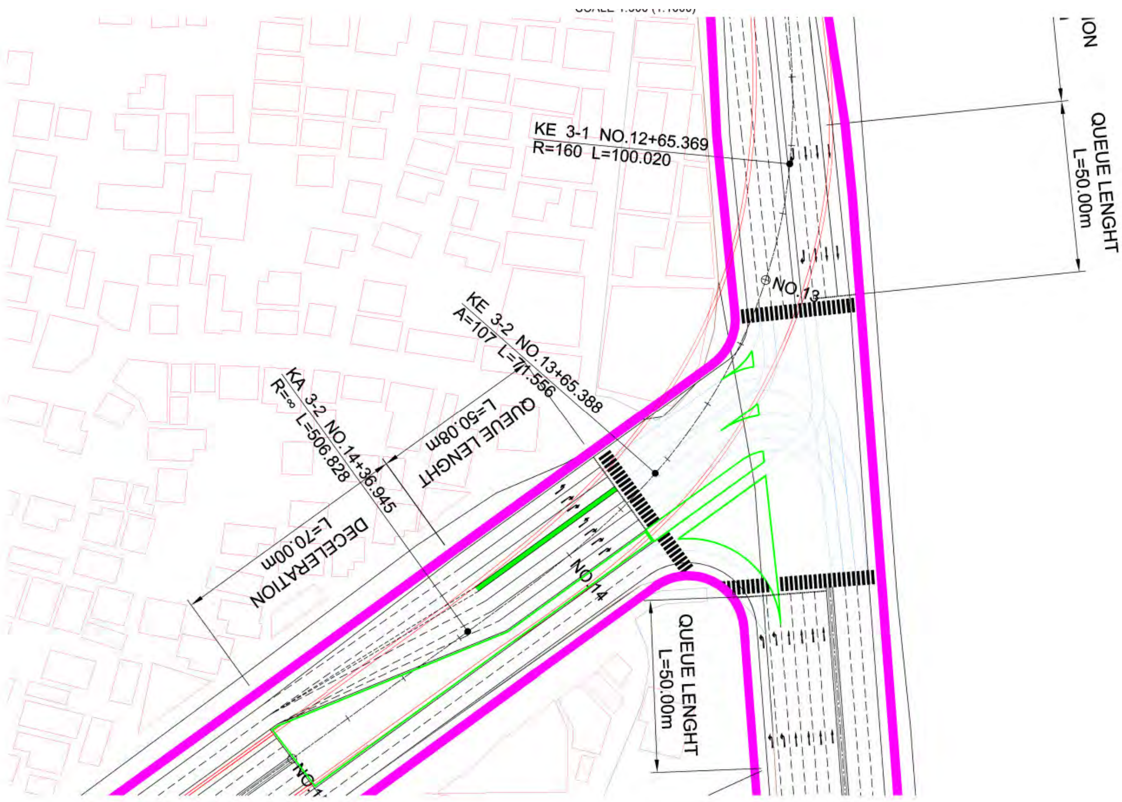
In order to solve this problem, an additional bypass provision which will divert the traffic flow from the Araniko Highway to and from the Ring Road south should be considered in order to avoid the concentration of the traffic flow to the Koteshwor intersection.

Currently, Highly Powered Committee for Integrated Development of Bagmati Civilization is implementing a river corridor development along the Manohara River. In order to enhance traffic flow passing through the Manohara River corridor, it is recommended to install good connections with grade separation and sufficient road flow capacity for the corridor.

Table 4.4.11 Result of Signalized Intersection Analysis for Koteshwor and Tinkune (Year 2030)

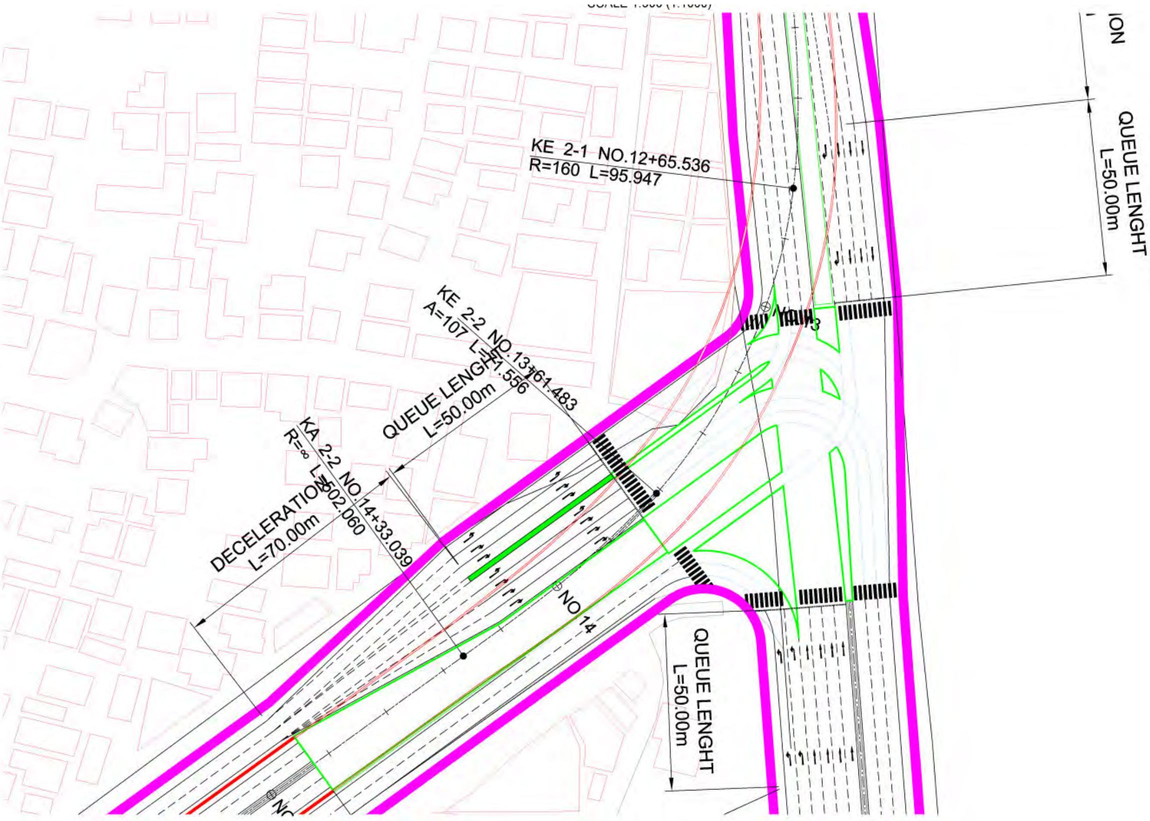
<table>
<tr><th rowspan="2">Name of Intersection</th><th rowspan="2">Name of Option</th><th colspan="3">Result/Evaluation of Signalized Intersection Analysis</th><th rowspan="2">Remarks</th></tr>
<tr><th>Cycle Time (sec.)</th><th>Saturation Degree</th><th>Evaluation</th></tr>
<tr><td rowspan="5">Koteshwor</td><td>Without Case</td><td>180</td><td>2.14</td><td>No good (> 0.90)</td><td>Cannot process traffic volume of SB/NB/EB left turn lanes</td></tr>
<tr><td rowspan="2">Alternative 4</td><td>120</td><td>0.91</td><td>Almost good</td><td rowspan="2">Slight traffic congestion will occur at the NB left turn lane.</td></tr>
<tr><td colspan="3">SB: 4-lane, NB: 6-lane and EB: 7-lane
Total of inflow lanes: 17-lane (Figure 4.4.10 and Figure 4.4.11)</td></tr>
<tr><td rowspan="2">Alternative 5</td><td>180</td><td>0.79</td><td>Excellent</td><td rowspan="2">Slight traffic congestion will occur at the NB/EB left turn lanes.</td></tr>
<tr><td colspan="3">SB: 4-lane, NB: 4-lane and EB: 7-lane
Total of inflow lanes: 15-lane (Figure 4.4.12)</td></tr>
<tr><td rowspan="5">Tinkune</td><td>Without Case</td><td>120</td><td>1.15</td><td>No good (> 0.90)</td><td>Traffic congestion will occur at the NB left turn lane.</td></tr>
<tr><td rowspan="2">Alternative 4</td><td>120</td><td>0.70</td><td>Excellent</td><td rowspan="4">Traffic volume can be processed at all inflows.</td></tr>
<tr><td colspan="3">SB: 3-lane, NB: 4-lane and EB: 3-lane
Total of inflow lanes: 10-lane (Figure 4.4.13 and Figure 4.4.14)</td></tr>
<tr><td rowspan="2">Alternative 5</td><td>120</td><td>0.59</td><td>Excellent</td></tr>
<tr><td colspan="3">SB: 3-lane, NB: 3-lane and EB: 2-lane
Total of inflow lanes: 8-lane (Figure 4.4.15)</td></tr>
</table>

Source: JICA Study Team



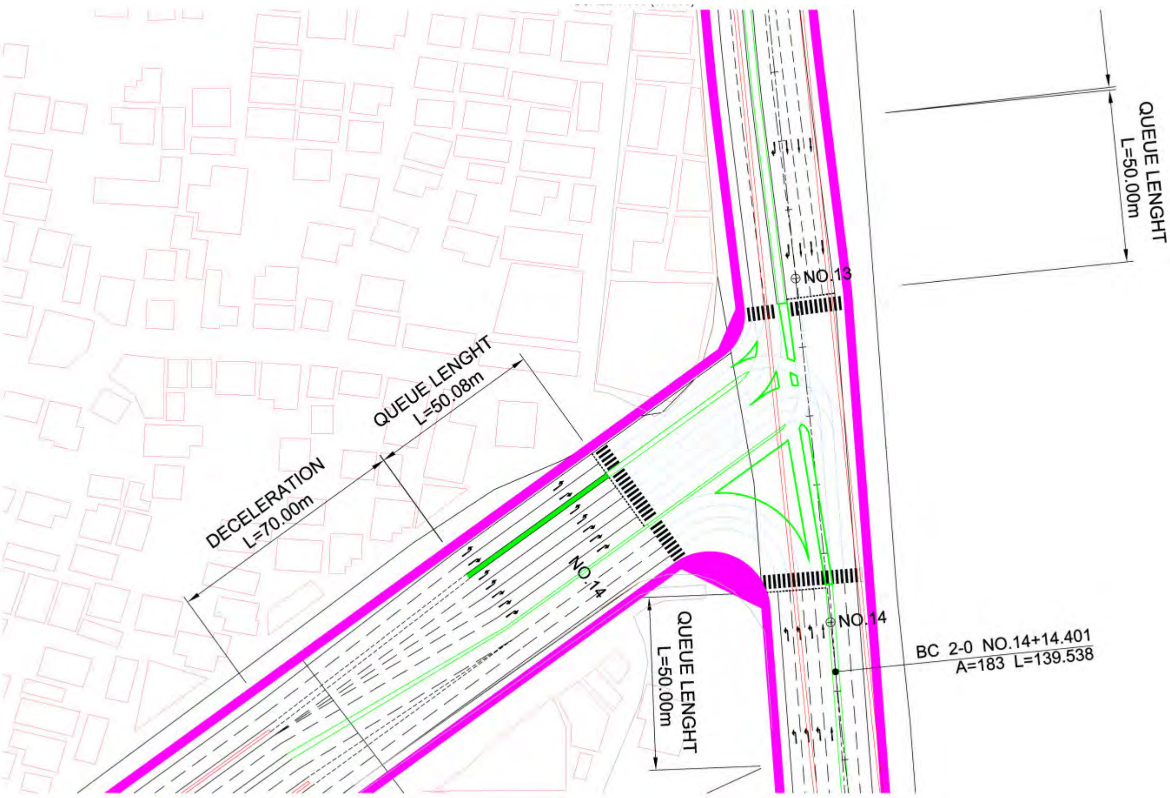
Source: JICA Study Team

Figure 4.4.10 Improvement Plan View of Koteshwor Intersection (Alternative 4-1) at Grade Level



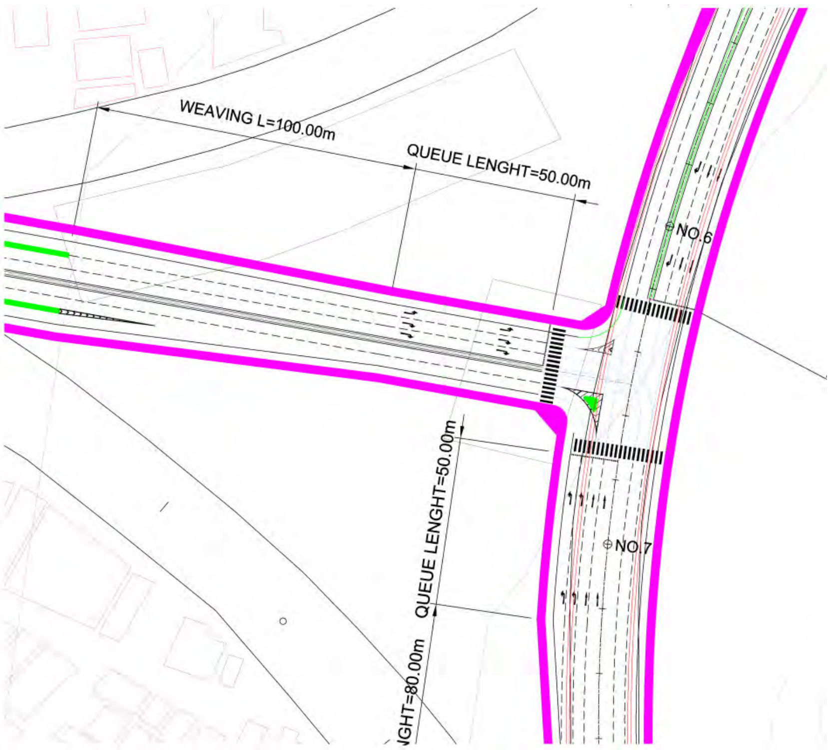
Source: JICA Study Team

Figure 4.4.11 Improvement Plan View of Koteshwor Intersection (Alternative 4-2) at Grade Level



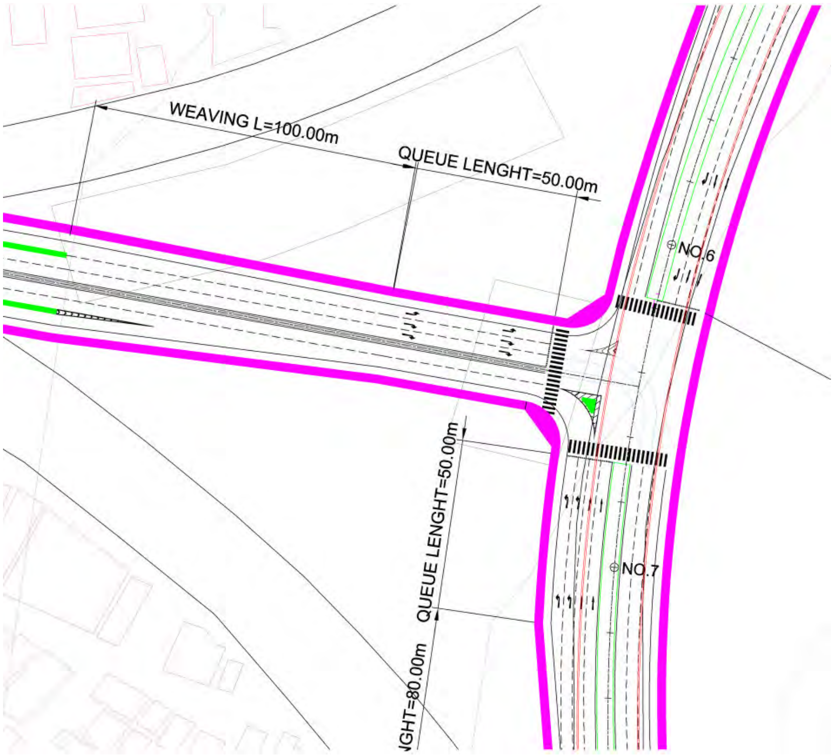
Source: JICA Study Team

Figure 4.4.12 Improvement Plan View of Koteshwor Intersection (Alternative 5) at Grade Level



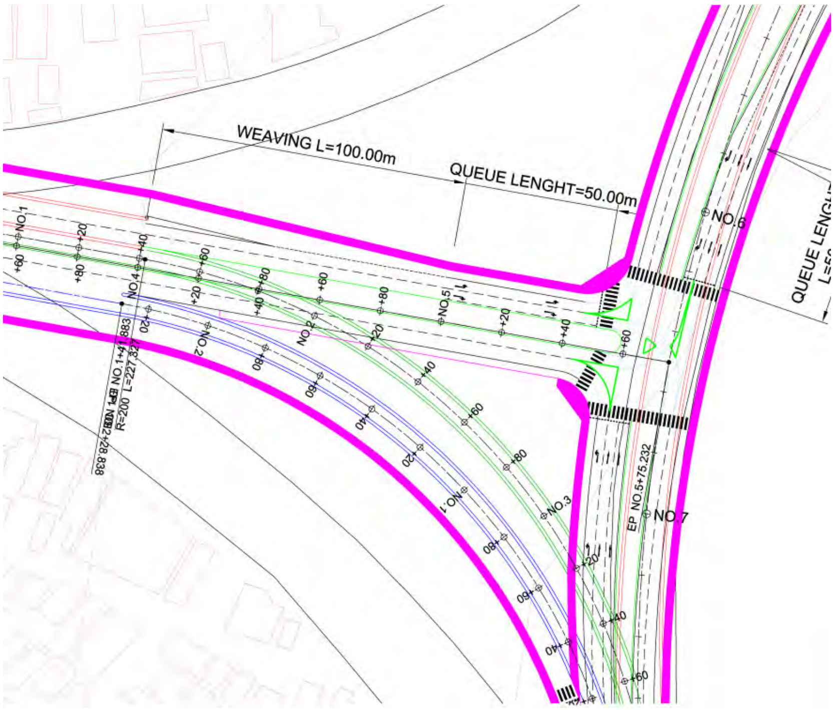
Source: JICA Study Team

Figure 4.4.13 Improvement Plan View of Tinkune Intersection (Alternative 4-1) at Grade Level



Source: JICA Study Team

Figure 4.4.14 Improvement Plan View of Tinkune Intersection (Alternative 4-2) at Grade Level



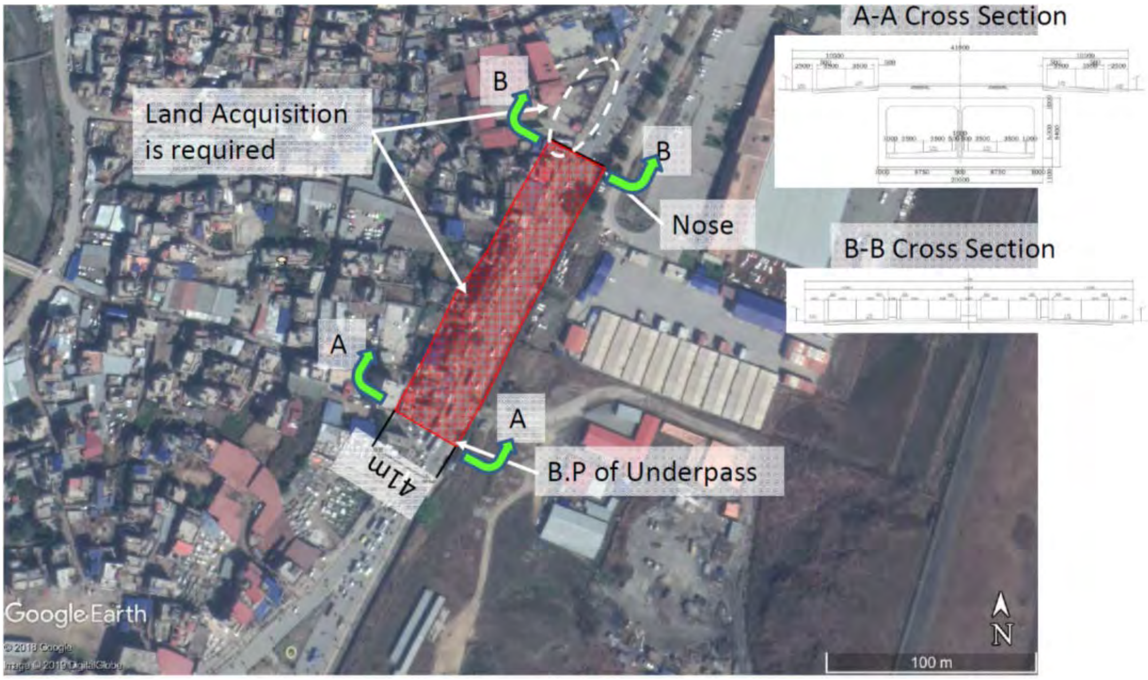
Source: JICA Study Team

Figure 4.4.15 Improvement Plan View of Tinkune Intersection (Alternative 5) at Grade Level

(4) Issues on Land Acquisition

1) Necessity of Land Acquisition at North of Tinkune Intersection (Alternatives 4-1 and 4-2)

The necessary land acquisition area at north of Tinkune intersection for both Alternative 4-1 by underpass and 4-2 by flyover is shown in Figure 4.4.16. Since the existing road width is not enough to secure the necessary width for installation of the grade separated structure, some land acquisition may be required because, although 50m of ROW is defined by DOR, the concept of "Corridor of Impact" has been applied in the Ring Road upgrade project, which means the narrower ROW has been acquired for the Ring Road project.

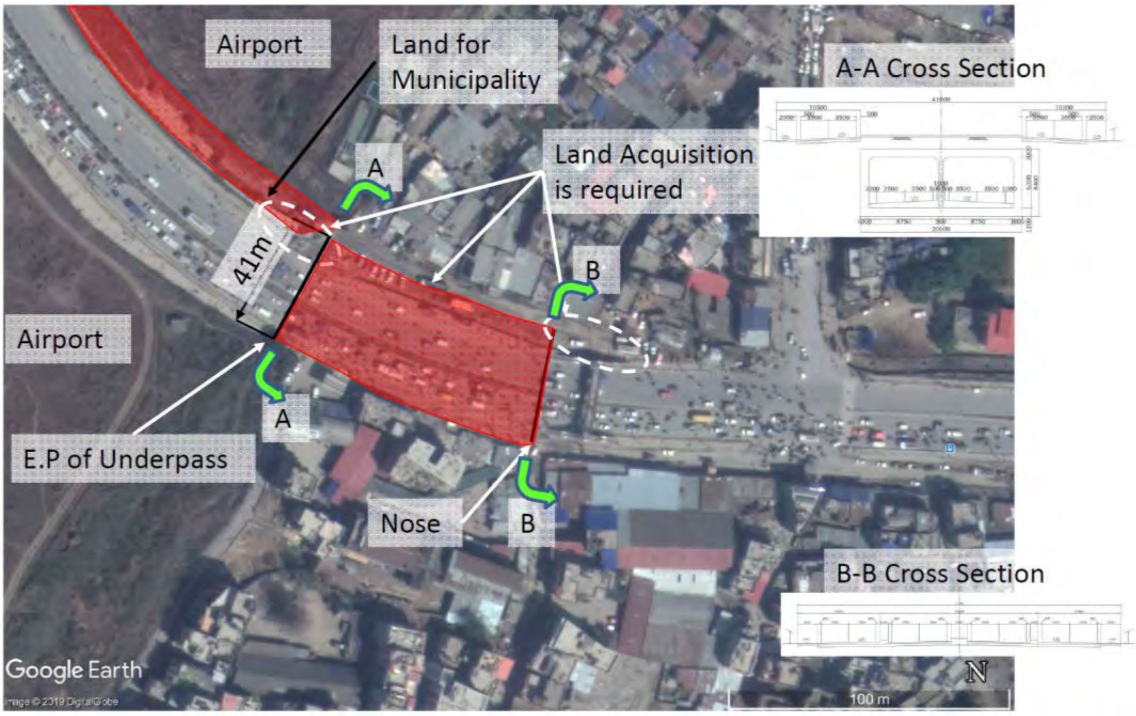


Source: JICA Study Team

Figure 4.4.16 Expected Land Acquisition Area at North of Tinkune Intersection

2) Necessity of Land Acquisition near Jadibuti Intersection (Alternative 5)

The necessary land acquisition area near Jadibuti Intersection for Alternative 5 is shown in Figure 4.4.17. Although it is necessary to increase the existing road width, doing this for a residential area is not required.



Source: JICA Study Team

Figure 4.4.17 Expected Land Acquisition Area near Jadibuti Intersection

(5) Intersection Analysis Result of Jadibuti Intersection

1) Traffic Flow in Year 2030

From West

From East

From North

Unit: [veh./day]

Source: JICA Study Team

Figure 4.4.18 Traffic Flow at Jadibuti Intersection for Small Vehicles

From East

From North

From West

Unit: [veh./day]
Source: JICA Study Team

Figure 4.4.19 Traffic Flow at Jadibuti Intersection for Heavy Vehicles

The ratio of heavy vehicles at Jadibuti Intersection is at 10.7%.

2) Result of Intersection Analysis at Jadibuti Intersection (Year 2030)

The result of the Jadibuti intersection analysis is shown in Table 4.4.12.

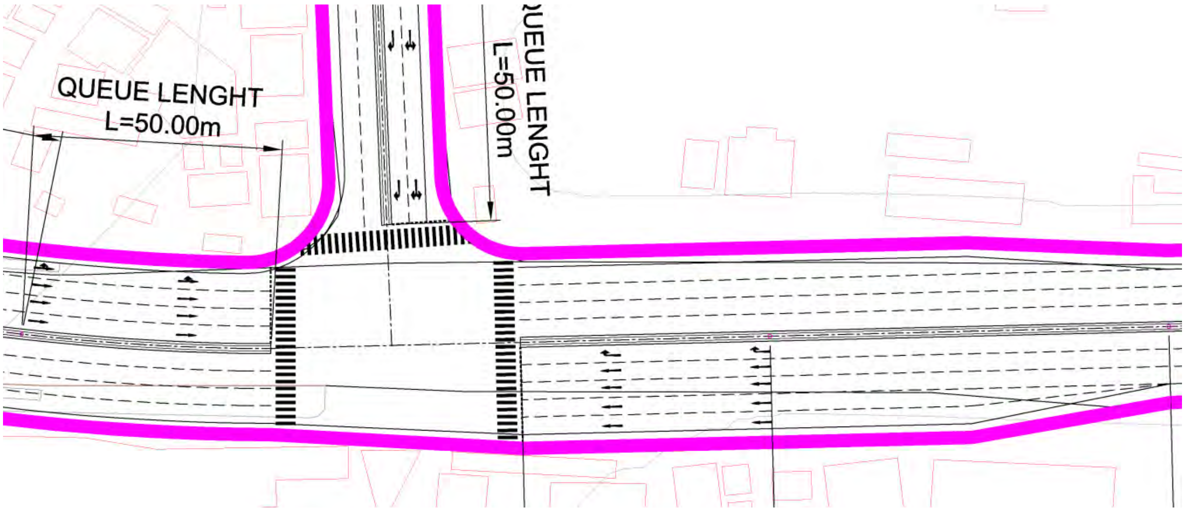
Table 4.4.12 Result of Signalized Intersection Analysis for Jadibudi (Year 2030)

Name of Intersection	Name of Option	Result/Evaluation of Signalized Intersection Analysis			Remarks
		Cycle Time (sec.)	Saturation Degree	Evaluation	
Jadibuti	Current lane arrangement	70	1.13	No good (> 0.90)	Cannot process the traffic volume of EB/WB through lanes.
		SB: 2-lns, EB: 3-lns and WB: 4-lns inflow lanes Total: 9-lns			
	Increase number of inflow lanes	70	0.92	Almost good	Slight traffic congestion will occur, but it can be processed.
		SB: 2-lns, EB: 4-lns and WB: 5-lns inflow lanes Total: 11-lns			

Source: JICA Study Team

From a viewpoint of traffic flow conditions at the intersection, it is proposed to increase the number of lanes in Araniko Highway. A proposed plan view of improvement of the intersection is shown in Figure 4.4.20.

In order to accommodate the necessary number of lanes, land acquisition at the south side of Jadibuti intersection will be required.



Source: JICA Study Team

Figure 4.4.20 Improvement Plan View of Jadibuti Intersection

4.4.5 Preliminary Design of Structure

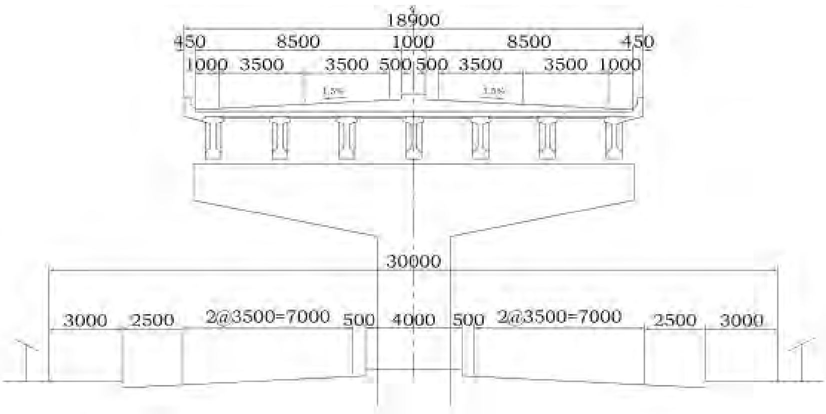
(1) Introduction

As described in the previous chapter, the grade-separated structure needs to be applied for the intersection improvement option. The following describes the study on the applicable structure type.

(2) Study on Flyover Alternative

1) Introduction

A flyover structure is constructed above the existing road. In order to secure space for the existing traffic on the ground level road, it is recommended that superstructure is supported by one pier column as shown in Figure 4.4.21.



Source: JICA Study Team

Figure 4.4.21 Typical Cross Section of a Flyover

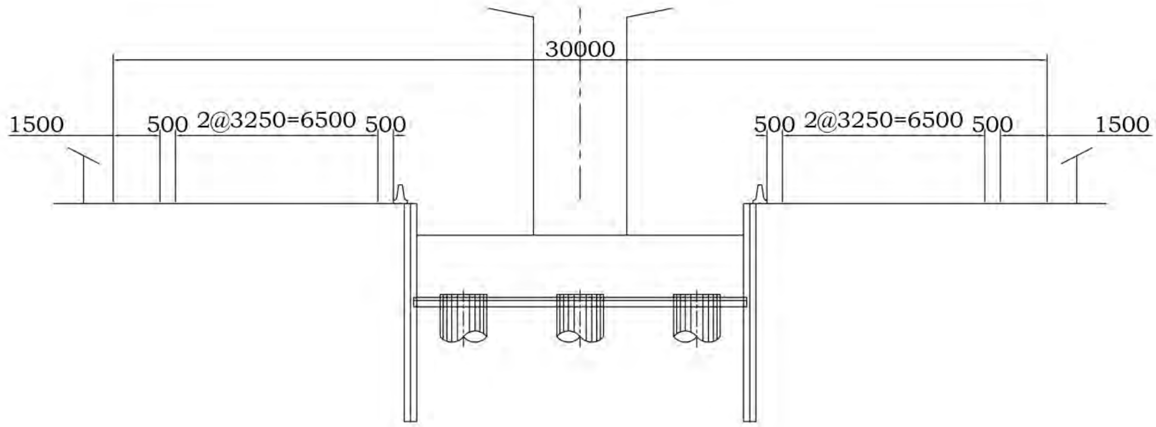
2) Type of Superstructures

Two types of superstructures can be considered for a flyover structure: one for the section on Throughway Link (between Koteshwor intersection and Tinkune intersection), and the other for crossing both the Koteshwor intersection and Tinkune intersection.

Since there is no major crossing structure at Throughway Link, a proposed superstructure type is PC-I girder, which is most economical type of superstructure. On the other hand, since it is necessary to avoid negative impact on the intersection area even during the construction stage, a steel girder type is preferable because the steel girder can be erected in a short time even though the erection time is limited only at nighttime (for a few nights). Although there is some negative impact to the existing traffic, the negative impact due to construction work can be limited compared with other superstructure type.

3) Type of Foundation

In consideration of the current practice in Nepal, a cast-in-situ concrete pile type is applied. A typical cross section during the construction of the pile cap is shown in Figure 4.4.22.



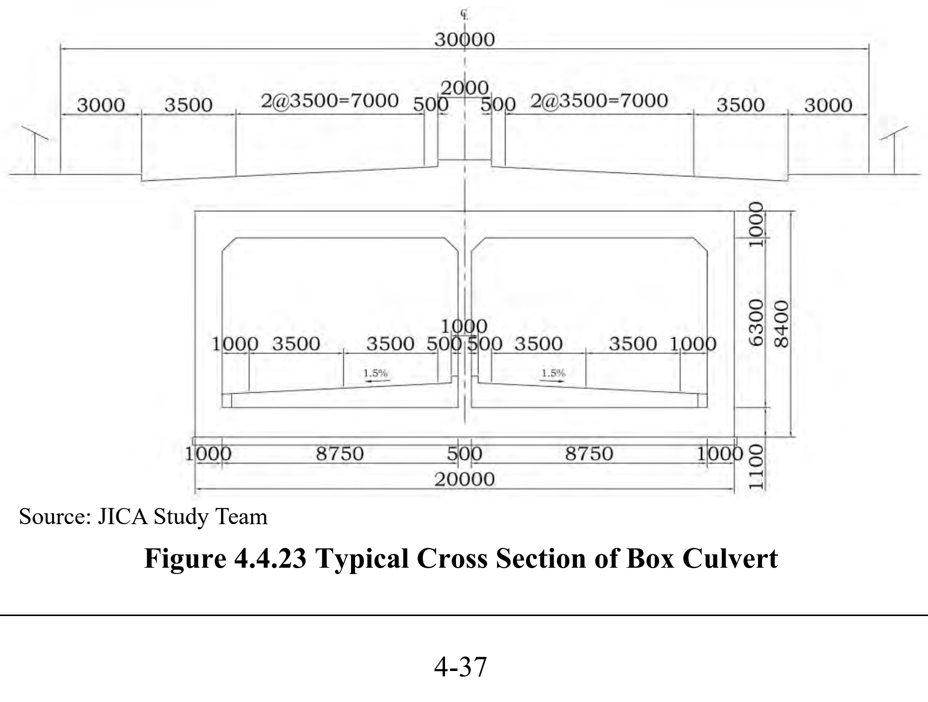
Source: JICA Study Team

Figure 4.4.22 Typical Cross Section of Foundation and Detour Road During the Construction of Pile Cap

(3) Study on Underpass Alternative

1) Introduction

There are 2 types of structures that can be applied for underpass: one is box culvert and the other is tunnel by Tunnel Boring Machine (TBM). Both structure types can be applicable for both Alternative 4 and Alternative 5 selected in Chapter 4.4.3. However, since the construction cost by TBM is too high, only box culvert structure shall be only option to examine in this chapter. A typical cross section of the box culvert is shown in Figure 4.4.23, which shows a cross section at the narrowest width within project area.



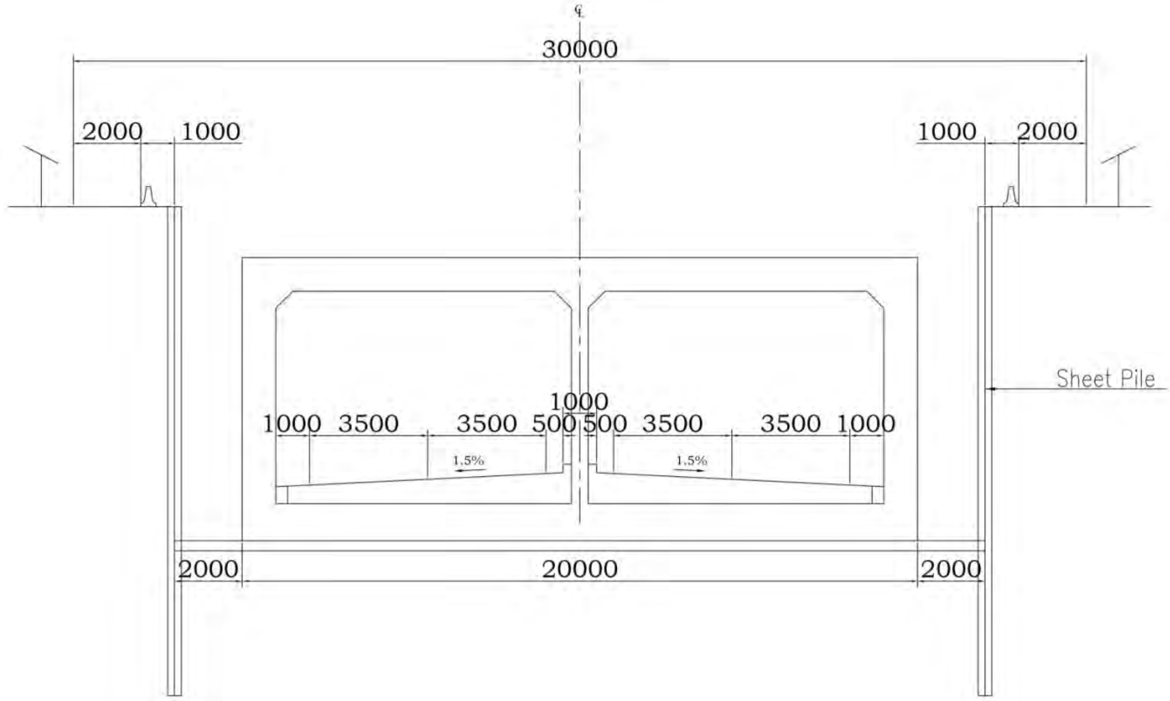
Source: JICA Study Team

Figure 4.4.23 Typical Cross Section of Box Culvert

2) Construction Method of Box Culvert

Generally, a box culvert is constructed by cast-in-situ. In order to construct the box culvert at the site, a temporary retaining wall structure should be required. However, the narrowest section of ROW in the alignment is located between Koteshwor and Tinkune intersection with 30m in width. If an open cut construction method is applied, the remaining width utilized for temporary road is only 2x2.0m as shown in Figure 4.4.24.

Obviously, it is difficult to manage the existing traffic by this narrow width (2x2.0m). Thus, a countermeasure should be considered.



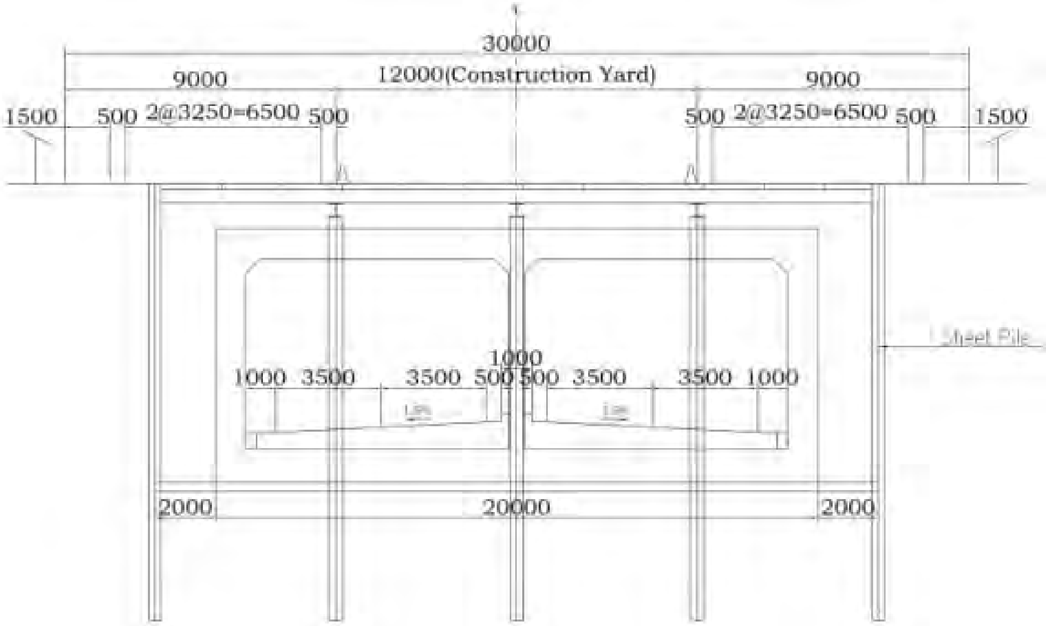
Source: JICA Study Team

Figure 4.4.24 Cross Section Applying Open Cut Construction Method for Box Culvert

In order to construct the box culvert while keeping the existing traffic, there are two construction methods as stated below:

i) Open-cut construction method with temporary platform
ii) Non-open cut construction method (box jacking method or element jacking method)

The total length of the box culvert for the Alternatives is anticipated to be more than 1,300m; however, the longest box culvert applied by non-open cut construction method is about 300m in Japan so far. Accordingly, open-cut construction method with temporary platform shall be applied as a construction method for box culvert. A typical cross section is shown in Figure 4.4.25.



Source: JICA Study Team

Figure 4.4.25 Cross Section Applying Open Cut Construction Method with Temporary Platform

Construction steps for the open-cut construction method with temporary platform are as follows:

Step1: Construction of Temporary Platform
Installation of sheet pile and H-shaped beam for pile of temporary platform
Trench excavation to install main beam and temporary deck slab for temporary platform
All works are expected to be done at nighttime with diversion of traffic

Step2: Excavation Work Under Temporary Platform
Excavation work is mainly done at nighttime. During this work, the width of diversion road is limited and the temporary platform is removed during nighttime.

Step3: Construction of Box Culvert
Installation of rebar and formwork can be done at daytime. However, mobilization of formwork and rebar material needs to be done during nighttime since the temporary platform needs to be removed.

(4) Construction Schedule

The construction schedules for each alternative are estimated as follows:

Alternative 4-1 (by underpass) : 48 months
Alternative 4-2 (by flyover) : 30 months
Alternative 5 (by underpass) : 48 months

The detailed construction schedules for each alternative are shown in Table 4.4.13 and Table 4.4.14, respectively.

Table 4.4.13 Construction Schedule for Alternatives 4-1 and 5 by Underpass

	First Year												Second Year												Third Year												Forth Year											
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Preparatiion Work	—	—	—																																													
Cofferdam Installation				—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—																								
Temporary Platform Installation				—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—																								
Excavation and Intallation of Supporting Frame for Cofferdam									—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—																				
Construction of Box Cuvert											—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—												
Backfilling Work																							—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—								
Pavement Work																												—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—				
Drainage Work																									—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—					
Ventilation Work																									—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—					
Lighting Work																															—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		
Re-installation fo At Grade Road																														—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		
Finishing Work																																															—	—

Source: JICA Study Team

Table 4.4.14 Construction Schedule for Alternative 4-2 by Flyover

	First Year												Second Year												Thrid Year					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Preparatiion Work	—	—	—																											
Foundation Work				—	—	—	—	—	—	—	—	—																		
Sub-Structure Work						—	—	—	—	—	—	—	—	—	—	—	—	—	—											
Fabrication of PC-I Girder				—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—											
Procurement and Fabrication of Steel Box Girder				—	—	—	—	—	—	—	—	—																		
Erection of PC-I Girder								—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—							
Erection of Steel Box Girder													—	—	—															
Deck Slab Work										—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—					
Parapet Work														—	—	—	—	—	—	—	—	—	—	—	—	—				
Pavement Work																		—	—	—	—	—	—	—	—	—	—			
Lighting Work																						—	—	—	—	—	—	—		
Finishing Work																													—	—

Source: JICA Study Team

(5) Cost Estimation

The preliminary cost estimation is made in consideration of the unit costs for flyover and underpass options in Nepal, other developing countries and Japan.

1) Construction Cost for Alternative 4-1 (Underpass)

The construction cost for this Alternative is estimated based on following assumptions:

- Width of box culvert is 20m and casted on-site.
- Cofferdam structure is steel sheet pile.

- Temporary platform structure by H-beam and I-beam is considered for diversion of traffic along the whole alignment of the underpass.
- As for the electrical and mechanical equipment, the cost for the ventilation system, drainage system, lighting system and emergency exit system is considered.

The preliminary construction cost for Alternative 4-1 (underpass) is shown in Table 4.4.15.

Table 4.4.15 Preliminary Cost Estimation for Alternative 4-1 (Underpass)

Item		Cost [Million NPR]
Box Culvert Construction	Length: 1,140m Width: 20m	18,500
Electrical and Mechanical Equipment	Ventilation System, Drainage System, Lighting System and Emergency Exist System	30% of civil cost
Total		24,100

Source: JICA Study Team

2) Construction Cost for Alternative 4-2 (Flyover)

The construction cost for this Alternative is estimated based on following assumptions:

- Width of flyover is 18.9m.
- Superstructure type crossing at Koteshwor intersection and Tinkune intersection is by steel box girder and PC-I girder for the remaining section.
- Foundation type is cast-in-situ concrete pile.

The preliminary construction cost for Alternative 4-2 (Flyover) is shown in Table 4.4.16.

Table 4.4.16 Preliminary Cost Estimation for Alternative 4-2 (Flyover)

Item		Cost [Million NPR]
PC-I Girder Bridge	Length: 980m Width: 18.9m	4,900
Steel Box Girder Bridge	Length: 340m Width: 18.9m	5,000
Total		9,900

Source: JICA Study Team

3) Construction Cost for Alternative 5 (Underpass)

Construction cost for this Alternative is estimated based on following assumptions:

- Width of box culvert is 14m from beginning point to Tinkune.
- Width of box culvert is 20m from Throughway Link to end point.
- Width of ramp is 7.5m to connect to NH2.
- Cofferdam structure is steel sheet pile.
- Temporary platform structure by H-beam and I-beam is considered for diversion of traffic along the whole alignment of the underpass.
- As for the electrical and mechanical equipment, the cost for the ventilation system, drainage system, lighting system and emergency exit system is considered.

The preliminary construction cost for Alternative 5 (underpass) is shown in Table 4.4.17.

Table 4.4.17 Preliminary Cost Estimation for Alternative 5 (Underpass)

Item		Cost [Million NPR]
Box Culvert Construction	Length:(BP to Tinkune) 360m Width: 14m Length (Tinkune to EP): 780m Width: 20m Length (Ramp to NH2): 720m Width: 7.5m	22,000
Electrical and Mechanical Equipment	Ventilation System, Drainage System, Lighting System and Emergency Exist System	30% of civil cost
Total		28,600

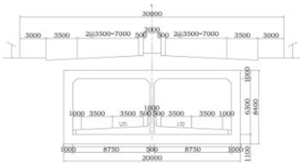
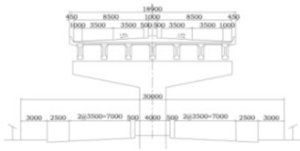
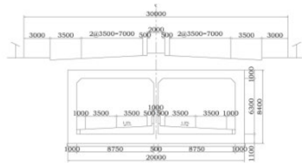
Source: JICA Study Team

4.4.6 Comparison Results on the Alternatives

Based on the study results for both highway/intersection and structure, a comparison table for Alternative 4-1 (underpass), Alternative 4-2 (flyover) and Alternative 5 is prepared in Table 4.4.18.

However, due to issues of economic benefit assessment and construction cost estimation as explained in details in Chapter 4.8.1, a final recommendation on the alternative is not made in this study.

Table 4.4.18 Comparison Table for the Alternatives

		Alternative 4-1	Alternative 4-2	Alternative 5
Image of the Alignment				
Cross Section				
Structure Type		Box Culvert	PC-I Girder and Steel Box Girder	Box Culvert
Traffic Improvement	**Koteshwor**	Total Inflow Lanes: 17 Lanes Saturation Degree: 0.91		Total Inflow Lanes: 15 Lanes Saturation Degree: 0.79
	Tinkune	Total Inflow Lanes: 10 Lanes Saturation Degree: 0.70		Total Inflow Lanes: 8 Lanes Saturation Degree: 0.59
	Throughway	V/C Ratio for G/S: 0.88 V/C Ratio for A/G: 1.44		V/C Ratio for G/S: 1.34 V/C Ratio for A/G: 0.97
Structural Summary		- Temporary Platform for Temporary Road and Construction Yard - Construction work at nighttime	- During the construction of the Sub-structure, the existing traffic is restricted. - Erection of Superstructure is carried out at nighttime.	- Temporary Platform for Temporary Road and Construction Yard - Construction work at nighttime
Structure Length		1,140m	1,320m	1,860m
Construction Period		48 Months	30 Months	48 Months
Land Acquisition		- Required at Koteshwor Intersection and BP at Ring Road North - Required for Drainage Pump Pit and Ventilation Tower	- Required at Koteshwor Intersection and BP at Ring Road North	- Required at Koteshwor Intersection
Social Impact		- Temporary road width should be reduced during nighttime. - Residents suffer due to nighttime construction.	- Traffic congestion is expected, especially during the construction of the Sub-structure.	- Temporary road width should be reduced during nighttime. - Residents suffer due to nighttime construction. - Land Acquisition will be required for the Drainage Pump Pit and Ventilation Tower.
Construction Cost		24.1 [Billion NPR] (2.43)	9.9 [Billion NPR] (1.00)	28.6 [Billion NPR] (2.89)

Note: G/S="Grade Separation", A/G="At Grade"
Source: JICA Study Team

4.5 Applicable Technologies

4.5.1 Technologies by Nepali Contractor

(1) Contractor in Nepal

Based on information from the Federation of Contractors' Associations of Nepal, all contractors are classified based on some criteria such as the technical manpower, value and number of works done, machinery and liquid assets available.

Most of the contractors are classified as Class D, and only 1~2% of contractors are classified as Class A. Some Class A contractors have experienced working with Japanese contractors. Even though their capitals are not large (only a few contractors have more than NPR 300 million), most of the contractors have about NPR 100 million or less.

(2) Major Construction Technology for Bridge in Nepal

1) Superstructure Type

The most common superstructure type in Nepal is PC-T/T girder type and PC box girder type. The span lengths of PC-T/I Girder and PC Box Girder are about 35~40m and 50~60m, respectively.

Regarding a steel superstructure type, there are several steel arch bridges, especially outside of Kathmandu Valley. In Nepal, there are a few steel fabricators, and the structure steel is imported from India.

RC Arch

PC-I Girder

Source: JICA Study Team

Figure 4.5.1 Photo of a Newly Constructed Concrete Bridge in Kathmandu

2) Foundation Type

The most common foundation type in Nepal is a cast-in-situ concrete pile by all casing method, and the diameter ranges from 1.0 to 1.5m which was previously introduced by a Chinese contractor. Regarding the prefabricated pile, there is neither a steel pile nor a PC pile constructed by a Nepali company, and RC pile is also very rare.

Source: JICA Study Team

Figure 4.5.2 Photo of the Construction of Cast-in-Situ Concrete Pile in Kathmandu

3) Pavement

Since there is no asphalt plant outside of Kathmandu area, a Double Bituminous Surface Treatment (DBST) has been generally utilized. However, asphalt concrete mix is available inside the Kathmandu Valley area, since some asphalt batching plants are owned by Nepali contractors for their own usage.

4) Temporary Work

Only sheet pile cofferdam of up to 10m in depth has been constructed by Nepali contractors. Temporary supporting frame such as H-shaped steel, I-shaped steel and so on are imported from India.

(3) Issues of the Contractor in Nepal

Most critical issue of the Contractor in Nepal is un-compliance with construction period. Following reasons are considered for this issue.

1) Sub-Contracting

Because of lack of proper government policy and political protection in Nepal, Nepali contractor usually sublet the work to small and local contractors for most of the projects. In most of the cases, these small and local contractors do not have enough resources required to execute the construction work, such as technical staff with proper management skills, labor force and equipment.

2) Labor Force

Labors in Nepal are mostly a part-time worker while they are fee from their household duties and agricultural work. Almost off of the contractors largely depend on either those part-time worker or labors from India in order to reduce their labor cost. Because of this, lack of labors occurs especially during rice planting (June/July), festival such as Dashain and Tihar and rice harvesting (October/November) season.

3) Price Change

Most of the construction materials need to be transported from India through road transport. Political instability in the county causes different types of strikes in different regions. Sometimes such factors create rise in prices of imported materials. In such situation, due to optimism consideration of the contractors, usually, they wait quietly for the cheaper material and prolong their construction period.

(4) Issues of the Contractor from China and India

It is believed that over 60% of International Competitive Bid contract projects of Nepal are awarded to either Chinese or Indian contractor. Especially in Kathmandu Valley area, Ring Road Construction Project included Kalanki intersection improvement which is first intersection improved by Underpass

Structure is implemented by Chinese Contractor. Although there was some delay in construction work, it looks construction quality is satisfactory. Regarding to other projects by Chinese and Indian Contractor, some projects were completed with successful condition, on the other hand, it is said that some projects taken by them are either cost overrun or time overrun due to the lack of construction management. In the worst case, there are some projects that the Chinese contactor left the project site without completion of construction work.

In addition, China and India are the top two donor countries. All the projects funded by them are taken by their own contractor. In such projects, most of resources including unskilled labor and construction materials are imported from their own countries. Therefore, there is minimum benefit or employment opportunity for local industries and people.

4.5.2 Advanced Technologies

(1) Introduction

As explained in this chapter, since all study intersections are located along very congested roads in Kathmandu, advanced technologies, which can minimize negative social impacts during construction, are introduced in this chapter to examine the possibility of their application to the mid-term improvement projects.

In order to minimize the negative social impacts, advanced technologies described in this chapter can reduce the construction period and space, and the release of harmful substances such as noise and air pollution, vibration, polluted sludge from the excavation site, and so on.

Since the expected structure types for these intersections improvement works are by flyover and underpass, advanced technologies focus on construction technique for both structural options. A list of advanced technologies is shown in Table 4.5.1.

Table 4.5.1 List of Applicable Advanced Technologies

Category	Name of Technology	Pros	Cons	Feature
Flyover	Composite Deck Slab	- High durability compared with conventional RC deck slab - Possible to open existing traffic under deck slab after installation of bottom steel plate	- N/A	New deck slab type which has high durability and safe for construction, especially, underneath the deck slab. This can also be applicable for steel girders.
	Rotation Steel Pile	- Possible to construct very narrow space - Possible to reduce adverse impact during construction	- Construction cost becomes higher.	New type of steel pile which can be constructed in a narrow space and can utilize a smaller size of pile cap due to large load carrying capacity compared with cast-in-situ concrete pile. In addition, it does not generate excavated soil and has low vibration and low noise, making this pile type very eco-friendly.
	PC Well	- Possible to construct very narrow space	- Construction cost becomes higher.	New type of foundation which can be constructed in a narrow space and can utilize a smaller size of foundation because no pile cap is required.

Category	Name of Technology	Pros	Cons	Feature
	Steel Pipe Socket Connection Method	- Possible to reduce construction period	- N/A	New connection method between steel pier column and pile cap/pile by omitting the anchor frame, enabling this method to achieve shorter construction time and with possible application to a PC well foundation.
Box Culvert	Application of Temporary Platform	- Construction cost becomes cheaper than none-open cut method.	- There is adverse impact to existing traffic especially at during installation of temporary platform and night time.	Temporary platform is installed above open-cut area of box culvert and is used for detour road. Construction work of box culvert is carried out under temporary platform. Mobilization and demobilization of material and equipment is carried out during night time.
	Box Jacking Method	- Possible to construct box culvert without any disturbance of existing traffic	- Construction cost becomes higher.	New construction method for box culvert without disturbing the existing traffic/railway infrastructure during construction by pushing/pulling of box culvert casted beside the placement location.
	Element Jacking Method	- Possible to construct box culvert without any disturbance of existing traffic	- Construction cost becomes higher.	New construction method for box culvert without disturbing the existing traffic/railway infrastructure during construction. Excavation from side of box culvert by element using manpower or machine, then casting a concrete at the site.

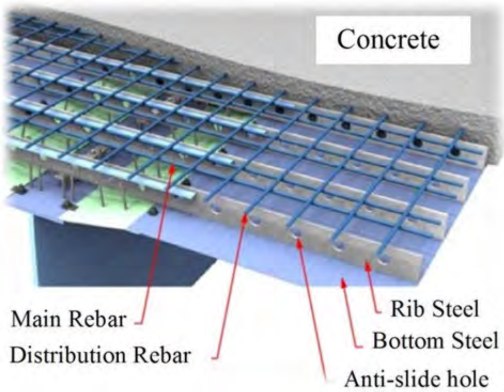
Source: JICA Study Team

(2) Outline of Advanced Technologies

1) Composite Deck Slab

This is a new type of deck slab structure with composite of steel structure and concrete structure. The bottom of the composite deck slab is covered by steel plate reinforced by T/I shaped steel. Afterwards, concrete will be poured after the installation of the bottom steel.

This deck slab has more durability compared with conventional RC deck slab and can achieve quick construction results. Since the steel plate is installed first, there is no risk of wet concrete leakage during construction, and it does not cause restriction of traffic usage underneath the deck slab during construction work. A sketch of the composite deck slab is shown in Figure 4.5.3.



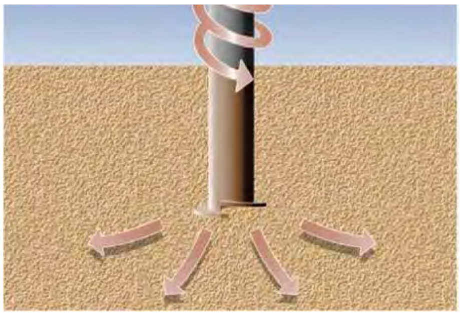
Source: Website of New Technology Information

Figure 4.5.3 Composite Deck Slab

2) Rotation Steel Pile

This is a steel pipe foundation in which a helical steel plate (wing) is welded to the tip of the steel pipe. The pile is then rotated so that it screws into the ground.

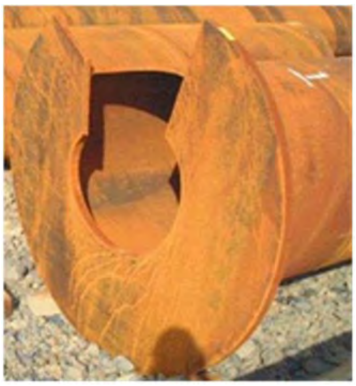
It obtains a large bearing capacity because of the base enlarging effect of the wing. Furthermore, due to the penetration method, there is no excavated soil to be wasted at the site. Therefore, it will be possible to employ eco-friendly construction with no emissions and low-vibration, and it can reduce the number of piles. Moreover, since the size of the construction equipment is not large and no additional equipment such as bentonite tank is required, it is possible to construct this steel pipe in a very narrow space.



Source: Pamphlet of NS Ecopile, Nippon Steel Corporation

Figure 4.5.4 Image of Rotary Penetration

Installation Machine



Tip of the Rotary Penetration Steel Pile

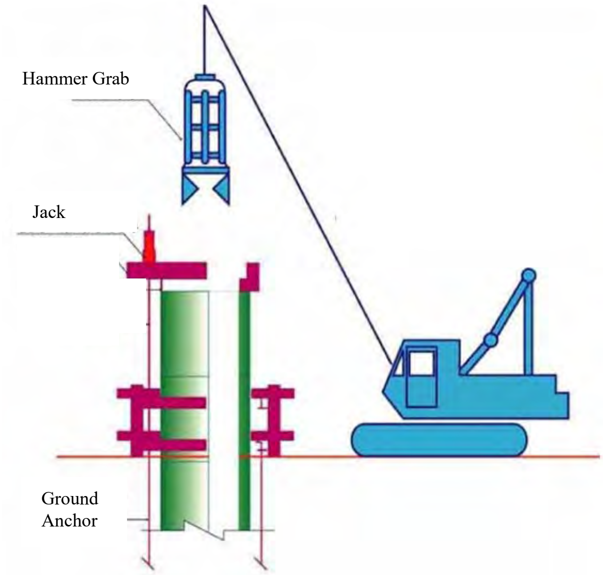
Source: Pamphlet of NS Ecopile, Nippon Steel Corporation

Figure 4.5.5 Photograph of Rotary Penetration Steel Pile

3) PC Well

A PC well foundation is composed of precast concrete cylinders (circular or oval shape). Each precast concrete cylinder is connected to the adjacent cylinder by a post-tension method after they are placed at the site. After placing the precast concrete blocks and connecting them to each other, excavation work is carried out and they are compressed into the ground.

This technique is very effective, especially inside a city, since, it is possible to construct a large diameter pile (up to D=8m) and bear all load with only such kind of large diameter pile.



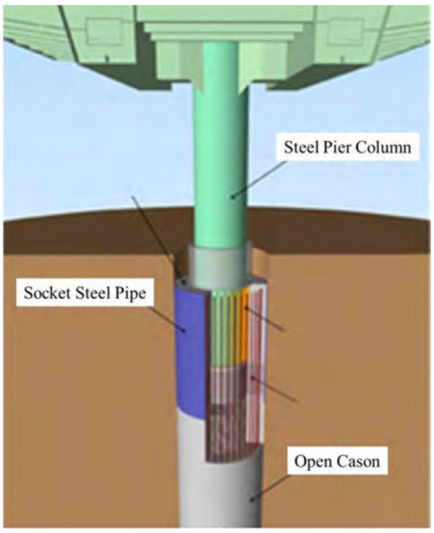
Source: Website of Nippon Hume Corporation Ltd.

Source: Website of Kanto Regional Development Bureau, Ministry of Land, Infrastructure, Transport and Tourism

Figure 4.5.6 Sketch and Photograph of a PC Well

4) Steel Pipe Socket Connection Method

The Steel Pipe Socket Connection method is a jointing technique of inserting a steel column into a steel pipe socket, which is constructed at the top of the foundation, and filling it with concrete. It is possible to reduce the construction period because it can omit the pile cap and anchor frame used in the conventional method.

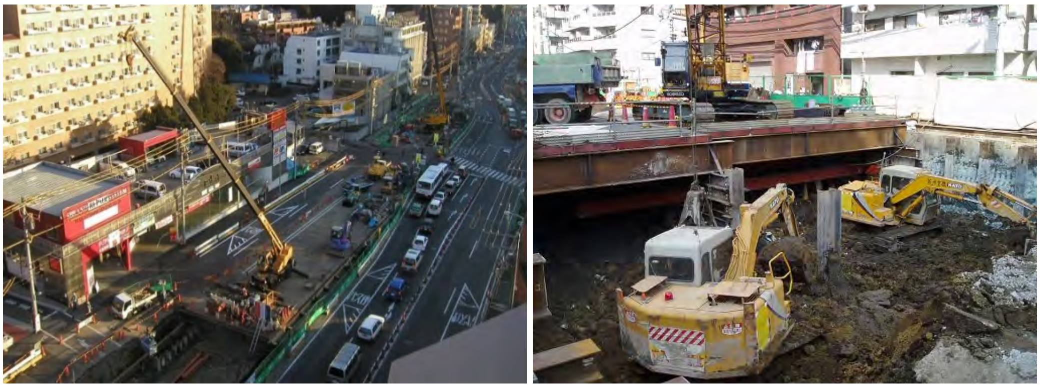


Source: Investigation Report by MLIT named "solidification construction by quick construction method for Kosaka intersection"

Figure 4.5.7 Sketch and Photograph of a Steel Pipe Socket Connection Method

5) Application of Temporary Platform

A temporary platform is used for securing the space of temporary road during the construction of box culvert under the ground. Since a box culvert is covered by temporary platform above the structure, most of the construction work on reducing the width of the temporary road and under the temporary platform is carried out at nighttime.

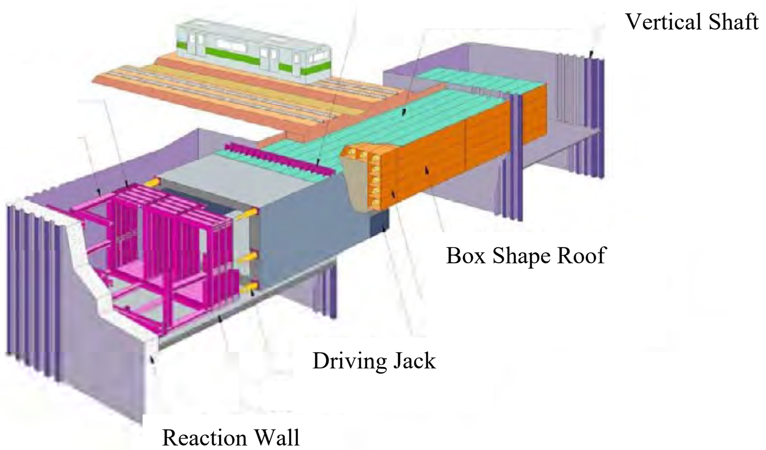


Source: Website of Hazama Ando Corporation

Figure 4.5.8 Photograph of Temporary Platform

6) Box Jacking Method

A Box Jacking Method is a construction method of box culvert without disturbing the existing traffic. A box culvert is constructed beside the final designated location. Excavation work is done transversally and supported by a rectangular box roof structure. After completion of the excavation, the box culvert structure is pushed into the final designated location using hydraulic jack.



Source: Website of "Underpass Engineering Association"

Figure 4.5.9 A Sketch of Box Jacking Method

7) Element Jacking Method

An Element Jacking Method is a construction method of a box culvert without disturbing the existing traffic condition. Excavation work is done transversally element by element using manual excavation or a small size excavation machine. After completion of the excavation work, all elements are filled by concrete and formulate as a part of the box culvert cross section.

Source: Website of "Society of Rail-Act"

Figure 4.5.10 Element Jacking Method

4.6 Environmental and Social Issues

4.6.1 Overview of Social and Environmental Guidelines in Nepal

Listed below (Table 4.6.1) are national laws and other regulations in Nepal on environmental and social impacts pertinent to infrastructural developments, especially the road sector. Under development review and permission, the EIA approval process is described in detail in Section 4.6.6. Guidelines on pollution prevention need to be consulted during the preparatory and design stages. Under natural environment, guidelines on rivers may be relevant to determine the approval procedures on waterway usage for bridge construction. No impacts on cultural heritage sites are expected. Under social considerations, land acquisition is likely to be the most sensitive topic for this project.

Table 4.6.1 Nepalese Laws and Regulations on Environmental and Social Impacts

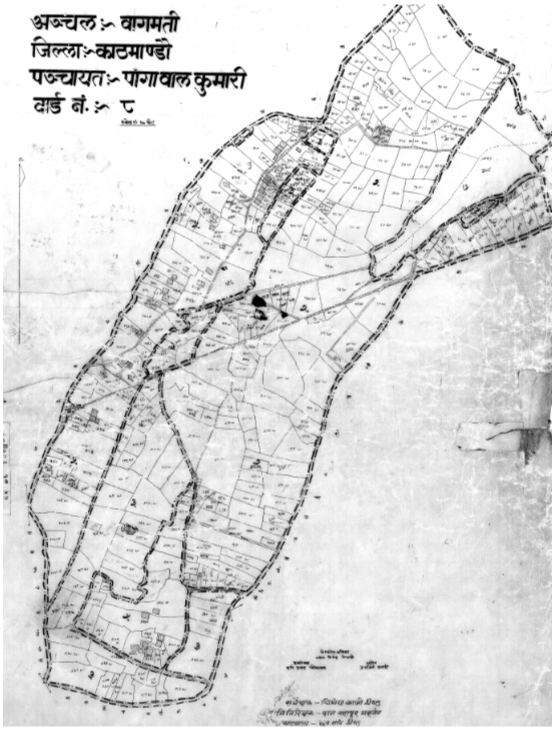
Category	Topic	Laws and Regulations	Relevant Institution
Development review and permission	EIA / IEE	Environmental Protection Act, 2053 (1997) Environmental Protection Rules, 2054 (1997)	MOFE
		Environmental and Social Management Framework, 2064 (2007)	DOR/GESU
Pollution prevention	Environmental Standards	Nepal Gazette, B.S. 2060/4/19 (4 August 2003) (Air), Nepal Gazette, B.S. 2054/9/8 (Gas emission from vehicles) Motor Vehicle and Transportation Management Act, 2050 (1993)	MOFE, MOPIT
	Soil disposal	Environmental and Social Management Framework, 2064 (2007)	DOR/GESU
	Waste control	Environmental and Social Management Framework, 2064 (2007)	DOR/GESU
Natural environment	Forest clearance, Biodiversity conservation	Nepal Forest Guidelines, 2063 (2006) Forest Products Collection & Sales Distribution Guidelines, 2058 (2001) Watershed Conservation Rule, 2042 (1985) Local Self-Governance Act, 2056 (1999)	MOFE, Local Government
	Underground water	None	N/A
	Rivers	Water Resources Act, 2049 (1992) Local Self-Governance Act, 2056 (1999)	MOWS, Local Government
	Nature conservation	National Parks and Wildlife Conservation Act, 2030 (1973) Soil and Watershed Conservation Act, 2039 (1982)	MOFE
Cultural heritage	Conservation of cultural heritage	Ancient Monument Protection Act, 2013 (1956) Ancient Monuments Preservation Rules, 2046 (1989)	MOCTCA
Social considerations	Land acquisition and compensation	Land Acquisition Act, 2034 (1977) Land Acquisition Guidelines, 2046 (1989)	DOR/GESU
		Land Acquisition, Resettlement and Rehabilitation Policy, 2072 (2015)	
		Immovable Property Acquisition Act, 2013 (1956)	
	Community forest	Forest Act, 2049 (1993) Forest Rules, 2053 (1995)	MOFE, District FUGs
	Drinking water	Nepal Water Supply Corporation Act, 2046 (1989) Drinking Water Regulation, 2055 (1998) Essential Commodity Protection Act, 2012 (1955)	DWSS
	Indigenous groups	National Foundation for Upliftment of Aadibasi /Janjati Act, 2058 (2002)	DOR/GESU
	Dalit groups	Caste-based Discrimination and Untouchability (Offence and Punishment) Act, 2068 (2011)	DOR/GESU
	Additional assistances	Environmental and Social Management Framework, 2064 (2007)	DOR/GESU
	Underground property rights	None	N/A

4.6.2 Land Survey and Land Administration in Nepal

Two departments under the Ministry of Land Management, Cooperatives and Poverty Alleviation (MOLMCPA) are responsible for land demarcation and administrative matters: the Survey Department and the Department of Land Reform and Management (DOLRM). The Survey Department is in charge of all matters related to land demarcation and cadastral mapping for both public and private lands. DOLRM undertakes land administrative works such as determination and collection of land revenues and issuing of ownership certificates and deeds. All land registration works are done in coordination with both authorities. Each district of Nepal has both offices.

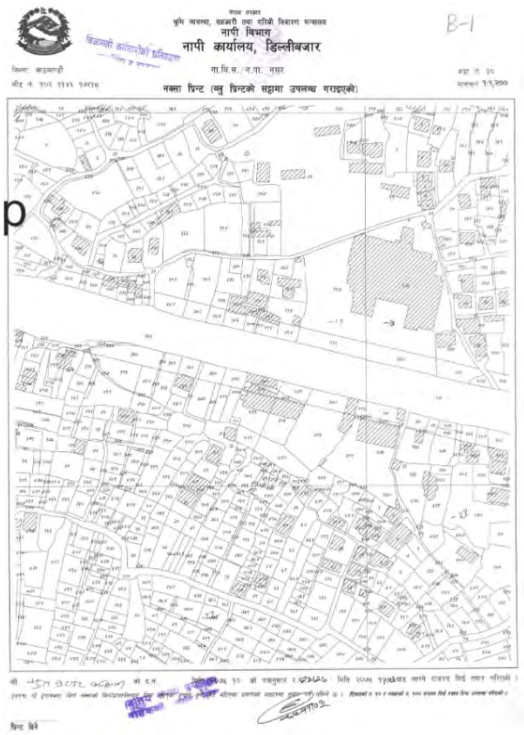
(1) Cadastral Mapping

All land parcels are given a plot number. Physical boundary verifications, land area calculation, and any legal changes to cadastral maps can only be carried out by registered surveyors of the Survey Office. Cadastral survey of the lands within Kathmandu Valley was first carried out in the 1960s (“old maps”), then updated in 1988/89 (“new maps”). Old maps were in feet units, non-coordinated, handwritten, and in 1:1200 scale (Figure 4.6.1). New maps are digital, prepared in metric units using National Grid Coordinates, and may be available in 1:500 scale (Figure 4.6.2). The old maps are still in use for areas where the revised cadastral survey is not complete. A written application specifying the cadastral map’s sheet number identification and a government fee of NPR110 per sheet are required to receive a printout of the cadastral map.



Source: Issued on 15/01/2019 by Kalanki Survey Office, Kathmandu

Figure 4.6.1 Example of an Old Cadastral Map Based on a 1960s Survey



Source: Issued on 17/02/2019 by Dilli Bazar Survey Office, Kathmandu

Figure 4.6.2 Example of a New Cadastral Map Based on a 1988/89 Survey

1) Building Boundaries

The Survey Office updates only land transactions on a regular basis, while structural footprints are updated and reflected on cadastral maps only during the overall large-scale mapping surveys, such as the one done in 1988/89. As such, a site visit may be required to be sure of the latest status of a given area. At Koteshwor intersection, the Study Team verified that there is a new governmental building (Koteshwor Traffic Police Office) and a small Shiva Temple on the southern corner between Ring Road and Araniko Highway that are not shown on the cadastral map (see Figure 4.6.4), but these will not have any impact on the Project. There were no old footprints of already demolished buildings.

2) Property Type and Ownership

A cadastral map alone cannot indicate the property type (private/public) or ownership records of each plot. These details must be looked up in the Ownership Register maintained at respective DOLRM offices.

4.6.3 Nepal Road Standards and Right-of-Way

Nepal's roads are broadly classified into categories, according to which the Right-of-Way (ROW) is determined. Basic classifications are defined by the Nepal Road Standards (2027) (NRS-2027), which was established in 1970 and revised in 1988 (NRS-2045) and 2013 (NRS-2070)[1] (see Table 4.6.2). However, because provisions in NRS are insufficient for urban settings, where road systems are complex and land is scarce, a different set of guidelines are applied for urban roads especially within Kathmandu Valley, as shown in Table 4.6.3. Published by the Kathmandu Valley Town Development Committee (now Kathmandu Valley Development Authority (KVDA)) and roughly translated into English as the "Construction Bylaws for Municipalities within Kathmandu Valley and Urbanizing VDCs – 2064"[2] ("Construction Bylaws"), these guidelines have been in effect since 15 May 2007 (Figure 4.6.3). The Construction Bylaws specifies exactly which sections of which roads of Kathmandu Valley fall into each road classification.

Table 4.6.2 Road Classifications and ROW as Defined by NRS (Applicable to Non-Urban Roads)

Road Classification	Minimum ROW	Distance Between Buildings
National Highways	50m (25m on either side of the center line)	62m (6m setback on either side)
Feeder Roads	30m (15m on either side of the center line)	42m (6m setback on either side)
District Roads	20m (10m on either side of the center line)	32m (6m setback on either side)

Source: NRS-2027, NRS-2045, NRS-2070

Table 4.6.3 Road Classifications and ROW as Defined in the Construction Bylaws (Applicable to Urban Roads)

Road Classification	Minimum ROW	
Ring Road	62m	(31m on either side of the road center line)
Highways (Araniko and Tribhuvan Highways)	50m	(25m on either side of the road center line)
Arterial Roads	22m	(11m on either side of the road center line)
Connect Roads	14m	(7m on either side of the road center line)
Feeder Roads	11m	(5.5m on either side of the road center line)
Access Roads – A	8m	(4m on either side of the road center line)
Access Roads – B	6m	(3m on either side of the road center line)
Access Roads – C	4.5m	(2.25m on either side of the road center line)
Access Roads – D	2.5m	(1.25m on either side of the road center line)
Special Roads	30m	(15m on either side of the road center line)

Source: Construction Bylaws for Municipalities within Kathmandu Valley and Urbanizing VDCs – 2064

[1] Vikram Samvat (BS) is the official lunar calendar used in Nepal. It roughly corresponds to: 2027 BS = 1970 CE; 2045 BS = 1988 CE; 2070 BS = 2013 CE.

[2] The document is only available in Nepalese. VDCs = Village Development Committees, lower administrative divisions under districts, which were dissolved and replaced by "Gaunpalikas" as of 10 March 2017.

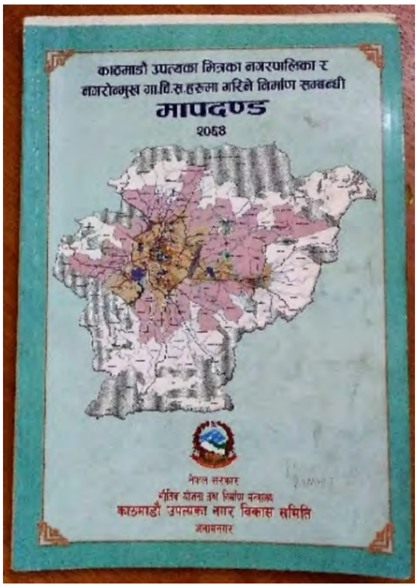


Figure 4.6.3 Construction Bylaws for Municipalities within Kathmandu Valley and Urbanizing VDCs – 2064

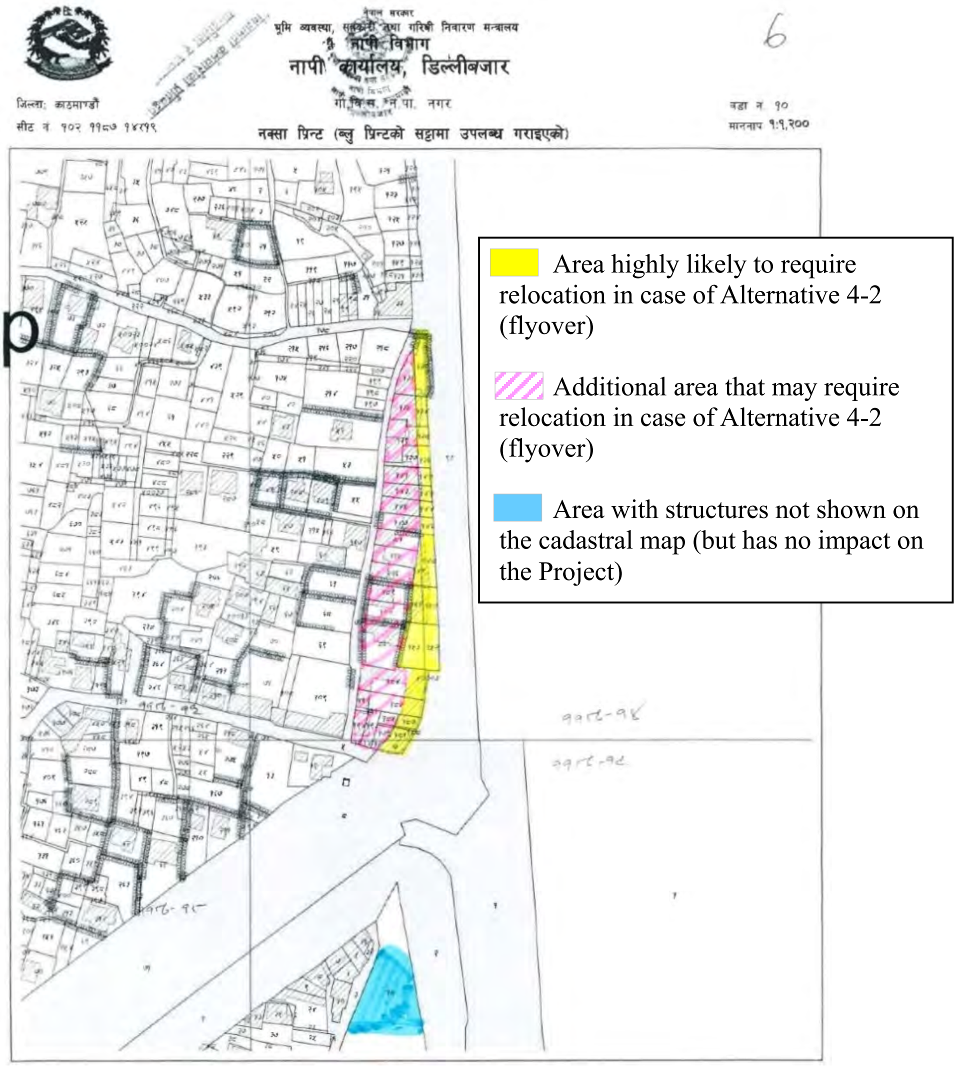
Furthermore, amendments may be made to existing laws and guidelines through the publication of a gazette by the Nepal Law Commission (NLC) or through official circulations. Over the years there have been several disputes and court cases between the landowners and the Government, resulting in the Government altering the ROW of specific sections. All such ROW amendments within Kathmandu Valley, already in place at that time, were included in the Construction Bylaws. For later amendments, gazettes and circulations should be consulted.

ROW alteration that may become crucial for this Project is the Koteshwor-Tinkune section of Araniko Highway (also overlapping with the Ring Road). As shown in Table 4.6.3, the established urban ROW is 50m for highways and 62m for the Ring Road. The DOR maintains that the ROW of 50m or more has been secured throughout Kathmandu Ring Road; however, according to the Construction Bylaws, the Koteshwor-Tinkune section is to be treated as a Commercial Sub-Zone[3]. The ROW on (only) the west side of the road is set as 15m from the centerline for a length of 303m from the center of the Koteshwor intersection, and ROW amendments have also been made at Tinkune intersection (see Figure 4.6.5and Figure 4.6.6). In case of Alternative 4-2 (flyover), the necessity for land acquisition and relocation of several land plots is highly likely along the west side, as shown in Figure 4.6.4. Depending on the structural design, applicable legal guidelines[4], and negotiation with the landowners, plots shaded in pink may also need to be acquired.

In another area close to the Project, for a stretch of 1.267km in the section from Chabahil to Gaushala on the Ring Road (to the north of Old Baneshwor), the ROW is set as 22m. Overall, it is clear that the development of roads in urban settings has been a difficult task, and the Government has not always been able to provide proper guidelines or enforcement.

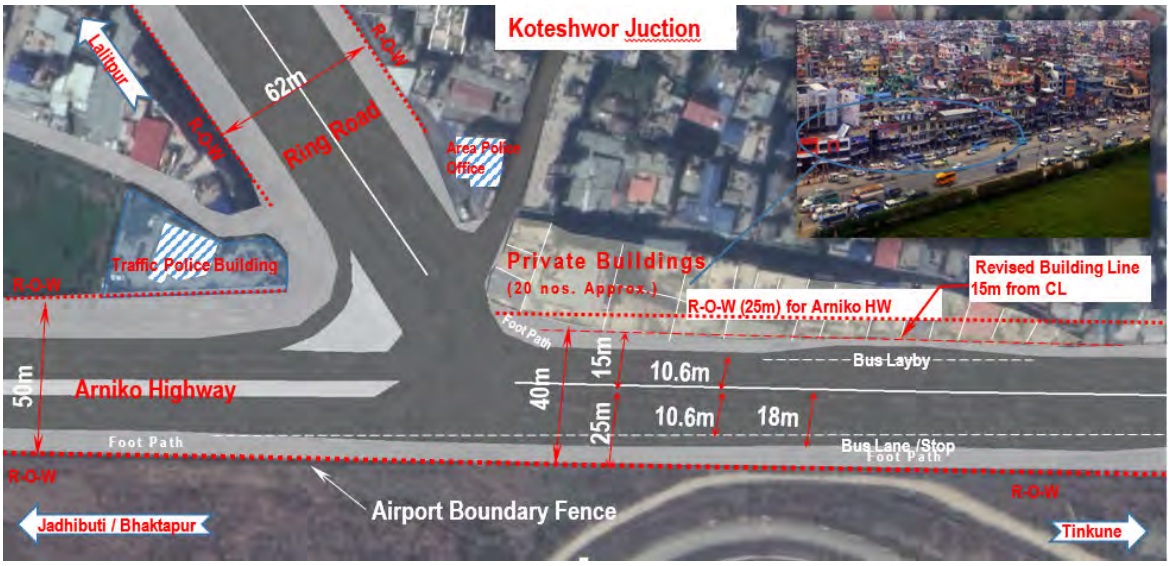
[3] This is another exceptional category created for this section, not shown in the standard classifications list of Table 4.6.3.

[4] Applicable guidelines may change according to the structural design. Furthermore, as discussed later in Section 4.6.5, applicable guidelines may not exist yet in Nepal, which may require lengthy discussions and negotiations with different authorities and stakeholders.



Source: Issued on 17/01/2019 by Dilli Bazar Survey Office, Kathmandu

Figure 4.6.4 Cadastral Map of Koteshwor Intersection



Source: JICA Study Team

Figure 4.6.5 Detailed ROW of Koteshwor Intersection

Source: JICA Study Team

Figure 4.6.6 Detailed ROW of Tinkune Intersection

4.6.4 Land Acquisition

There are mainly two practices of land acquisition for infrastructure development projects.

(1) Compensation

The first method is acquisition through monetary compensation to its owners, as per Land Acquisition Act and Guidelines. In this practice, a Compensation Determination Committee (CDC) consisting of the following members (Table 4.6.4) determine the amount of compensation. Although technically not mandatory, it is a standard practice to invite representatives of people affected by the project.

Table 4.6.4 Members of the Compensation Determination Committee

Member		Position
i	Chief District Officer	Chairperson
ii	Representative of the District Development Committee (DDC)	Member
iii	Mayor of Municipality / Chairperson of Village Development Committee (VDC)[5]	Member
iv	Chief of the Land Revenue Office	Member
v	Chief of the Concerned Project	Member Secretary
vi	Specially Invited Members (members of the legislature parliament of the concerned constituencies, representatives of people affected by the project, representatives from the office of land measurement, and experts of resettlement and rehabilitation programs)	Invitees

(2) Land Pooling

The second method is through land pooling, as prescribed by the Town Development Act. In a land pooling scheme, small land parcels from many landowners are acquired, consolidated into a single large plot, then provided with all necessary infrastructure; after which, the parcels are re-plotted and given back to the owners as per the agreed terms of land contribution. It is a land management technique intended for managing residential land development programs in a planned manner and also fulfilling the basic need of the residents[6]. This scheme allows the Government to make use of necessary lands without

[5] As mentioned in footnote 2, VDCs no longer exist, but this is the term used in older official documents.
[6] Town Development Act, 2045 (1998)

providing monetary compensation. KVDA has commissioned several land pooling projects within the Valley, and plans for developing a residential area along the second Ring Road in Kathmandu Valley is also being considered.

4.6.5 Lack of Underground Property Rights and Other Regulations

Alternatives 4-1 and 5 would require the construction of an underpass at Koteshwor-Tinkune intersection. As of now, there are no acts, rules, or policies in Nepal which regulate the ROW or underground property rights related to tunnel works. The Government is currently constructing Nagdhunga Tunnel Road in the western entry point of Kathmandu Valley, funded by JICA. In this project, the surface and underground ROW, or the restricted zone, was proposed to be the width of the tunnel diameter on either side and twice the depth of the diameter. The Nagdhunga Tunnel is 10m in diameter; thus, the restricted zone is 2D (2x10m=20m) above the tunnel and 1D (10m) on either side from the edge of the tunnel[7]. Compensation to landowners was given only where land had to be acquired, i.e. at the tunnel entrance. For the time being, those living above the tunnel have been given permission to continue using their land as is, and no notable complaints have been filed. However, without an official legal basis, uncertainties and risk of conflicts remain in the long-term, especially if landowners change or if any negative impacts possibly associated with tunnel construction works may arise. Given these concerns, a “Draft Concept Note for Rule of Tunnel Construction (Draft ROW Acquisition, Underground Right for Tunnel ROW)” was prepared by consultants and others involved in the Nagdhunga Tunnel Project, suggesting the establishment of appropriate legal guidelines related to tunnel works in Nepal. The document was submitted to the Government for consideration, but nothing has been done with it as of March 2019[8].

Alternative 4-2 case would also present Nepal with a new challenge, as no specific rules or guidelines are in place to manage the potential impacts of a flyover, including the obstruction of view/light, emission of noise, and structural damages from vibration. Regarding setbacks, new guidelines on urban building setbacks were introduced in 2015 in the aftermath of the devastating April 2015 earthquake, but these only apply to buildings, with the aim of providing better disaster risk management[9]. Currently, no similar standards applicable to non-building structures such as flyovers exist. Similar to underground property rights, the Government and stakeholders will have to consider how to manage potential impacts if these projects are to be implemented.

Furthermore, no detailed guidelines exist for the use of the river for public development projects. The river is a public, state-owned property, but most of the land plots along the river are private-owned, and according to KVDA, land ownership disputes along the shifting river boundaries are common. At present most of the rivers in Kathmandu Valley’s urban areas have artificial permanent boundaries, and KVDA has established setbacks for these rivers (see Table 4.6.5). The setback area does not belong to the Government (if the land is private-owned), but it is a “restricted zone” where no permanent structures are allowed. If permanent structures such as bridges are to be built on private land, the land needs to be acquired.

Table 4.6.5 Setback Distance from the Current River Edge for Rivers in Kathmandu Valley

River Name	Distance	River Name	Distance	River Name	Distance
Bagmati	20m	Balkhu	10m	Karkhushi	6m
Vishnumati	20m	Karmanasha	10m	Tukucha	4m
Manohara	20m	Kudku	10m	Samakhushi	4m
Dhobikhola	9m	Sangle	10m	Hanumante	20m
Nakkhu	12m	Mahadev	10m		

Source: Construction Bylaws for Municipalities within Kathmandu Valley and Urbanizing VDCs – 2064

7 Source: EIA of Nagdhunga Tunnel Construction Project, CTII & FBC, December 2015
8 Based on discussions with Foreign Cooperation Division of DOR, KVDA, and JICA Nepal Office during field mission in January and March 2019.
9 “Fundamental Construction Bylaws on Settlement Development, Urban Planning and Building Construction 2015”

4.6.6 Environmental Impact Assessment and Resettlement Action Plan

Based on the JICA Guidelines for Environmental and Social Considerations (April 2010), ("JICA Guidelines"), the proposed road and railway project in Kathmandu Valley would be classified as a Category A project, as it would have a significant adverse impact on the environment and society. An Environmental Impact Assessment (EIA) is required for Category A projects. For projects that will result in large-scale involuntary resettlement, a Resettlement Action Plan (RAP) would also be required. Similarly, under laws of Nepal, construction of new alignment of national highways is subjected to an EIA study, and infrastructure development projects that will lead to land expropriation and/or involuntary resettlement require a preparation of a Resettlement Action Plan (RAP). The EIA goes through a series of approval steps, as summarized in Figure 4.6.7, while the RAP is approved by the implementing agency and the donor agency. The two reports are generally prepared in parallel, since there is much overlap in their required information. Based on JICA Guidelines, the EIA must be approved at least 120 days prior to concluding the agreement documents (for public disclose online). Assuming about 2.5 months for preparatory works (scoping), 3.5 months for EIA study/approval, and 4 months for JICA's disclosure period, preparations for a loan agreement must be started at least one year in advance, preferably much earlier.

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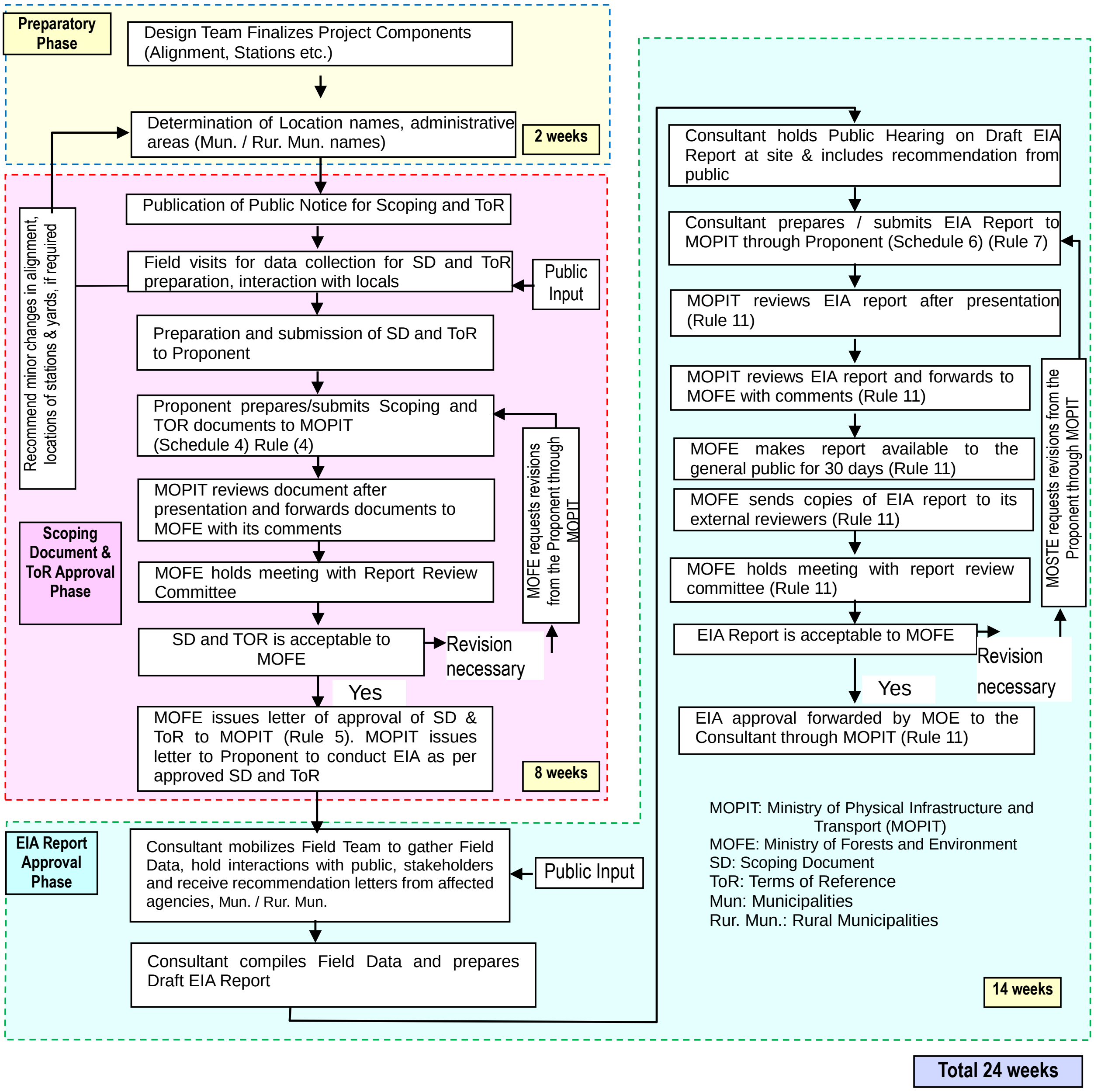


Note: Time periods are only estimates

Source: JICA Study Team based on Environmental and Social Management Framework (2007)

Figure 4.6.7 Flow Diagram and Estimated Required Time of Approval Process for EIA in Nepal

4.7 Traffic Analysis and Economic Impacts

4.7.1 Influence of the Improvement and Scheme of the Traffic Analysis

(1) Preconditions for Traffic Analysis

The traffic analysis preconditions are summarized as follows:

- It is assumed that the E-W directional railway (Gongabu - Tinkune - Koteshwor - Bhaktapur as specified KSUTP-MTOPS prioritized section, named as Option 4) will be opened in January 2030. The railway will absorb the traffic from the direction of Araniko Highway and influence the traffic analysis at Koteshwor and Tinkune.

- The opening timing of flyover/underpass are specified by alternatives. See Table 4.7.3.
- The target years of traffic analysis are 2020 (short term), and 2030 (long term), as the OD and network have been specified for those two timings by the KSUTP-MTOPS model.

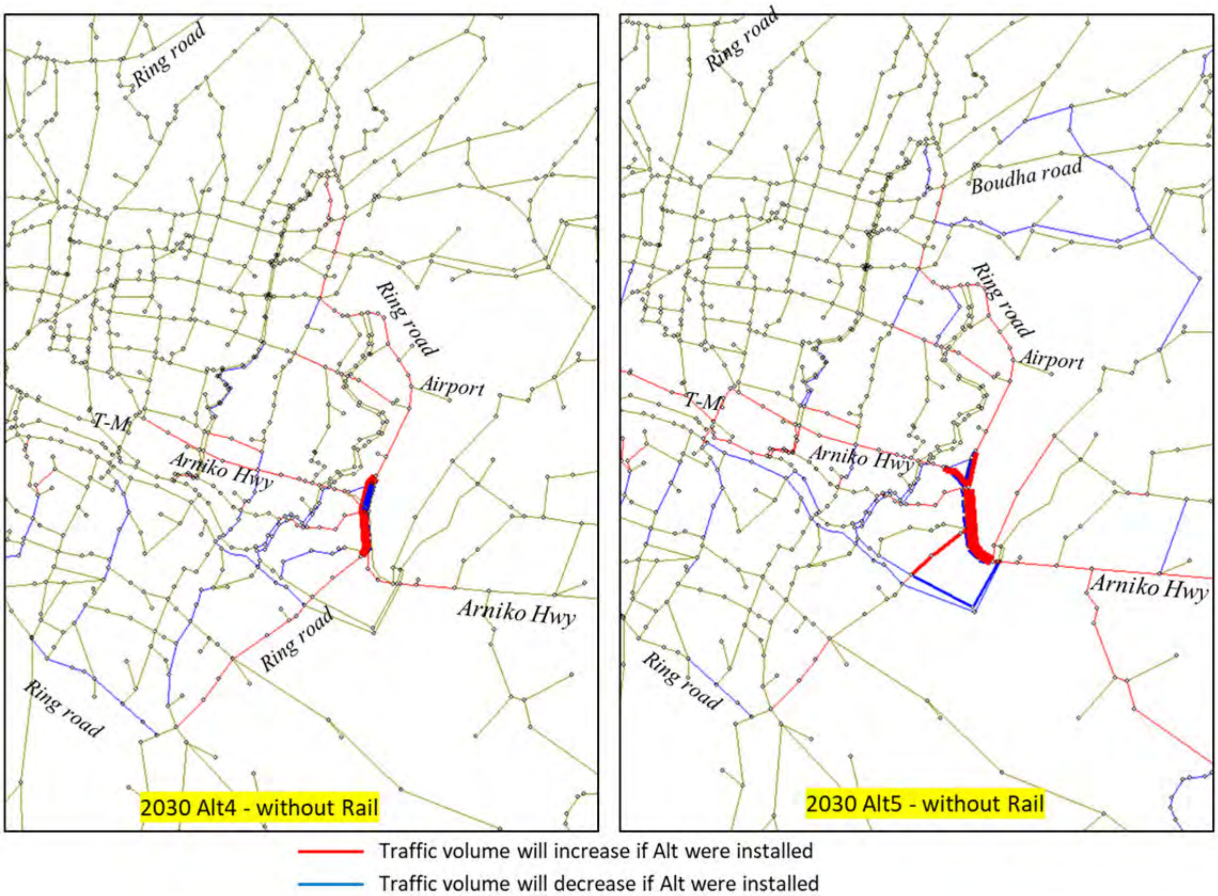
The setting of the flyover/underpass in capacity and travel speed are specified as follows. The lengths of the new links were designed to be of the same lengths as the parallel routes.

Table 4.7.1 Setting of Flyover/Underpass in Capacity and Travel Speed

	Before		After	
	Capacity	Vmax	Capacity	Vmax
Existing road (6 lanes)	106,700 (pcu/day)	60km/h	106,700 (pcu/day)	60 km/h
New route (4 lanes)	--	--	93,700 (pcu/day)	62 km/h
New route (2 lanes)	--	--	34,800 (pcu/day)	50 km/h

(2) Geographical Influence of the Improvement and Area for Analysis

Figure 4.7.1 shows the influence of the flyover/underpass installation to traffic flows by alternatives[10]. The red-colored sections represent where traffic will be increased after installations, and the blue ones are sections where traffic will be decreased.



Source: JICA Study Team

Figure 4.7.1 Influence of the Improvement to Traffic in Network – Comparison of With/Without Traffic Flow in 2030

[10] It should be noted that the same analysis can be applied for the Alt4-1 (underpass) and Alt4-2 (flyover).

The major findings are as follows:

- Alt 4, adding road capacity in circular direction, brings traffic along the ring-road direction and diverts the traffic from north-south directional routes inside of the ring road.
    - The area of influence is relatively smaller than that of Alt 5.
- Alt 5, adding road capacity in radial direction, diverts traffic of other radial roads (e.g., Boudha Road) and brings traffic along the Araniko Highway.
    - The area of influence is relatively broader than that of Alt 4.
- Both alternatives have positive influence in traffic calming in the city center; however, Alt 5 scenario may bring more traffic into the city center (around the T-M junction), as it gives higher capacity and speed along the Araniko Highway.
- As shown above, the influence of the intervention is dispersed to the whole sections of the valley network; therefore, the whole network has been adopted for the economic impact analysis[11].

4.7.2 Preliminary Economic Analysis

In this section, the preliminary economic analysis of the Project is explained. The analysis is based on the traffic demand forecast, project scope and cost explained in the previous sections of this report. The methodology and the results of the preliminary economic analysis are described below.

(1) Methodology for Economic Analysis

The preliminary economic analysis has been conducted estimating the benefits for with-project and without-project scenarios. Below is a description of the scenarios, evaluation period, costs, and benefits. It shall be noted that all benefits and costs are valued at 2018 prices, and inflation has not been taken into account within the analysis.

1) Scenarios

As described in the previous sections, three alternative scenarios – Alternative 4-1, Alternative 4-2, and Alternative 5 – have been considered for the economic analysis. In addition, as rail operation may start from 2030, “with rail” and “without rail” scenarios have also been considered. In order to estimate the benefits of the three alternative scenarios, nine types of analysis have been conducted as shown in Table 4.7.2 and Figure 4.7.2.

- Alternative 4: The benefits of 2025-2029 are interpolations of benefits derived from Analysis 1 minus 3 and Analysis 4 minus 6. The benefits of 2030 are derived from Analysis 7 minus 9, and is constant onwards.
- Alternative 5: The benefits of 2025-2029 are interpolations of benefits derived from Analysis 2 minus 3 and Analysis 5 minus 6. The benefits of 2030 are derived from Analysis 8 minus 9, and is constant onwards.

[11] Note that the JICA MP Pre FS for T-M junction adopted limited links close to the junction for economic analysis.

Table 4.7.2 Nine Analysis for Benefit Calculation

Analysis No.	OD Year	Railway	Scenario
1	2020	No	Alternative 4
2	2020	No	Alternative 5
3	2020	No	Without Project
4	2030	No	Alternative 4
5	2030	No	Alternative 5
6	2030	No	Without Project
7	2030	Yes	Alternative 4
8	2030	Yes	Alternative 5
9	2030	Yes	Without Project

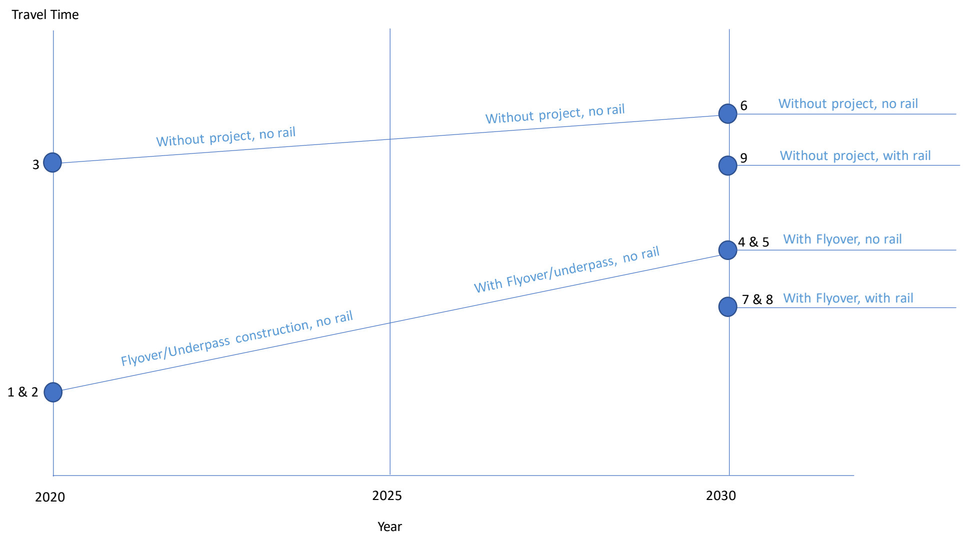


Figure 4.7.2 Nine Analysis for Benefit Calculation

2) Evaluation period

The evaluation period has been assumed at 40 years. The construction period has been assumed as 48 months, and start of operation has been assumed at January 2025 for Alternative 4-1 and Alternative 5, and 30 months and July 2023 for Alternative 4-2 as shown in Table 4.7.3.

Table 4.7.3 Evaluation Period

Scenarios	Construction Period	Operation Start
Alternative 4-1 (with and without rail)	48 months January 2021 to December 2024	January 2025
Alternative 4-2 (with and without rail)	30 months January 2021 to June 2023	July 2023
Alternative 5 (with and without rail)	48 months January 2021 to December 2024	January 2025

Source: JICA Study Team

3) Costs

- Project Costs:
  - The project costs are estimated at NPR 25.8 billion for Alternative 4-1, NPR 10.6 billion for Alternative 4-2, and NPR 30.7 billion for Alternative 5, in economic costs. It includes construction costs, physical contingencies and engineering costs.
  - No residual values are included in the analysis.
  - The total of these project costs is assumed to be invested from 2021 to 2024 at 25% each year for Alternative 4-1 and Alternative 4-2, and at 35%, 35%, 30% from 2021 to 2023 for Alternative 5 as shown in Table 4.7.4.
  - The standard conversion factor of 0.91[12] has been assumed to convert financial costs to economic costs.

Table 4.7.4 Project Cost Estimate (in Economic Costs)

(in million NPR)

Scenarios	2021	2022	2023	2024	Total
Alternative 4-1	6,470	6,470	6,470	6,470	25,879
Alternative 4-2	3,721	3,721	3,189	-	10,631
Alternative 5	7,678	7,678	7,678	7,678	30,711

Source: JICA Study Team

- Operation and Maintenance Costs:
  - The total O&M cost of the project, converted to economic costs, are 2,829 million NPR for Alternative 4-1; 1,239 million NPR for Alternative 4-2; and 3,357 million NPR for Alternative 5 as shown in Table 4.7.5.
  - Routine maintenance costs are necessary every year, and periodic costs are every 5 years and 10 years.

Table 4.7.5 Operation and Maintenance Cost Estimate (in Economic Costs)

(in million NPR)

Scenarios	Annual Routine Cost	Periodic Cost (Every 5 years)	Periodic Cost (Every 10 years)	Total O&M Cost
Alternative 4-1	21.9	219.3	438.6	2,829 (Year 2025-2060)
Alternative 4-2	9.0	90.1	180.2	1,239 (Year 2023-2060)
Alternative 5	26.0	260.3	520.5	3,357 (Year 2025-2060)

Note: Periodic costs (5 years, 10 years) include all O&M costs necessary for those years, including the annual routine cost

Source: JICA Study Team

4) Benefits

The following benefit items are considered in the economic analysis:

- Travel Time Savings
  - Travel time savings are estimated based on the saved time and the value of time by vehicle type; therefore, the travel time savings are calculated using the equation below:

[12] The standard conversion factor has been referred from "The Project on Urban Transport Improvement for Kathmandu Valley in Federal Democratic Republic of Nepal, Final Report", JICA, May 2017

$$(\text{TTC Savings}) = \text{TTC}_\text{o} - \text{TTC}_\text{w}$$

$$\text{TTC}_\text{i} = \sum_{j}\sum_{is}(\text{Q}_{js} \times \text{T}_{ijs} \times \alpha_j) \times 365$$

Where,

$\mathbf{TTC_i}$	: Travel time cost in case *i* (NPR/year)
$\mathbf{Q_{js}}$	: Traffic volume of vehicle type *j* on section *s* (vehicle/day)
$\mathbf{T_{ijs}}$	: Travel time of vehicle type *j* on section *s* in case *i* (hr)
$\boldsymbol{\alpha_j}$	: Unit value of TTC of vehicle type *j* (NPR/hr-vehicle)
$\boldsymbol{i}$	: Without-Project case (*O*) and With-Project case (*W*)
$\boldsymbol{j}$	: Vehicle types
$\boldsymbol{s}$	: Section

Unit values used for estimating the value of time are shown in Table 4.7.6. The unit travel time cost of a motorcycle is estimated at NPR 55.57 NPR/hour/vehicle and at NPR 142.06 NPR/hour/vehicle for cars. The value of time is assumed to be affected mainly by the income level, which can be measured by GDP per capita. Therefore, the future value of time was set for each year during the evaluation period, assuming this value would increase with the estimated growth rate of GDP per capita[13].

Table 4.7.6 Unit Values of TTC by Vehicle Type, 2018 Prices

(in NPR/hour/vehicle)

	Motorcycle	Tempo	Car	Taxi	Light Truck	Truck	Micro Bus	Mini Bus	Large Bus
Unit Values of TTC	55.57	380.37	109.75	102.69	142.06	168.31	821.69	1066.84	1733.80

Note: CPI data from the *World Development Indicators* were used for the conversion to 2018 figures.
Source: Estimated by the JICA Study Team based on "The Project on Urban Transport Improvement for Kathmandu Valley in Federal Democratic Republic of Nepal, Final Report", JICA, May 2017

- Vehicle Operating Cost Savings:
  - The savings of vehicle operating costs (VOC) were estimated by applying the unit values of VOC according to vehicle type and calculated using the equation below:

$$(\text{VOC Savings}) = \text{VOC}_\text{o} - \text{VOC}_\text{w}$$

$$\text{VOC}_\text{i} = \sum_{j}\sum_{is}(\text{Q}_{js} \times \text{L}_{is} \times \beta_{ij}) \times 365$$

Where,

$\mathbf{VOC_i}$	: Vehicle operating cost in case *i* (NPR/year)
$\mathbf{Q_{js}}$	: Traffic volume of vehicle type *j* on section *s* (vehicle/day)
$\mathbf{L_{is}}$	: Length of section *s* in case *i* (km)
$\boldsymbol{\beta_{ij}}$	: Unit value of VOC of vehicle type *j* in case *i* (NPR/vehicle-km)
$\boldsymbol{i}$	: Without-Project case (*O*) and With-Project case (*W*)
$\boldsymbol{j}$	: Vehicle types
$\boldsymbol{s}$	: Section

Unit values used for estimating the vehicle operating costs are shown in Table 4.7.7. The average speed and peak speed were estimated for each link to identify the corresponding unit vehicle operating costs.

[13] GDP per capita of the evaluation period is assumed at 4.56%, the average growth rate for the past ten years in Nepal.

The ratio of average speed to peak speed utilized is 9:1. Figure 4.7.3 shows the economic benefits per year for each scenario.

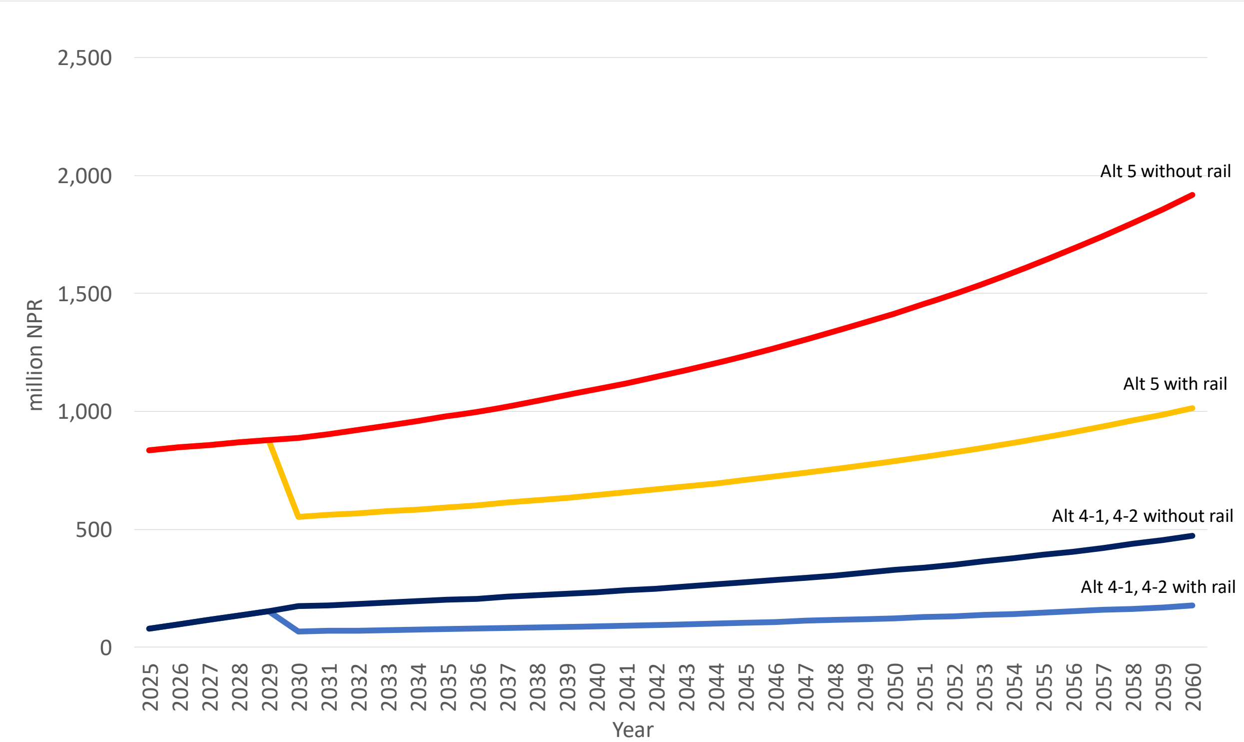
Table 4.7.7 Unit Values of VOC by Vehicle Type, 2018 Prices

(in NPR/km/vehicle)

Km/h	Motorcycle	Tempo	Car	Taxi	Light Truck	Truck	Micro Bus	Mini Bus	Large Bus
<5	9.13	34.88	50.91	48.13	71.02	113.65	64.67	73.31	87.69
10	8.90	33.43	49.04	46.31	67.58	108.19	62.67	71.13	83.43
15	8.64	31.86	46.92	44.28	64.08	102.54	60.34	68.56	78.83
20	8.35	30.16	44.54	42.03	60.50	96.73	57.67	65.58	73.92
25	8.02	28.32	41.91	39.56	56.84	90.73	54.65	62.18	68.74
30	7.65	26.36	39.01	36.86	53.08	84.55	51.26	58.33	63.33
35	7.24	24.27	35.84	33.94	49.19	78.20	47.49	54.00	57.80
40	6.77	22.07	32.40	30.79	45.14	71.67	43.34	49.17	52.26
45	6.25	19.79	28.70	27.44	40.87	64.97	38.80	43.81	46.90
50	5.66	17.51	24.81	23.94	36.28	58.11	33.91	37.88	42.05
>55	4.95	15.49	20.95	20.55	31.08	51.02	28.79	31.45	38.30

Note: CPI data from the *World Development Indicators* were used for the conversion to 2018 figures

Source: Estimated by the JICA Study Team, based on "The Project on Urban Transport Improvement for Kathmandu Valley in Federal Democratic Republic of Nepal, Final Report", JICA, May 2017



Note: The benefit stream of Alternative 4-2 with and without rail starts from July 2023 after the operation begins, though this is not shown in the graph above.

Source: JICA Study Team

Figure 4.7.3 Economic Benefits per Year

(2) Results of Preliminary Economic Analysis

Based on the above assumptions, the economic costs and benefit streams are estimated for each scenario (for "with rail" cases). Observations on the cost/benefits are as follows:

- Alternative 5 brings a higher benefit than Alternative 4-1 or Alternative 4-2
    - This is due to increase in traffic volume with the new flyover/underpass; also, the average and peak speeds of the vehicles are lowered, thus lowering the VOC savings.
    - Based on a strong recommendation by KVDA, the traffic analysis assumes the development of a city as big as the size of Kathmandu in the eastern region, which has not been assumed in the past studies and which is in favor of the Alternative 5 scenario.
- Both VOC and TTC savings of the "with rail" scenarios for both Alternatives 4 and 5 are lower than the "without rail" scenarios.
- This is because the increase in the traffic volume is larger for the "with rail" scenario than the "without rail" scenario even if the rail is assumed to start operation in 2030.
- The costs exceed the benefits, and the Net Present Values are negative; therefore, the EIRR cannot be calculated for all scenarios[14].

It should be noted that the applied framework of the benefit estimation were very conservative.

- [Fixed Benefit after 2030] The benefit flow of the VOC and TTC savings after 2030 are fixed with the amount in 2030 as shown in Figure 4.7.3, as there is no base to specify the growth after 2030. The study team has a traffic model for 2040, and the application of the model can increase the benefit. However, the reliability of the model should be confirmed in further stages.
- [Rail makes the benefit smaller] It may be too conservative to assess the investment with the assumption of the E-W railway opening in 2030. It will not calculate the NET benefit of the grade separation itself.

The model has the following characteristics to minimize the benefit estimation:

- [High population scenario and poor network] There is no major parallel road in the network between the present CBD and eastern new cities, and the population increase scenario in the eastern new cities will make the congestion in Koteshwor worse even with the installation of the grade separation. Therefore, TTC savings becomes smaller.
- [Detour] The Benefits of VOC savings become smaller than expected. As shown in Figure 4.7.1, the traffic in the parallel road will be attracted by the Koteshwor junction. The Alt-5 improvement will attract traffic along the Boudha Road and Outer Ring Road to Koteshwor, where the total travel hour are smaller. Therefore, some traffic detour will increase fuel consumption, and VOC savings become smaller.

The following are the ideas which can improve the IRR estimation:

- Consider to develop the parallel road improvement [This is examined in the next section]
    - Manohara Road, Boudha Road improvements, together with Koteshwor improvement, should be considered to avoid the detour.

[14] In comparison with Option 1 of the two-lane flyover case study for the T-M Flyover of "The Project on Urban Transport Improvement for Kathmandu Valley in Federal Democratic Republic of Nepal, Final Report", JICA, May 2017, the investment cost analyzed for this project is 3.9 times larger for Alternative 4-1, 1.6 times larger for Alternative 4-2, and 4.7 times larger for Alternative 5, respectively. For the O&M costs, they are 173 times, 76 times, and 205 times larger, respectively. It should be noted that the O&M costs for the previous study has been estimated rather low at around 100,000 NPR for the annual routine maintenance and 1,200,000 NPR for the periodic maintenance (pg. 13-37), thus being one of the factors posing a large difference in the total cost. For the VOC and TTC savings, in the previous study, it has been estimated 7 times larger for VOC and 23 times larger for TTC for Alternative 4 scenarios, and 0.57 times for VOC and 6 times larger for TTC for Alternative 5. In total, the benefit estimates are larger by 19 times for Alternative 4 scenarios and 3 times for Alternative 5 in the previous survey compared to this project's estimations. Although the detailed calculations in the previous study have not been obtained, as the unit costs of VOC and TTC utilized in the analysis are the same (changed to 2018 figures by CPI), it is likely that there is a difference in the estimation of traffic demand, which may be caused by the possibilities noted in the next page. Furthermore, it should be noted that the previous study has not considered the "with rail" scenarios.

- Modify the framework by making it not to be too conservative.
  - Apply the 2040 model and extraporate the benefit increase after 2030.
  - Consider the framework without rail installation.
  - More modest population increase scenario can be applied.
- Apply the micro-simulation model
  - Benefits during the construction period and peak hours need to be further considered. Microsimulations could be applied.

For urban transport planning aspects, the following can be suggested:

- This is a preliminary assessment, and a multi-criteria analysis is necesary. The EIRR is just one criteria.
- The benefits of the development of the northern sections of the ring road by 2030, which would disperse the urban functions, have yet to be further considered.
  - These interventions will provide a positive impact to the circulations among the subcenters along the ring road, which was proposed by the JICA MP 2017 (see Figure 2.2.1).
  - In this aspect, Alt-4 shows positive influence to increase the connectivities along the ring road sub centers; however, this influence cannot be assessed by the model.
- Since the east-west urban development is currently being focused on, it shows benefits for scenario Alternative 5 in particular. If the urban development of the north-south will be enhanced in the future, the benefits of Alternative 4 would be expected to increase, and thus would need to be further considered.

(3) Additional Economic Analysis

In the calculation shown in the previous section, the cost exceeded the benefits; thus the Economic Internal Rate of Return (EIRR) could not be calculated. In such situation, the JICA Study Team further analyzed additional scenarios in order to provide a few more options for the Nepalese Government. The details of the scenarios, cost and the result are explained in this section. It should be noted that the same evaluation period and unit costs of VOC and TTC have been applied.

1) Scenarios

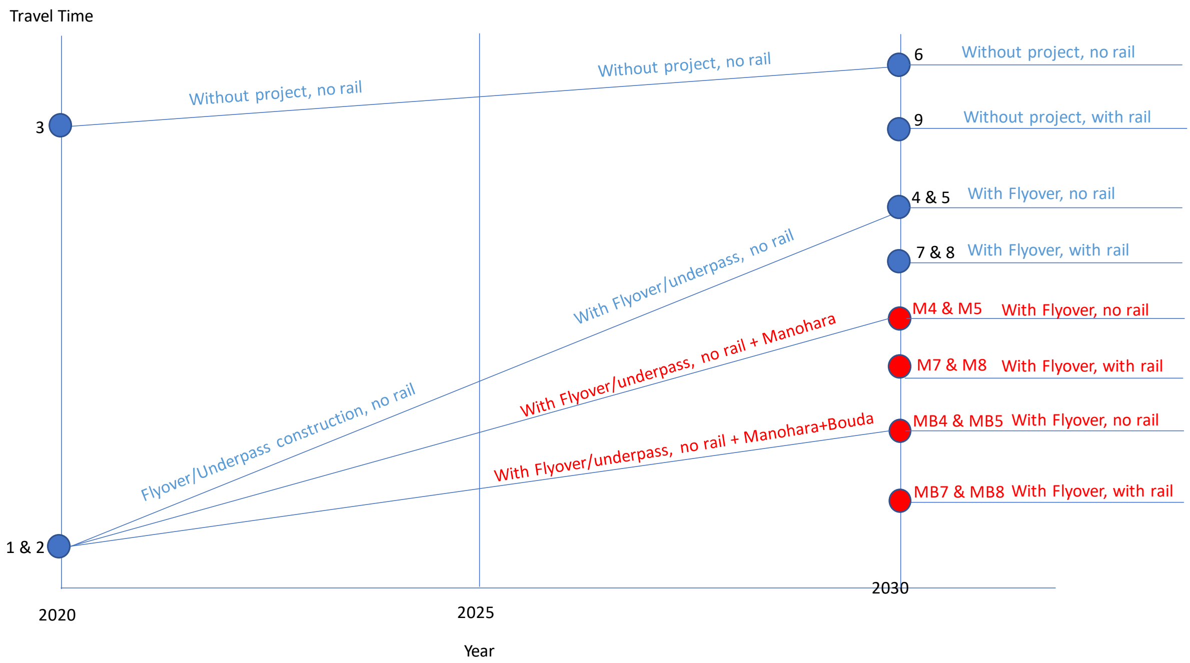
In addition to the three alternative scenarios – Alternative 4-1, Alternative 4-2, and Alternative 5 – additional scenarios have been considered for the economic analysis as shown in Table 4.7.8, Table 4.7.9 and Figure 4.7.4.

- Alternative 4 - Manohara: The benefits of 2025-2029 is the same as the previous analysis. The benefits of 2030 are derived from Analysis M7 minus 9, and is constant onwards.
- Alternative 5 - Manohara: The benefits of 2025-2029 is the same as the previous analysis. The benefits of 2030 are derived from Analysis M8 minus 9, and is constant onwards.
- Alternative 4 – Manohara+Bouda: The benefits of 2025-2029 is the same as the previous analysis. The benefits of 2030 are derived by Analysis MB7 minus 9, and is constant onwards.
- Alternative 5 - Manohara+Bouda: The benefits of 2025-2029 is the same as the previous analysis. The benefits of 2030 are derived by Analysis MB8 minus 9, and is constant onwards.

Table 4.7.8 Additional Analysis for Benefit Calculation

Analysis No.	OD Year	Railway	Scenario
1	2020	No	Alternative 4
2	2020	No	Alternative 5
3	2020	No	Without Project
4	2030	No	Alternative 4
5	2030	No	Alternative 5
6	2030	No	Without Project
7	2030	Yes	Alternative 4
8	2030	Yes	Alternative 5
9	2030	Yes	Without Project
M4	2030	No	Alternative 4 – Manohara
M5	2030	No	Alternative 5 – Manohara
M7	2030	Yes	Alternative 4 – Manohara
M8	2030	Yes	Alternative 5 – Manohara
MB4	2030	No	Alternative 4 – Manohara+Bouda
MB5	2030	No	Alternative 5 – Manohara+Bouda
MB7	2030	Yes	Alternative 4 – Manohara+Bouda
MB8	2030	Yes	Alternative 5 – Manohara+Bouda

Note: The additional analysis is shown in red



Note: The additional analyses are shown in red dots
Source: JICA Study Team

Figure 4.7.4 Additional Analysis for Benefit Calculation

Table 4.7.9 Setting of Manohara and Bouda Roads in Capacity and Travel Speed

	Before		After	
	Capacity	**Vmax**	**Capacity**	**Vmax**
Manohara Road	33,200 (pcu/day)	32km/h	58,300 (pcu/day)	55 km/h
Bouda Road	34,900 (pcu/day)	40km/h	55,400 (pcu/day)	40 km/h

Source: JICA Study Team

2) Costs

- Project Costs:
  - A preliminary cost estimate of an additional 1,500 million NPR (1,365 million NPR in economic cost) have been added to the overall project costs for the additional analysis. Table 4.7.10 shows the summary of the project cost by year.
  - All other conditions, including the maintenance costs applied, are the same as the conditions applied in the previous section.

Table 4.7.10 Project Cost Estimate (in Economic Costs)

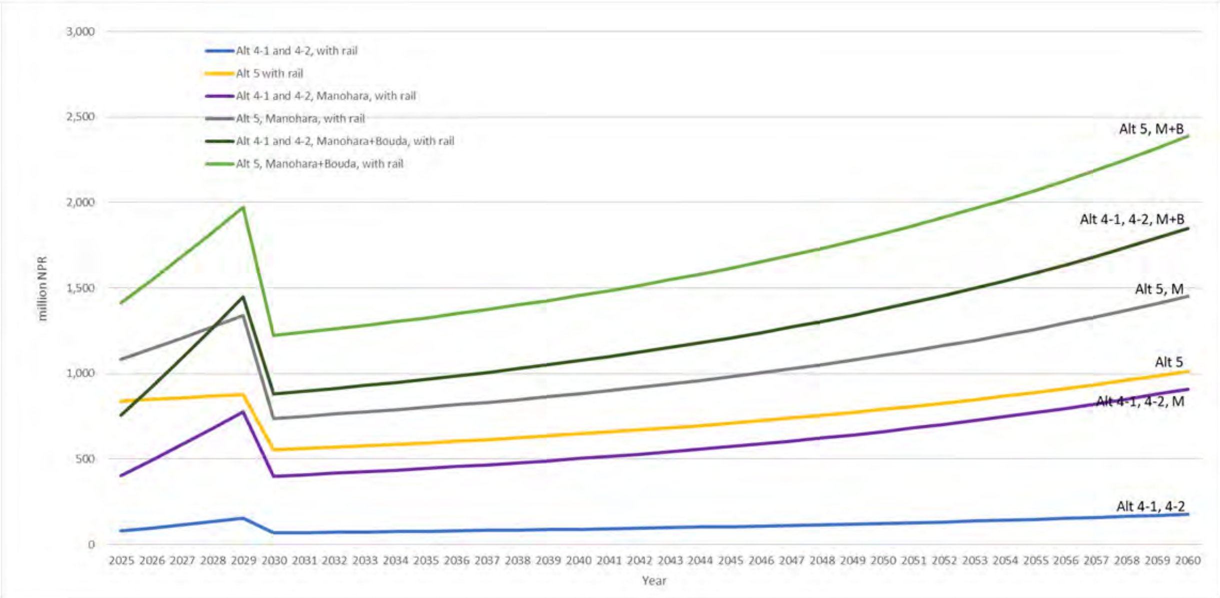
(in million NPR)

Scenarios	2021	2022	2023	2024	Total
Alternative 4-1	6,470	6,470	6,470	6,470	25,879
Alternative 4-2	3,721	3,721	3,189	-	10,631
Alternative 5	7,678	7,678	7,678	7,678	30,711
Alternative 4-1 Manohara	6,811	6,811	6,811	6,811	27,244
Alternative 4-2 Manohara	4,198	4,198	3,599	-	11,996
Alternative 5 Manohara	8,019	8,019	8,019	8,019	32.076
Alternative 4-1 Manohara+Bouda	6,811	6,811	6,811	6,811	27,244
Alternative 4-2 Manohara+Bouda	4,198	4,198	3,599	-	11,996
Alternative 5 Manohara+Bouda	8,019	8,019	8,019	8,019	32.076

Note: The additional cost estimate (preliminary) is shown in red
Source: JICA Study Team

3) Results of the Additional Economic Analysis

The benefits for the alternative scenarios for “with rail” cases are shown in Figure 4.7.5. The highest benefit is derived from Alternative 5 scenario with Manohara and Bhouda improvements, followed by Alternative 4-1 and 4-2 scenarios with Manohara and Bouda improvements.



Note: The benefit stream of Alternative 4-2 with and without rail starts from July 2023 after the operation begins, though this is not shown in the graph above.
Source: JICA Study Team

Figure 4.7.5 Economic Benefits per Year for Additional Scenarios (With Rail)

The EIRR calculations are shown in Table 4.7.11, where the highest EIRR was derived from Alternative 4-2 scenario with both Manohara and Bouda improvements. This is due to the lower cost of Alternative 4-2 scenario compared to Alternative 4-2 and Alternative 5 scenarios.

Table 4.7.11 Economic Internal Rate of Return for Additional Scenarios (With Rail)

Scenarios	EIRR (%)
Alternative 4-1 Manohara	-1.61%
Alternative 4-2 Manohara	2.69%
Alternative 5 Manohara	0.32%
Alternative 4-1 Manohara+Bouda	2.06%
Alternative 4-2 Manohara+Bouda	7.47%
Alternative 5 Manohara+Bouda	2.95%

Note: This is a preliminary analysis, and further clarifications are necessary.
Source: JICA Study Team

Table 4.7.12 shows the results of the sensitivity analysis when the total project costs were discounted.

Table 4.7.12 Sensitivity Analysis for Alternative 4-2 Manohara+Bouda Scenario (With Rail)

Scenarios	EIRR (%)
(a) Base Case	7.47%
(b) Project Cost: 10% down	8.30%
(c) Project Cost: 20% down	9.28%

Note: This is a preliminary analysis, and further clarifications are necessary.
Source: JICA Study Team

Table 4.7.13 shows the result without railway. This may present EIRR with net influence of interventions.

Table 4.7.13 EIRRs for Without Railways Case for Manohara+Bouda Scenario

Scenarios	EIRR (%)
Alternative 4-1 Manohara+Bouda	5.01%
Alternative 4-2 Manohara+Bouda	10.80%
Alternative 5 Manohara+Bouda	5.77%

Note: This is a preliminary analysis, and further clarifications are necessary.
Source: JICA Study Team

4) Suggestions

As shown above, the improvement of parallel road can increase the EIRR of the Koteshwor interventions. As aforementioned, it is impossible to handle all E-W bound traffic at Koteshwor, and parallel road development should be considered because the Koteshwor intervention will attract all traffic in the region. Other than the Manohara and Bouda Roads, Gwarko-Lamatar Road, Satdobato-Godavati Road and other roads in the eastern region can make the EIRR more positive.

4.8 Recommendations / Further Steps

This sub-chapter provides recommendations for further steps of the realization of the project to be financed by Japanese yen loan.

4.8.1 Koteshwor-Tinkune Intersection Improvement

(1) Determining the structural option for the alternative

Since this intersection has been already congested and does not have sufficient space to accommodate the future traffic flow, more considerations should be given to determine the final alternative with structural option covering the Koteshwor-Tinkune intersection – considering not only the construction costs and periods, but also taking into account the different viewpoints. The proposed items for consideration, both qualitatively and quantitatively, are as follows:

- Improvement effects (benefits) on congestion alleviation at the targeted intersections
- Construction cost and construction period
- Adverse effects by traffic closure/restrictions during construction (number of affected people and vehicles , particularly economic loss due to congestion)
- Required land acquisition area and costs
- Flexibility for traffic management such as bus operation, pedestrian movement and future BRT introduction on the ground level after completion of the grade-separation improvement
- Coordination with future urban railway system structures, multi-modal transport hub (bus terminals and urban railway station as interchange points)
- Consideration of the risks of the alternatives against earthquakes and flooding
- Operation and maintenance burden and costs and rehabilitation costs in the future from the Nepal side
- Applicability of new construction technologies to other places in the future
- Urban aesthetics; suitability of modern structure (flyover) to the surrounding buildings

Table 4.8.1 briefly summarizes the advantages and disadvantages of the structural option for the said intersection.

Table 4.8.1 Pros/Cons of Structural Option for Improvement Alternative

	Pros	Cons
Flyover	• There have been several experiences on the application of advanced Japanese technology for flyover option in Japanese yen loan projects, such as steel narrow-box girder type and steel rotation pile in other countries. • Construction cost can generate more savings compared to the underpass option. • By applying pre-fabricated girders and block erection method, there is a possibility to shorten the construction time.	• In case the F/O option is applied, after its completion, there is less flexibility on the application of traffic management methods at the project roads/intersection for buses, and for nearby residents and pedestrians. For example, it becomes difficult if the BRT plan is decided to be introduced on the Ring Road. • There is a risk of girders collapsing in the event of an earthquake, although there are some countermeasures applicable to the flyover option to avoid such risk. • In case of introducing a railway system along the project road in the future, attentive consideration shall be required in terms of structural option on how to over/underpass the flyover, although it is not impossible to realize.
Underpass	• More flexibility of application of traffic management measures (for bus and pedestrian movement) at the project intersection after completion of improvement by underpass. • It is possible to minimize the traffic control measures during the construction by application of platform above the open-cut area, and/or special tunneling method, and the non-open cut method which may cause longer construction time. • It would contribute to realizing smooth traffic flow bound for the city center on Araniko Highway as there are no obstacles above the road surface, even if there are delays in introducing the mass transit system for the eastern development area.	• High construction cost is anticipated even though a cost-saving method, achieved by combining the open-cut and non-open cut methods, is applied. • Longer construction period shall be anticipated in general compared to the flyover option. • All underground utilities need to be relocated along the structure. • Maintenance burden and costs shall be higher than the flyover option because the underpass structure requires both ventilation and drainage system. (It is possible to avoid the ventilation system and save on the lighting system cost if the underpass section allows the opening of a segment on the top slab for fetching air and skylight.)

Source: JICA Study Team

In the next step of the study, items raised in this sub-chapter shall be elaborated in comparison with the flyover option and the underpass option to make the final decision on the structural option. Particularly, it is suggested to analyze both the economic benefit of the grade separation structure, and the economic loss caused by traffic control/closure during the construction period by using the micro-traffic model. Furthermore, a detailed investigation of public utilities, particularly under the ground along the project road, should be conducted because its existence largely affects the construction period of the project.

(2) Necessity of the Manohara River Corridor Development

It is confirmed that the Manohara River corridor would also play an essential role to alleviate the traffic congestion at Koteshwor intersection by diverting vehicles to/from Araniko Highway and the Ring Road (south). Since the traffic demand forecast indicated that both alternatives for Koteshwor-Tinkune intersection improvement cannot accommodate the traffic flow to/from the Araniko Highway and the Ring Road (south), it should be enhanced to install good connections between the corridor and the two major roads and to provide sufficient road flow capacity with good alignment to enhance traffic diversion.

(3) Improve Economic Benefit Assessment

The present result of the economic analysis does not show the positive impact of the intervention.

The present economic evaluation calculates the benefit from the whole network, as the influence of the interventions reaches a broad area as shown in Figure 4.7.1. However, it also aggregates the negative impact of the whole network.

As aforementioned, it is forecasted that the traffic situation in 2030 at Koteshwor will have quite a large volume. Hence, the expected travel flow would not improve much to justify the large construction cost, as the traffic will be saturated on the newly added sections. It is necessary to consider another approach to calculate the net, accuracy, and specific traffic improvement as follows:

- Microscopic simulation could be applied to evaluate the small-scale impact
- Revision of population growth scenario
- Integrated assessment of the Manohara bypass installation with the grade separation at Koteshwor

(4) Precise Cost Estimation in Consideration of the Transport Cost

Since Nepal has less experience in the construction of urban flyover or underpass, the transportation costs of imported material – such as steel girder, equipment/facility, and temporary materials such as platform, sheet piles, etc. – can be the determinant factors of the construction cost. Further careful cost estimation is required in consideration of an appropriate construction plan. In addition, the necessity of ventilation system and evacuation system should be examined and reflected in the construction cost.

4.8.2 New Baneshwor Intersection Improvement

It is confirmed that the installation of the grade separated structure is not required in accordance with the result of the signalized intersection analysis by traffic flow by year 2030. Within the current ROW, it is manageable if the lane width for urban area in Nepal is narrower to 2.8m to 3.25m, which have been applied in other countries.

4.8.3 T-M Intersections Improvement

Based on results of both the network flow analysis and signalized intersection, it is confirmed that the installation of the grade separated structure with flyover/viaduct connecting the two intersections is less effective from the viewpoint of traffic flow conditions. Only the physical improvement at each intersection is recommendable, such as increment of the lane number and installation of signal control system in order to accommodate the future traffic volume by year 2030, especially since it is recommended to change the intersection type from roundabout to signalized both at Maitighar and Tripureshwor intersections.

CHAPTER 5 SHORT-TERM SOLUTION

5.1 Project Idea 1: Technical Assistance for Urban Road Specification and Intersection Improvement

5.1.1 Issues and Direction

Based on the survey findings, issues on urban roads and intersections can be summarized as follows:

- Guidelines governing the design of urban roads and intersections do not exist. Therefore, proper design guidelines are required to expand the throughput capacity of a limited carriageway in a densely built-up urban area.
- Exiting traffic signals are not functioning, so deploying a large number of traffic police officers for traffic control in the valley is necessary. Since an appropriate urban traffic management system is not in place, traffic signal improvement is essential.
- From a long-term perspective, widening or constructing wide roads within the densely built-up area is difficult and undesirable. In this sense, it is necessary to establish an urban road network including the narrow streets; therefore, the intersections, which are the network's nodal points, become increasingly important to enhance smooth urban traffic movement.

In response to these issues, formulating a framework that promotes technical cooperation between the relevant agencies – such as the Department of Roads (DOR), Department of Traffic Management (DOTM), Kathmandu Metropolitan City (KMC), and Kathmandu Metropolitan Police Division (KMPD) – to enhance the capacity of urban traffic management and control is necessary. The formulation of a TA encompassing this objective is proposed hereunder.

5.1.2 Proposal for Technical Assistance (TA)

(1) Introduction

Under the JICA TA scheme, experienced experts are dispatched to work with Nepalese officers as counterparts; the budgets for implementing pilot projects as trial installations and geometrical improvements of intersections are set aside; and training(s) in Japan and/or third-party countries for capacity development of Nepalese officers are conducted.

To address the issues under the short-term urban traffic management scheme, the proposed TA covers three broad aspects:

- **Engineering**: enhancing the capacity of urban road and intersection design (design guidelines (e.g. lane width in urban area, motorcycle box, lane and bus-bay arrangements and geometrical improvements), traffic signal control and safety devices for traffic management/control)
- **Education**: raising public awareness so that manner/discipline and safety measures for vehicle driving and pedestrian crossing are promoted.
- **Enforcement**: regulating driving rules including bus-stop operation and parking policy, and disseminating information on traffic conditions and instruction.

(2) Project Outline

1) Project title

- The project for the introduction of the urban traffic management guidelines in Kathmandu Valley.

2) Implementing agency

- Department of Roads (DOR);
- Department of Traffic Management (DOTM);
- Kathmandu Metropolitan City (KMC);
- Kathmandu Metropolitan Police Division (KMPD).

3) Project period

- The project period shall be in the range of three years in order to accomplish the planned activities.

(3) Project overview

Table 5.1.1 provides an overview of the proposed TA project.

Table 5.1.1 Overview of the Proposed TA Project

Narrative Summary		Remarks
Overall goal	Safe and smooth traffic flow on major urban roads in Kathmandu Valley is achieved.	
Project purpose	The capacity to implement intersection improvement, traffic safety education, and traffic regulation in Kathmandu Valley by counterpart (C/P) agencies is enhanced.	
Outputs	1. Urban traffic management policy is strengthened	[UTMP, with government officers] - Set vision, strategy, and plan the following activities: o Intersection improvement plan (physical/ geometric improvement, signal installation) o Traffic safety education plan o Strengthening of traffic enforcement plan o Sustainable funding/financial plan - Set monitoring plan/tool (GPS probe data, etc.) - Further TA/Grant Aid scheme
	2. Urban intersection improvement capacity is enhanced.	[Urban Traffic Management Guidelines (UTMG)] - A series of technical manuals/guidelines pertaining to: o Physical (geometric) improvement of urban road intersection (e.g. lane width) o Traffic signal operation and installation [Pilot project on intersection improvement] - To be conducted at selected intersection to demonstrate the introduction of the guideline which may include o Geometric improvement project (New Baneshwor, Maitighar) o Traffic signal installation project

Narrative Summary		Remarks
	3. Traffic signal operation and maintenance capacity are improved.	[Principle and practices in traffic signal operation & maintenance] are the main focus.
	4. Capacity for implementing road safety education and awareness program is enhanced.	[Road safety management] - Awareness campaign for vulnerable road users (pedestrians, motorcyclists, etc.) [Safe road user behavior] - Education and awareness strategy on traffic rules and manners; - Action plan on road safety education - Improvement plan for pedestrian crossing facilities in urban area
	5. Traffic enforcement capacity is improved.	[Safe and smooth traffic flow with proper enforcement by traffic police] - Traffic rules enforcement program (violation and penalty) - Enforcement supporting devices/ technologies (camera, etc.) in view of effectiveness, efficiency, and safety.
Inputs	Japanese side: - 6 fields of experts (approximately 80 man-months) - Pilot projects costs (equipment, construction work/Japanese technology materials, system development, etc.) - Training in Japan and third-party countries	
	Nepalese side: - Sufficient number of C/P staffs from MOPIT, DOR, DOTM, KMC, and KMPD; - Pilot projects costs (i.e. detailed design, civil works, installation costs, etc.) - O&M costs for equipment provided by the Japanese side - Provision of office and utilities	

Note: UTMP refers to Urban Traffic Management Plan, and UTMG refers to Urban Traffic Management Guidelines which include the necessary guidelines/manuals relevant to intersection design, traffic signal operation/maintenance, etc.

(4) Draft Project Design Matrix (PDM)

The details of the draft PDM for the proposed TA are in Appendix 8.

5.1.3 Pilot Project Implementation

(1) Background

This section presents the preparation of the pilot project at two intersections, which is the outcome of the Short-Term Working Group discussions under the survey. It also indicates the coordination productivity among relevant agencies. The expected outcomes are as follows.

- A 2.8-meter lane width is the basis for tentative recognition of the clause “urban road” in the Nepal Road Design Standard that requires a 3.5-meter lane width.
- Although DOR and the traffic police are technically linked, there have been few specific collaboration opportunities. Thus, strengthening their cooperation in respect to urban road and

traffic management is important for the future introduction of intersection improvement and traffic signal.

- The pilot project is small in scale, but it brings about improvement on traffic behavior during peak hours. Additionally, it provides evidence that the promotion of collaboration between DOR and traffic police results to better traffic control with simple geometric improvement without traffic signal. Moreover, a comprehensive proposal, including intersection design and traffic signal control for New Baneshwor which is one of the only two functioning signalized intersections, is established.

(2) Concept Plan of Pilot Project

Table 5.1.2 and Table 5.1.3 show the pilot concept plans drafted for discussion among Short-Term Working Group members.

Table 5.1.2 Pilot Concept Plan at Maitighar Junction

<table>
<tr><th colspan="3">Pilot Concept Plan 1</th></tr>
<tr><td>1</td><td colspan="2">Background
Inefficient use of bus stops. Maitighar intersection is heavily congested, with five legs of road intricately connected. Along these congested roads, bus stops are placed within the vicinity of the intersection. All public vehicles (e.g. bus, taxi, tempo) stop for passengers' boarding/disembarking at on-street bus stops, disrupting the movement of other vehicles queuing to exit. The traffic police manually control the flows of traffic at present, yet face difficulties in ensuring sufficient intersection capacity for the exit of vehicles. The inefficient use of bus stops worsens congestion within and outside of Maitighar intersection, often stretching all the way to nearby intersections such as Thapathali.

Merging traffic. Madan Bhandari Road – located at the southeast of Maitighar intersection – is a 4-lane highway including 2-lane service roads (each way). Traffic coming from New Baneshwor merges at the entrance of Maitighar intersection, creating a conflict point where buses on the service roads entering the intersection may collide with other vehicles approaching the side road to make a left turn. A traffic separation scheme is necessary to optimize the direction of traffic flow.</td></tr>
<tr><td>2</td><td colspan="2">Objectives
Mitigate traffic congestion at Maitighar intersection and secure sufficient intersection capacity for the entry and exit of vehicles through the arrangement of bus stops and traffic flow separation scheme.</td></tr>
<tr><td rowspan="4">3</td><td colspan="2">Concept Plan</td></tr>
<tr><td>(i) Detailed plan
Bus stops will be arranged as follows: (1) existing bus stop at the southwest exit (4 bays) to be used by medium buses and vans; (2) a new bus stop (3 bays) to be established at the southeast entry point; and (3) taxi/tempo stands (2 bays each) to be established in an unused open area (before the southwest corner).

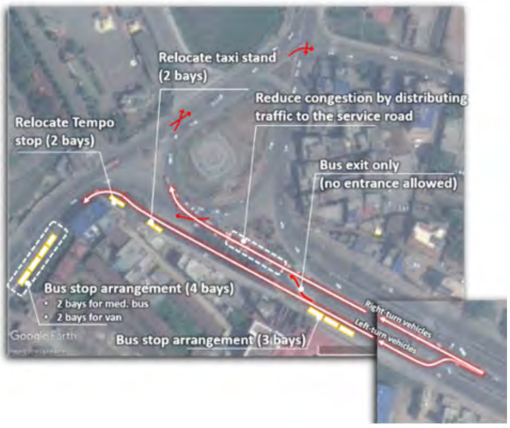
Traffic separation will be enforced for left-turn vehicles and straight-through vehicles. The starting point will be at a small junction, 340m southeastward from Maitighar intersection. Strict traffic enforcement on the ground with the help of the traffic police is a must for project success.</td><td>
</td></tr>
<tr><td colspan="2">(ii) Rationale
Inefficient bus stop locations, the resulting traffic in queue (especially at the southwest corner) and unavoidable conflicting points are the main sources of congestion. The two-stage pilot project will optimize traffic flows across the intersection while reducing traffic congestion on a small scale.</td></tr>
<tr><td colspan="2">(iii) Case studies
Traffic management schemes are well practiced across the world. A solution depends on local conditions and the environment.</td></tr>
<tr><td>4</td><td colspan="2">Expected Outcomes
- Reduce levels of traffic congestion
- Increase intersection capacity
- Facilitate the flows of traffic within the intersection
- Minimize potential collisions at conflict points
- Increase safety of both drivers and motorcyclists as well as pedestrians crossing</td></tr>
</table>

Table 5.1.3 Pilot Concept Plan at New Baneshwor Intersection

<table>
<tr><th colspan="3">Pilot Concept Plan 2</th></tr>
<tr><td>1</td><td colspan="2">Background
Motorbikes in traffic queues. The New Baneshwor intersection is busy with high vehicle, motorbike and pedestrian traffic volumes. During the red signal phase (controlled by traffic police), motorbikes cut ahead of queuing traffic or weave between queuing cars. This common behavior lowers the visibility of motorcycle riders and may endanger their safety. Moreover, queuing motorbikes may obstruct the movement of other vehicles or delay the transition from congested traffic to free flow when the signal turns green, i.e. the lost time increases.</td></tr>
<tr><td>2</td><td colspan="2">Objectives
Facilitate traffic movement at New Baneshwor intersection by separating motorbike traffic from other vehicles.</td></tr>
<tr><td rowspan="4">3</td><td colspan="2">Concept Plan</td></tr>
<tr><td>(iv) Plan detail
The pilot project is to create bike boxes in front of the vehicle stop line. A bike box is a type of advanced stop bar that is used at controlled (signalized) intersections. The bike box includes two elements: (1) an advanced stop line for drivers to wait behind, and (2) a marked space for motorcycle riders to wait in. When the traffic signal is red, drivers must wait behind the bike box and behind the stop line. Motorcycle riders are allowed to ride to the front of the traffic queue into the bike box and wait for the green signal. When the traffic signal turns green, vehicles must yield to motorbikes before proceeding or making a turn.

The design and location of bike boxes and pavement markings for the left-turn lane need to be discussed between DOR and the traffic police.</td><td rowspan="3">


</td></tr>
<tr><td>(v) Rationale
Placing motorcycles in front of the queue is already being practiced at this intersection without physical design. Road users, including the traffic police, are accustomed to this practice, thus it can be easily accepted by the public. The pavement of bike boxes will increase the visibility of motorcyclists and also help the traffic police manage traffic more efficiently on the ground. No major infrastructure works are required. However, pavement markings for the bike box and turning lane are necessary.</td></tr>
<tr><td>(vi) Case studies
Many developed countries, including UK (London), USA (Portland), Taiwan and Indonesia, practice this type of traffic management.</td></tr>
<tr><td>4</td><td colspan="2">Expected Outcomes
- Increase visibility of motorcyclists
- Reduce traffic collisions between motorists and motorcyclists
- Facilitate the flows of traffic and the transition from congested traffic to free flow at the change of signal</td></tr>
</table>

(3) Road Marking Plan for the Pilot Project

After obtaining the basic approval of the concept plan, the Working Group members visited the sites and measured the dimensions of the intersection on March 18th and 19th, 2019 (Figure 5.1.1). Based on the actual dimensions, the JICA Study Team prepared road marking plans for the pilot projects as shown in Figure 5.1.2, Figure 5.1.3, and Figure 5.1.4.

Source: JICA Study Team

Figure 5.1.1 Photos of the Site Visits at New Baneshwor, Maitighar and Babar Mahal by Working Group Members

Source: JICA Study Team

Figure 5.1.2 Road Marking Plan for Pilot Project at Maitighar Intersection

Source: JICA Study Team

Figure 5.1.3 Road Marking Plan for Pilot Project at Babar Mahal

Source: JICA Study Team

Figure 5.1.4 Road Marking Plan for Pilot Project at New Baneshwor

(4) Implementation Plan

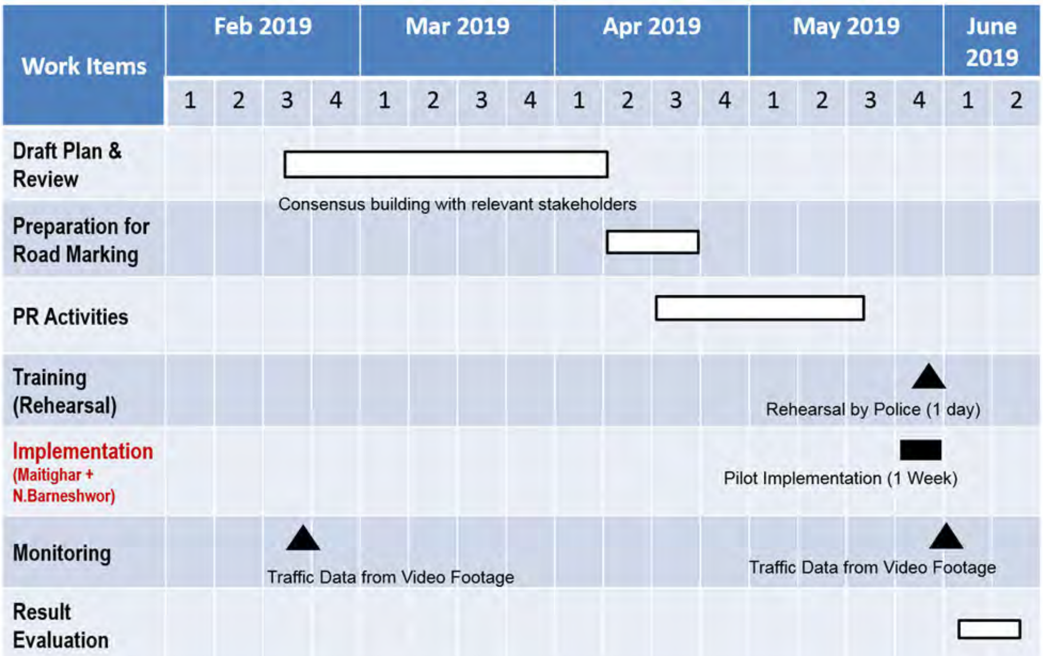
Table 5.1.4 and Table 5.1.5 show the role and responsibilities as well as the preliminary implementation schedule. However, some activities fall behind schedule since approval process requires longer time than initially planned. Therefore, this schedule needs update after DOR cost estimates and arrangement of procurement are confirmed.

Table 5.1.4 Roles and Responsibilities

Activities	MOPIT	DOTM	DOR	Traffic Police	KMC	JST
Detial Plan of the Pilot	●	●	●	●	●	●
Overall Facilitation, Permission, and Monitoring	●	○	○	○	○	○
Neighborhood Consensus	○	○			●	
Coordination with Target Route Associations/ Entrepreneur Associations	○	●	○		○	
Road Marking (Bus stop, Mcy box)		○	●	○		○
Traffic Control in the Vicinity	○	○		●	○	
PR Activities (announcement, banner, etc.)	○	●		○	○	

Black dot: main authorities in charge, circle: sub authorities in charge

Table 5.1.5 Preliminary Schedule



5.2 Project Idea 2: SDG Business for Electric Tricycles

5.2.1 Background

(1) Degrading Air Quality and EV Introduction

Rapid urban growth, coupled with increasing numbers of automobiles and motorbikes, is the main source of air pollution in Kathmandu Valley. Deteriorating air quality causes over 35,000 deaths per year in Nepal[1] posing a serious environmental health risk. In fact, air quality in Nepal is the worst on this planet[2]. To tackle this acute problem, the government aims to increase the share of electric vehicles up to 20% by 2020. Electric vehicles promotion is on the rise.

(2) SDG Business Schemes

JICA has long supported the activities of private companies in developing countries to realize inclusive and dynamic development towards achieving the Sustainable Development Goals (SDGs). JICA also sees SDGs as a business opportunity and encourages Japanese companies to bring their know-how and technology for SDG innovations. Under SDG's business scheme, JICA supports data collection and business plan design to correspond to the local challenges and needs of developing countries.

In line with this SDG's business scheme and in response to the country's efforts to tackle air pollution through EV promotion, SAFA Tempo electric tricycles is emerging as a home-grown innovative solution. SAFA Tempo, the three-wheeled electric vehicles, operates purely on electricity, thus environmentally friendly with "zero" CO_2 emissions. It provides sustainable, accessible and affordable means of transport to the wider community. Also, it contributes to generating local employment and prompting social advancement of female drivers. In short, SAFA Tempo has a huge potential in achieving four goals of the SDGs as shown below.

Source: JICA Study Team

Figure 5.2.1 Achieving SDGs through SAFA Tempo

(3) SAFA Tempo Main Problem

SAFA Tempo currently faces several technical challenges that affect daily operation – the foremost is battery life. The USA-made battery quality has deteriorated in recent years, from 3 years to less than one year. In effect, the operation cost has increased. Currently the SAFA Tempo organization is considering replacing old lead batteries with lithium one. Ongoing discussions with USA (Trojan: current battery provider) and Chinese companies have not seen fruitful results as of February 2019.

[1] https://thehimalayantimes.com/nepal/air-pollution-causes-annual-death-toll-of-35000/
[2] http://kathmandupost.ekantipur.com/news/2018-01-25/nepals-air-quality-is-worst-in-the-world-epi-report.html

5.2.2 SDGs Business Proposal

JICA has promoted collaboration with the activities of the private sector to bring their know-how and technology for SDG innovations in developing countries. The following proposals for technological improvements and private investment can be considered to formulate SDGs business promotion schemes in SAFA Tempo industry.

(1) Sustainable Battery

- SAFA Tempo is a simple structured vehicle, equipped with a DC motor powered by a 72 V battery pack made up of 12 batteries. The DC motor is controlled by a simple electronic control device. The battery uses lead batteries manufactured by Trojan of USA (a set with 12 batteries costs USD 1,300, and the battery life is about 3 years). SAFA Tempo faces deteriorating battery quality and short battery life (from 3 years to less than one year).
- SAFA Tempo needs a low-standard battery that is reasonable and sustainable with longer life cycle to overcome challenges in daily operation.

(2) Tempo Location System

- Investment in emerging technology such as GPS devices, in collaboration with local IT companies, would optimize SAFA Tempo operation efficiency and save the running cost, while improving a systematic operation management.

(3) Modernized EV Vehicle

- SAFA Tempo vehicles are obsolete due to restrictions on procurement of new tempo fleets, thereby requiring fleet modernization to provide better services. According to a meeting with representative of SAFA Tempo entrepreneur, they seek to upgrade the current 3-wheel vehicles (12 max passengers) to the 4-wheel EV vehicles with 14 seating capacity.
- Tempo vehicles are currently produced by local manufacturers. Providing technical support to upgrade vehicle specifications is possible, however, there should be no impact on the local industry.

5.3 Project Idea 3: Potential Assistance for the Public Transport Fare Collection and Fare Structure Consultation

5.3.1 Background

Referring to the experience in Dhaka, Bangladesh, JICA had initiated the installation of IC-Card fare payment system to the transport services since 2012. Initially JICA served for the fare payment system installation to the bus sector, to minimize the fare collection leakages and improve boarding and alighting efficiency. After success of the initial bus fare card system installation, JICA assisted to establish a clearing house services to enhance the common usage of the IC card fare payment among various transport service operators, not only bus, but also national railway, metro (under construction), and retail services. The clearing house is a function of payment clearing.

The present service of the bus fare collection service is just experimental stage for two major bus companies, Sajha and Digo, and expansion and dissemination among the other bus routes should be considered. The present tariff is distance based, which required locational information of loading and alighting of passengers, and the system comes complicated, and installation seems delay. The present fare collection system is designed to keep compatibility among cash and other intelligent ways, including QR-code and NFC (IC-card).

The bus companies as well as individual operators are suffering from the fare collection leakages, and installation of IC-card system can retrieve the 20% loss of present fare collection[3]. At present, N-Cloud PVT is just exclusive for technology development and there is no budget for promotion and marketing of the system, which could be authorized and covered by the public investment.

5.3.2 Project Idea

(1) Fare Collection System Improvement

The first component will fit to the technology transfer of intelligent fare collection in other country, which would be implemented in B-B (private business to private business) basis, e.g., bus fare collection technology company. The fare collection of the bus needs quick response to minimize the stopping time at the bus station on street, and minimize influence to the traffic flow. JICA's SDG B-B scheme can be applied to support the activities. It is expected that the experienced private business operators of Japan can advise the system for distance-based fare collection, and, how to utilize latest NFC on smartphone technology, etc.

(2) Fare Collection System Expansion, Marketing and Promotion

This would be covered by the public expenditure. The installation of the intelligent fare system could be required for the syndicate consolidation (see later section), and necessary equipment installation should be funded by the public investment.

Marketing and promotion cost of the system should be enhanced by the public investment, and which is suitable to be supported by TA program (JICA and other donors). The present system is designed to be compatible for cash-payment users, which makes the systems complicated, however, the public investment can support to grant the IC-card as promotion purpose.

(3) Fare Structure Revision and Operational Regulation

The present fare structure of KV bus service is specified by the same tariff regulation for the intercity fare structure, which is financially in-sufficient to urban services. A study for preferable rate for urban bus operation and tariff structure, including fixed rate, can be implemented as TA.

(4) Clearing House Setting

Referring to the Dhaka case, the clearing house development could be considered as the next step for the intelligent fare collection system installation for buses. It would be a base fare collection system of Metro and BRT in future.

5.4 Project Idea 4: Immediate Support to Enhance Private Initiative

The bus route restructuring along S5 pilot route is one of the latest successful initiatives to improve public transport services. Starting with the consolidation syndicates, the pilot project introduced a package of optimized transport services with advanced technologies, including GPS, payment system. In six months' time after the introduction, the modern bus system has benefited the public substantially – according to opinions of users and operators. To keep with this momentum, the pilot project should be expanded in scale to achieve a more integrated network of bus system.

5.4.1 Syndicate Consolidation for Better Public Transport Services

For consolidation, the KSUTP public transport restructuring study (2014) has already identified the priority routes for consolidation, i.e., 4 Primary routes, 3 Secondary Routes (S5, S4 and S3) and 8 Tertiary

[3] Source: Meeting with Digo Yatayat on 5th February, 2019

routes. The total cost of S5 restructuring is about USD 1.9 million[4], of which USD 700,000 was spent to purchase 17 buses. This consists of USD 140,000 through grant equity, and USD 560,000 through soft loan with 5% interest rate in an 8-year repayment period. The funding sources from the TDF management. Additional funding is needed for development of bus depots (USD 80,000 for S5 route) and consulting services. The 2014 study formulated a long list of potential pilot routes. Assuming that the project cost for secondary routes equals to that of S5 and the cost for primary routes increases by 150%, the total cost of consolidation of target primary and secondary routes will be USD 11.3 million for bus fleets modernization and USD 10.81 million for other costs including consulting services (excluding bus depots cost). The proposed funds could be secured through international loans and grants.

Table 5.4.1 Overview of Potential Bus Pilot Projects

Potential Pilot Projects

Route	Description	Length (km)	No of Buses	Bus fleet cost (USD mil)	Other cost (USD mil)	Total cost (USD mil)
S3	Naya Bazar (Kirtipur) -ChappalKarkhana	13.2	29	1.2	1.2	2.4
S4	Naya Bazar (Kirtipur) -Jorpati	16.4	36	1.5	1.5	3.0
P1/P2	Ring Road	27.3	64	2.6	3.8	6.4
P3	Narayangopal Chowk -Satdobato	11.2	49	2.0	1.6	3.6
P7	Koteshwor - New BusPark	11.4	46	1.9	1.6	3.5
P8	Koteshwor - Kalanki	8.2	51	2.1	1.1	3.2
			Total	**11.3**	**10.8**	**22.1**

Reference Project (Completed)

Route	Description	Length (km)	No of Buses	Bus fleet cost (USD mil)	Other cost (USD mil)	Total cost (USD mil)
S5	New Bus Park - Airport	12.1	17	0.7	1.1	1.8

Source: JICA Study Team

There are six vital factors prompting consolidation and bus modernization.

1) **Political will to end syndicate system**. Government has addressed to end syndicate system in the transport industry[5]. A move to consolidate individual transport operators and associations/committees is expected to continue and will be guided by existing laws and policies of the government.

2) **Sound business environment**. DIGO Yatayat Pvt Ltd., newly established S5 operator, confirmed operation is managed purely on farebox revenues. Consolidation of inefficient, uncoordinated buses has resulted in establishment of the sound business environment for bus operators.

3) **Better travel experience**. Passengers are happy with S5 restructuring and Digo operation, particularly in terms of improved service quality.

4) **Transferable and applicable local knowledge**. TDF and other stakeholders have fresh experience and knowledge of S5 restructuring, thereby able to transfer and apply gained skillsets and expertise in different local settings.

5) **Obsolete bus fleets**. Existing bus fleets are poorly maintained – most are older than 20 years. Modern and efficient bus vehicles (i.e., EURO4) are a key element of better transport services.

6) **Local readiness**. The reason why the KSUTP did not consolidate the proposed S3 route was a lack of implementation time. Local stakeholders are keen to expand consolidation initiatives to other routes.

[4] The funding for 2 pilot projects (S3 and S5) totalled USD 3.8 million. We assumed 50% of the fund was spent on S5, as unable to receive a response from the TDF.
[5] https://thehimalayantimes.com/business/government-set-to-act-against-transport-syndicate/

5.4.2 ICT Application

On the other hand, the GPS/bus operational information, payment system and applications are implemented by the private initiative. The public transport regulator, DOTM, should support and enhance the private company involvement with proper standard, however, at present, the private investors are negotiating directly with the Kathmandu Municipality to realize the concession contract for PFI approaches.

The following services and sectors should be supported by the government:

(1) Authorization of Private Investment Initiative by Sector:

Authorization and monitoring system for private investment in transport sector should be enhanced. The private sector may escape from investment, therefore, the proper contract for continuity of the services should be secured.

(2) GTFS (General Transit Feed Specification, Static and Dynamic)

Standardizing and opening public transport data make public transport system more efficient and improve user experience.

GPS devices are installed in over 800 buses belonging to public operator, i.e. Sajah Yataya, and other private operators in Kathmandu Valley. The data from these GPS devices is managed by Technology Sales Pvt (RamLaxman Pvt)., one of the most prominent ICT companies in public transport sector.

General Transit Feed Specification (GTFS) comes along with standardized the data and creates an open and well documented format for organizing transit data. In this format, transit data is universally understood and easily integrated into online applications. Using GTFS means using a common language for transit data that is shareable. Therefore, if the bus operation data is standardized and access to it is streamlined, the following improvements can be envisioned:

- Operator, in addition to monitoring the number of trip, can review their operation plan, optimize fleet allocation by route by (peak/off-peak) hour to minimize their running cost. In return, bus fleet that are not in operation may undergo routine maintenance or may be allocated to on-demand service, which is another source of profit.
- Regulator or licensing institution such as DOTM can monitor the service level in each bus route and exercise necessary policy to strengthen route permit (e.g. introducing quota limit) and upgrade the public transport service level. The data also support the public transport regulator’s decision in opening new potential bus route.
- User can enjoy the convenience of real time location information and choices of preferred route and mode. If the data of informal transit or paratransit (e.g. ride-hailing services) is also uploaded and shared in GTFS format, a seamless travel is enable as a bus user can reserve the paratransit to complete her/his last mile. This trunk-feeder service integration allows public transport service to overcome the present inconveniences and to leapfrog into a new paradigm of Mobility as a Service (Maas) with ICT application.

CHAPTER 6 LONG-TERM SOLUTION

6.1 Introduction

In Kathmandu Valley, the development of urban transport system is highly required to support the increase of urban population and traffic volume due to urban development. Particularly, the urban railway system is necessary to respond to the traffic demand generated in the eastern development area.

Under these circumstances, the previous master plan of JICA and the subsequent KSUTP-MTOPS proposed the transport network plan including the railway system development, and proposed a priority route for the initial introduction of the railway.

This study assessed the proposals and added engineering development principles and concept to be considered when introducing the urban railway system to Kathmandu Valley.

In addition, this study proposed the creation of a Road Map that describes the steps for the realization of an urban railway system, and recommended items to be considered immediately, including Depot and land acquisitions.

6.2 Necessities of Urban Railway in Kathmandu Valley

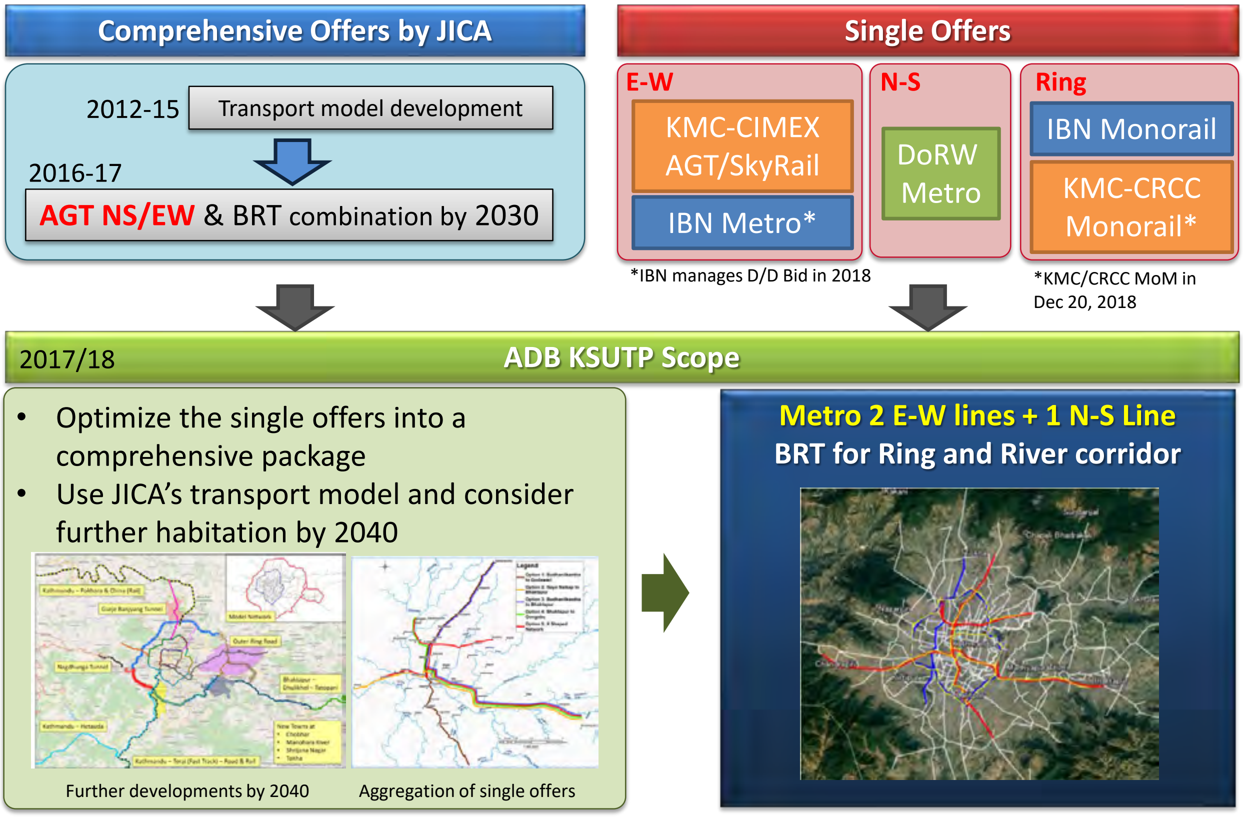
6.2.1 Review of the Existing Urban Railway Plan

As mentioned in Section 2.2, there were several plans on urban railway system in Kathmandu Valley as shown in Figure 6.2.1, which were roughly classified into two categories: i) comprehensive plans and ii) individual plans.

For comprehensive plans, “The Detailed Planning Survey on Traffic Improvement in Kathmandu Valley” was implemented by JICA in 2013, and “The Project on Urban Transport Improvement for Kathmandu Valley” was implemented by JICA in 2017. In these surveys, it was proposed that AGT should be installed on the north-south axis and east-west axis where traffic demand is concentrated, and that BRT should be installed on major routes with relatively low traffic demand.

For individual plans, the IBN is going to implement the “Study for PPP development on the East-West Line” by 2020. The Study includes the FS, detailed design, and assistance for contractor procurement. Similarly, the DORW requested EOIs to make the Detailed Project Report on the North-South Line. There are individual proposals for monorail along the Ring Road.

In 2017-18, KSUTP-MTOPS – having more comprehensive approaches – collected and assessed these previous comprehensive and individual proposals and re-summarized the proper concept of future railway and mass transit network, comprising of 2 east-west metro lines, 1 north-south metro line, and several BRT lines for the Ring Road and river roads, and gave proposals on prioritized sections for 2030.



Source: JICA Study Team

Figure 6.2.1 Progress of the Consideration for Urban Transport System

6.2.2 Envisioned Urban Developments in Eastern KV and the Necessity of Railway

As mentioned in Section 2.2, KVDA has a plan to develop new cities in the eastern region of the Valley, and an urban railway is expected as the means of securing transportation in this new development area.

According to the strategic analysis in Chapter 3, the road network connecting the eastern region to the urban center is insufficient to cover the traffic demand generated in the newly developed region, and concentrations of road traffic along Araniko Highway and at Koteshwor junction are still expected despite the facilitation of grade separation at Koteshwor.

It is assessed that the road network cannot handle such large traffic demand without the development of urban railway network, particularly along the Araniko Highway corridor, from Bhaktapur to the urban center.

Also, the urban railway will be useful for tourists in Bhaktapur.

6.3 Principles for Urban Railway Development

6.3.1 What is Urban Railway Development?

Urban railway system has various aspects of development. As a transport means, it can provide a new service with large carrying capacity of passengers; with speed,and punctuality; and a highly comfortable, safe and stable service. All of these features would be new to Kathmandu.

The urban railway system cannot work by itself. It requires proper access, including footpath, feeder service to/from stations and proper information systems. Proper accessibility can expand the catchment area of the railway services.

Urban railway development also contributes to local industries by creating railway-related businesses and employment, and can also revitalize cities through station development and urban development.

6.3.2 Key Parameters for Urban Railway System Development

Unlike road development projects, urban railway requires more 'systematic' considerations, as the urban railway system would consist of civil structure engineering, rolling stocks engineering, operation planning, and passenger services, and these elements influence each other. The following aspects should be considered properly from the initial planning stage:

(1) Route Planning

There are two elements in the planning of urban railway routes. The first one is to integrate urban development project and urban railway project to secure potential passengers along the expected railway route. The second one is for the new railway to absorb the existing road traffic to alleviate road congestion.

(2) Alignment Considerations

In consideration of alignment, it is necessary to follow the minimum curve radius and the vertical gradient to secure the operating speed. In addition, since urban railways are required to operate trains at short intervals, it should be planned on double tracks.

In addition, the space generally required for the installation of elevated structures and underground structures is shown in Table 6.3.1 for reference. The width of the structure changes depending on the width of the rolling stock and the maintenance width, and so it should be considered in detail at FS and detailed design stage.

(3) Location of Depot

The location of depot should be specified initially as it requires the acquisition of a large area, and its location in the route will influence the operation capacity.

The area required for a Depot is about 6ha -7ha, depending on the alignment pattern (serial arrangement or parallel arrangement). In the depot, stabling tracks for accommodating, maintenance tracks for maintaining and washing, and inspection tracks for inspecting and repairing are required.

(4) Location of Stations

The location of each station needs to be determined based on the existing main roads and future urban development plan. Stations are generally installed at intervals of about 1 km.

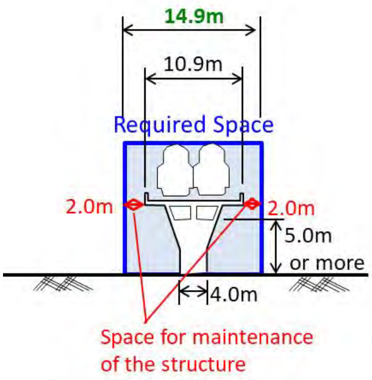
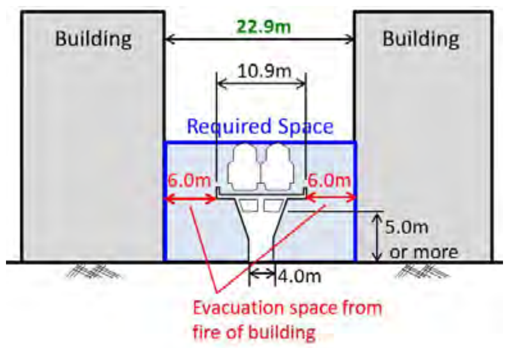
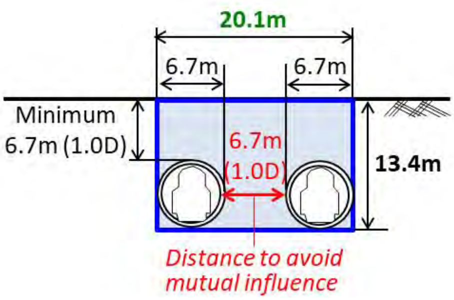
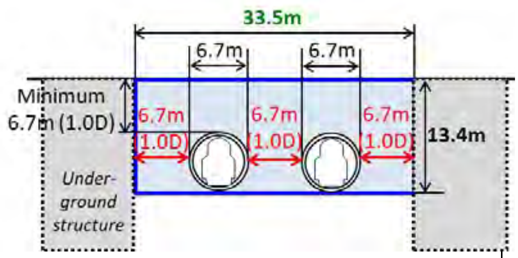
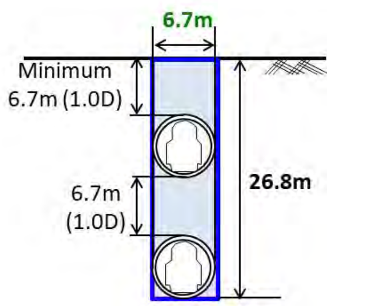
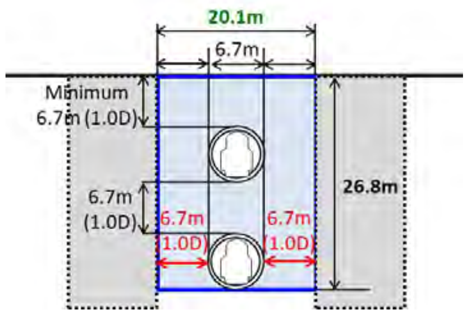
(5) Size of Rolling Stock

The size of a rolling stock for an urban railway is generally 2.8m - 3.0m width and 18 - 20m length. However, the width needs to be determined by the allowance of the standing space in the rolling stock, and the length needs to be determined by the turning radius of the rolling stock. For Kathmandu, the road conditions for delivery will influence the length of the rolling stock.

(6) Power Supply

There are two types of power supply methods: one is the overhead catenary system, and the other is the third rail system. The overhead catenary system obtains power from the overhead catenary by pantograph, while the third rail system obtains power from the third rail by the collecting device attached to side of the rolling stock. In the third rail system, there is an advantage that the tunnel size can be reduced and that the appearance is good because pantograph and over head catenary are not required. However, it requires more substations than the general DC1500V in the overhead line system because DC750V, which is generally used in the third rail system, has a large power loss. In addition, it is necessary to consider the problem of difficulty in collecting power at high speed operation and the measures for preventing electric shock. The electric shock is not much problem in the case of urban railways where level crossing is not installed, but it is necessary to judge comprehensively.

Table 6.3.1 Required Space for Installation of the Structure (Reference Value)

<table>
<tr><th>Item</th><th>General Section</th><th>Building Adjacent to Both Side</th></tr>
<tr><td>Elevated Structure</td><td>
</td><td>
</td></tr>
<tr><td rowspan="2">Underground Structure (TBM, single Track)</td><td>[Parallel]

</td><td>[Parallel]

</td></tr>
<tr><td>[Vertical]

</td><td>[Vertical]

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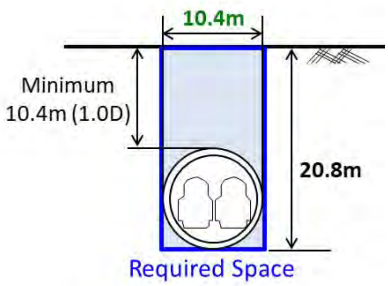
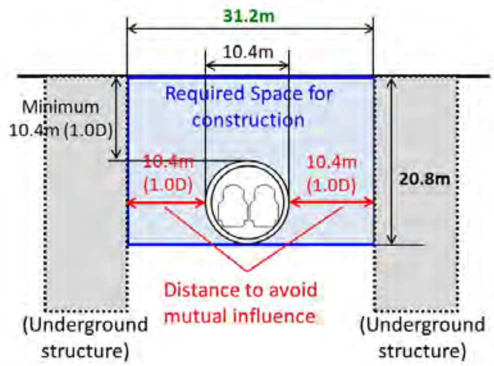
<tr><td>Underground Structure (TBM, Double Track)</td><td>
</td><td>
</td></tr>
</table>

Source: JICA Study Team

(7) Salient Features of AGT and MRT Systems

As urban railways in Kathmandu Valley, AGT and MRT have been proposed in previous studies.

Table 6.3.2 shows the features of the AGT and MRT. AGT has more climbing capacity and smaller curve radius compared to MRT. In this study, the alignment is basically considered for MRT, since it is possible to change to AGT later on if the alignment to be able to operate by MRT is planned without any problem.

Table 6.3.2 Salient Features of AGT and MRT

Item	AGT (Automated Guideway Transit)	MRT (Mass Rapid Transit)
Wheel Type	Rubber tires (needs a guide tire)	Steel wheels
Operation System	Automatic Operation	Automatic or Manual Operation
Power Supply	Supply by Third Rail (DC600V, DC750V or AC600V)	Supply by Overhead Line (DC1500V or AC25000V) Supply by Third Rail (DC750V)
Minimum Curve Radius	30m ~ 60m	160m (In general)
Maximum Gradient	60‰ (6%)	35‰ (3.5%)
Features	• Since the vehicle length is short (about 11 m) compared to MRT, the number of vehicles increase to meet the same transport capacity. • It is effective in the route with small carve and steep gradient. • Depot can be made compact. • Technology is required for the maintenance of the rolling stock.	• As there are many vehicle manufacturers, it is possible to secure competitiveness. • MRT has expressiveness, but cannot cope with small curves and steep gradient. • MRT depot needs to be larger than the AGT depot. • Maintenance of rolling stock and track is required.

Source: JICA Study Team

6.4 Proposed Concept of the Urban Railway System Development

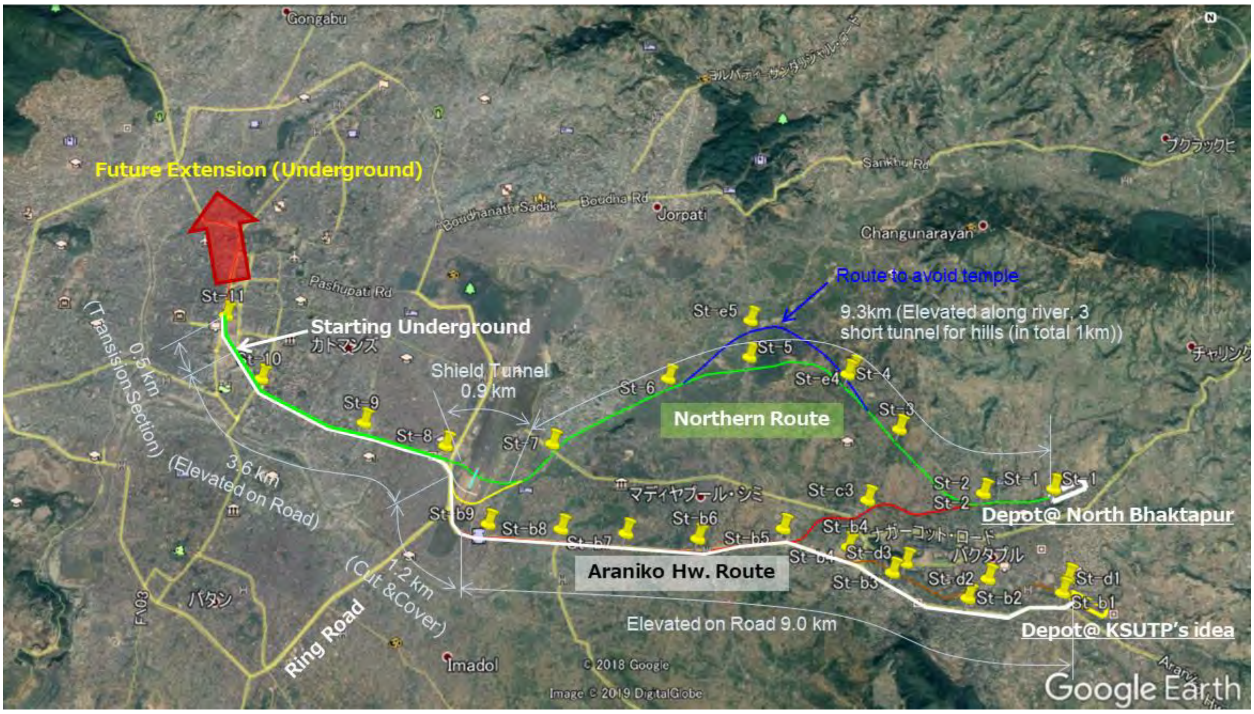
6.4.1 Route Planning

The JICA Study Team assessed the local situation and identified a new route of urban railway between Bhaktapur and the urban center. The section was prioritized by the KSUTP-MTOPS, and it was proposed as to be built along the Araniko Highway. However, this study has revised the route in KSUTP-MTOPS due to the following reasons.

- Following the (3) depot location in the previous section, the study team identified in North Bhaktapur candidate lands for Depot with higher possibility of land acquisition based on site surveys.
- Following the (2) route alignment, the study team identified that a route along the Manohara River has less undulation than the route along the Araniko Highway.
- Minimize the structural conflict with the road grade separation at the Tinkune junction.

6.4.2 Route Plans

The basic route plans, including a new route (Northern Route), are proposed as shown in Figure 6.4.1.



Source: JICA Study Team

Figure 6.4.1 Alternative Route Plans (Northern Route)

(1) General Concept

The route up to the urban center from the Bhaktapur urban area and the eastern new urban development area is considered for initial implementation. The KSUTP-MTOPS proposed the section between Bhaktapur and Gongabu bus terminal; however, it is considered that the implementation for the section between the city center and Gongabu can be postponed to minimize the initial scale of investment. It is noted that the construction cost in the developed area would be underground, and it would be higher than the suburban. According to the demand characteristics, the section between Bhaktapur and city center will satisfy the initial function.

(2) Bhaktapur to Tinkune and Depot Candidate Sites

The section from Bhaktapur to Tinkune has two options. One is the route along the Araniko Highway, and another is the Northern route plan which passes through the undeveloped area and Manohara River basin. In Northern route, the routes that avoid watershed protection forest near the temple are also one of option and need to be decided after discussion with relevant organizations.

Two locations are identified as depot candidate sites. First was the area proposed by KSUTP, where it occupies a national brick factory, and the other one was identified by the study team during the site survey. Therefore, there are three different route plans based on the depot locations.

At Tinkune junction, the area should be developed as a station square connecting the railway and the road-based transport terminal.

(3) Tinkune to Urban Center

Elevated structures will be applied between Tinkune and the city center, as the NH2 has enough width to accommodate the viaducts. It is proposed that the last station in the city center (St-11) would be constructed as an underground structure, as it would be the starting point of underground tunnels for further extension.

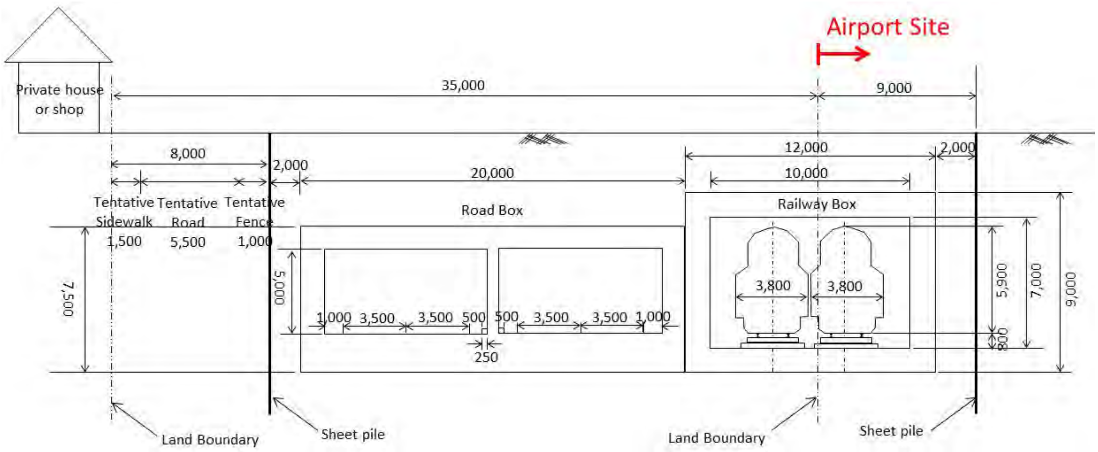
6.4.3 Detailed Route Plan between Bhaktapur and Tinkune Intersection

(1) Route Plan (Appendix 9)

Two routes are proposed from Bhaktapur Depot to Tinkune intersection.

One is a route passing through the Araniko Highway, which mainly promotes the shift from road traffic to railway traffic in response to traffic demand on Araniko Highway. About 9km from the Bhaktapur Depot, the route has constructed viaducts on Araniko Highway, and about 1.2km from Koteshwor to Tinkune intersection, an underground tunnel is planned using cut-and-cover method. Ten elevated stations are built about 10.2km from the Depot to Tinkune intersection.

A typical cross section considering the connection with the railway tunnel and road tunnel when the intersection improvement between Tinkune and Koteshwor is conducted on the underground tunnel (using cut-and-cover method) is shown in Figure 6.4.2. The road box-culvert will be set back about 8m to the airport side in consideration of the temporary roads to private houses and stores along the road during the construction of the road box-culvert. Therefore, even if the railway box is constructed as close as possible to the road box-culvert, the airport land needs to be used partially. Therefore, it is necessary to discuss with the airport's Management Department at the time of planning and construction.



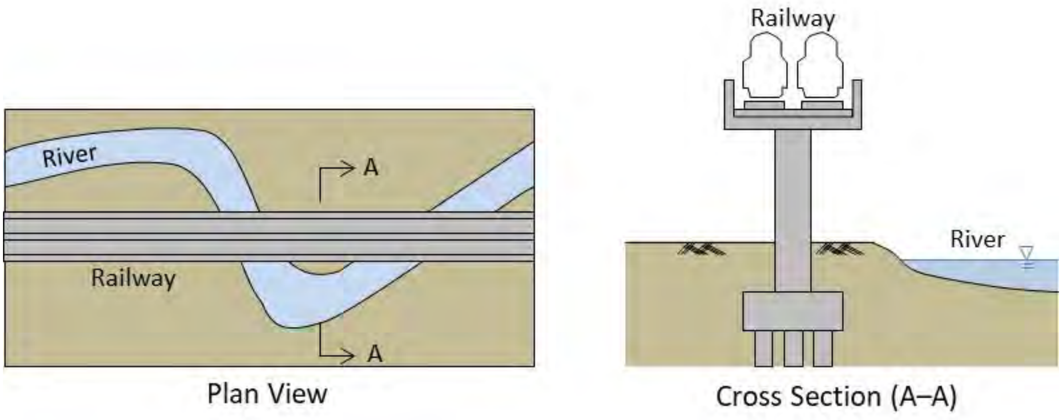
Source: JICA Study Team

Figure 6.4.2 Cross Section of the Railway Tunnel and Road Tunnel

Another route plan passes through the undeveloped area from North Bhaktapur Depot to Tinkune intersection, and it generates new traffic demand due to urban development in new residential and commercial areas. A total of about 1km of the three short mountains in about 9.3km from the North Bhaktapur Depot to the vicinity of the airport is planned using the New Austrian Tunnel Method (NATM), and the others (about 8.3km) are planned with elevated structure. About 4km, which is roughly half of the elevated section, is planned along the river for the following reasons:

- The vertical alignment becomes ideal and economic, because there are little undulations along the river.
- Since the area along the Bhagmati River has not yet been developed, construction can be done without traffic restrictions during the construction if ROW can be secured before the development begins.

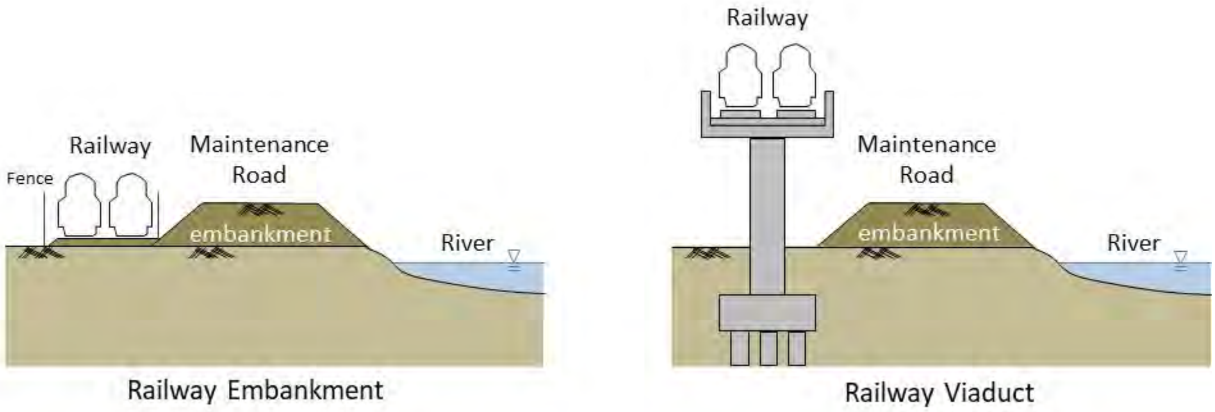
The elevated structure along the river is considered to be a viaduct structure as shown in Figure 6.4.3. This is because the viaduct is less likely to obstruct the flow of the ricer than the embankment, and can be relatively flexibly coped with when the river channel changes in the future.



Source: JICA Study Team

Figure 6.4.3 Railway Structure along the Manohara River (Without River Improvement)

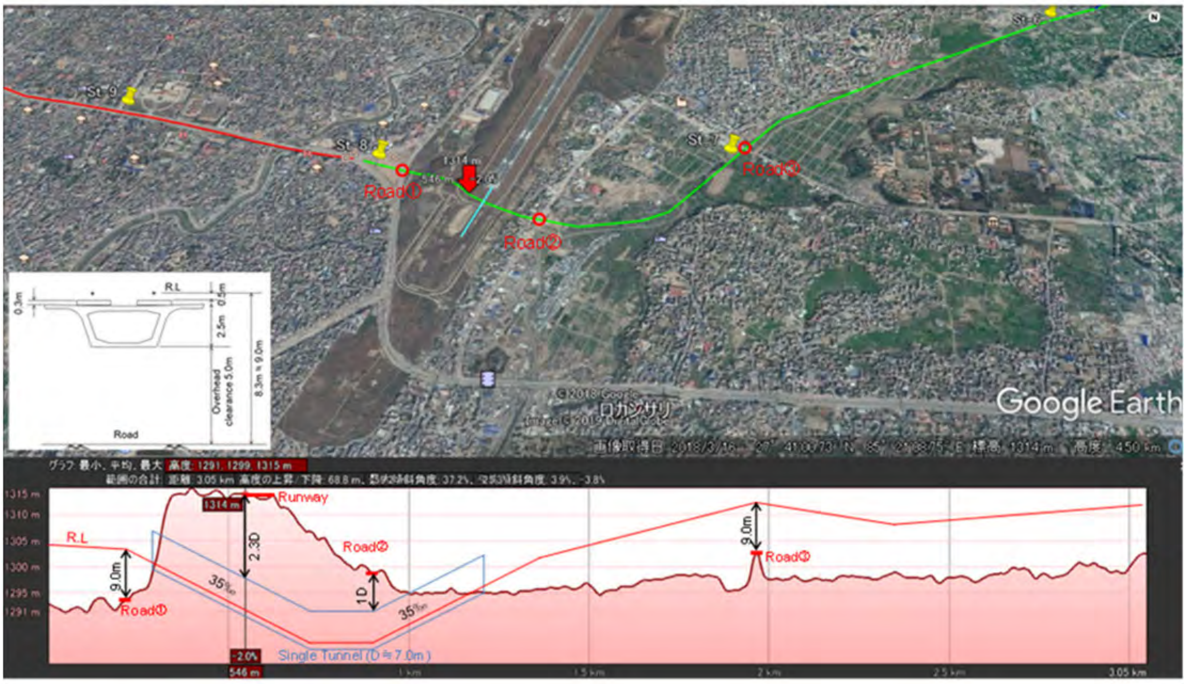
However, the river channel of the Manohara River has changed significantly from the past maps, and it is highly necessary to carry out dike construction for flood control measures. Therefore, when the river improvement is carried out with this dike construction and the river channel can be made relatively straight, it is possible to construct the railway embankment or viaduct inside of the dike as shown in Figure 6.4.4. If the embankment structure can be installed, the construction cost can be reduced as compared with the case of viaduct installation. However, since it is necessary to consider the fence and the crossing structure of the river maintenance road and railway, it should be comprehensively compared and judged based on the road plans in the future.



Source: JICA Study Team

Figure 6.4.4 Railway Structure along the Manohara River (With River Improvement)

The shield tunnel under the airport in operation is planned for construction at the section of about 0.9km from the vicinity of the airport to Tinkune intersection. The longitudinal cross section in the airport area is shown in Figure 6.4.5. At the crossing point of the railway viaduct and the road, the height from the road to rail level is set to 9.0m so that the clearance under the girder can be secured at 5.0m. The shield tunnel is a parallel single-track tunnel, and it is designed to secure one diameter (1D) or more of earth covering. Under the runway, it is designed to secure a double diameter (2D) or more of earth covering with reference to the construction under the runway in operation as in the case of Haneda Airport. As described in 6.6.3, Japan has experience in constructing the shield tunnel under the runway in operation, and this is possible to happen in Kathmandu.



Source: JICA Study Team

Figure 6.4.5 Longitudinal Alignment in the Airport Section (Northern Route)

(2) Comparison of Routes

Table 6.4.1 shows the comparison of the two proposed routes mentioned above. For the plan on Araniko Highway, the road width during the construction and completion of the railway viaducts will be slightly reduced because the piers of viaduct are constructed on the road, but land acquisition will hardly occur. However, the following disadvantages will occur.

- Since the access road from the eastern area in Kathmandu to the urban center is only on the Araniko Highway, the city cannot be accessed when this road is cut off by the earthquake.
- It will be necessary to construct using a part of Airport lnad in the open cut tunnel installed along Araniko Highway to avoid the height restriction of the airport, if it is possible.
- In the transition section from open cut tunnel to elevated, it will be necessary to reduce the number of lanes on the road or to be secured the Airport land, because the railway structure with a width of about 12m is installed in the existing road.

On the other hand, the Northern route plan needs to secure the ROW before urban development begins, and the construction cost increases by about 5% compared to the route plan on Araniko Highway as described in 6.4.5 because the shield tunnel under the runway is needed and the total length is extended to about 400m. However, the following advantages will occur.

- It can support new urban area development for residential or commercial. And it can disperse current traffic trips.
- It can provide better access to Bhaktapur town and palace for commuter or tourists.
- Construction is easy compared to another plan because there is little influence on the traffic during the construction.

The relationship between the station locations in the Northern route plan and urban development area by KVDA is shown in Figure 6.4.6. The station (St-4) is planned on the west side of the urban development area described as “C”. Therefore, it is concluded that the traffic demand in the future is extremely high.

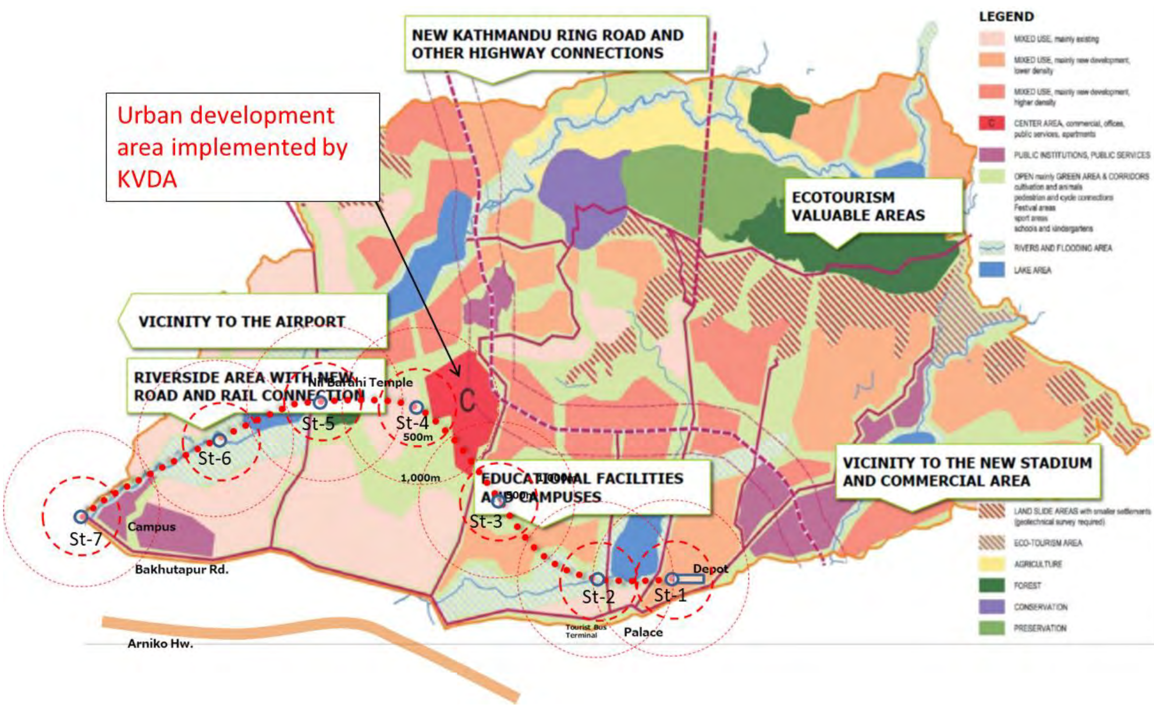
In addition, as shown in Figure 6.4.7, if construction by cut-and-cover method is possible by avoiding the section under the runway following the discussion with the airport's Management Department, construction cost will not differ much from the route plan on Araniko Highway.

The JICA Study Team recommends the Northern route plan based on a comprehensive judgment of the development effects, economy, construction, and convenience of the two routes.

Table 6.4.1 Comparisons of Northern Route Plan and Route Plan on Araniko Highway

Option	Northern Route (green-line), Depot (white marked area)	Route on Araniko Highway (white-line), Depot (yellow marked area)
Length Station No.	L = 14.7km 11 Stations	L = 14.3km 13 Stations
Concept	Fine-tuning of JICA'S MP Concept	Similar Concept of KSUTP (on Araniko Highway)
Notes	• Support the new urban area development (residential and commercial) • Provide better access to Bhaktapur town and palace for commuter/tourists • Need to cooperate with KVDA to start securing land due to envisioned/commenced individual residential developments • Utilize river side space which can reduce project costs and traffic impacts during construction • Need to tunnel under small mountains, or avoid this area • Need a TBM (tunnel boring machine) for the tunnel under the airport area (the machine might be used for further extension lines) • The total length is about 400m longer than the Araniko route.	• Tend to be a countermeasure for mainly current traffic demands along Araniko Highway to shift from buses and private cars, not for the demands from North-side new urban developments • Utilize the land of Araniko Highway to less land acquisition (vs. reduced road space) • Need to accept the risk that all traffic will be directed on the Araniko Highway, which causes less resilience and redundancy • It will be necessary to construct using a part of airport land in the open cut tunnel installed along Araniko Highway to avoid the height restriction of the airport, if it is possible • Necessary to reduce the number of road lanes or to be secure the airport land at the transition section from open cut tunnel to viaduct beside Araniko Highway

Source: JICA Study Team



Source: JICA Study Team

Figure 6.4.6 Relationship between the Northern Route Plan and Urban Development Area

Source: JICA Study Team

Figure 6.4.7 Runway Divert Route Plan

6.4.4 Detailed Route Plan Between Tinkune and Urban Center (Appendix 9)

The section of about 4.1km from the Tinkune intersection to the urban center is constructed with viaducts of 3.6km on the road, and it is transferred from elevated to underground using the park in urban center. The transition section of about 0.5km is planned for construction by cut-and-cover method. Four stations are built about 4.1km from Tinkune intersection and urban center, three stations are elevated stations and one end station is an underground station. The JICA Study Team recommends that the first phase is up to the underground station, and the extension section should be constructed for each station according to the budget with the underground structure because there are many existing buildings and narrow roads. At the time of the extension of underground structures, it is considered as one plan to hold and use tunnel boring machine (TBM) which was used at the tunnel under the airport.

6.4.5 Cost Estimation of Each Plan

As for the reference for future discussion, the Study Team estimated the construction costs at the preliminary or reference level for each alternative such as the Northern route (Alt.-1) and Araniko Highway route (Alt.-2) in the Table 6.4.2 with each items of urban railway system. Note that it is suggested to estimate the construction costs carefully when further feasibility study is conducted.

In order to estimate the construction costs, each unit price is applied in reference to a general unit price extracted from the experiences of other countries.

When further study such as feasibility study or more in-depth study is conducted, it is advised to take into consideration the soil condition, applied design conditions/standards and other local conditions with a more detailed on-site investigation.

Since it is the base cost only for the construction, the project cost needs to add the construction management/consultant and supervision costs, administration costs, VAT, import tax and land acquisition costs.

Table 6.4.2 Construction Base Costs for Each Alternative (Reference Level)

No.	Item	Unit	Alternative-1: Northern Route (Green Line) Depot (White)			Alternative-2: Araniko Route (White Line) Depot (Yellow)			Note
			Q'ty	Unit Cost ('000 USD)	Total ('000 USD)	Q'ty	Unit Cost ('000 USD)	Total ('000 USD)	
1	Rolling Stock	cars	102	2,300	234,600	102	2,300	234,600	
2	Substation	Ls	1	59,825	59,825	1	59,825	59,825	
3	Power Line	km	14.7	5,000	73,500	14.3	5,000	71,500	
4	Signalling & Train Operation Management System	km	14.7	2,080	30,576	14.3	2,080	29,744	
5	Telecommunication System	km	14.7	1,630	23,961	14.3	1,630	23,309	
6	Track Work	km	14.7	3,730	54,831	14.3	3,730	53,339	
7	Spare Parts	%	8	-	19,415	8	-	19,017	8% of (Item2-6)
8	Testing & Commissioning	Ls	1	10,600	10,600	1	10,600	10,600	
9	Civil Structure (Elevated)	km	12.3	22,000	270,600	12.6	22,000	277,200	
9-1	Civil Structure (TBM)	km	0.9	80,000	72,000		80,000	0	
9-2	Civil Structure (Cut & Cover)	km	0.5	19,000	9,500	1.7	19,000	32,300	
9-3	Civil Structure (NATM)	km	1.0	31,000	31,000		31,000	0	
10	Station (Elevated)	station	10	10,000	100,000	12	10,000	120,000	
10-1	Station (Under Ground)	station	1	30,000	30,000	1	30,000	30,000	
11	Depot	Ls	1	150,000	150,000	1	150,000	150,000	
Total			**1,170,408**			**1,111,434**			
Cost Ratio			1.05			1.00			

Source: JICA Study Team

6.5 Ridership Projection

This section revises the passenger demand projection of the E-W prioritized railway section for 2030 as proposed in the KSUTP-MTOPS study. The details of the route proposed by KSUTP-MTOPS are shown in Figure 2.2.5(c).

This study proposed 1) the route alternative (North route) to minimize the conflict with the intersection improvement of Koteshwor; and 2) shorten the whole line and terminate at the Ratna Park to avoid large initial investment. These changes will influence the ridership forecast estimated by the KSUTP-MTOPS. Also, 3) the grade separation at Koteshwor – Tinkune may influence the ridership of the urban railway. The revisions of passenger forecast condition are summarized in Table 6.5.1:

Table 6.5.1 Outline of the Route Alternatives

	KSUTP – MTOPS	Shortened	North
Length	18.7km	14.6km	14.7km
No of Stations	18	14	11

Source: JICA Study Team

The projection result is summarized in Table 6.5.2.

Table 6.5.2 Ridership per Route Alternatives for E-W Routes (2030, passenger per day)

Route	Ridership[1]	Note
KSUTP	9,05,000	KSUTP-MTOPS prioritized route, Gongabu to Bhaktapur (Opt 4 in the MTOPS study[2])
Shortened	9,00,000	Ratna Park to Bhaktapur – along Araniko Hwy
North	8,26,000	Ratna Park - Tinkune - Bhaktapur (North route)

Source : JICA Study Team

It should be noted that the shortened route has little influence on the original. The extension by underground seems to have low viability and needs to be disscussed further.

It can be said the application of the Northern route will not have much influence on the ridership, although the number of the stations of the route are less. The KVDA's habitation scenario expects large increase in Bhaktapur City, and major ridership will not drop down if the route is connected to Bhaktapur City. The section passing through the new city core and new districts along the outer ring road can generate passengers, but the amount is smaller than in Bhaktapur City.

As mentioned in Section 2.2.2(1), IBN and the National Planning Committee expect that the implemetation of the E-W route would be arranged in a PPP (BOOT) scheme. Generally, private investors prefer the route running along the populated Araniko Highway to minimize the ridership risk. Railway planners must offer a package of the land value to capture private investors if KVDA needs to bring railway access to the new cities in the eastern region.

1 The forecast figures are rounded off to thousands.
2 The ridership estimation of the KSUTP-MTOPS Opt4 scenario was 1,015 thousand pax per day. However, this study was revised in the network setting (NH2, Boudha Road, Manohara River road bypass), and the ridership has dropped from the original.

6.6 Challenges and Issues for Implementation

6.6.1 Institutional Arrangements

DORW was established under the Ministry of Physical Infrastructure & Transport (MOPIT) in 2011. DORW has the authority for planning, construction and operation of railway, metrorail and monorail. Engineers who were originally from DOR transferred to DORW because there were no railway engineers.

The Railway Act already exists, but DORW drafted the New Railway Act to cope with the new railway construction for the development of the National Railway. However, this Act does not cover the urban railways. Hence, it is necessary to develop the Urban Railway Act for construction, operation and maintenance of urban railways. It should not be limited to railway, as it is also necessary to develop laws regarding the underground in urban areas and formulate a Land Expropriation Law as described in 6.6.4.

6.6.2 Multi-Modal Transport Facility Development

Tinkune intersection is a focal point that connects the Ring Road and the Araniko Highway. It is possible to create a more attractive public transport network and increase the number of public transport users by creating a good connection with other modes strategically in the urban transport network. The unused land in a channeling site of the intersection will be used as a construction yard during the improvement of intersection, and it will be developed as a bus terminal after the improvement. The JICA Study Team proposed it to be developed as a station square connecting the railway and the bus terminal after the completion of urban railway (Figure 6.6.1).

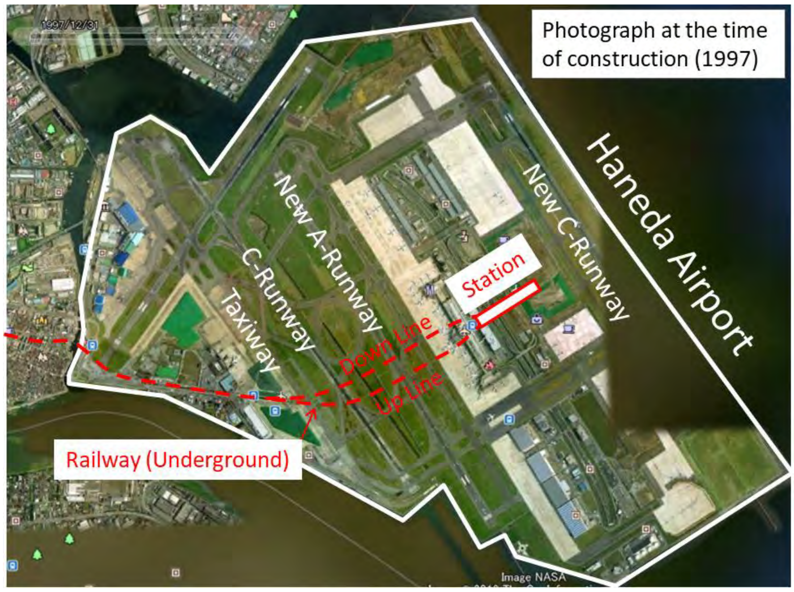
Note: Road improvement Alternative 5, which underpasses from Araniko Hwy. to NH-2 and Ring Road North (in red dotted lines)

Source: JICA Study Team

Figure 6.6.1 Multi-Modal Center Concept for Railway and Bus

6.6.3 TBM (Tunnel Boring Method)/ Shield Tunnel under the Airport in Operation

In the Northern route recommended in this study, it is considered to construct a tunnel boring machine (TBM)/ shield tunnel under the airport in operation. Tokyo International Airport (hereinafter called "Haneda Airport") has experience regarding the construction of a shield tunnel under the runway and taxiway in operation. Haneda Airport is located in Tokyo, Japan's capital which has 270 daily flights (departure and arrival at 540 times per day), with approximately 44 million passengers per year and 500 thousand tons of air cargo per year. Thus, this airport is a very important base, and the construction of tunnel was required to be done without affecting the operation. The plane map at the time of construction is shown in Figure 6.6.2. The railway tunnel passes under the taxiway, C-runway and New A-runway with earth covering of about double diameter (2D). In addition, it was difficult to perform excavation on the soft ground (N value is 2 to 10) while cutting the ground improvement material (drain material) installed in the construction of airport embankment. However, the shield tunnel was constructed safely without affecting the operation of the aircraft due to improvement of the shield machine and the adoption of a comprehensive drilling management system and dynamic measurement. The comprehensive drilling management system is a system that can manage the results of the automatic direction control of the shield machine, conduct automatic tunneling surveying, automatic ground deformation measurement, and automatic flammable gas concentration measurement at the control center. Japan has the technology to construct safely and carefully under the runway in operation by using the shield machine.

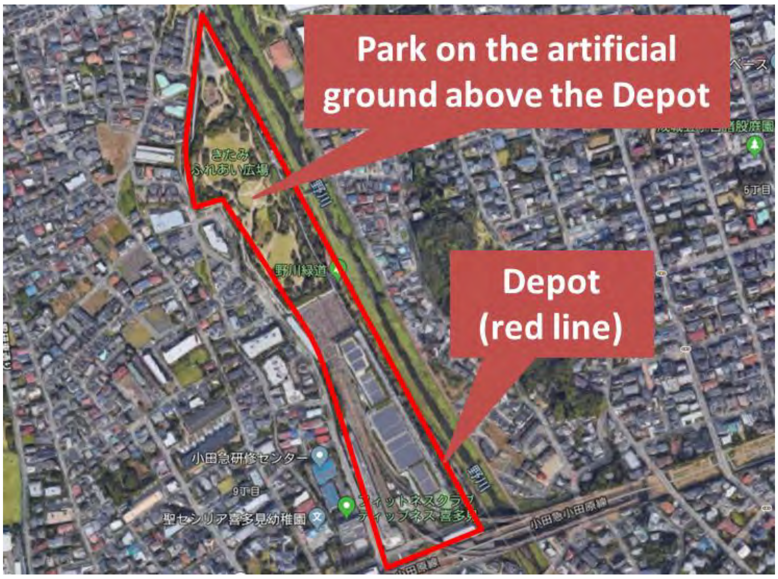


Source: JICA Study Team

Figure 6.6.2 Haneda Airport at the Time of Tunnel Construction (1997)

6.6.4 Effective Use of Depot

Since North Bhaktapur Depot proposed in this study is located in the urban development area by KVDA, it is desirable to harmorize with surround residential area. At the Kitami Depot of Odakyu Electric Railway Co., Ltd in Japan, the above of the depot has been developed as a park to take account of the surround residential area as shown in Figure 6.6.3, and it is used for the residents. This park can be expected not only to have the physical effect of minimizing noise and light leakage at night, but also to mitigate the negative emotions of the surround residents.



Source: JICA Study Team

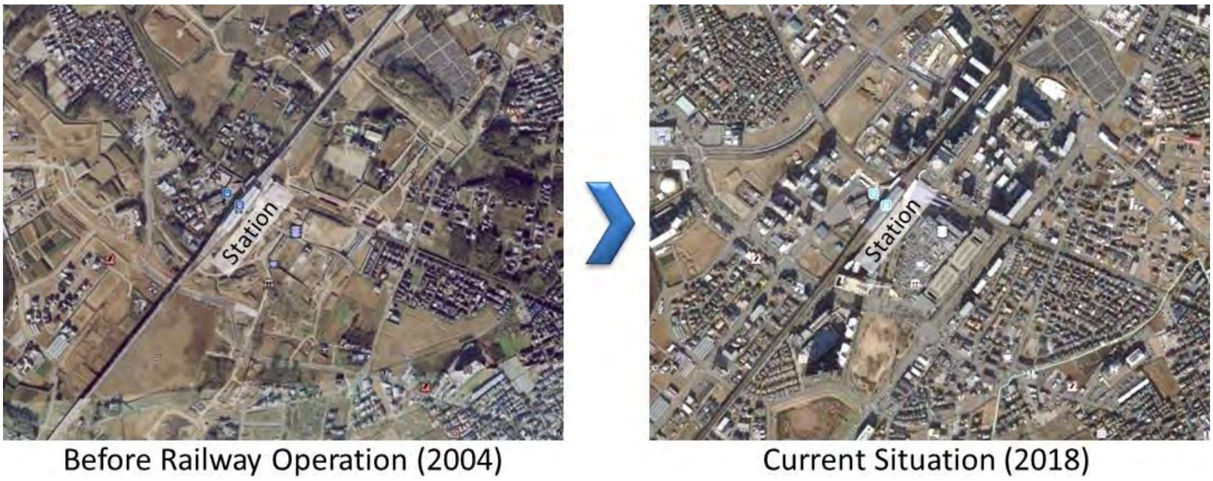
Figure 6.6.3 Example of Kitami Depot (Odakyu Electric Railway Co., Ltd)

6.6.5 Integrated Development of Urban Development and Railway Development

The Northern route propsed in this survey creates new traffic demand and disperse traffic trips by integrating new urban development and railway development, and KVDA is expected to play a major role for integrated development. However, KVDA does not have sufficient experience in developing satelite cities, therefore it is necessary to develop their capacities.

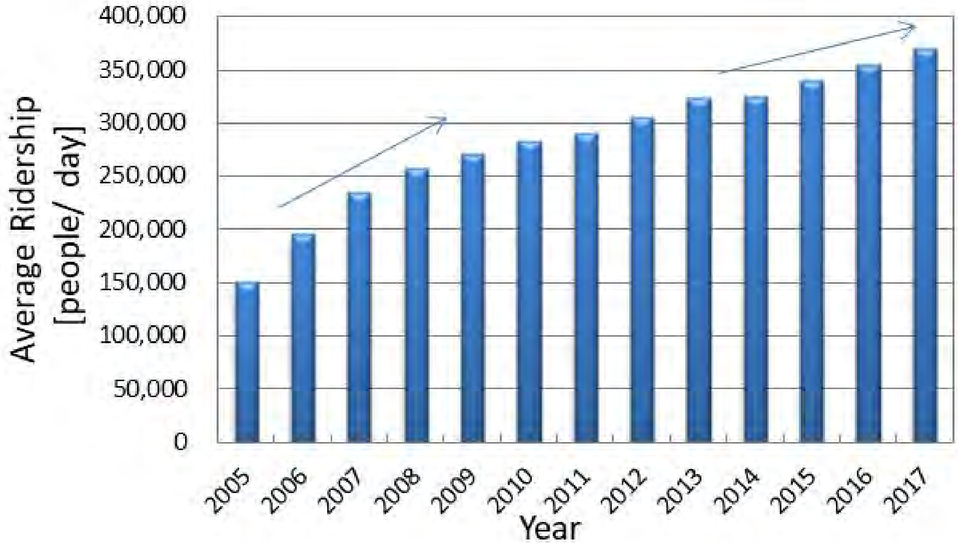
Japan has experience of the integrated deveropment in Tsukuba Express. Figure 6.6.4 shows the development example of Nagareyama-Otakanomori Station in Tsukuba Express. New road and residential areas have been developed with railway development. And because of urbanization along the railway route, ridership has increased even after 13 years of opning as shown in Figure 6.6.5.

As integrated development of urban development and railway development is the first in Nepal, the JICA Study Team reccomend to be developed the capacity based on these cases and experiences.



Source: JICA Study Team

Figure 6.6.4 Development example of Nagareyama-Otakanomori Station in Tsukuba Express



Source: Website of Nagareyama City

Figure 6.6.5 Ridership in Tsukuba Express

6.6.6 Underground Space for Urban Railway Installment at Urban Area/ Airport Runway

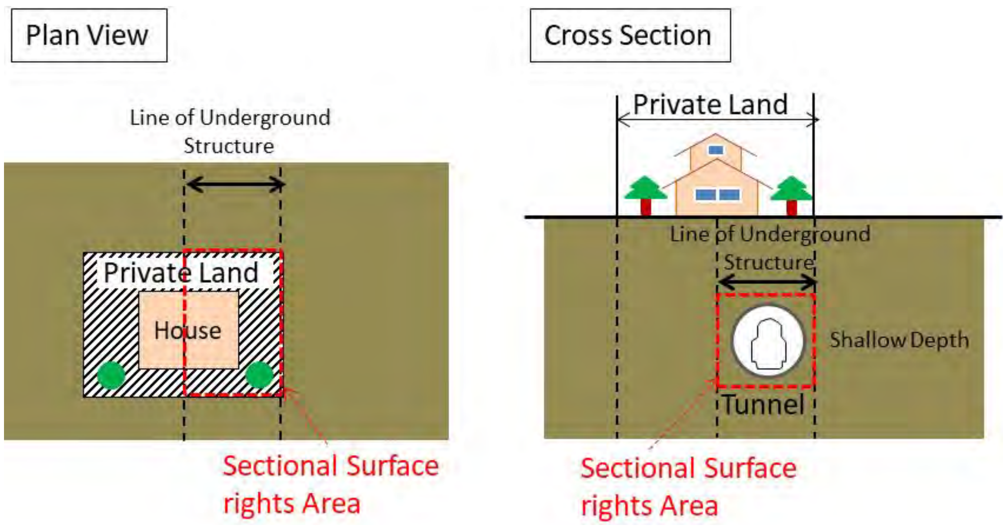
(1) Nepal

In Nepal, there is no law or technical standard for using the underground space of private land in urban areas.

In relation to construction works at Nagdhunga Tunnel, located in the west of Kathmandu Valley, guidelines on property rights for underground works have been considered, but no progress has been seen so far (see Section 4.7.5).

(2) Japan

In Japan, when constructing an underground structure under a private land, it is legally possible to set the Sectional Surface Rights for the area where the underground structure passes, except when the depth exceeds the limit for the application of this right. As shown in Figure 6.6.6, the area of Sectional Surface Rights is generally set by adding management space to the width and height of the tunnel structure.



Source: JICA Study Team

Figure 6.6.6 Sectional Surface Rights Area

In the Sectional Surface Rights Area, the landowner can continue to use the property without relocating the surface structure, but land use is restricted in exchange for compensation. Items that are generally restricted are listed below.

- The Sectional Surface Rights Area cannot be excavated. (For example, the pile foundation and well are restricted in the Sectional Surface Rights Area.)
- When excavating on the upper area of the Sectional Surface Rights Area, it is necessary to discuss the design and construction plan with the Railway Facility Department in advance.
- It is not possible to construct buildings and structures that exceed the design load above the Sectional Surface Rights Area. (For example, the number of buildings is limited in the Sectional Surface Rights Area.)
- When excavating on the upper area of the Sectional Surface Rights Area, it is not possible to excavate below the minimum design load. (For example, the amount of excavation is limited in the upper area of the Sectional Surface Rights Area.)

In the extension section to the north of urban center, it is assumed that the construction of elevated structures is difficult because there are many buildings and narrow roads. Therefore, it will be necessary to consider the method of underground use as mentioned above.

In addition, there is Land Expropriation Law, or the law regarding land acquisition in Japan. Land Expropriation Law is a legal tool for compulsory expropriation of land at an appropriate price when the landowner's agreement cannot be obtained for public works. In a line system such as railway structure, it is extremely important to enact the Land Expropriation Law because the entire system would not function even if only one land cannot be secured.

In Nepal, it is necessary to develop similar laws with reference to existing Japanese laws.

6.6.7 Procurement of Railway System

In order to develop the urban railway, it is necessary to procure the rolling stock, rails, E&M equipment, construction materials (PC cables, reinforcement bar), etc.

In particular, rolling stock is difficult to assemble in Nepal, so it needs to be transported to Kathmandu Valley by truck, railway or air transportation. As mentioned in 6.3.2, the size of rolling stock sought as urban railway is 2.8m-3.0m in width and 18-20m in length, though it is not as large as commuter railway or high-speed railway.

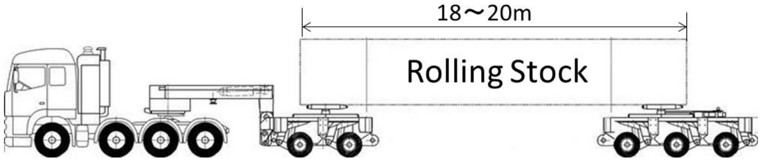
Rails are generally purchased and transported in 25m length in order to improve ride comfort, reduce wheel maintenance, and reduce the number of welds when using continuous welded rail. After transporting, the bending processing and welding of rails are performed at the site.

Figure 6.6.7 shows the current situation of container transportation in Kathmandu. The trailers loaded with 40ft (L=12m) container come from India through the narrow mountain road to Kathmandu. Therefore, E&M equipment and construction materials less than 12m in length can be transported from India.

Source: JICA Study Team

Figure 6.6.7 Container Transportation (40ft) in Kathmandu

On the other hand, it is considered physically possible to transport the rolling stock by using a transport trailer shown in Figure 6.6.8 via Chitwan under special permission during low traffic hours.



Source: JICA Study Team

Figure 6.6.8 Transport Trailer

The transportation of the 25m rail requires detailed consideration, but since the rail bends are so flexible, it is considered physically possible if the transport vehicles can follow the curve.

When the Fast Track Road under construction is completed, the physical problems of truck transportation can be further reduced. However, transportation cost issues remain because of the very long transportation distance from India.

Especially for rolling stock transportation, since one car is transported per trailer, the cost and time of transportation are considerable. In the case of railway transportation, the rolling stock can be transported economically and efficiently because it can be transported by a trainset, so it is desirable that the national railway is constructed. However, as mentioned above, it can be transported by truck even if the construction of the national railway has not been completed. In addition, at the China-Nepal Summit in 2018, it has been agreed that a feasibility study on the railway construction about 350km from Shigatse to Kathmandu will be conducted, and there is information that this will be completed in April 2019. Therefore, it is necessary to pay attention to this progress when considering the transportation issues.

6.6.8 Geological Risk

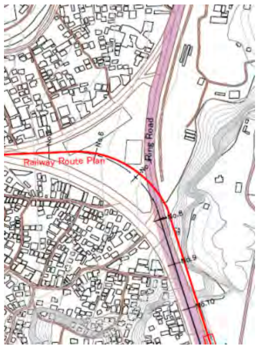
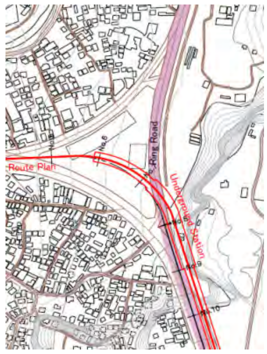
As described in Appendix 5, there is no bearing layer in the ground of this area at a depth of 50m from ground surface, but relatively dense sand or clay layers with N-value of about 10 to 30 are widely distibuted. Although it needs to be considered in the detailed design, it is considered that the elevated structure can be sufficiently supported by fiction piles.

Methane gas is detected with high concentration (4.7% - 58.4%) at four sites of the five surveyed sites. Methane gas is generally said to explode in a concentration range of 5 -15% because it requires some oxygen to cause an explosion. However, even if the concentration exeed the upper explosion linit (15%), it is necessary to be careful because the concentration may be diluted by air. Therefore, if it exceed the explosion lower limit (5%) in the TBM section, it is necessary to consider using the TBM of explosion resistance type.

6.6.9 Consistency with Tinkune Intersection Improvement Project

Tinkune intersection is a focal point that connects the Ring Road and the Araniko Highway. As a large-scale intersection improvement is planned, it is necessary to confirm the consistency between the intersection improvement plan and the railway alignment. In the intersection improvement, there are two plans: the Ring Road elevated plan and the underground plan. There are also two plans for railway: the Northern route and Araniko route. In this study, it is considered whether the railway alignment can be physically planned in the four patterns as shown in Table 6.6.1.

Table 6.6.1 Various Preconditions for Considering Railway Alignment

Item	Alternative 1-1	Alternative 1-2	Alternative 2-1	Alternative2-2
Image of Alignment				
Railway Plan	Northern Route (Under the Airport)	Northern Route (Under the Airport)	Araniko Route	Araniko Route
Structure Plan of Ring Road	Underground	Elevated	Underground	Elevated
Railway Structure at Ring Road Intersection	Elevated	Underground	Elevated	Underground

Source: JICA Study Team

(1) Alternative 1-1 (Railway: Northern Route, Ring Road: Underground)

In the case of Ring Road, the plan view and longitudinal alignment of the railway is improved by underground structure and the railway is planned on the Northern route. An elevated station, which is proposed to be developed as a multi-modal center, will be constructed on the west side of the triangle land, and the railway cross the underground Ring Road by viaduct. The railway viaduct on the Ring Road will be secured at a height of 9.0m from the level road to rail level so that the clearance under the girder is 5m. In addition, by passing under the airport with maximum gradient (3.5%) from the intersection of the Ring Road, the earth covering under the runway will be able to be secured with double diameter (2D). Therefore, it is considered that the railway can be planned without any structural problems in Alternative1-1.

(2) Alternative 1-2 (Railway: Northern Route, Ring Road: Elevated)

Plan view and longitudinal alignment of the railway in the case of the Ring Road is improved by elevated structure and the railway is planned on the Northern route. The railway will be planned by underground method from the triangle land, and an underground station will be constructed under the intersection of the Ring Road. Most of the underground station will be built by open cut method because earth covering is small, and the level road under the elevated Ring Road will be diverted to the triangle road during the construction. In the transition section from elevated to underground, it will be necessary to reduce the number of lanes on the road or to be secured the land, because the railway structure with a width of about 12m is installed on the existing road.

On the other hand, since the earth covering under the runway will be secured with a triple diameter (3D) or more, the construction of the tunnel is easier than Alternative1-1.

(3) Alternative 2-1 (Railway: Araniko Route, Ring Road: Underground)

In the case of the Ring Road, the plan view and longitudinal alignment of the railway is improved by underground structure, and the railway is planned on the Araniko route. An elevated station will be constructed on the west side of the triangle land, and the railway crosses the underground Ring Road by viaduct. The railway viaduct on the Ring Road will be secured at a height of 9.0m from the level road to rail level so that the clearance under the girder is 5m. After crossing the Ring Road, the underground structure will be planned via cut-and-cover method in consideration of the height limit set by the airport. After that, a viaduct will be constructed again, and it will be planned at a height of 9.0m from the road to rail level at Jadibuti intersection. In the transition section from underground to elevated, it will be necessary to reduce the number of lanes on the road or to secure the land because the railway structure with a width of about 12m is installed in the existing road. In particular, if the intersection improvement project makes the transition section from the underground to the ground in a similar position, further land acquisition will be required. However, since the site is an airport land, if it is difficult as a result of the discussion, it will be necessary to take measures such as changing the vertical alignment and installing the transition section from underground to be elevated for Bhaktapur side of Jadibuti intersection.

(4) Alternative 2-2 (Railway: Araniko Route, Ring Road: Elevated)

In the case of the Ring Road, the plan view and longitudinal alignment of the railway is improved by elevated structure, and the railway is planned on the Araniko route. The railway will be planned by underground method from the triangle land, and an underground station will be constructed under the intersection of the Ring Road. The underground station will be built by open cut method because the earth covering is small, and the level road under the elevated ring road will be diverted to the triangle road during the construction. In the transition section from elevated to underground, it will be necessary to reduce the number of lanes on the road or secure the land because the railway structure with a width of about 12m is installed in the existing road. In addition, even if the earth covering is reduced by using the maximum gradient (3.5%) after passing the station, there is a section where construction by cut-and-cover method is difficult because the earth covering is still large.

In consideration of the above, some challenging issues will occur depending on the combination with the intersection improvement, but any alternatives would be structurally possible at this stage. However, in the detailed design of the intersection improvement, it is necessary to mention in detail the positional relationship in consideration of each structure.

6.7 Road Map toward Smooth/ Efficient Implementation

6.7.1 Road Map

Since this urban railway system development is new for the Nepal government, several challenges are required to realize smooth development and implementation. In this section, the items that need to be started immediately and continued for future development are discussed together with proposed road map.

The Study Team recommends that institutional arrangements are quite essential because strong relationships exist between railway development and urban/town development, such as securing the lands for railway routes and depot as well as for station area development. In view of urban/town development, the location of railway stations should be well considered and developed together with good feeder transport services and routes for dedicated walking and non-motorized modes (e.g. bicycle) to/from residential/commercial areas. Therefore, it is suggested that the first item of the Road Map will be to establish close communication, coordination and cooperation mechanism (e.g. task-force team) among MOPIT-DORW, DOR and KVDA.

As mentioned above, integrated public transport mode exchanging facility is proposed at Tinkune area. It will provide all the public transport users a smooth transfer from urban railway to city buses/long distance buses by the strategic connection of Ring Road, and reduce private vehicles to alleviate the traffic congestion on roads. To build the multi-modal center, it needs the consensus of a large number of stakeholders such as those in the bus service industries, intersection improvement and airport area.

Regarding the technical aspects, the location of the airport area is a physical barrier for the connection between Kathumandu and Bhaktapur. Since the Tunnel Boring Machine (TBM) is proposed to be applied below the airport runway if the shortest route is required, government officers should learn from Japan's experience regarding the technical applicability of the TBM method, which was applied for the installment of the railway line under the Haneda airport runway during its operation.

Property ownership for underground private land/buildings should be discussed and utilized for the smooth implementation of railway development. Some Japanese laws and regulations might serve as reference points. In addition, the utilization of the river side area of Manohara River is quite essential, and coordination with the KVDA should start soon to discuss how to control the river flow and flooding in order to create lands for developments.

In the planning stage, it is advised that the development of urban railway system should be discussed based on how to operate the train. Therefore, internal discussions with the operating body/company for urban railway should start as soon as possible, and the operator's requirements should be incorporated into the design of the railway system. Note that even the PPP scheme applied, the government should have the responsibility to check how the private operator would operate in terms of providing safe, smooth and appropriate public transport system services. Before construction and operation of the urban railway, necessary legal documentation should be discussed such as urban railway acts for construction, operation and maintenance.

Finally, technical issues to start the construction and operation and the transporting of components of the railway system (e.g. rolling stock (20m-long), rail (25m-long)) should be secured from the border of Nepal to Kathmandu from the logistics point of view. Also, the capability of power supply is one of the important points to be confirmed and secured before starting the operation.

The items discussed above are illustrated into the proposed Road Map in Figure 6.7.1.

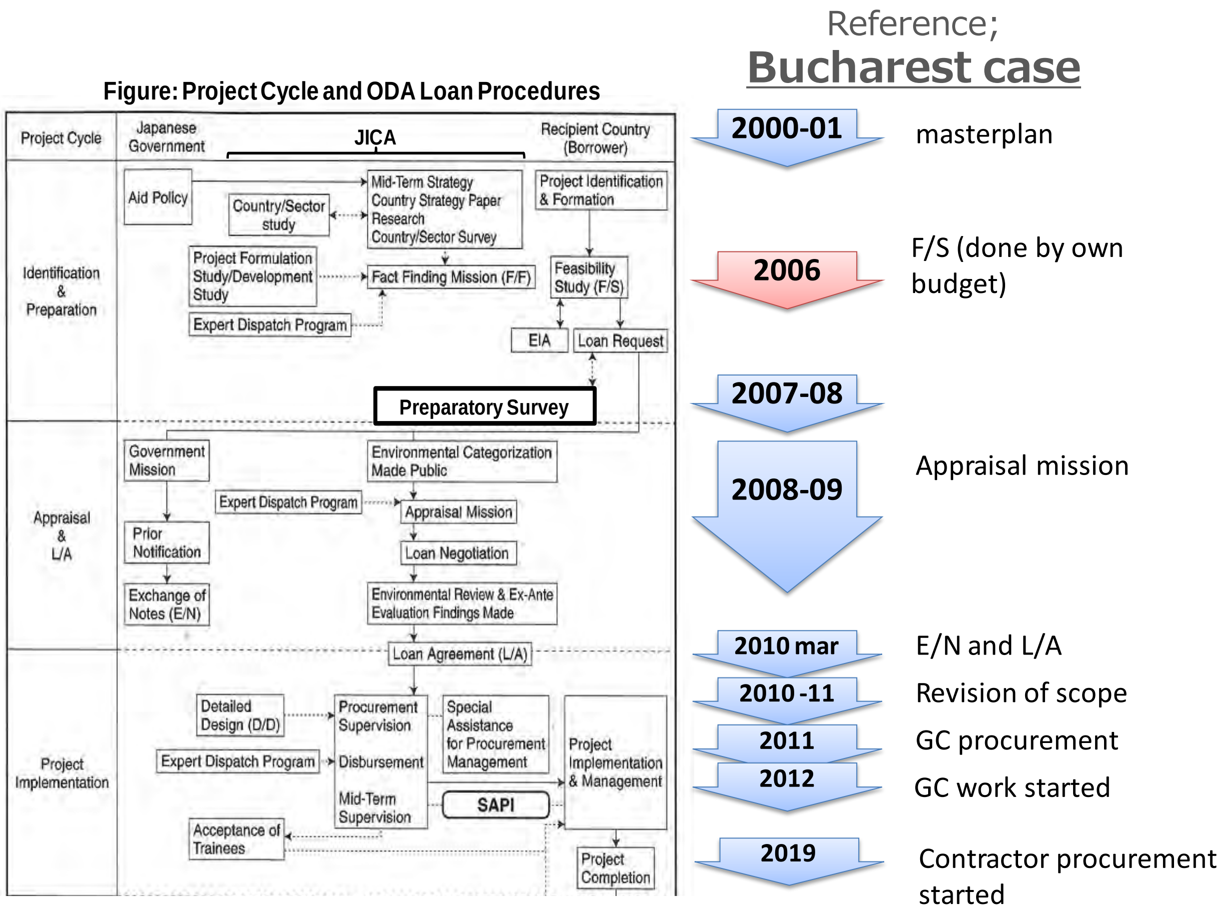
Source: JICA Study Team

Figure 6.7.1 Road Map toward Smooth/Effective Implementation

6.7.2 Efficient Implementation

(1) Metro Construction takes Time

It should be noted that the metro construction will need 10–20 years of construction from the initial planning stage. The following drawing shows the time schedule of the Bucharest Metro Line 6, funded by JICA. Bucharest Metro took more than 10 years to formulate the project package.



Source: JICA Study Team

Figure 6.7.2 Road Map toward Smooth/Effective Implementation

The BOX 1 explains the timing of the first Metro operation in the cities and its socio-economic circumstances. Considering the lead time of the metro construction, it is a good timing for Kathmandu to start its realistic exercise for metro construction.

(2) JICA is the Leading Metro Funding Agency in Asia

Since the 1970s, JICA has a long historic record of metro development in Asian cities – such as Beijing's and Seoul's 1st Metro – including the provision of technical assistance and funding packages[3]. Table 6.7.1 shows the recent records of metro and suburban railway development projects funded by JICA in Asian cities. JICA and its affiliate Japanese institutions have tremendous experiences in the development of metro mobility services not only in terms of physical infrastructure, but also in planning, feasibility study, funding arrangement, land value capturing scheme, establishment of operating bodies, and O&M service.

3 Including the funding records of OECF and JBIC Japan (merged into JICA after 2009)

Table 6.7.1 Major On-going Metro Projects Funded by JICA (as of June 2017)

City, Country	Line	Funding Condition
Jakarta, Indonesia	Jakarta MRT North-South Line	STEP
	Jakarta MRT North-South Line Extension	Not yet decided
Ho Chi Minh, Viet Nam	HCMC Metro Line 1	STEP
	HCMC Metro Line 3a	Not yet decided
Hanoi, Viet Nam	Hanoi Metro Line 2	STEP
Bangkok, Thailand	MRT Red line	Preferable Condition for environmental improvement
Manila, Philippines	Mega Manila Metro Project	STEP
	Extension of LRT Line 1	STEP
	North South Commuters Train System	STEP
Chennai, India	Chennai Metro Phase 2	Bilateral Tied Condition
Delhi, India	Delhi Metro Phase 4	Bilateral Tied Condition
Mumbai, India	Mumbai Metro Line 3	Bilateral Condition
Colombo, Sri Lanka	Colombo Elevated LRT	STEP
Dhaka, Bangladesh	Dhaka Metro Line 6	LDC condition
Panama City, Panama	Panama Metro Line 3 (Monorail)	Preferable condition for environmental improvement
Cairo, Egypt	Cairo MRT Line 4 Phase 1	STEP

Source: Masuda, Issues and Visions of Railway Development Assistance of Japan, JORSA Report No 274, 2018

(3) International Event and Commitments for Metro

Metro investments always face turbulences of political and administrative intentions due to large initial investment and significance of influences. Referring to recent experience of metro installation, it appears that international events and commitments will facilitate the implementation and domestic turbulences. The PPP arrangement may work initially; however, the agreement can be canceled easily if private investors could find political and economic instabilities, as in the case of Hopewell project in Bangkok or the monorail project in Jakarta. International commitments for international events, involving international or bilateral funding agencies can minimize such risks.

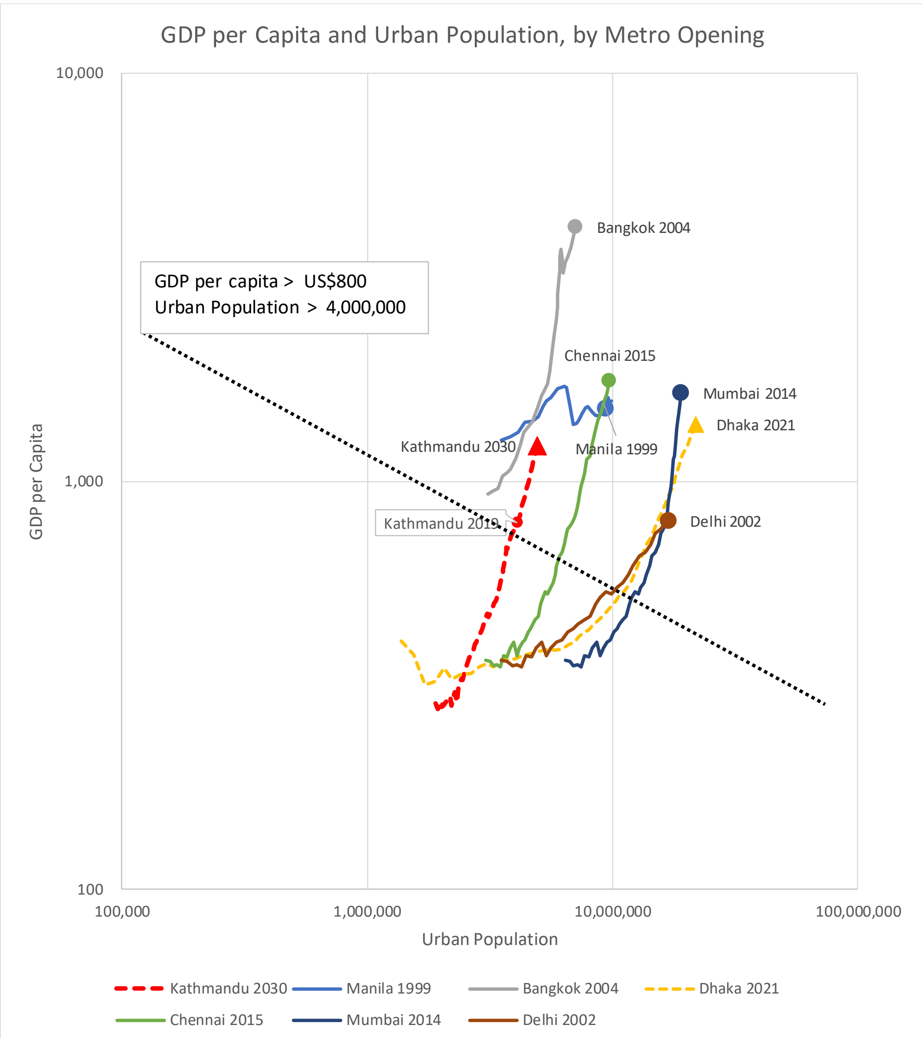
- Delhi Airport Line, Common Wealth Games in October 2010, with JICA funding
- Jakarta Airport Line LRT, Asian Games in August 2018, self-financing
- Bucharest, Metro Line 6, targetted for Euro Football Game 2020 (not yet opened), with JICA funding
- Japan Tokaido Shinkansen, Tokyo Olympic Games in October 1964, with WB funding

BOX 1: Timing of Metro Development in Other Asian Countries

The table below shows the timing of the development of the first metro in neighboring cities within Asia according to the GDP per capita and population of the cities, with historic statistics trace information. It can be seen that Kathmandu is at the right timing to develop its own metro by and around the year 2030.

Cities	Metro Opening Year	GDP per capita (US$, constant 2010)	Urban Population
Manila	1999	1,573	9,846,621
Delhi	2002	802	16,891,671
Bangkok	2004	4,190	7,096,699
Mumbai	2014	1,645	19,104,072
Chennai	2015	1,759	9.677,072
Dhaka	2021	Est 1,220	Est 21,735,261
Kathmandu	2030	Est 1,380	Est 4,924,467

Source: JICA Study Team, based on World Bank Data



Source: JICA Study Team, according to the World Bank Data

CHAPTER 7 CONCLUSION AND SUGGESTIONS

7.1 Findings and Proposals

7.1.1 Findings

The findings of the study are summarized below. The government aims to establish an efficient and effective administrative structure for urban transport planning and management under the current institutional reform, with comprehensive and integrated decision-making procedures. Also, the Kathmandu Valley Public Transport Authority will play an essential role and start initiatives to provide guidance for the management of public transport services.

Urban transport-related service industries are envisioned and led by the private sector with challenges to develop innovative ICT solutions without government subsidies. These private initiatives such as "open market with quality licensing scheme" shall be kept and backed by proper government support and management. This would encourage and create new urban transport services by digital platform such as MaaS (Mobility-as-a-Service) to enrich the quality of urban transport services.

The southern part of the Ring Road widening project, completed in the summer of 2018, made a significant impact on the valley transport environment. It may divert heavy traffic from major focal points in the city, but traffic accidents increased and air pollution is at a serious level. The ongoing river road and affiliated bridge development will form the proper road network structure within the Ring Road; however, the present approach shows high dependency on road-based transport.

To overcome the above situation, there are several plans, studies and offers for mass transit development, but feasibility studies are just merely arranged and started, without any strong commitments for funding.

Currently, envisioned urban development outside of the Ring Road will increase the traffic demands, especially in the eastern area of Kathmandu Valley. Due to the presence of the international airport from eastern area for crossing the ring road and insufficient road network, Koteshwor junction will face serious traffic congestion in the near future.

In this Data Collection Survey, based on the macroscopic transport demand analysis (JICA STRADA) developed by the JICA MP and fine-tuned by ADB's KSUTP-MTOPS, the Study Team suggests the following interventions:

- Urban railway system development is essential to absorb the future transport demand for east-west passengers in 2030. It is proposed to be a long-term project.
- Even with the urban railway system installed, the Koteshwor junction still requires physical improvements (e.g. separation of the overlapping the Ring Road and national trunk road). This intervention should be started as soon as possible as mid-term project, which takes more time for construction. Note that several new bypass roads for this junction (e.g. Manohara River corridor) are also required to be examined. It is proposed to be a mid-term solution for junction improvement.
- Since the Ring Road can support the diversion of unnecessary trips through the city center as well as the distribution of entering points from the Ring Road, the improvement of traffic management at each intersection becomes highly important. It is possible to start immediately as a short-term project. In addition, the enhancement of road network within the Ring Road is also important such as increasing traffic capacity for crossing the Bagmati River.

7.1.2 Mid-Term Solution: Intersection Improvement for Immediate Action Towards Japanese ODA Loan

Based on the macroscopic analysis of traffic demand versus road network capacity development plan, the sections of Koteshwor junction and Tinkune junction will incur serious congestion even with the installation of the urban railway system. This is because the national trunk road (Araniko Highway and National Highway No.2 (NH-2)) and the Ring Road merge between these junctions, forming an overlapping section. Also, the intersection at Koteshwor has a large number of turning traffic volume. As a result, intersection improvement is essential.

The intersection improvement at Koteshwor junction alone will not solve the problem caused by the overlapping section. Therefore, grade-separation needs to be included until the Tinkune intersection due to short length (approx. 500m) between these two intersections.

With the considerations of geometrical conditions, height clearance and estimated traffic volume, possible alternatives for grade separation with different civil structures are examined. At the result, the Study Team recommends alternatives listed as follows:

- Alt. 4-1: Underpass connecting the Ring Road (North) and Ring Road (South)
- Alt. 4-2: Flyover (viaduct) connecting the Ring Road (North) and Ring Road (South)
- Alt.5: Underpass connecting the Araniko Highway to two separate directions – one for NH-2 bound for city center and the other for Ring Road (North)

During this survey, the Study Team conducted the preliminary design for the abovementioned alternatives, and found several pros and cons for each of the alternatives.

Since this section is already congested and does not have enough space for traffic, in addition to construction costs and periods, several other items need to be jointly considered for further selection of alternatives. The proposed items for consideration are as follows:

- Adverse effects due to traffic closure/restrictions during the construction (affected numbers of vehicles and peoples)
- Required land acquisition area/costs
- Flexibility on traffic management such as buses, pedestrian and future BRT on ground level
- Coordination with future urban railway system structures and multi-modal transport hub (bus terminals and urban railway station as interchange points)
- Risks of the alternatives against earthquakes and flooding
- Operation and maintenance costs, rehabilitation costs
- Applicability of new construction technologies to other places in the future
- Urban aesthetics, sustainability of modern structure to the surrounding buildings

Regarding the land for the above alternatives, the ROW of 50m or more was thought to be secured throughout the Ring Road. However, upon reviewing the legal documents, it was found that there are sections where ROW has been reduced. In the case of Alt. 4-2, land acquisition is likely to be required at Koteshwor intersection.

According to laws of Nepal, an Environmental Impact Assessment will be required for any of the proposed road improvement projects. A Resettlement Action Plan may also be required depending on the scale of resettlement (if any). The process is expected to take about 2.5 months for preparation (scoping) and 3.5 months for EIA study/approval.

To consider the further alleviation of traffic demands focusing on Koteshwor intersection, it is noted that the Manohara River corridor would be effective to alleviate traffic congestion at Koteshwor intersection. It can be used to divert several vehicles to/from Araniko Highway and Ring Road (South). It should be enhanced to install good connection and capacity together with the above solution.

The present result of the economic analysis does not show the positive impacts of the intervention. Hence, it is necessary to consider another approach to calculate the net, accurate, and specific traffic improvements; microscopic simulation and revision of population growth scenario; and integrated assessment of Manohara bypass installation.

Regarding the congestions at Maitighar, Thapathali, Tripureshwor and New Baneshwor intersections, based on the preliminary analysis of traffic flow/capacity under signal control, congestions will be manageable if the lane width for urban area in Nepal will be reduced in accordance with other countries' proven width such as 2.8-3.25m. The Study Team suggests physical changes from roundabout to signal control intersection in these areas.

7.1.3 Short-Term Solution: Traffic Management Project and Private Initiative Facilitation

Based on the data collected for identifying issues on current traffic environment, the Study Team identified the potential projects for the improvement of urban transport in Kathmandu Valley which may be supported by JICA's schemes such as Technical Assistance, SDGs/SME supporting and Grant Aid.

As for the JICA Technical Assistance (TA) scheme, the enhancement of capacity for traffic management and control is the one of the candidates with following outputs/activities:

- Engineering: improvement of design capacity at intersections (design guidelines (e.g. lane width in urban areas, motor cycle box, lane and bus-bay arrangements and geometrical improvements), traffic signal control and safety devices for traffic management/control)
- Education: raising awareness to observe manner/discipline and safety for vehicle driving and pedestrian crossing
- Enforcement: regulating driving rules including bus-stop operation, parking policy, dissemination of information on traffic conditions and instructions

TA can include experienced experts working with Nepalese officers, the budget of pilot projects for trial installations and geometrical improvements, and trainings in Japan/3rd-party countries for capacity development of Nepalese officers. Grant Aid is supposed to be discussed when the pilot project is evaluated as an effective solution for a wide installation stage.

As for SDGs/SME supporting scheme, EV tempos and buses are among the candidates under EV modernization program. The program aims to develop efficient battery and charging system with proper operation and management system in collaboration with Japanese companies with practical experiences in this field. Also, payment modernization program with IC card is one of the potential candidates for future JICA assistance if private companies are supported and recognized by government entities.

7.1.4 Long-Term Solution: Urban Railway System Development

The Study Team reviewed the previous discussions, proposals and plans for the urban railway system in Kathmandu Valley and proposed several route options for supporting the envisioned new urban development in eastern area.

The Study team suggested the following development principles for urban railway system:

- Urban electrical railway system aims to provide fast, comfortable riding, improved mass transit capacity and well-connection with a feeder public service.
- It is noted that urban railway system can create a large number of employment and various types of service industries linked to urban railway transport services.

It is essential to describe the key technical parameters, secure the land for depot (maintenance workshop and stabling yard; more than 6 - 7 ha) and select the appropriate size of rolling stocks (2.8-3.0m width, 18-20m long) to meet the development principles above.

Based on the field survey and new urban development plan, the Study Team proposed two alternative routes from the city center to Bhaktapur, (1) the North route (14.7km) and (2) the Araniko Highway route (14.3km). In the case of North route, the Study Team recommended KVDA to integrate the urban railway route into its new development plan. In addition, since this route runs along the Manohara River, it will be a good chance to utilize the river side space with appropriate flood control for urban land use development.

In terms of the financial situation of the Government of Nepal, having a strong 7.9% GDP growth rate in 2017 combined with the government's effort to decrease the debt balance to 26.4% of GDP in 2017 (vs 60% in 2003), the risk of debt distress remains low. Although the railway sector currently accounts for only a minor portion of the overall budget for the transport sector, the Nepal government has exceeded its neighboring countries' GDP per capita of the years they received their first ODA railway sector funding from Japan (Bangladesh: US$541 in 2007, Nepal: US$ 849 in 2018), which could be one indicator of the timing of the railway development.

In order to realize the smooth development and implementation of the project, several challenges exist which have been listed as follows:

- Institutional arrangements, such as coordination and cooperation for urban railway system development and urban development (e.g. MOPIT-DORW, DOR and KVDA)
- Integrating public transport mode exchanging point (to be proposed at the Tinkune area) which will benefit all public transport users
- Tunnel Boring Machine (TBM) needs to be applied below the airport runway if the shortest route is required. The TBM method was applied for the installation of railway line under the Haneda Airport runway in Japan during its operation.
- Property ownership for underground private land/buildings should be discussed and utilized.
- Transporting components of the railway system (e.g. rolling stock (20m long), rail (25m long)) should be secured from the border of Nepal to Kathmandu from the logistics point of view.

It is recommended to set the "Road Map" describing the necessary actions and required time frame for smooth implementation for urban railway system development.

As of now, no regulations regarding underground property rights exist in Nepal. Following the case of the ongoing Nagdhunga Tunnel project, a draft concept note suggesting the establishment of appropriate legal guidelines related to tunnel works was submitted to the Government, but no action has been taken as of March 2019.

7.1.5 Recommendations:

Mid-term solution for intersection improvement from Koteshwor - Tinkune shall proceed to the Feasibility Study (FS), with multi-criteria evaluation to select the civil structure type and in consideration of the applicability of advanced construction technologies. In addition to this solution, the Manohara River corridor development shall be discussed to enhance its capacity for diverting the traffic from Araniko Highway to Ring Road (South).

The Government of Nepal shall officially request to conduct the enhancement of capacity for traffic management and control for short-term solution under the Technical Assistance program. Also, SDGs/SME supporting scheme will be applicable if private companies, both in Nepal and Japan, are interested in developing the EV modernization program.

For long-term solution, urban railway system development needs to be integrated with the new urban development plan led by KVDA to secure the land for route and depot.

7.2 Suggestions for Kathmandu
Wayward to Enrich Urban Transport in Kathmandu Valley

(1) Unlocking the Potentials of the Intersections

Urban transport challenges in Kathmandu Valley lie in intersections. With the increasing number of vehicles and motorbikes, the existing intersections can no longer satiate the increasing traffic volumes. This leads to congestion and results in air pollution. To put it in another way, improving intersections can unlock opportunities for the city's growth. This study proposed a range of intersection improvement measures, comprising of short, medium and long-term solutions.

One short-term measure is to implement small-scale pilot projects at two intersections, Maitighar and New Baneshwor. The pilot project at the former intersection consists of bus stops design and traffic lane arrangement to ensure sufficient intersection capacity while alleviating potential conflict points. The other pilot project at the latter intersection will introduce the concept of "bike boxes" for better traffic management, with pavement markings to direct the flows of motorbikes. In addition, technical assistance to enhance capacity building of relevant agencies is proposed as a succeeding short-term proposal. Intersection improvement requires a coordinated response among the government, especially between DOR and the traffic police.

Another short-term solution is to make geometric improvements to existing roads. The standard national road width of 3.5m is not always easy to apply in congested urban areas, partly due to land acquisition issues. This study proposed a flexible road design in which the road width can be adjusted anywhere between 2.75 to 3.5m subject to local traffic conditions. This will help generate additional lanes around small intersections, thereby creating more intersection capacity for traffic.

The Koteshwor - Tinkune grade separation proposal stands on the same idea. As the area is too small to handle the forecasted traffic, this study proposed to add four lanes as grade separation to the limited space. Even though it may be costly, which seems difficult to justify in this stage as the whole traffic from the east is concentrated at the Koteshwor and the congestion will continue, it could be justified with microscopic analysis in the further stage.

The long-term approach suggested building a multimodal transport hub for the East-West railway, buses, BRTs and district transport at Tinkune. Both the road grade separation and rail passage plans are designed to avoid structural conflicts at Tinkune. The proposed road grade separation followed the encroachment regulation of the air traffic.

Strategic analysis also suggested the importance of network formulation rather than large-cost investment in a grade separation. Large investment at T-M junction and New Baneshwor in the city center could be avoided, and it is suggested to disperse the traffic by network formulation, which will generate more small intersections.

Connected intersections bring countless benefits to the city. Improved traffic flows, less congestion and better travel experiences are some of the expected outcomes. They also provide immediate benefits for public safety. People will be more engaged in their daily activities, a key driver to further enhance the city's economic and social development. Moreover, improved intersections are the foundation for future transport innovations – this is especially true for Kathmandu, where public transport modernization and ITS technologies are already emerging.

(2) A New Paradigm Shift for Urban Transport

The institutional environment for urban transport is changing. The central government is reorganized under the newly established federation structure. Kathmandu Valley now has 18 elected mayors whose key mandate is to tackle congestion and air pollution. The KV public transport authority will be established to handle urban transport issues.

As aforementioned, the Nepali road design standard requires 3.50 meter application for all multi-lane roads everywhere in Nepal. It is suitable for intercity road development to form the national road network by the central government. At present, the Study Team suggests prioritizing the city transport rather than the national transport in Kathmandu Valley under the federation scheme.

The main goal of the suggested TA for intersection improvement is to form a concept of urban mobility in the road sector, including flexibility regarding the use of lane width regulation, harmonization with public transport services, pedestrian and NMT, and minimize the conflict among each other through road space design. In short, roads in Kathmandu should be re-designed as streets.

The streets must accommodate the transport services for passengers. As proposed in the long-term, the streets in Koteshwor and Tinkune shall accommodate the multi-modal terminal, including air traffic. The Koteshwor junction improvement can handle the transport services at the surface level through the installation of grade separation, and the other major junction can find a space by applying the geometric improvement, which is in the short-term intervention.

New mobility initiatives are also emerging. LetZ Go application can virtually present all individual bus operators on its digital platform and provide optimized transport services to end-users. The standard and compatible intelligent payment system proposed in the short-term project will realize seamless mobility experience for passenger.

The long-term plan suggested revising the alignment from Araniko Highway to northern part to provide mobility to passengers in the new city.

(3) Branding the City through Transport

Kathmandu is entering a new era of city growth. With its socioeconomic dynamics and geopolitical significance, the capital of Nepal presents vast opportunities to become a middle-class city in South Asia. The city needs to brand itself to attract lucrative customers, and all cities compete with each other. Kathmandu needs to be unique among the others.

Urban railway system, as proposed in the long-term, is Kathmandu’s first ticket to be an active player in city competition. It gives an image of punctuality, safety, energy efficiency, high aestheticism, and so forth. SAFA tempo is unique, but seems rusted after 20 years operation; however, it can be a symbol of eco-friendliness of Kathmandu by rejuvenation of the system proposed in the short-term interventions. The Tinkune multi-modal center can be a unique entry point for international customers to Kathmandu.

The traffic calming, transit and pedestrian-oriented development in the city center is another approach to city branding to enhance the city’s attractiveness.