CHAPTER 5

TRAFFIC STUDY

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5.1 PRESENT TRAFFIC CONDITION

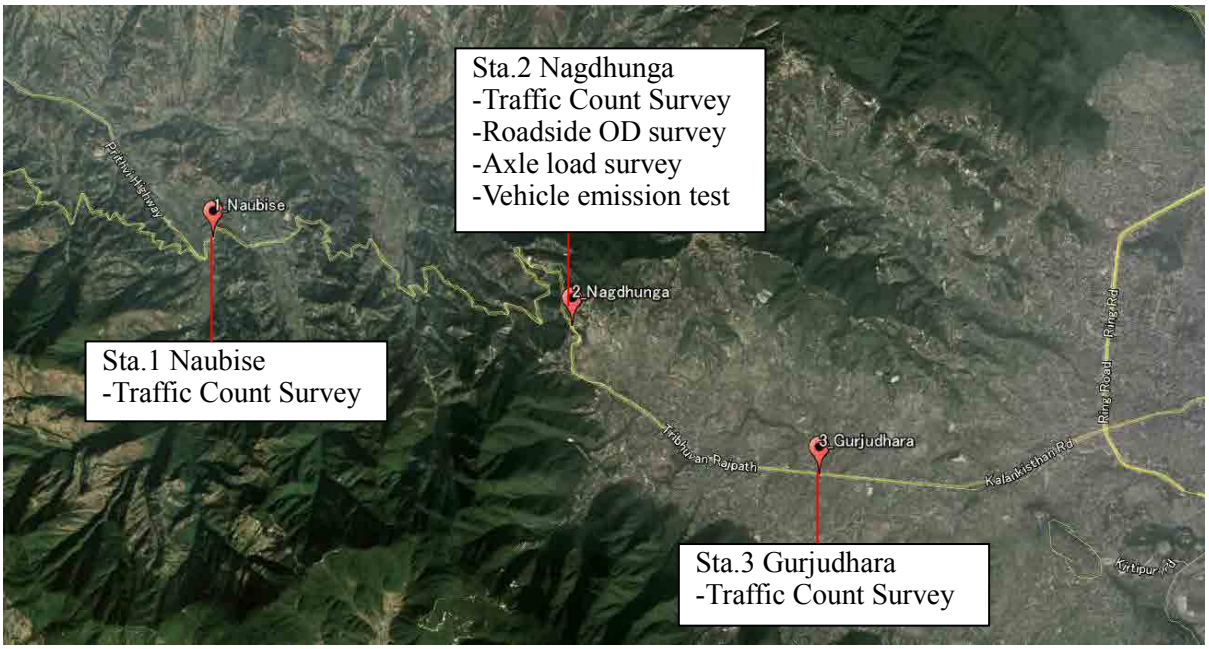
5.1.1 Type of Traffic Surveys Undertaken

The Study team conducted the traffic survey to understand the current situation of traffic characteristic at existing road of tunnel construction alignment. The survey item is specified shown in **Table 5.1-1**. The summary of results is described from next section. The result of traffic count survey is shown in section 5.1.2. The result of travel speed and travel time survey is presented in section 5.1.3. The result of OD survey is summarized in section 5.1.4. And, the result of the axle load survey and vehicle emission test are shown respectively in section 5.1.6 and 5.1.7.

TABLE 5.1-1 DESCRIPTION OF TRAFFIC SURVEY

Survey item	Purpose	Description
Traffic count survey	The traffic Count Survey shall be carried out at the three (3) locations on the Tribhuvan Highway in order to obtain the vehicular traffic volume. Data collected will be basic information for traffic demand forecast.	- Week day: Thursday, July 17, 2014 - 3 survey stations (Sta.1.Naubise, Sta2.Nagdhunga, Sta.3.Gurjudhara) - Weekend day: Saturday, July 19, 2014 - 1 survey station (Sta.2. Nagdhunga) - 24-hour survey - 10 classifications - Manual count by direction per vehicle type and tallying of hourly and daily traffic volume.
Travel Speed Survey	Travel Speed and Travel Time was conducted to understand service level of existing road	- Week day (Morning, Daytime, Night time) - 2 way direction - Heavy truck, Passenger car
Roadside Origin Destination survey (OD survey)	The roadside OD survey shall be carried out in order to understand trip pattern of vehicle passing the plan section of Nagdhunga tunnel. Data collected will be basic information for traffic demand forecast.	- Week day: July 17/18/20, 2014 - Weekend day: July 19, 2014 - 1 survey station (Sta.2. Nagdhunga) - 12-hour survey (From 7 a.m. to 19 p.m.) - About 4500 samples
Axle Load Survey	The Axle load survey shall be carried out to collect the actual loading data of heavy vehicle. Data collected will be basic information of pavement design.	- Week day: August 16, 2014 - 1 station (Sta.2. Nagdhunga) - Large Bus, Large Truck
Vehicle Emission Test	The Vehicle Emission Test shall be carried out in order to obtain the emission volume by vehicle type. Data collected will be basic information for air infiltration design of tunnel.	- Week day: July 27/28, 2014 - Weekend day: July 26, 2014 - 1 station (Sta.2. Nagdhunga) - Car, Large Bus, Large Truck - Type of gas (CO, NOx, SOx)

Source: JICA Study Team



Source: JICA Study Team

FIGURE 5.1-1 LOCATION OF TRAFFIC SURVEY STATION

Source: JICA Study Team 17 July, 2014

PHOTO 5.1-1 TRAFFIC COUNT SURVEY

Source: JICA Study Team, 17July 2014

PHOTO 5.1-2 ROADSIDE ORIGIN DESTINATION SURVEY (OD SURVEY)


Source: JICA Study Team, 16 august 2014

PHOTO 5.1-3 AXLE ROAD SURVEY


Source: JICA Study Team, 28 July 2014

PHOTO 5.1-4 VEHICLE EMISSION TEST

5.1.2 Traffic Volume

(1) Traffic volume

The result of traffic count survey at 3 stations is shown in **Table 5.1-2**. According this survey result, total traffic volume including motorcycle is 7,462 veh. on Sta.1 Naubise, 7,890 veh. on Sta.2 Nagdhunga, and 15,454 veh. on Sta.3 Gurjudhara shown in **Figure 5.1-2**. In the same way, total traffic volume without motorcycle is 5,778 veh. on Sta.1 Naubise, 6,474 veh. on Sta.2 Nagdhunga, and 9,393 veh. on Sta.3 Gurjudhara **Figure 5.1-3**. Based on Nepal Road Standards 2070, The equivalency Factors in terms of PCU shown in **Table 5.1-2** was used to convert to PCU from traffic volume.

TABLE 5.1-2 RESULT OF TRAFFIC COUNT SURVEY

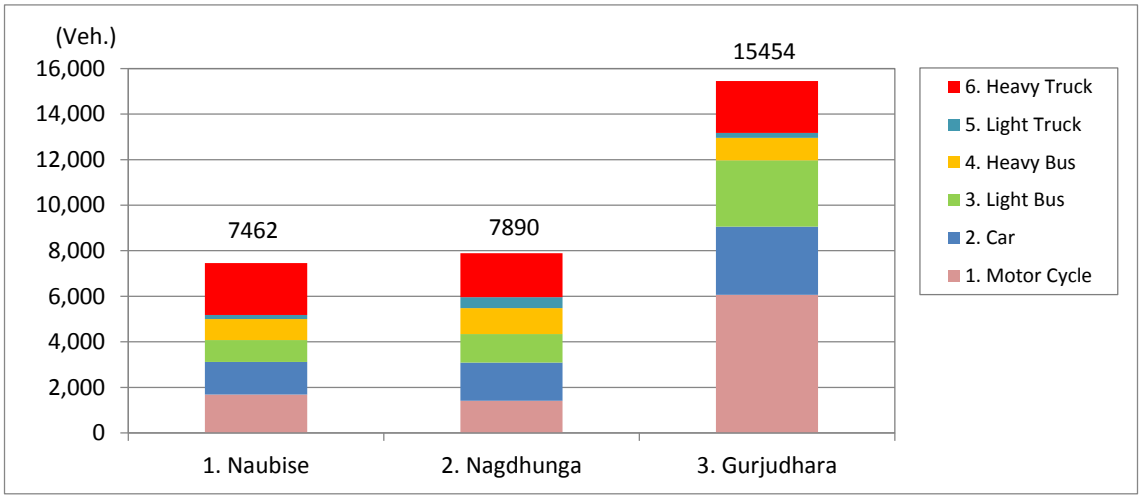
Classification	1. Naubise	% Total	% w/o MC	2. Nagdhunga	% Total	% w/o MC	3. Gurjudhara	% Total	% w/o MC
1. Motor Cycle	1,684	23%		1,416	18%		6061	39%	
2. Car & Taxi	1,132	15%	20%	1,347	17%	21%	2116	14%	23%
3. Utility Pick up	287	4%	5%	330	4%	5%	752	5%	8%
4. Micro Bus	668	9%	12%	771	10%	12%	1886	12%	20%
5. Mini Bus	291	4%	5%	480	6%	7%	1024	7%	11%
6. Heavy Bus	926	12%	16%	1,138	14%	18%	986	6%	10%
7. Light Truck	175	2%	3%	480	6%	7%	212	1%	2%
8. Heavy Truck	1,392	19%	24%	1,097	14%	17%	1438	9%	15%
9. Multi-axel Truck	894	12%	15%	831	11%	13%	846	5%	9%
10. Others	13	0%	0%	0	0%	0%	133	1%	1%
Total (All type of Veh.)	7,462	100%	-	7,890	100%	-	15,454	100%	-
Share of Heavy Veh.	*43%*	-	-	*39%*	-	-	*21%*	-	-
Share of Heavy truck	*31%*	-	-	*24%*	-	-	*15%*	-	-
PCU	5,778	-	-	6,474	-	-	9,393	-	-
Total(w/o 1.Motor Cycle)	5,778	-	100%	6,474	-	100%	9,393	-	100%
Share of Heavy Veh.	*56%*	-	-	*47%*	-	-	*35%*	-	-
Share of Heavy truck	*40%*	-	-	*30%*	-	-	*24%*	-	-
PCU	5,778	-	-	6,474	-	-	9,393	-	-

Source: JICA Study Team

TABLE 5.1-3 EQUIVALENCY FACTORS IN TERMS OF PCU

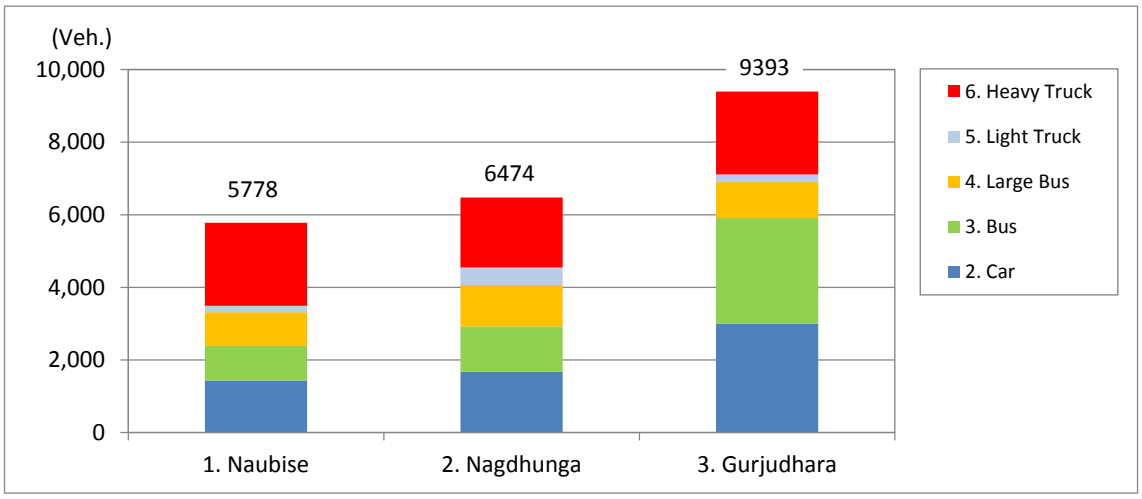
SN	Vehicle Type	PCU Equivalency Factor
1	Motorcycle	0.5
2	Car	1.0
3	Utility	1.0
4	Microbus	1.5
5	Minibus	3.0
6	Bus	3.0
7	Light Truck	1.5
8	Heavy Truck	3.0
9	Multi Axle Truck	3.0
10	Other	1.0

Source: Nepal Road Standards 2070 (2013)



Source: JICA Study Team

FIGURE 5.1-2 TOTAL TRAFFIC VOLUME BY VEHICLE TYPE



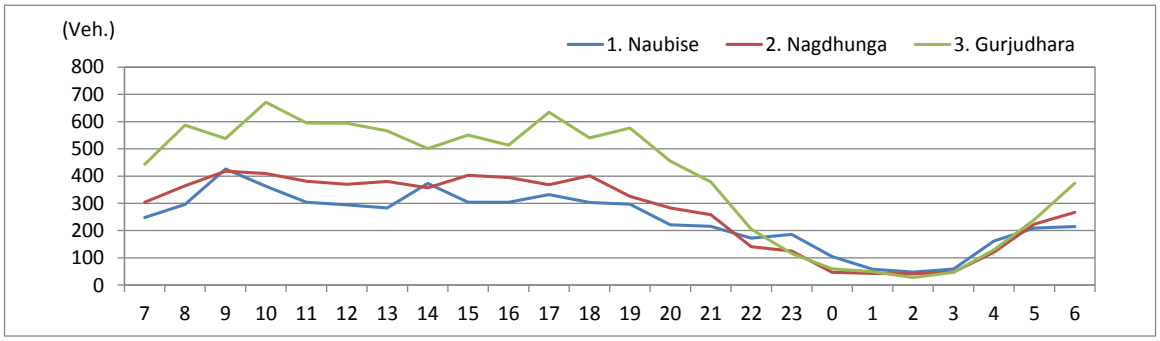
Source: JICA Study Team

FIGURE 5.1-3 TOTAL TRAFFIC VOLUME W/O MOTOR CYCLE BY VEHICLE TYPE

(2) Hourly variation of traffic volume

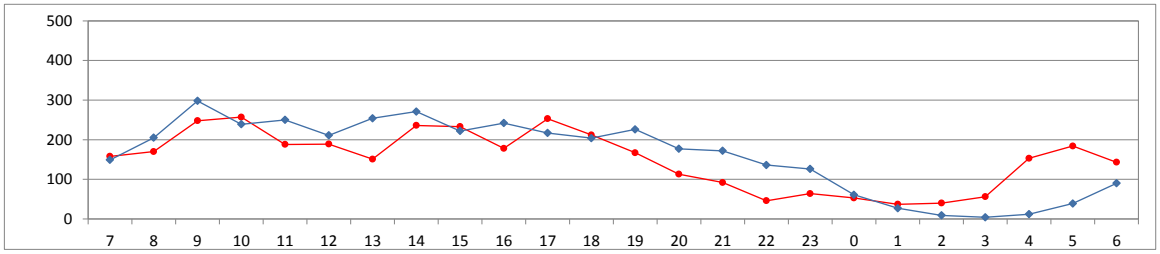
Regarding hourly variation for 24 hour, a similar trend was observed generally in 3 stations. The peak time in Sta.1 and Sta.2 is 9 a.m. On Sta.3 where has shops and houses on roadside, its peak time is 10 a.m. No major hourly variation is identified during daytime. After 19 p.m.

Traffic decreased gradually after 19 p.m. and that of night time during 23 p.m. to 4 a.m. is small.



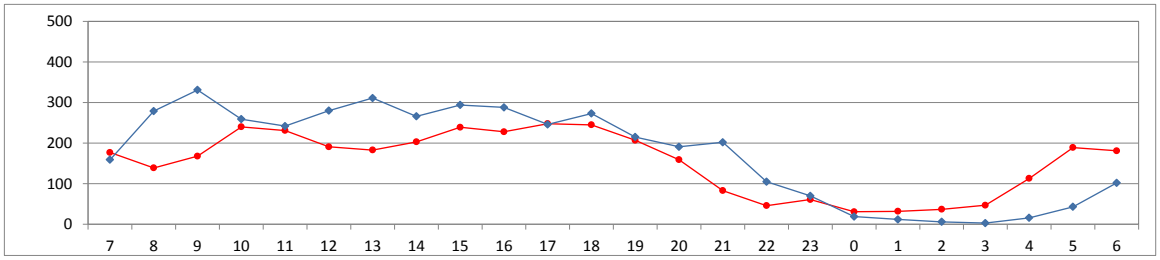
Source: JICA Study Team

FIGURE 5.1-4 HOURLY VARIATION OF TRAFFIC VOLUME (W/O MOTOR CYCLE)



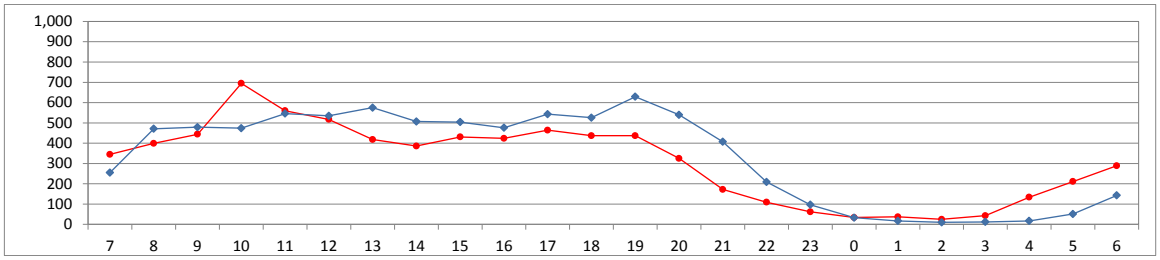
**Red line is eastbound, blue line is westbound*
Source: JICA Study Team

FIGURE 5.1-5 HOURLY VARIATION BY DIRECTION AT STA.1 NAUBISE



**Red line is eastbound, blue line is westbound*
Source: JICA Study Team

FIGURE 5.1-6 HOURLY VARIATION BY DIRECTION AT STA.2 NAGDHUNGA

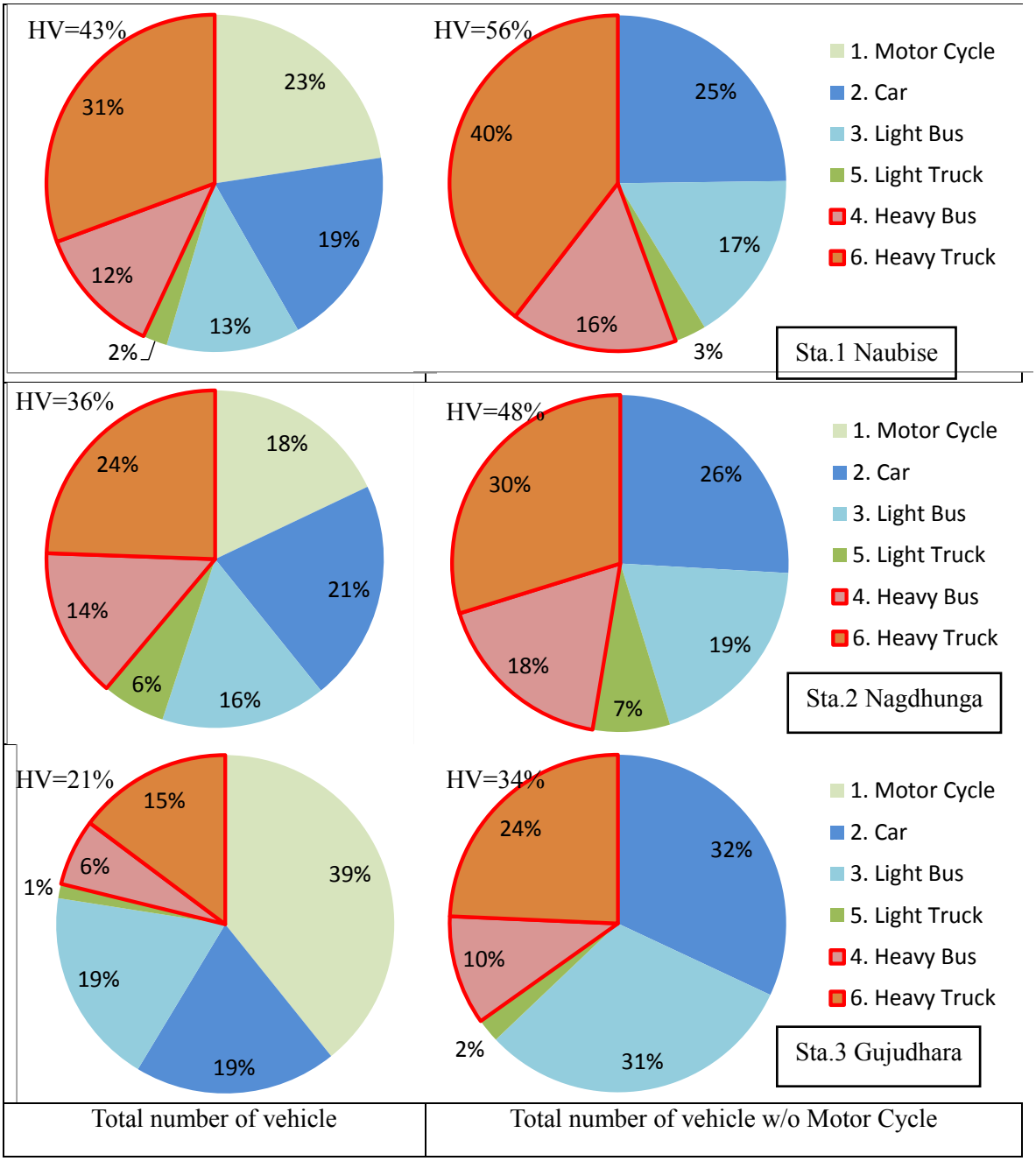


**Red line is eastbound, blue line is westbound*
Source: JICA Study Team

FIGURE 5.1-7 HOURLY VARIATION BY DIRECTION AT STA.3 GURJUDHARA

(3) Traffic composition and share of heavy vehicle

Figure 5.1-8 illustrates traffic composition of 3 stations. The circle graph on left shows Total number of vehicle, that on right is total number w/o motor cycle. The share of heavy vehicle for the case of no motor cycle is approximately 50% at Sta. Nagdhunga.



*HV: Heavy Vehicle
Source: JICA Study Team

FIGURE 5.1-8 TRAFFIC COMPOSITION OF 3 STATIONS

TABLE 5.1-4 SHARE OF HEAVY VEHICLE OF 3 STATIONS

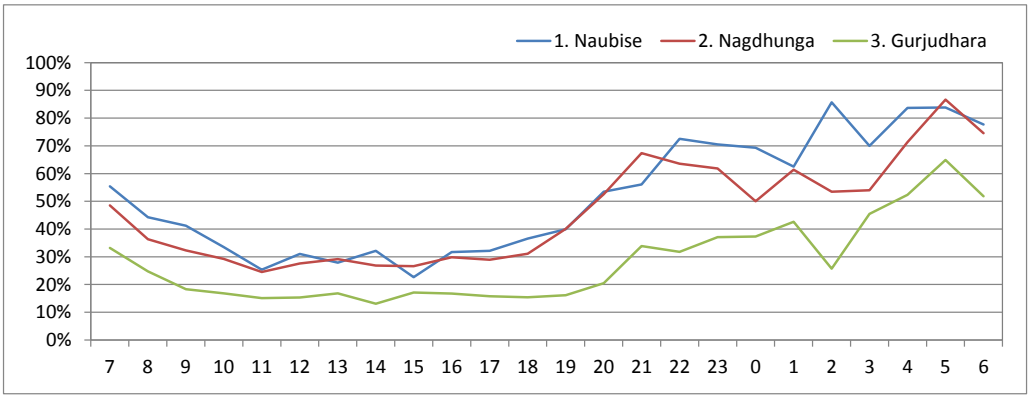
Classification		1. Naubise	%	2. Nagdhunga	%	3. Gurjudhara	%
Light Vehicle		4,250	*57%*	4,824	*61%*	12,184	*79%*
Heavy Vehicle	Bus	926	*12%*	1,138	*14%*	986	*6%*
	Truck	2,286	*31%*	1,928	*24%*	2,284	*15%*
Total		7,462	*100%*	7,890	*100%*	15,454	*100%*

Source: JICA Study Team

TABLE 5.1-5 SHARE OF HEAVY VEHICLE W/O MORTAR CYCLE OF 3 STATIONS

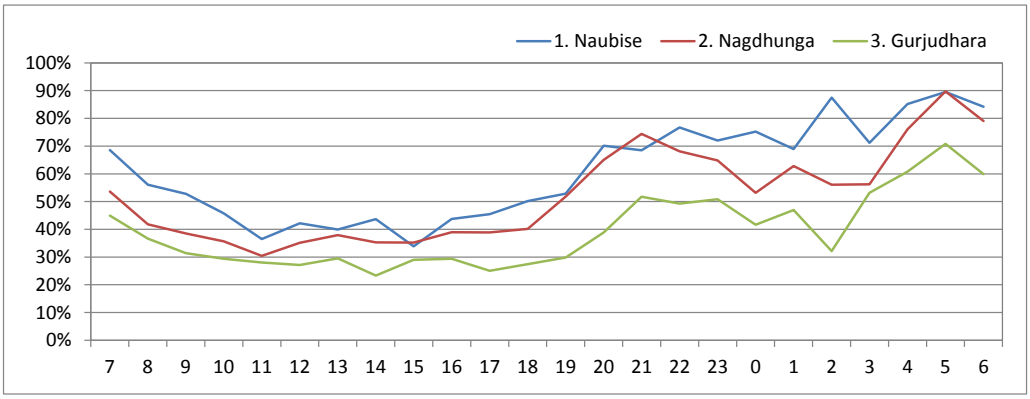
Classification		1. Naubise	%	2. Nagdhunga	%	3. Gurjudhara	%
Light Vehicle		2,566	*44%*	3,408	*53%*	6,123	*65%*
Heavy Veh.	Bus	926	*16%*	1,138	*18%*	986	*10%*
	Truck	2,286	*40%*	1,928	*30%*	2,284	*24%*
Total		5,778	*100%*	6,474	*100%*	9,393	*100%*

Source: JICA Study Team



Source: JICA Study Team

FIGURE 5.1-9 SHARE OF HEAVY VEHICLE OF ALL TYPE VEHICLES AT 3 STATIONS



Source: JICA Study Team

FIGURE 5.1-10 SHARE OF HEAVY VEHICLE OF ALL TYPE VEHICLES W/O MOTOR CYCLE

(4) Share of day –night time traffic volume

The share of day - night time between 1.35-1.43 is about average. Sta.3. Gurjudhara where is a roadside land use indicates a relatively low value. This means that the traffic of nighttime is larger in comparison to other two stations.

TABLE 5.1-6 SHARE OF DAY – NIGHT TIME TRAFFIC VOLUME

(Veh.)

	1. Naubise	2. Nagdhunga	3. Gurjudhara
Day time (7 am – 19 pm)	5,235	5,720	11,411
Night time (19 am – 7 am)	2,227	2,170	4,043
Total	7,462	7,890	15,454
Total / Day time	*1.43*	*1.38*	*1.35*

Source: JICA Study Team

(5) Comparison of Weekday-Holiday

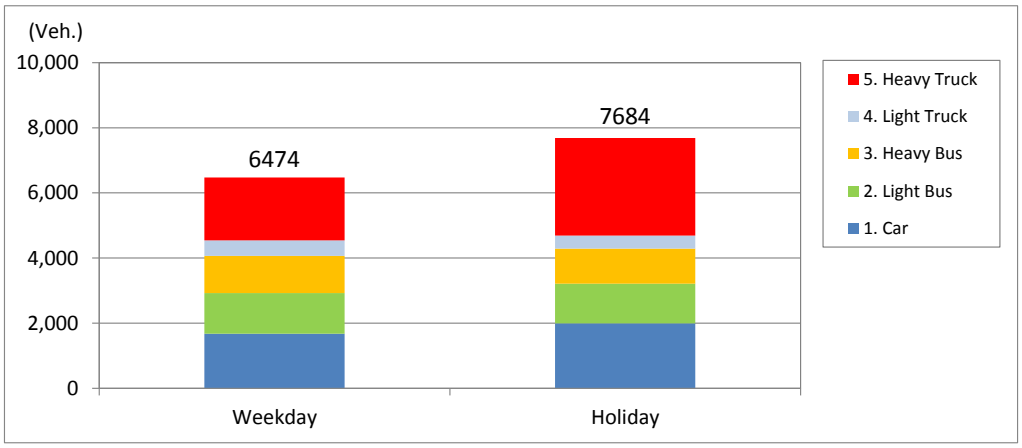
1) Traffic Volume

In this section, a comparative analysis of traffic on weekday and holiday is done with the traffic survey result on Sta.2 Nagdhunga. Regarding the traffic volume of the road section, the traffic on holiday is 1.3 times larger than weekday based on hour survey.

TABLE 5.1-7 TRAFFIC SURVEY RESULT AT STA.2 NAGDHUNGA

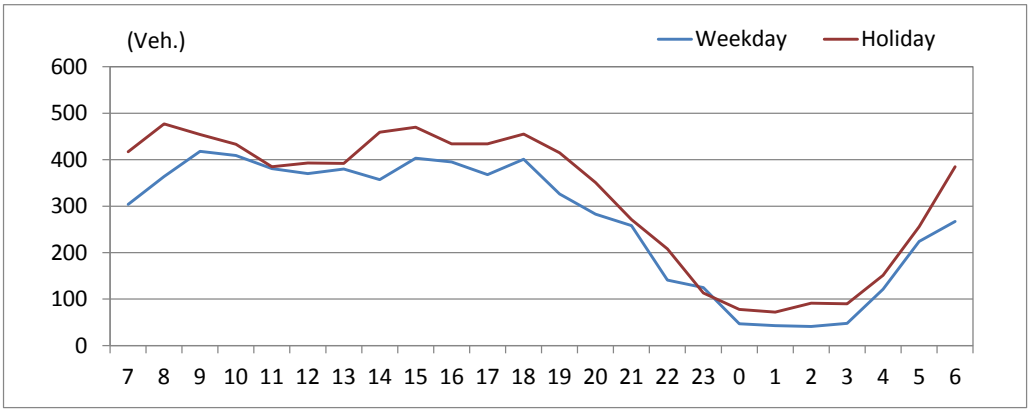
Classification	Week day (a)	% Total	% w/o MC	Holiday (b)	% Total	% w/o MC	b/a
1. Motor Cycle	1,416	18%		1,789	19%		1.26
2. Car & Taxi	1,347	17%	21%	1,673	18%	22%	1.24
3. Utility Pick up	330	4%	5%	321	3%	4%	0.97
4. Micro Bus	771	10%	12%	764	8%	10%	0.99
5. Mini Bus	480	6%	7%	456	5%	6%	0.95
6. Heavy Bus	1,138	14%	18%	1,075	11%	14%	0.94
7. Light Truck	480	6%	7%	404	4%	5%	0.84
8. Heavy Truck	1,097	14%	17%	2,243	24%	29%	2.04
9. Multi-axel Truck	831	11%	13%	748	8%	10%	0.90
10. Others	0	0%	0%	0	0%	0%	#DIV/0!
Total (All type of Veh.)	7,890	100%	-	9,473	100%	-	1.20
Share of Heavy Veh.	*39%*	-	-	*43%*	-	-	-
Share of Heavy truck	*24%*	-	-	*32%*	-	-	-
PCU	12,567	-	-	15,906	-	-	1.27
Total(w/o 1.Motor Cycle)	6,474	-	100%	7,684	-	100%	1.19
Share of Heavy Veh.	*47%*	-	-	*53%*	-	-	-
Share of Heavy truck	*30%*	-	-	*39%*	-	-	-
PCU	11,859	-	-	15,012	-	-	1.27

Source: JICA Study Team



Source: JICA Study Team

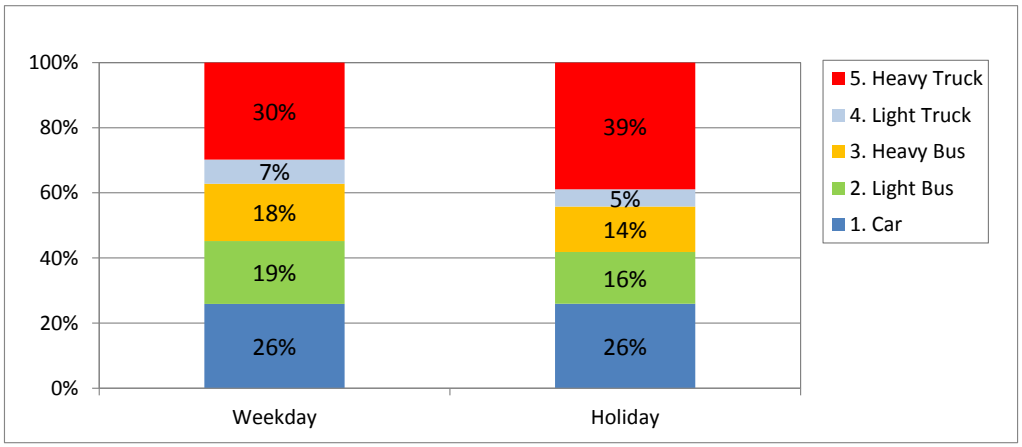
FIGURE 5.1-11 COMPARISON OF TOTAL TRAFFIC VOLUME BY VEHICLE TYPE



Source: JICA Study Team

FIGURE 5.1-12 HOURLY VARIATION OF WEEKDAY AND HOLIDAY AT STA.2 NAGDHUNGA

2) Traffic Composition



Source: JICA Study Team

FIGURE 5.1-13 TRAFFIC COMPOSITION OF WEEK-DAY AND HOLIDAY AT STA.2 NAGDHUNGA

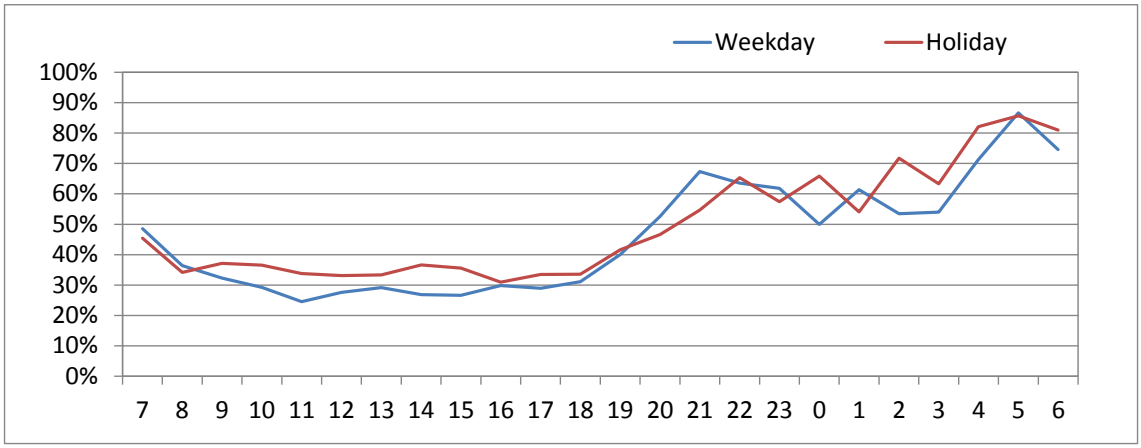
3) Share of Large Size Vehicle

TABLE 5.1-8 SHARE OF LARGE SIZE VEHICLE W/O MORTAR CYCLE OF 3 STATIONS

(Veh.)

Classification		Weekday	%	Holiday	%
Light Veh.		3,408	*53%*	3,618	*47%*
Heavy Veh.	Bus	1,138	*18%*	1,075	*14%*
	Truck	1,928	*30%*	2,991	*39%*
Total		6,474	*100%*	7,684	*100%*

Source: JICA Study Team



Source: JICA Study Team

FIGURE 5.1-14 SHARE OF LARGE SIZE VEHICLE WITH WEEK-DAY AND WEEKEND-DAY

(6) Estimation of Annual Average Daily Traffic

Table 5.1-9 shows the Annual Average Daily traffic of each station form traffic survey result using the seasonal coefficient of DoR. AADT without motor cycle on Nagdhunga was estimated to be 7704 veh./day in 2014.

TABLE 5.1-9 ESTIMATION RESULT OF AADT OF TOTAL VEHICLES

	Total vehicles (veh.)		Total vehicles w/o MC (veh.)		*Seasonal Coefficient*
Station	**Survey Result**	**AADT**	**Survey Result**	**AADT**	
1. Naubise	7,462	8,880	5,778	6,876	*1.19*
2. Nagdhunga	7,890	9,389	6,474	7,704	*1.19*
3. Gurjudhara	15,454	16,845	9,393	10,238	*1.09*

** w/o MC: without motor cycle*
Source: JICA Study Team

The annual variation of traffic volume of Nagdhunga based on AADT is shown in **Table 5.1-10**. In seven years from 2007 to 2014, traffic volume on Nagdhunga showed an increase of 7.7% per annum, and in case of without motorcycle was 6.7% of annual average growth.

TABLE 5.1-10 ANNUAL VARIATION OF TRAFFIC VOLUME AT NAGDHUNGA

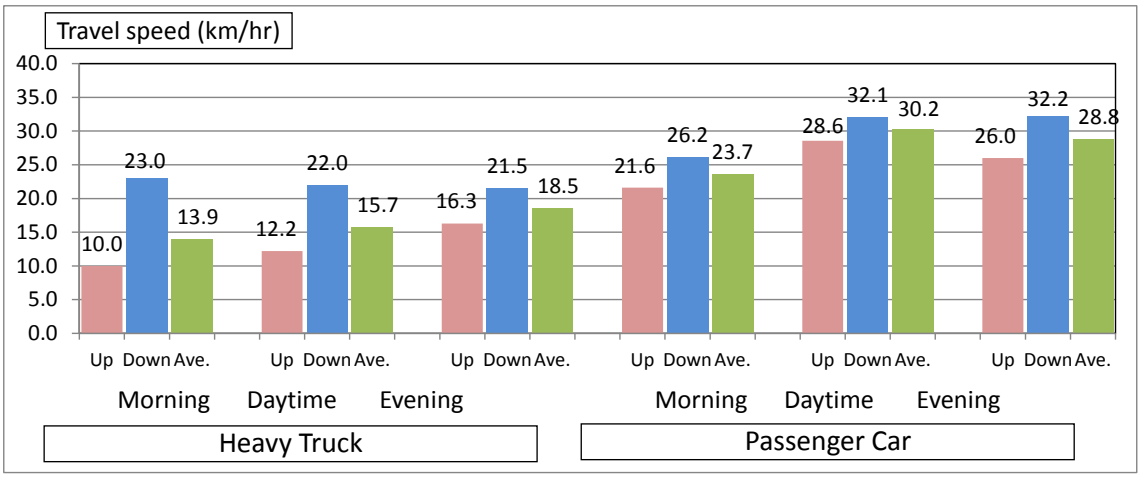
year	AADT (veh.)	AADT w/o MC (veh.)
2007	5,582	4,891
2008	6,861	5,682
2009	6,479	5,379
2010	8,020	6,280
2011	9,773	8,668
2012	7,899	6,653
2013	9,022	7,062
2014	9,389	7,704
AGR('07-'14)	*7.7%*	*6.7%*

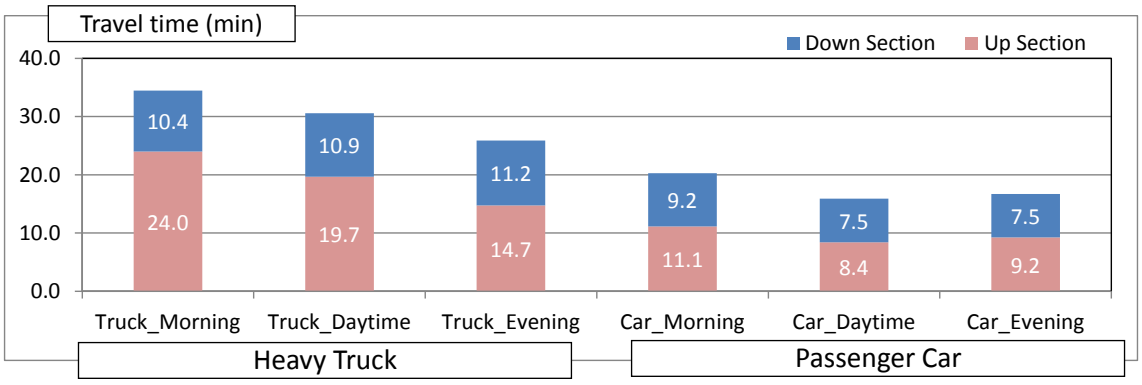
**year: April-March*
Source: JICA Study Team based on traffic survey on July 17, 2014. And data of DoR

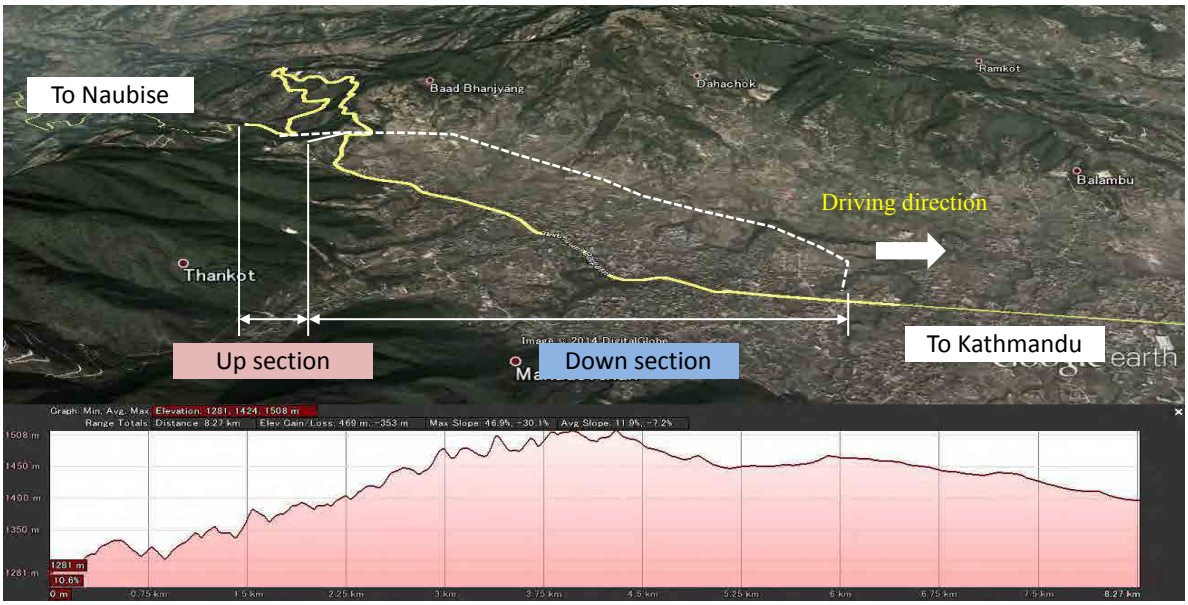
5.1.3 Travel Speed and Travel Time

(1) Travel speed survey result of Eastbound (from Naubise to Kathmandu)

The average travel speed of heavy truck on eastbound is less than 20km/hr. Uphill section at morning time is just around 10km/hr. and total travel time for existing road of 8km is 30min.

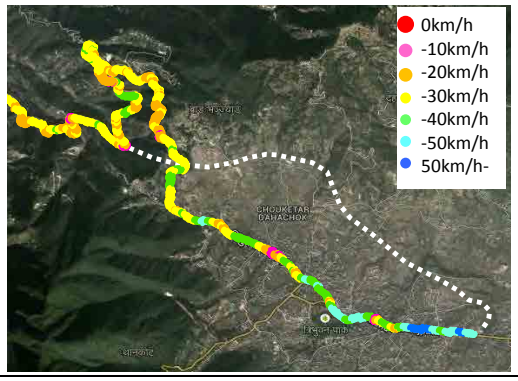
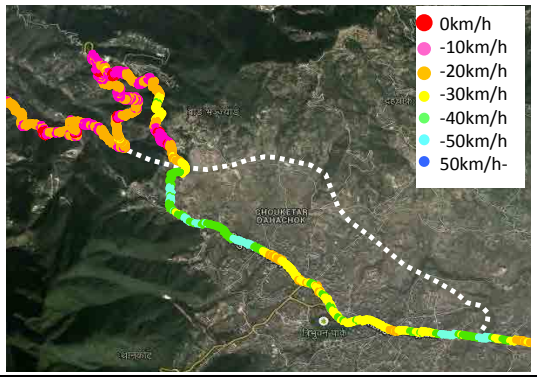
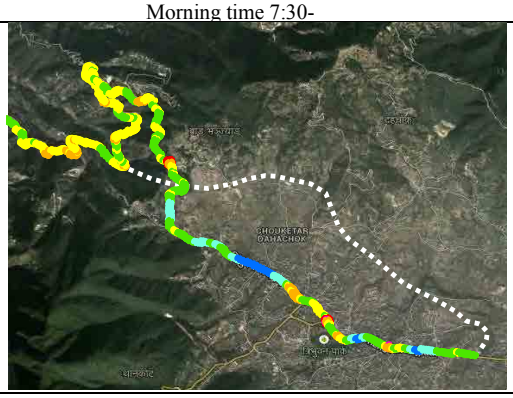
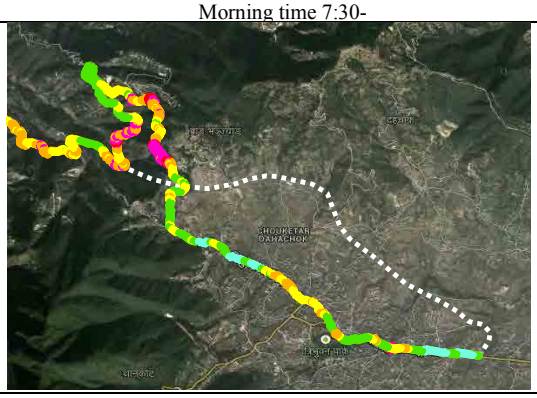






Source: JICA Study Team

FIGURE 5.1-15 TRAVEL SPEED SURVEY RESULT OF EASTBOUND (FROM NAUBISE TO KATHMANDU)

Car (Light vehicle)	(Truck) Heavy vehicle
	
Morning time 7:30-	Morning time 7:30-
	
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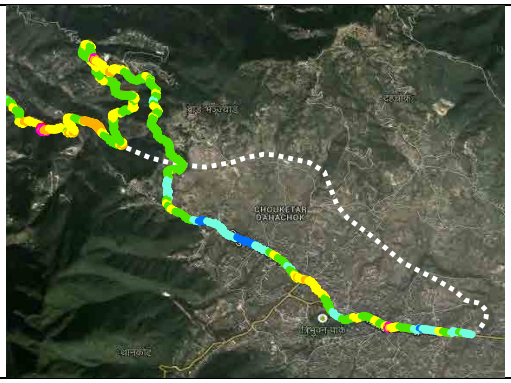	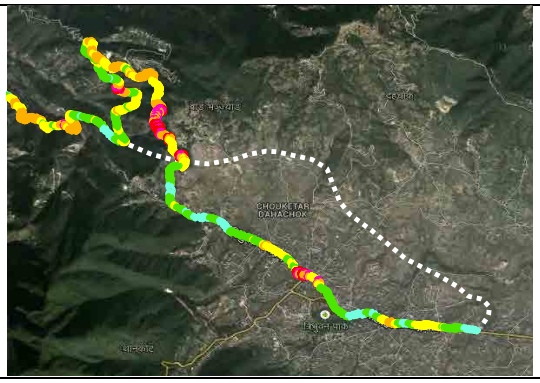
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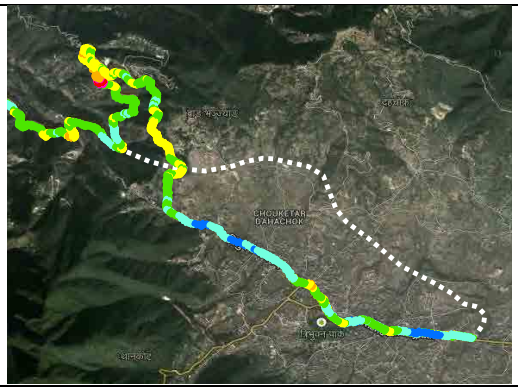
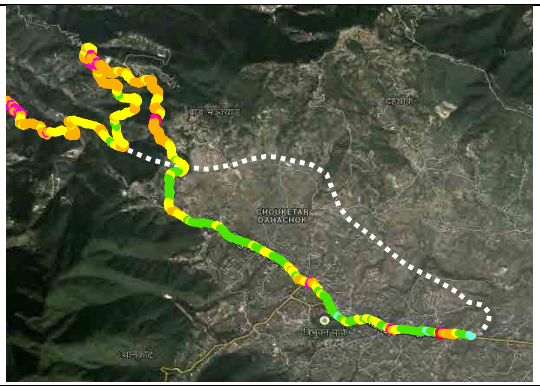
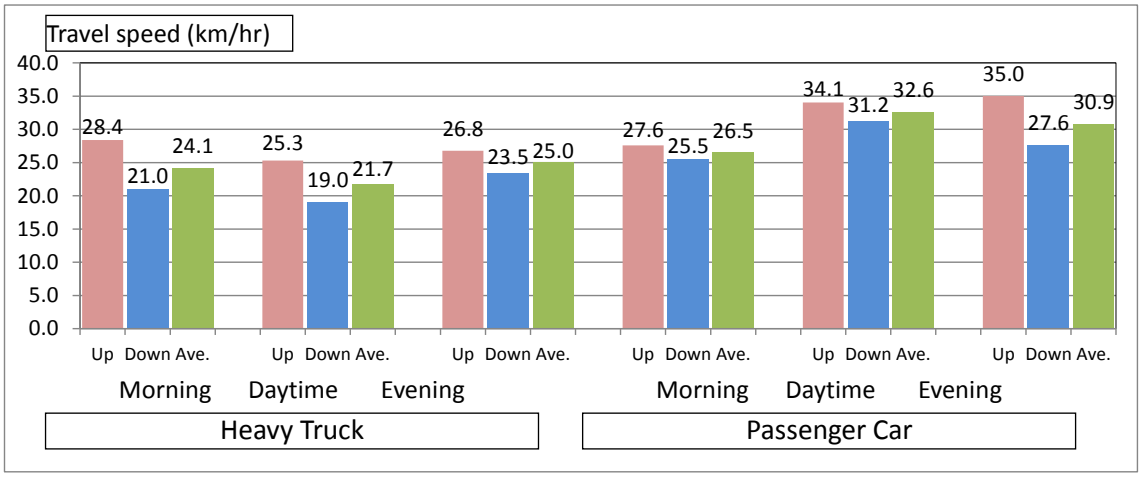
	
Night time: 19:00-	Night time: 19:00-

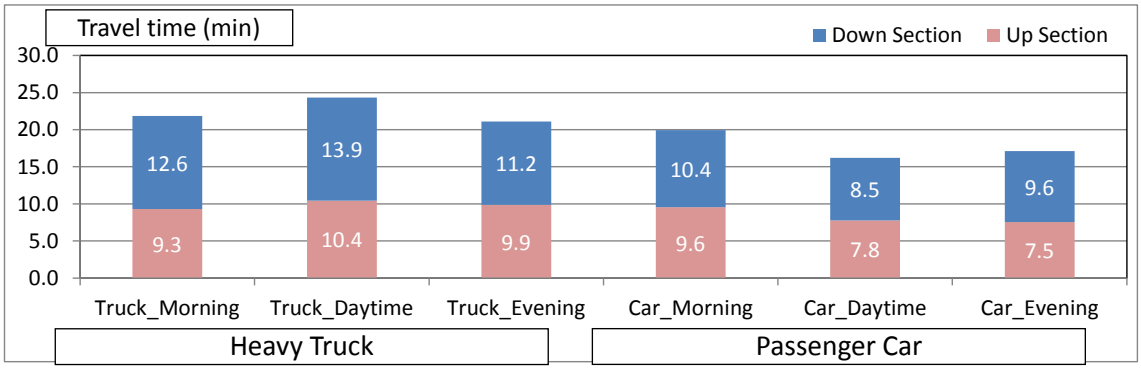
Source: JICA Study Team

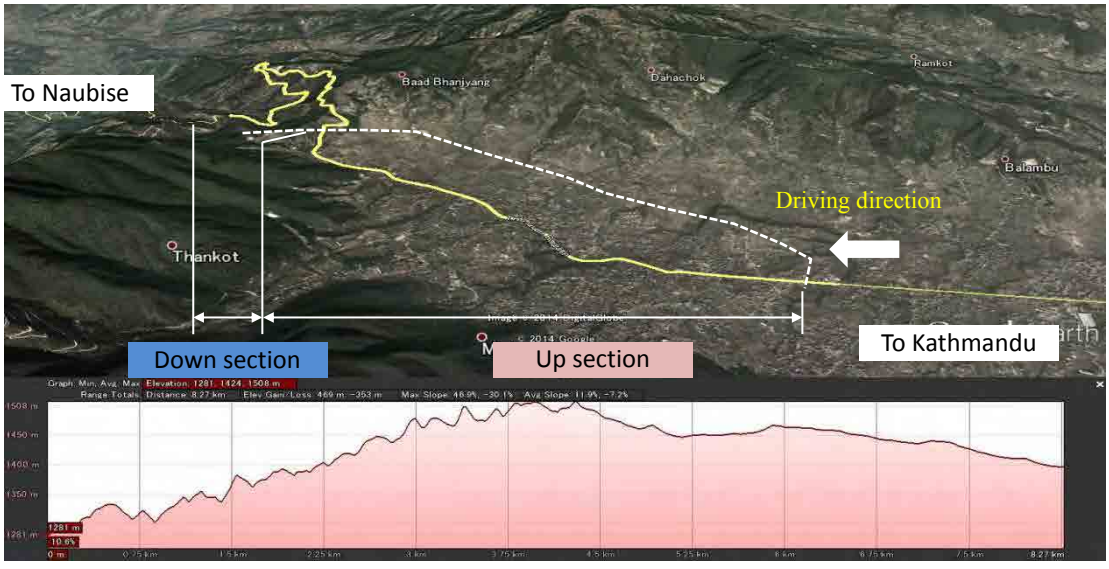
FIGURE 5.1-16 TRAVEL SPEED: EASTBOUND (FROM NAUBISE TO KATHMANDU)

(2) Travel speed survey result from Kathmandu to Naubise

The average travel speed of heavy truck on eastbound is less than 25km/hr and travel time is 22 min. Even if downhill section, travel speed is approximately 20km/hr.

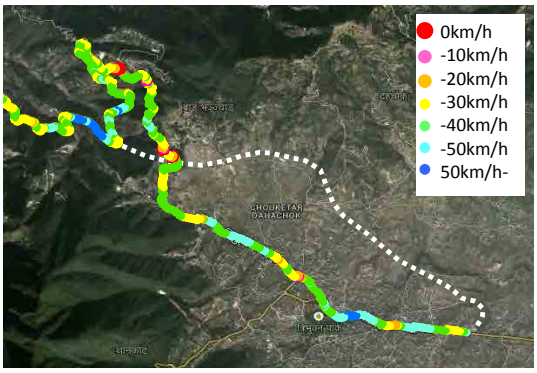
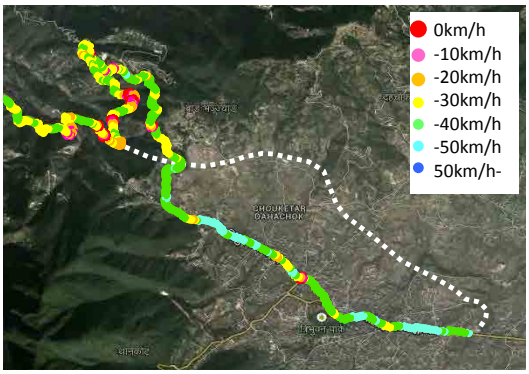
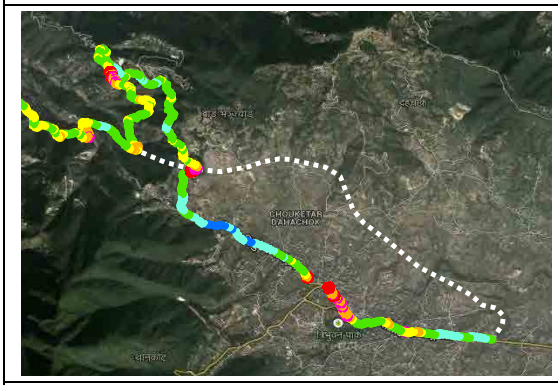
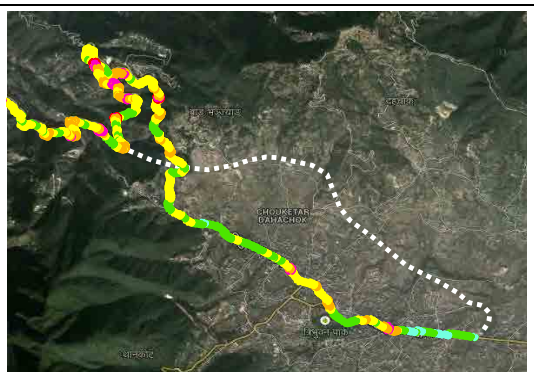
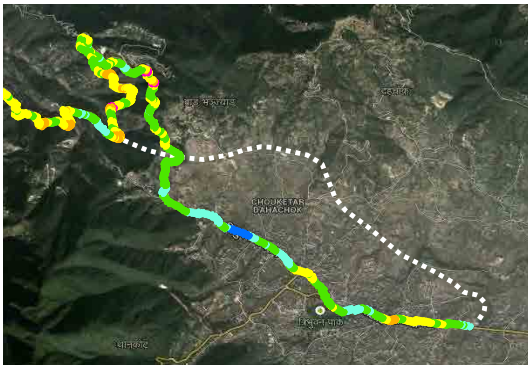
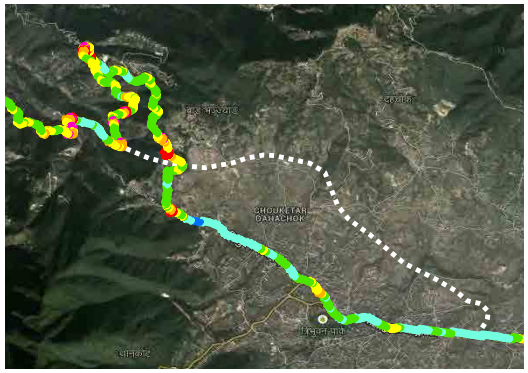
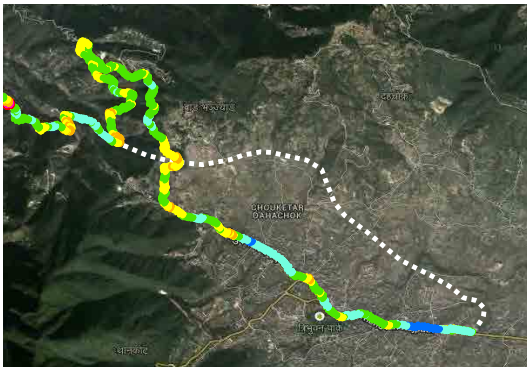
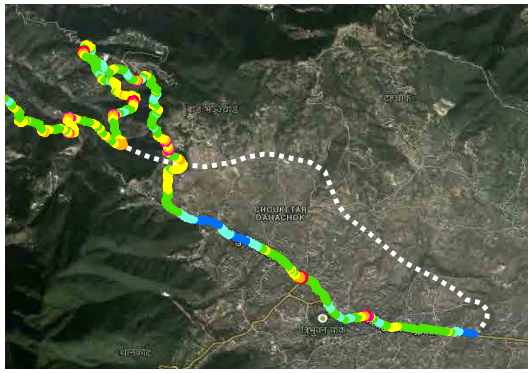






Source: JICA Study Team

FIGURE 5.1-17 TRAVEL SPEED SURVEY RESULT OF WEST BOUND (FROM KATHMANDU TO NAUBISE)

Car (Light vehicle)	(Truck) Heavy vehicle
	
Morning time 7:30-	Morning time 7:30-
	
Daytime 12:00-	Daytime 12:00-
	
Daytime 14:00-	Daytime 14:00-
	
Night time: 19:00-	Night time: 19:00-

Source: JICA Study Team

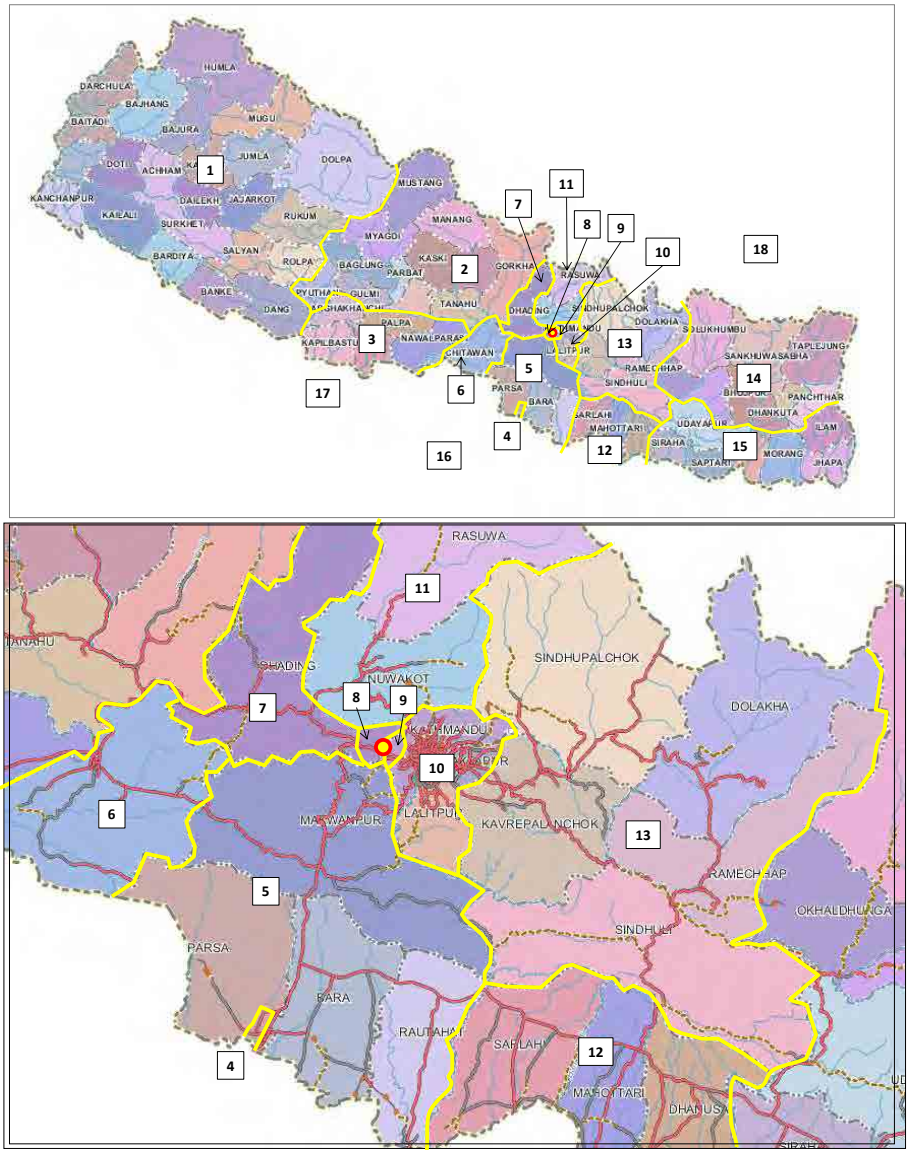
FIGURE 5.1-18 TRAVEL SPEED: WESTBOUND (FROM KATHMANDU TO NAUBISE)

5.1.4 Characteristics of Traffic Composition and OD Pattern

(1) Characteristics of Traffic composition

OD survey was conducted to understand the traffic flow on the road of Nagdhunga section. The current traffic flow is analyzed based on the OD survey results. OD zone for analysis is 18 zones that 15 zones of Nepal and 3 zone of India and China shown in **Figure 5.1-19** OD survey results is taken the enlargement process using the traffic count survey.

OD pattern is examined the data after magnification correction to daily amount using the traffic count survey result.



Source: JICA Study Team

FIGURE 5.1-19 MAP OF OD ZONING SYSTEM

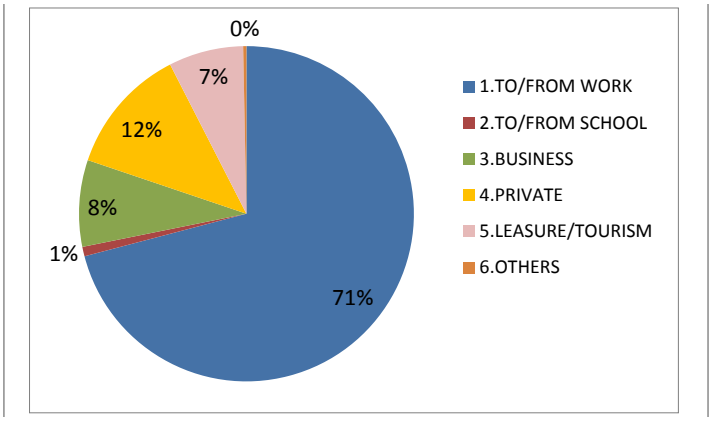
TABLE 5.1-11 OD ZONING CODE

Zone Code			
Zone ID	Zone name	Region Level	Dstrict / VDC level
1	Far and Mid-Western	Far-Western Region	All district
		Mid-Western Region	All district
2	Western_North	Western Region	All district
3	Western_South	Western Region	Dist. Nawalparasi
			Dist. Rupandehi
			Dist. Kapilbastu
			Dist. Palpa
			Dist. Arghakriandhi
4	Birgunj ICD	Central Region	Birgunj ICD/ Indian Border / Industrial area
5	Central West_1	Central Region / Narayani zone	Dist. Makwanpur
			Dist. Rautahat
			Dist. Bara
			Dist. Parsa
6	Central West_2	Central Region / Narayani zone (with Dhading)	Dist. Chitawan
7	Dist. Dhading without VDC.Naubise		Dist. Dhading without VDC.Naubise(zone 5)
8	Naubise	Central Region / Bagmati zone	VDC. Naubise (Dhading district)
9	East of Nagdhunga	Central Region / Bagmati zone 5 VDC in Kathmandu district	VDC. Baad Bhanjyang
			VDC. Thankot
			VDC. Dahachok
			VDC. Mahadevsthan
			VDC. Matatirtha
10	Kathmandu valley	Central Region / Bagmati zone	Dist.Kathmandu (without VDC in Zone 6)
			Dist.Bhaktapur
			Dist.Lalitpur
11	Central East_1	Central Region / Bagmati zone	Dist.Rasuwa
			Dist.Nuwakot
12	Central East_2	Central Region / Janakpur zone	Dist. Dhanusa
			Dist. Mahottari
			Dist. Sarlahi
13	Central East_3	Central Region / Bagmati zone	Dist.Sindhupalchok
			Dist.Kavrepalanchok
			Dist. Sindhuli
			Dist. Ramechhap
			Dist. Dolakha
14	Eastern Region_1	Eastern Region	Other district
15	Eastern Region_2 (South)	Eastern Region	Dist. Siraha
			Dist. Saptari
			Dist. Sunsari
			Dist. Morang
			Dist. Jhara
			Dist. Ilam
			Dist. Udaypur
16	India		India via Birgunj
17	India		India via other places, Bangladesh
18	China		China

Source: JICA Study Team

1) Purpose of trip

The share of purpose of trip by all type of vehicle is illustrated in **Figure 5.1-20** and the detail data of Purpose of trip by passenger vehicle is shown in **Table 5.1-12**.



Source: JICA Study Team

FIGURE 5.1-20 PURPOSE OF TRIP BY PASSENGER VEHICLE

TABLE 5.1-12 DETAIL DATA OF PURPOSE OF TRIP BY PASSENGER VEHICLE

	1.WORK	2.SCHOOL	3.BUSINESS	4.PRIVATE	5.LEASURE	6.OTHERS	Total
Car	487	5	254	892	347	10	1,996
Micro bus	813	8	6	15	76	0	917
Mini Bus	513	20	6	13	18	1	571
Heavy bus	1,200	25	11	0	115	3	1,354
Light truck	444	1	99	26	0	0	571
Heavy truck	2,007	11	267	0	0	9	2,294
Total	5,463	70	644	947	556	24	7,704

	1.WORK	2.SCHOOL	3.BUSINESS	4.PRIVATE	5.LEASURE	6.OTHERS	Total
Car	6%	0%	3%	12%	5%	0%	26%
Micro bus	11%	0%	0%	0%	1%	0%	12%
Mini Bus	7%	0%	0%	0%	0%	0%	7%
Heavy bus	16%	0%	0%	0%	1%	0%	18%
Light truck	6%	0%	1%	0%	0%	0%	7%
Heavy truck	26%	0%	3%	0%	0%	0%	30%
Total	71%	1%	8%	12%	7%	0%	100%

Source: JICA Study Team

2) Occupancy

The average occupancy is shown in **Table 5.1-13**.

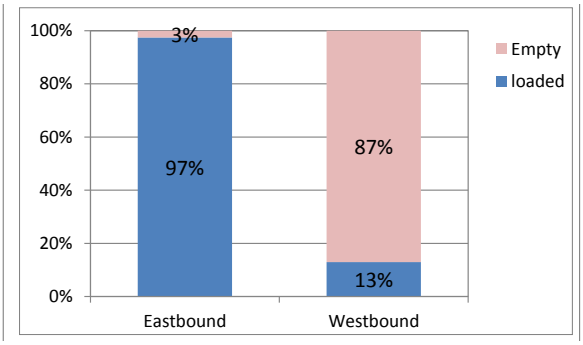
TABLE 5.1-13 OCCUPANCY BY TYPE OF VEHICLE

Car	Micro bus	Mini Bus	Heavy bus	Light truck	Heavy truck
3.1	15.2	25.3	40.4	1.7	2.6

Source: JICA Study Team

3) Ratio of loading truck and empty truck

The 97% of Heavy truck of eastbound, which is into Kathmandu, is loaded. In contrast, the empty truck accounts 87 % in the direction out of the Kathmandu.



Source: JICA Study Team

FIGURE 5.1-21 LOADING RATIO OF HEAVY TRUCK BY DIRECTION

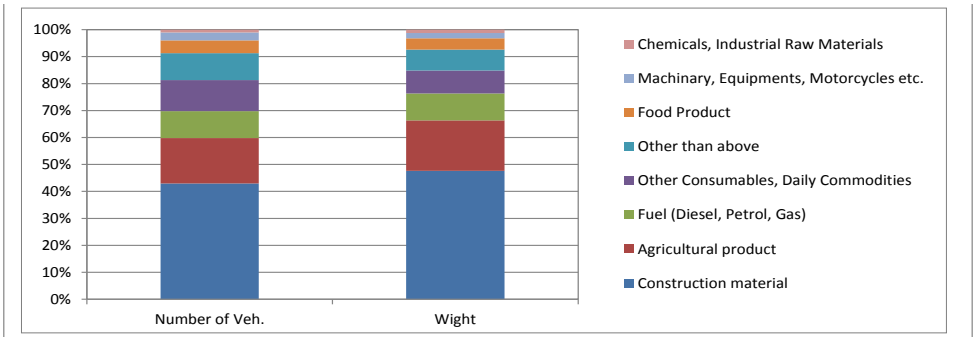
4) Average loading weight of heavy truck

TABLE 5.1-14 AVERAGE LOADING WEIGHT BY COMMODITY TYPE

Commodity type	Loading weight
Construction material	14 ton
Agricultural product	14 ton
Fuel (Diesel, Petrol, Gas)	13 ton
Other Consumables, Daily Commodities	9 ton
Other than above	10 ton
Food Product	11 ton
Machinery, Equipment, Motorcycles etc.	9 ton
Chemicals, Industrial Raw Materials	15 ton
Average	13 ton

Source: JICA Study Team

5) Commodity type

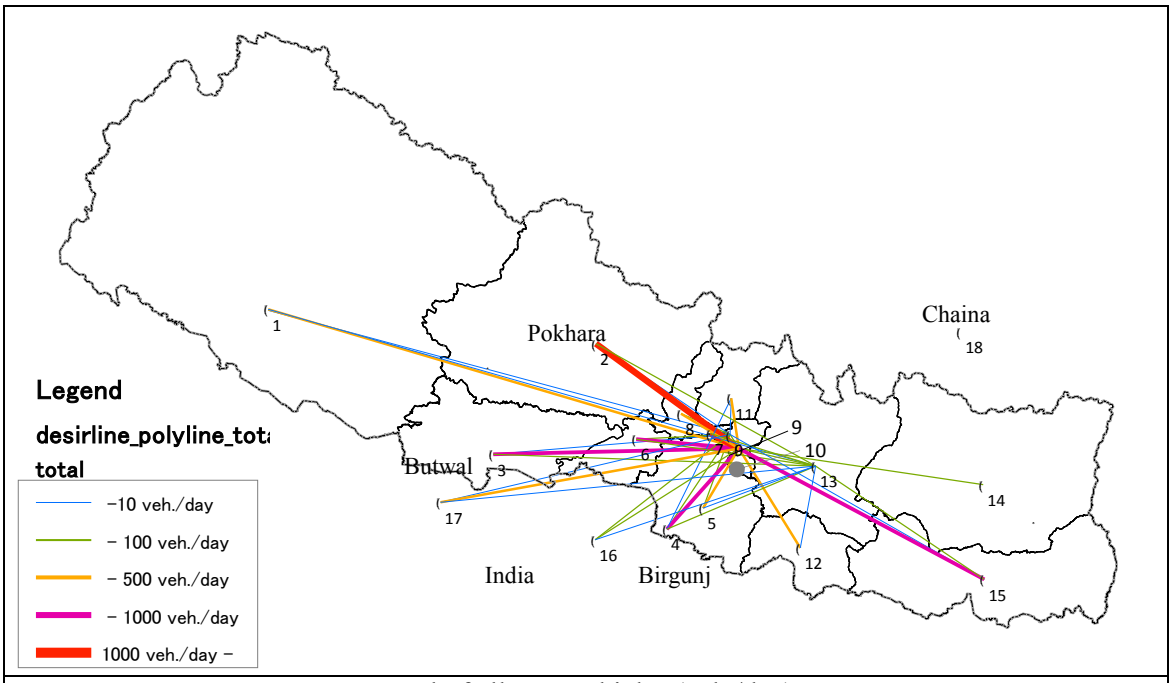


Source: JICA Study Team

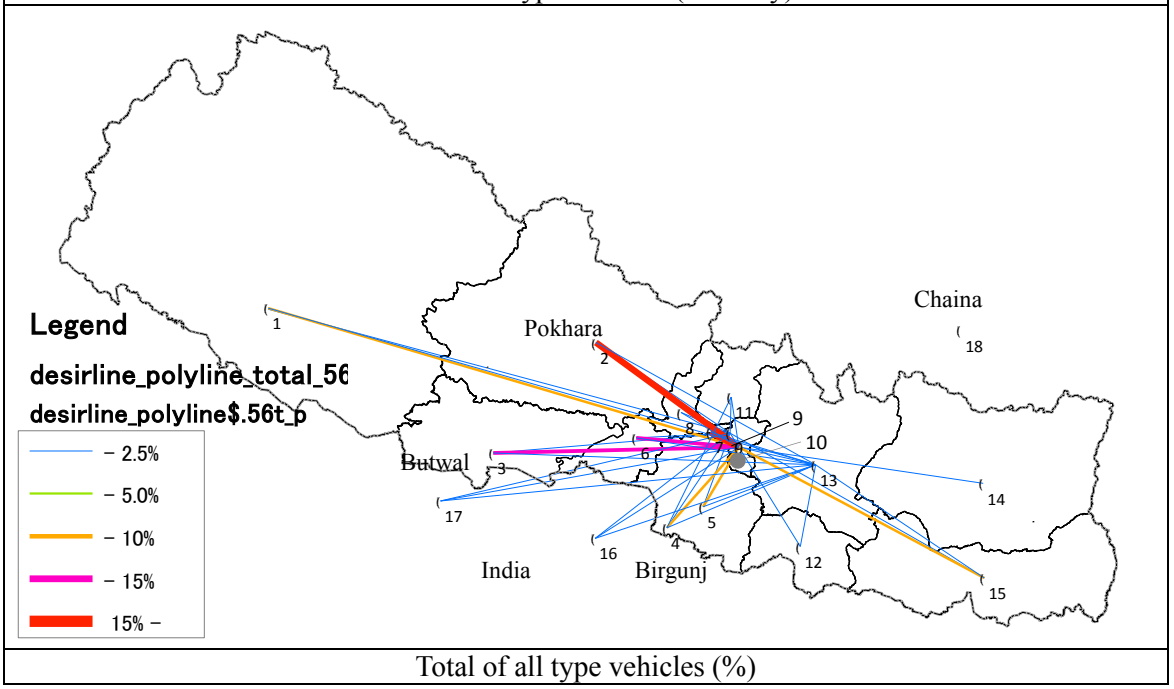
FIGURE 5.1-22 SHARE OF COMMODITY BY NUMBER OF VEHICLE AND BY LOADING WEIGH

(2) Desire Line at road of Nagdhunga section

From desire line obtained of total traffic, the largest traffic that passes Nagdhunga section is the traffic between Kathmandu and Western-North zone including Pokhara. And then, Western-south (zone 3), Central-west 2 (zone 6) is major traffic generation and attraction zone.



Total of all type vehicles (veh./day)

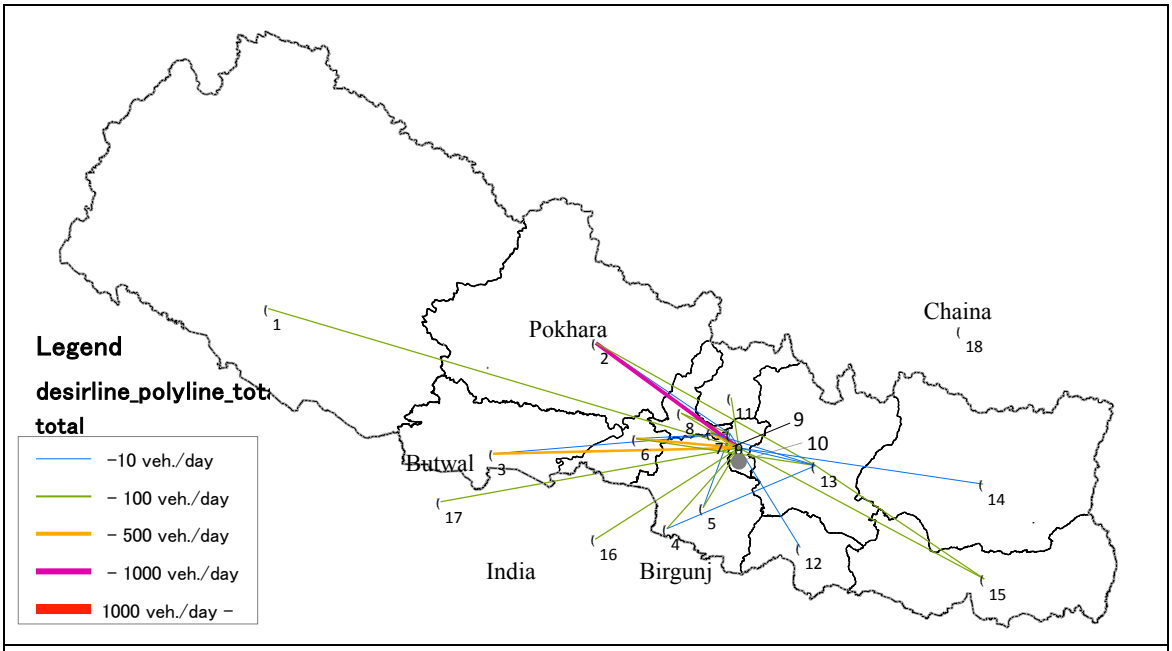


Total of all type vehicles (%)

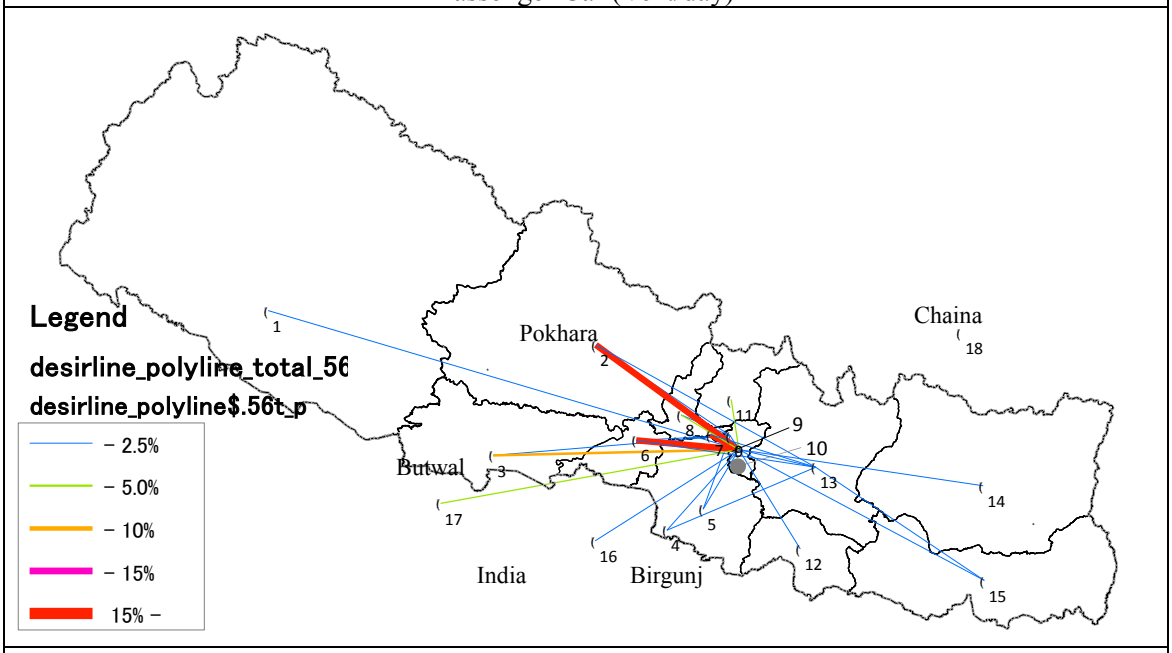
Source: JICA Study Team

FIGURE 5.1-23 DESIRE LINE OF ALL TYPE VEHICLES

From the result of desire line of passenger car, the short-length or mid-length trip is major trip of passenger trip. In particular, the large OD pair is the trip between Kathmandu and Dhading district (zone 7), Western-north (zone 2) and Central west 2 (zone 6).



Passenger Car (Veh./day)

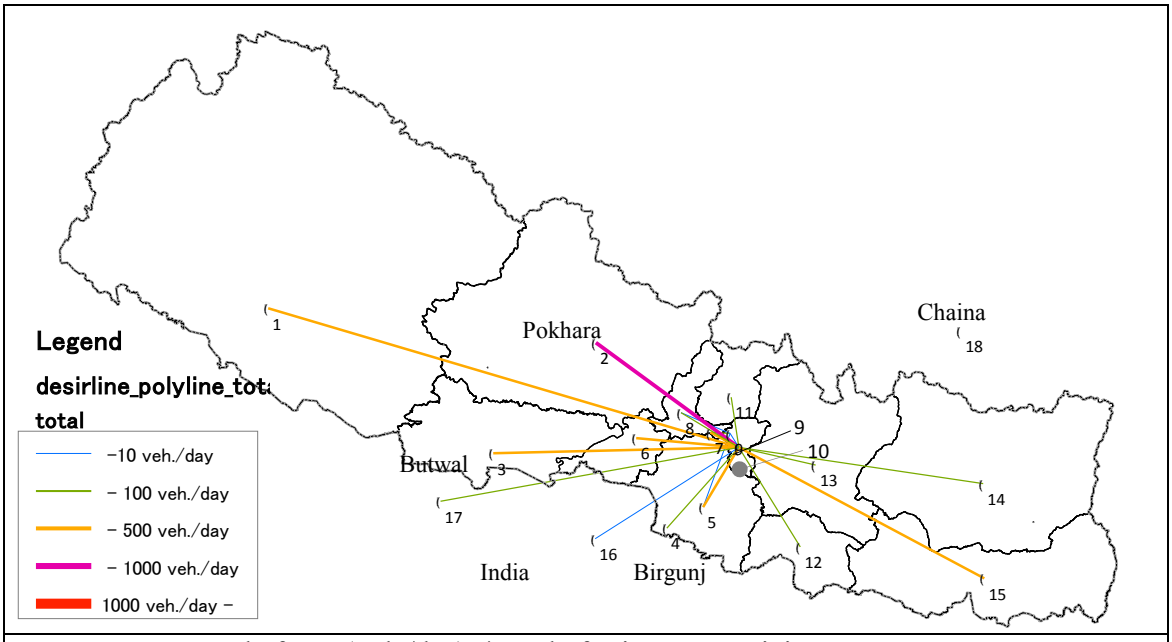


Passenger Car (%)

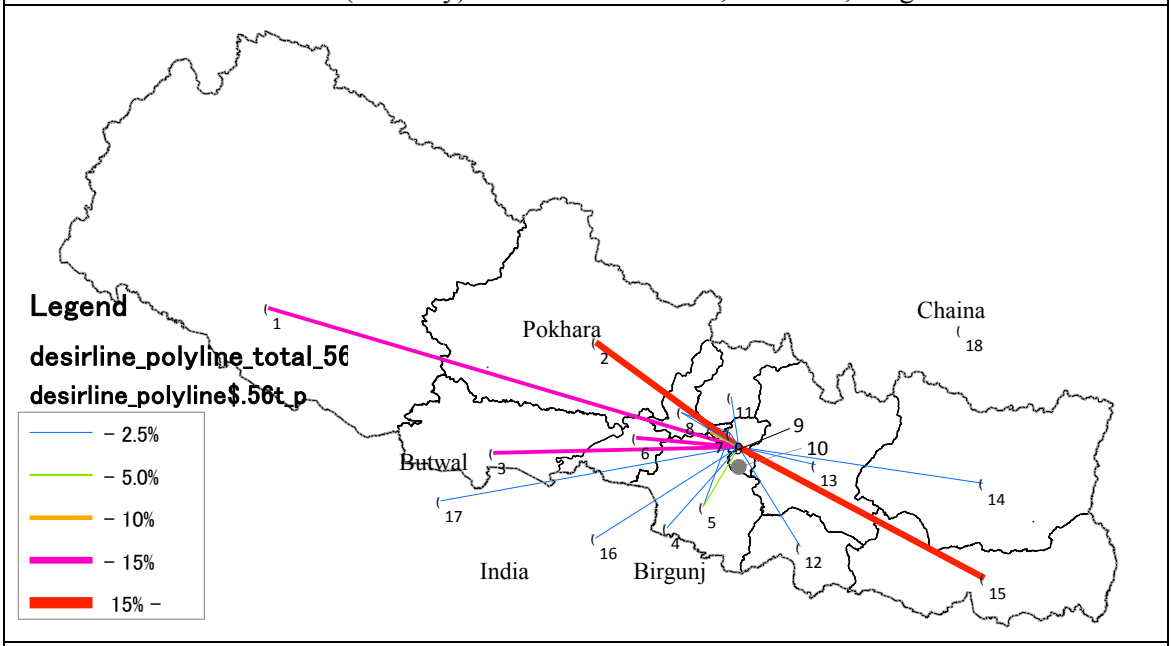
Source: JICA Study Team

FIGURE 5.1-24 DESIRE LINE OF PASSENGER CAR

Regarding the trip of bus that are used mainly for tourist trip, although the major OD pair is from /to Western-north (zone 2), long trip from Far and mid-western region (zone 1) and Eastern region (zone 15) is observed.



Total of Bus (Veh./day) *Total of Micro Bus, Mini Bus, Large Bus

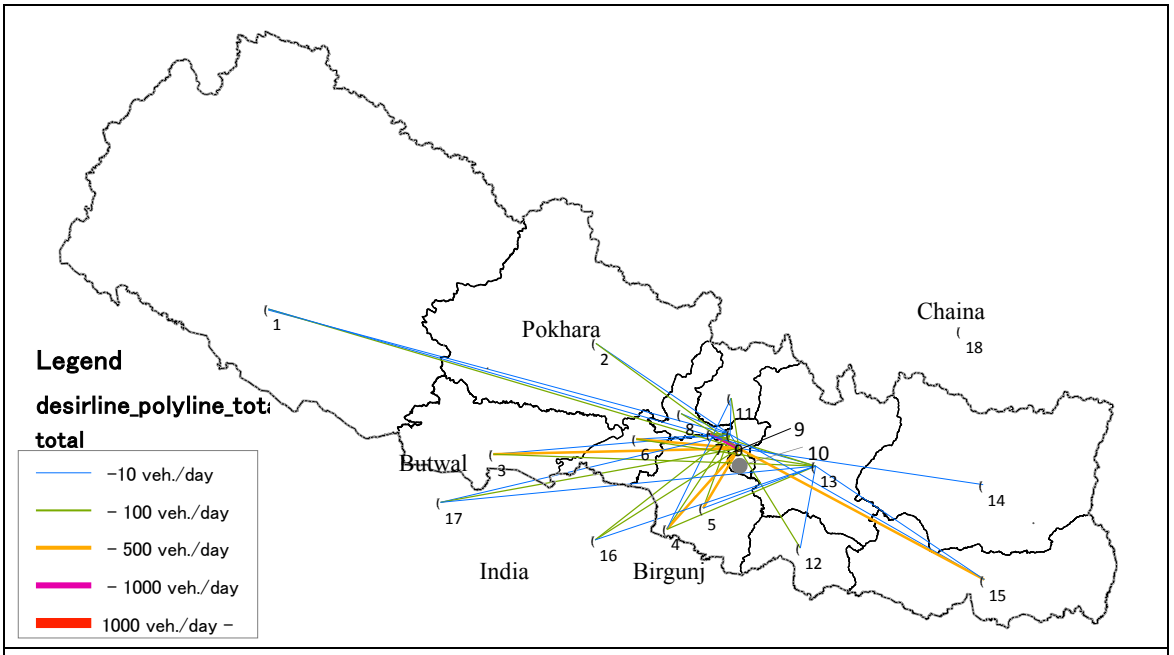


Total of Bus (%) *Total of Micro Bus, Mini Bus, Large Bus

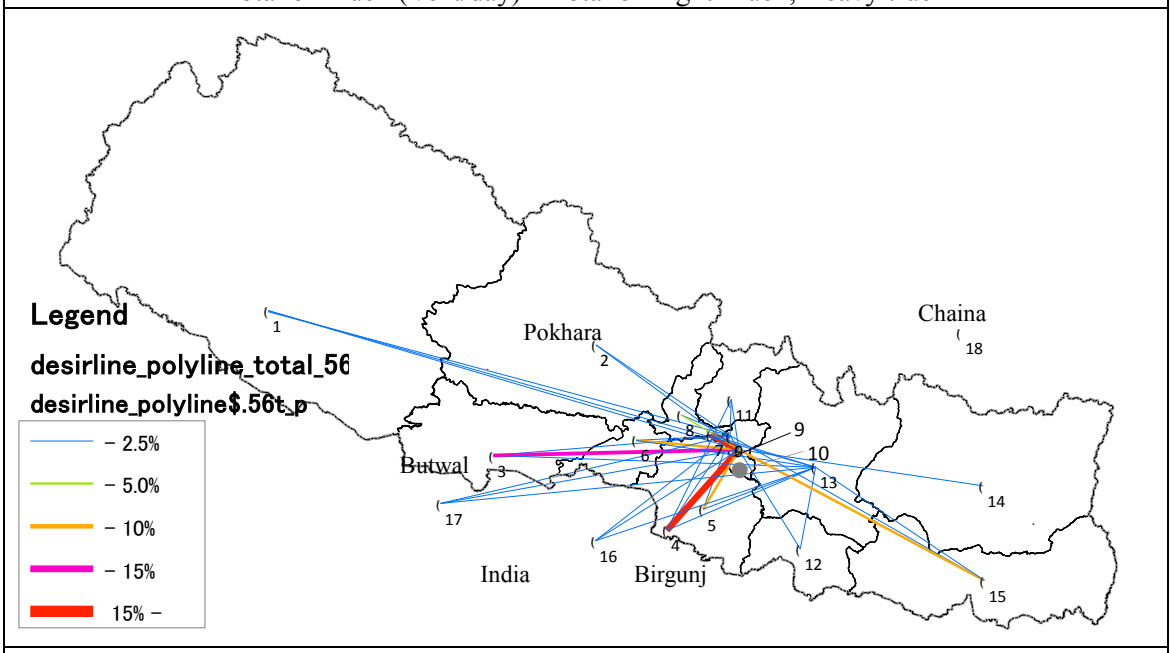
Source: JICA Study Team

FIGURE 5.1-25 DESIRE LINE OF BUS

As regards the freight traffic mainly of heavy truck, two type of trip characteristic was observed. Firstly, it is the traffic between south area near the Indian border such as Birgunji ICD (zone 4) and Western-south (zone 3) including Siddharthanagar ICD. Secondly, the short length trip between Dhading and Kathmandu is observed.



Total of Truck (Veh./day) *Total of Light Truck, Heavy truck



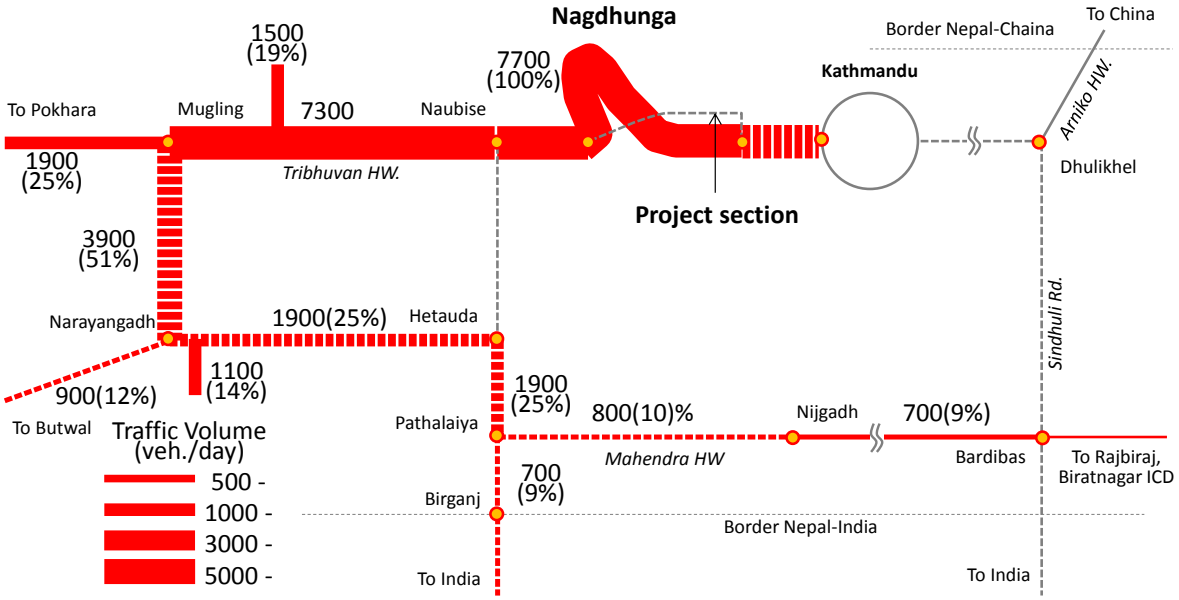
Total of Truck (%) * Total of Light Truck and Heavy truck

Source: JICA Study Team

FIGURE 5.1-26 DESIRE LINE OF TRUCK

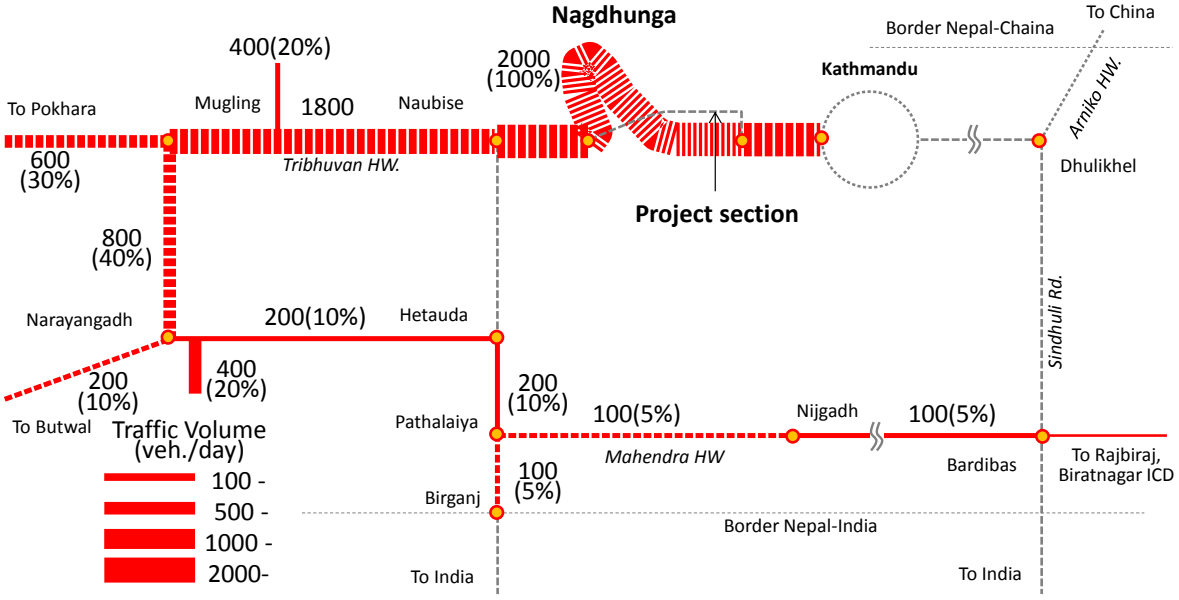
(3) Traffic flow passing Nagdhunga road section

Based on the traffic survey result, the traffic flow passing Nagdhunga is shown in this section. **Figure 5.1-27** illustrates the traffic flow of total of all vehicles passing Nagdhunga. **Figure 5.1-28** illustrates the traffic flow of passenger car.



Source: JICA Study Team

FIGURE 5.1-27 TRAFFIC FLOW OF TOTAL OF ALL VEHICLES

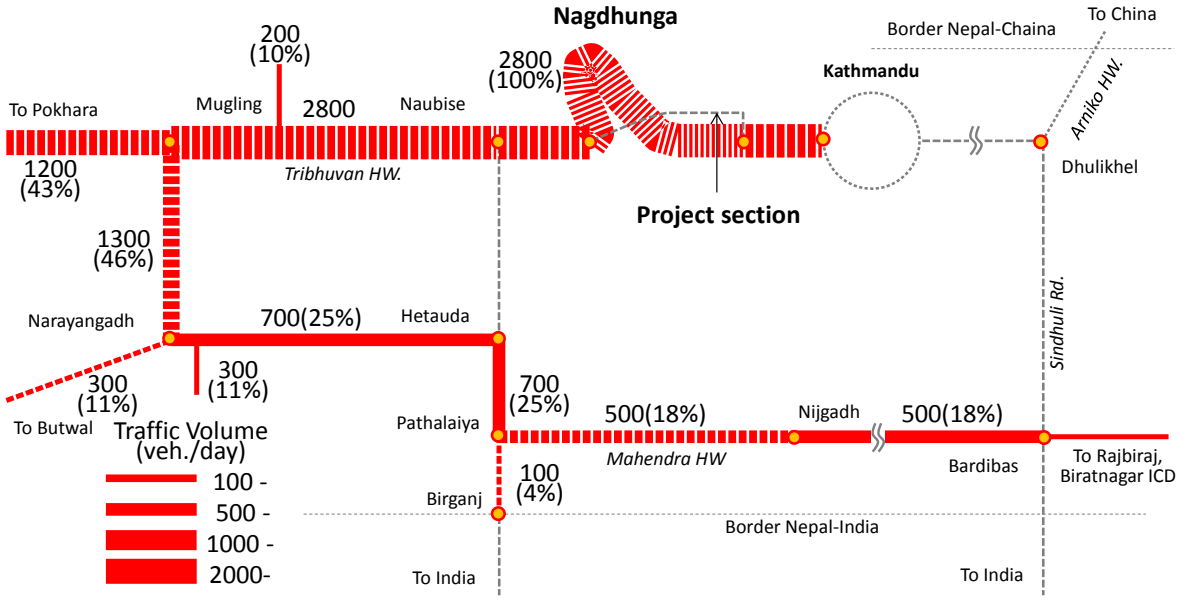


Source: JICA Study Team

FIGURE 5.1-28 TRAFFIC FLOW OF PASSENGER CAR

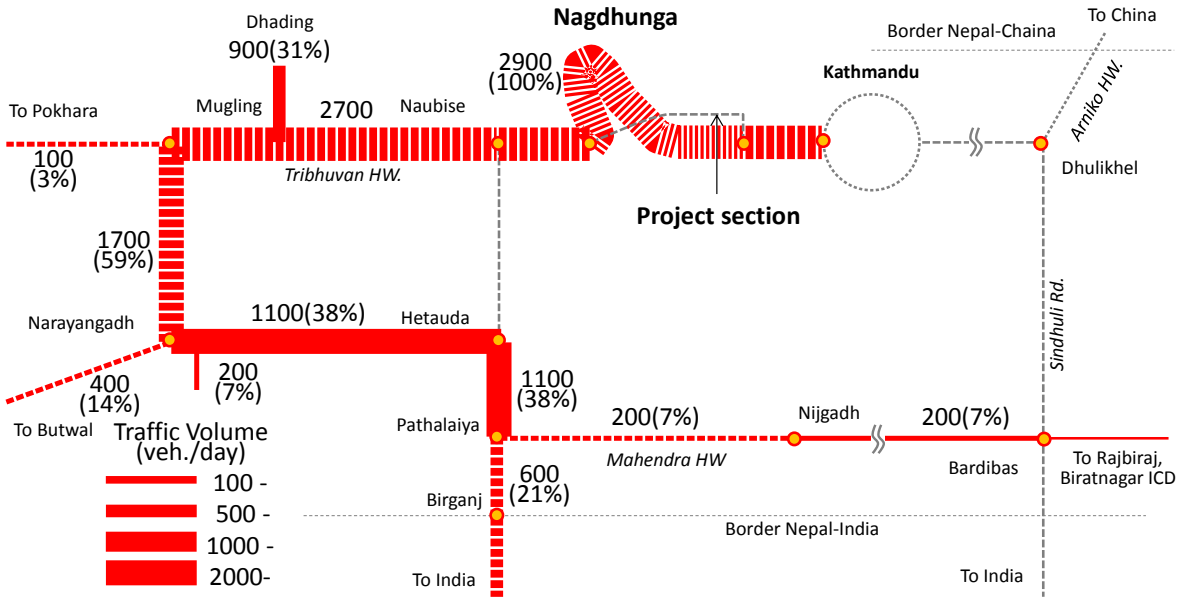
Figure 5.1-29 illustrates the traffic flow of bus. 43% of total bus traffic come from / to western region including Pokhara. The other is traffic of south area of Nepal.

Regarding the freight flow**, Figure 5.1-30** illustrates the traffic flow of truck. Around 60% of total truck is from / to south area of Nepal. Traffic of starting from Birganj ICD including the freight of India is largest traffic.



Source: JICA Study Team

FIGURE 5.1-29 FLOW OF BUS (TOTAL OF THREE TYPE OF BUS)



Source: JICA Study Team

FIGURE 5.1-30 TRAFFIC FLOW OF TRUCK (TOTAL OF LIGHT TRUCK AND HEAVY TRUCK)

5.1.5 Commodity flow

The estimated commodity flow in 2013 based on customs data is shown in **Figure 5.1-31** and **Figure 5.1-32**. The data is value basis. In the import, the around 60% of import commodities including air cargo are imported through Birgunj ICD. And 44% is passing Nagdhunga section to transport to mainly Kathmandu valley. On the other hand, the freight that is passing Nagdhunga section is only 10% of total export.

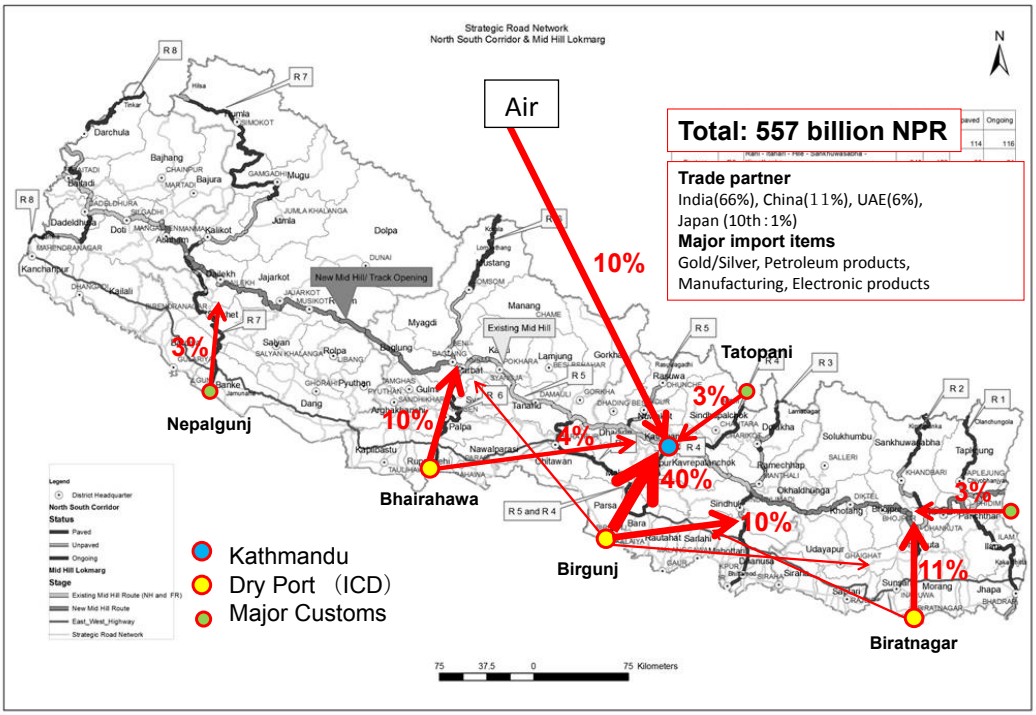
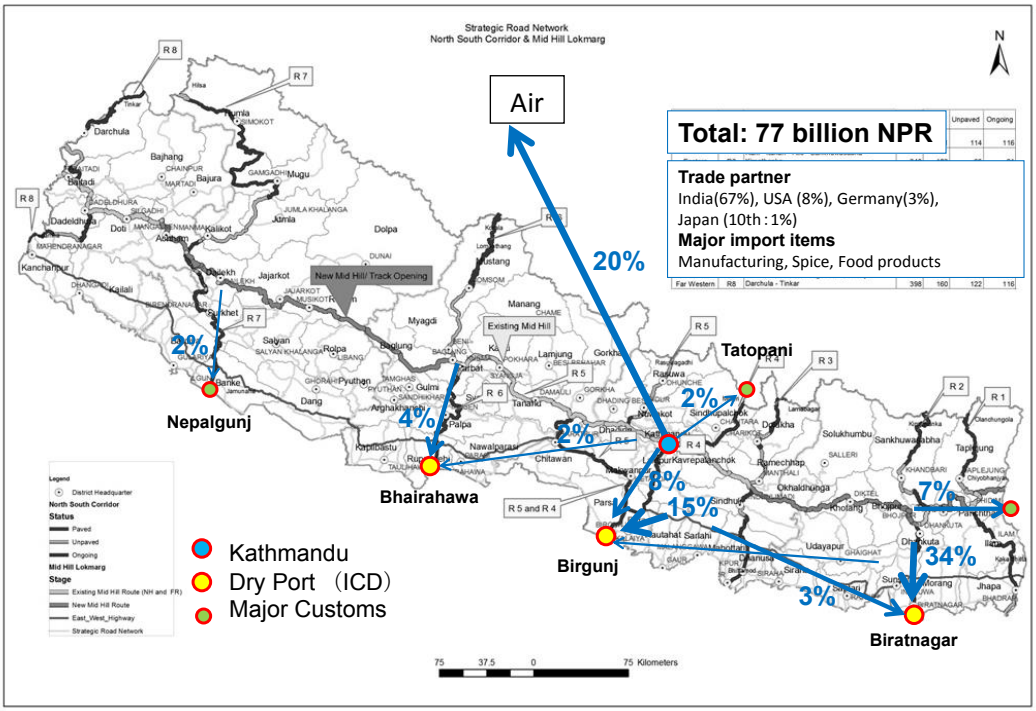


FIGURE 5.1-31 COMMODITY FLOW OF IMPORT IN 2013



Source: JICA Study Team Based On Customs Data

FIGURE 5.1-32 COMMODITY FLOW OF EXPORT IN 2013

5.1.6 Axle Load

(1) Purpose and Survey Method

The Axle load survey was carried out to collect the actual loading data of heavy vehicle and for the basic information of pavement design. The survey equipment is manual weight scale.

(2) Survey Result

1) Ratio of loading truck and empty truck

The 97% of Heavy truck of eastbound, which is into Kathmandu, is loaded. In contrast, the empty truck accounts 87 % in the direction out of the Kathmandu. In total of road section, the ratio of empty is 52%.

TABLE 5.1-15 LOADING END EMPTY RATIO OF TRUCK AT NAGDHUNGA

	Westbound	Eastbound	Total
Loaded	13%	97%	48%
Empty	87%	3%	52%
Total	100%	100%	100%

Source: JICA Study Team

(3) Gross Vehicle Load

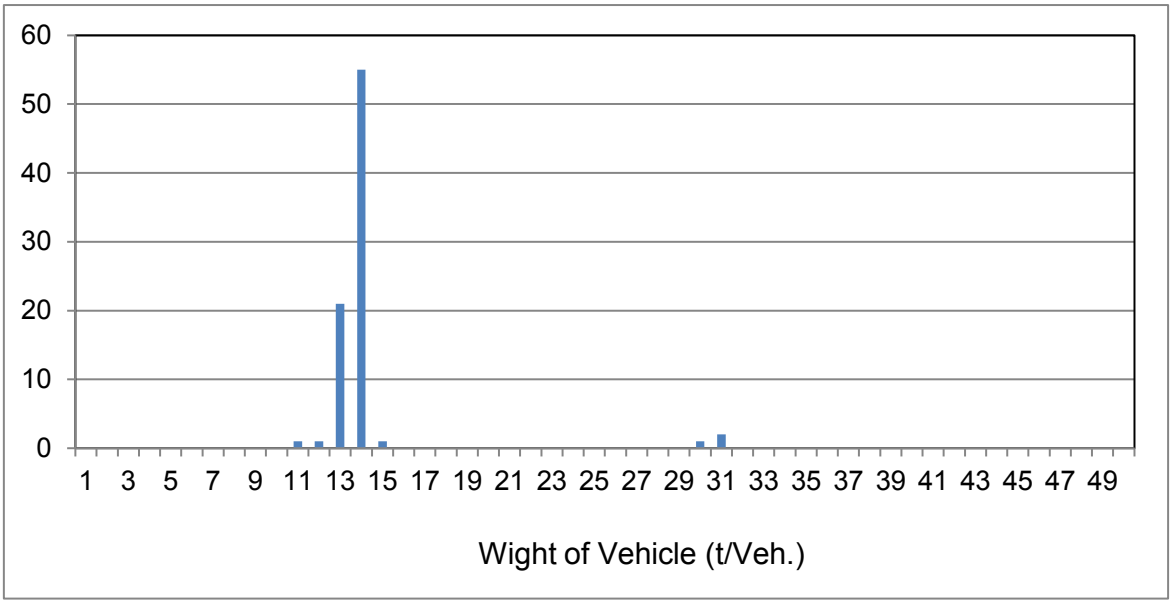
The result of gross vehicle load is shown in **Table 5.1-16**. The gross bus weight is 15 ton at the both direction. The result of gross truck load has the clear difference between directions. The weight of 2 axle truck at the eastbound is 18 ton and that of westbound is 12 ton. The weight of 3 axles truck at the eastbound is 32 ton and that of westbound is 21 ton. In the section, the weight of 2 axle truck is 15 ton, and 3 axles is 30 ton. This difference is resulted from the empty truck ratio mentioned in previous section. Distribution chart of bus is illustrated in **Figure 5.1-33**. Distribution chart of truck is illustrated in **Figure 5.1-34**. Distribution charts of gross vehicle load by type of vehicle and direction are illustrated in **Figure 5.1-35**.

.

TABLE 5.1-16 AVERAGE GROSS VEHICLE LOAD

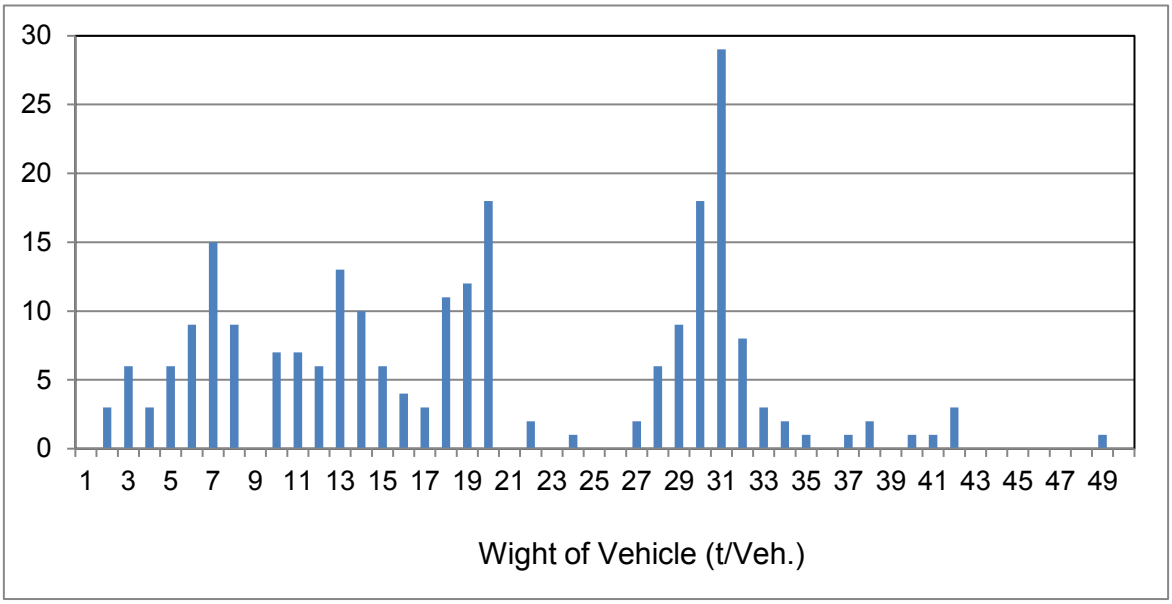
Direction	Bus (t)	Truck (t)		
		2 axle Truck	3 axle Truck	Total of Truck
East Bound	15	18	32	28
West Bound	15	12	21	17
Total	15	15	30	25

Source: JICA Study Team



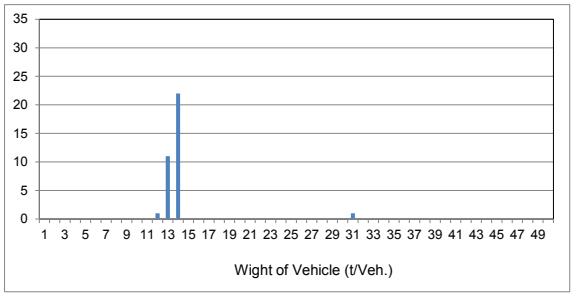
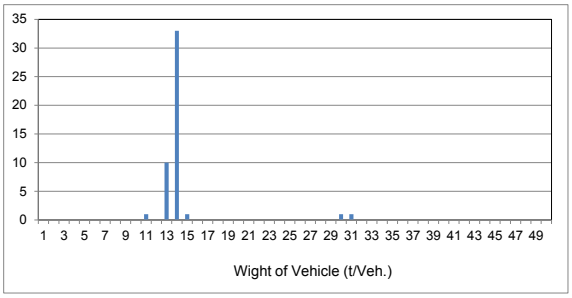
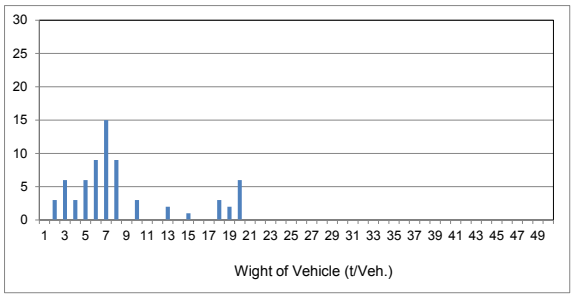
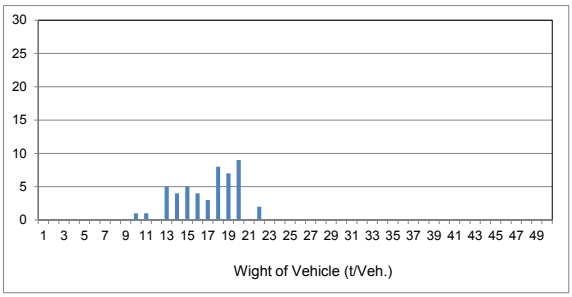
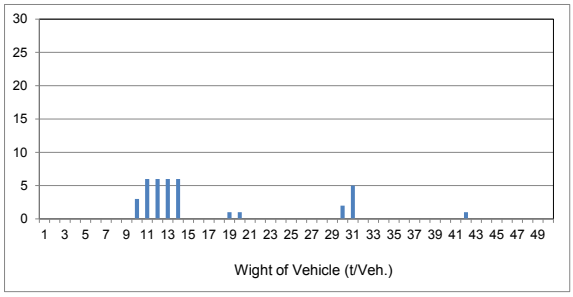
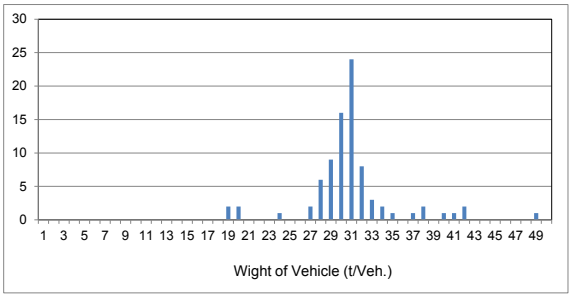
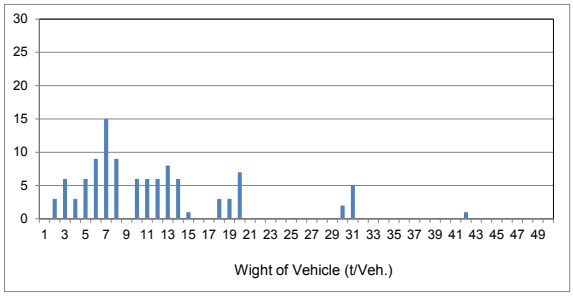
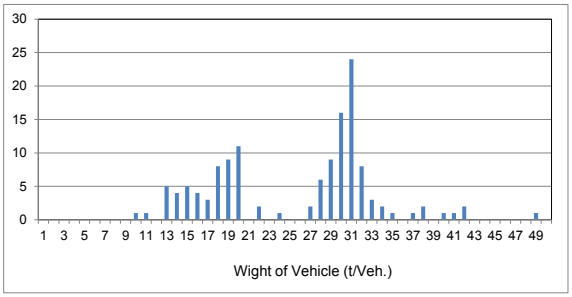
**Total of eastbound and westbound*
Source: JICA Study Team

FIGURE 5.1-33 DISTRIBUTION OF GROSS VEHICLE LOAD OF BUS



**Total of eastbound and westbound*
Source: JICA Study Team

FIGURE 5.1-34 DISTRIBUTION OF GROSS VEHICLE LOAD OF TRUCK

 Tandem Axle Bus	 Tandem Axle Bus
 Tandem Axle Truck	 Tandem Axle Truck
 Tridem Axle Truck	 Tridem Axle Truck
 Total	 Total
Westbound	Eastbound

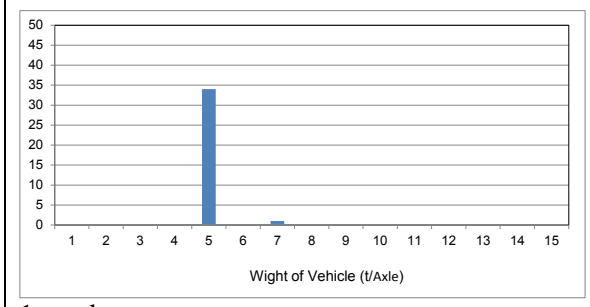
Source: JICA Study Team

FIGURE 5.1-35 DISTRIBUTION OF GROSS VEHICLE LOAD BY DIRECTION

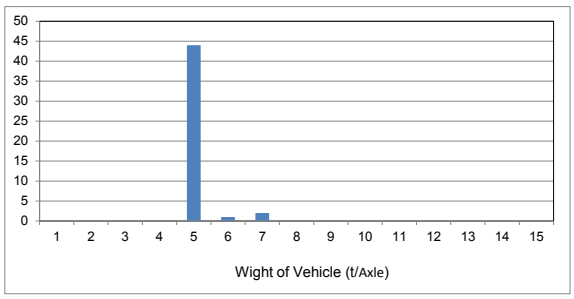
(4) Axle Load

1) Bus

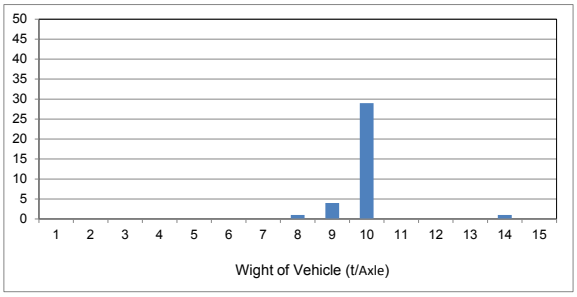
Distribution charts of axle load of bus by direction are illustrated in **Figure 5.1-36**. The mode of first axle is 5t and the mode of second axle is 10t. Both directions are the same trend.



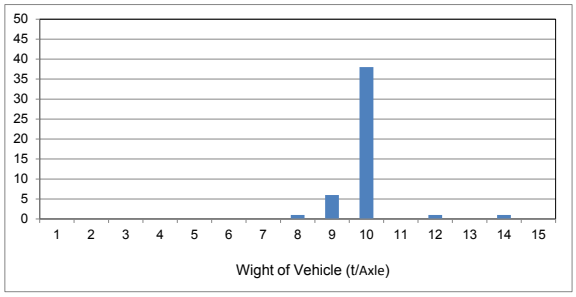
1st axle



1st axle



2nd axle



2nd axle

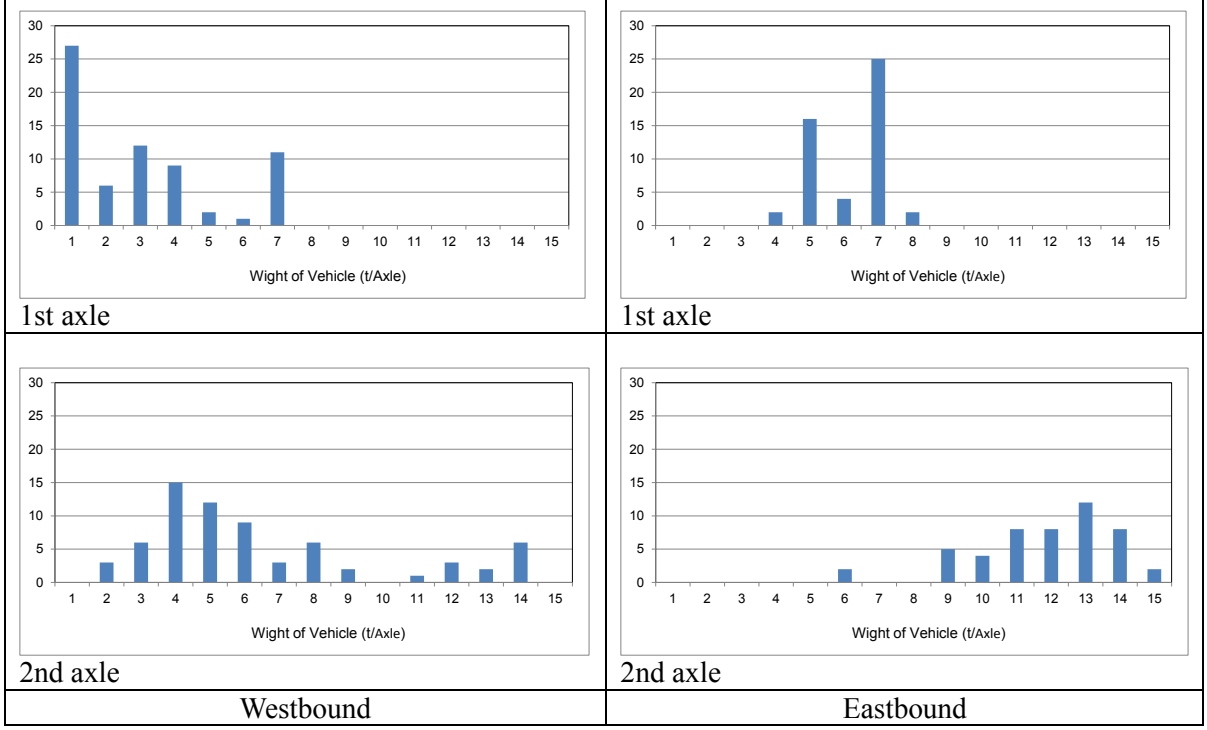
Westbound	Eastbound

Source: JICA Study Team

FIGURE 5.1-36 DISTRIBUTION OF AXLE LOAD OF BUS

2) Tandem Axle Truck

Distribution charts of axle load of tandem axle truck by direction are illustrated in **Figure 5.1-37**. On westbound, the load of first axle is distributed between 1 tons to 7 tons. The load of second axle is distributed between 2 tons to 14 tons. On eastbound, the load of first axle is distributed between 4 tons to 8 tons. the load of second axle is mainly distributed between 9 tons to 15 tons.

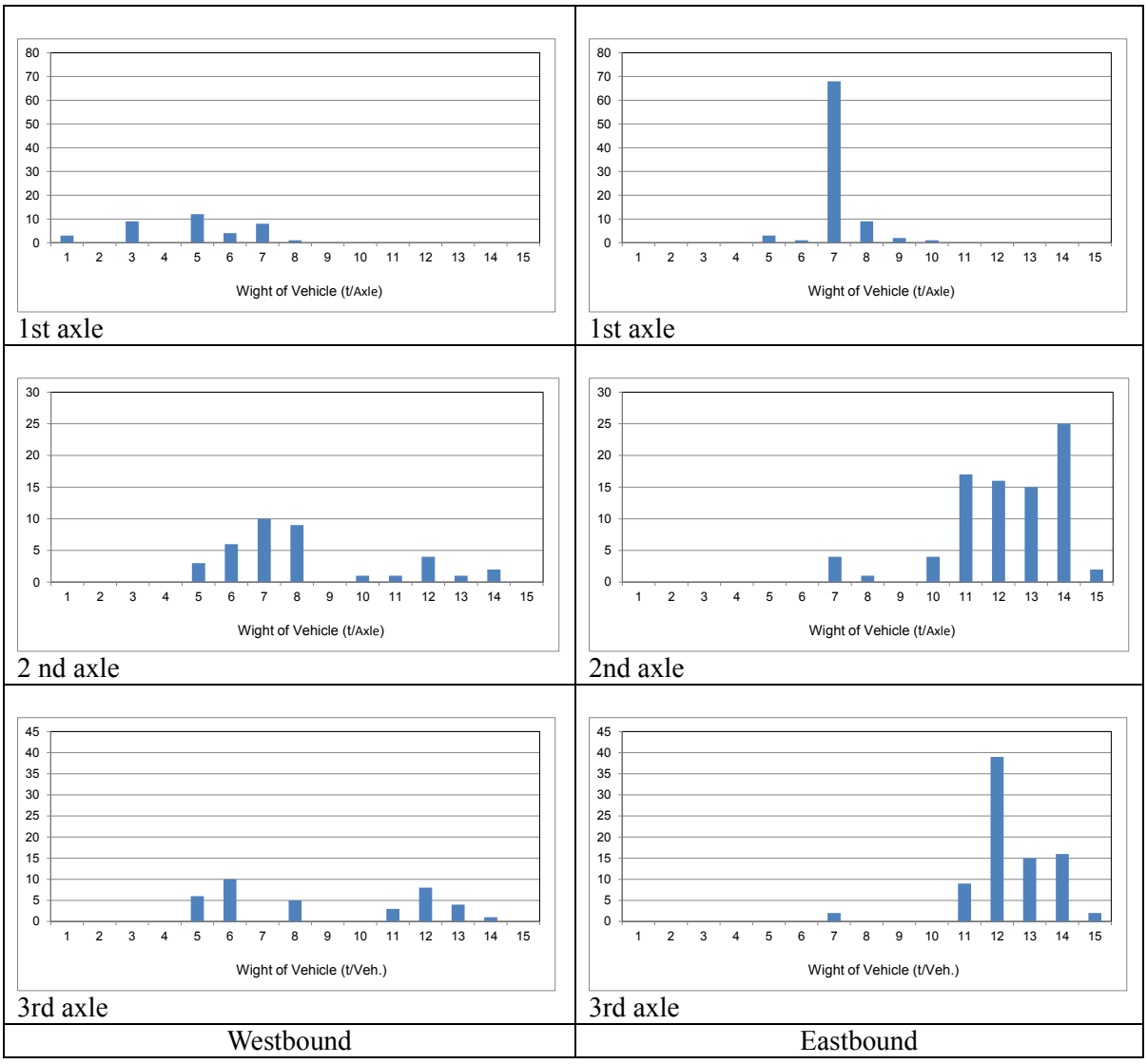


Source: JICA Study Team

FIGURE 5.1-37 DISTIBUTION OF AXLE LOAD OF TANDEM AXLE TRUCK

3) Tridem Axle Truck

Distribution charts of axle load of tridem axle truck by direction are illustrated in **Figure 5.1-38**. On westbound, the load of first axle is distributed mainly between 3 tons to 7 tons. The load of second and third axle is distributed between 5 tons to 14 tons. On eastbound, the load of first axle is distributed between 4 tons to 8 tons. the load of second and third axle is mainly distributed between 11 tons to 14 tons. The difference between the direction-trend is due to the high rate of empty rate on the westbound direction.



Source: JICA Study Team

FIGURE 5.1-38 DISTRIBUTION OF AXLE LOAD OF TRIDEM AXLE TRUCK

5.1.7 Vehicle Emission Gas

(1) Purpose and survey method

The vehicle emission test was carried out in order to obtain the emission volume by vehicle type. The intended gas for test is CO, NOx and SOx and each gas were measured by vehicle type under the condition of the idling and 3,000 r/min of engine revolutions. The emission test was conducted at Station 2 Nagdhunga for three days. The measuring instruments is the flue gas analyzer HT-2700 produced by Hodaka Co. Ltd.

Source: JICA Study Team, July 2014

PHOTO 5.1-5 CURRENT SITUATION OF EMISSION GAS FROM VEHICLE

(2) Survey result

The emission gas test result by vehicle type is shown in **Table 5.1-17**. The result of all type of gas and vehicle has high concentration. It can be supposed that the poor combustion efficiency of vehicle is one of the causes. The volume of emission gas will be increased on the uphill section where the large engine speed is required. Regarding CO, the gas concentration in the passenger cars and buses shows a relatively low value. But, the emission from heavy truck shows a high concentration which exceeds 5.0% at idling. In the exhaust gas regulation of 1970 in Japan, the acceptable limit of the carbon monoxide concentration at the time of idling is 4.5%. Regarding NO_X, the gas concentration of large bus and large truck, more than 200 ppm, is very high result. This level corresponds approximately to the emission standard of coal-fired boiler in Japan.

TABLE 5.1-17 RESULT OF VEHICLE EMISSION GAS TEST

Type of Veh.	Condition of engine	CO [%]	NOx [ppm]	SO_2 [ppm]
Car	3,000 r/min	6.0%	117	8
	Idling	1.6%	83	3
Large Bus	3,000 r/min	7.2%	263	9
	Idling	2.2%	209	5
Heavy Truck	3,000 r/min	9.7%	237	15
	Idling	5.4%	204	7

Source: JICA Study Team

5.1.8 Traffic Accidents and Breakdown Vehicles

According to traffic police, traffic accident of 241 is generated in the year of 2013 on Nagdhunga section. This number of accident is high ratio that corresponds approximately to 2 times per 3 days. Half of the total number of accidents has led to casualties accidents. Poor vertical, poor horizontal curvature and narrow road width has been pointed out to be an accident factor.

Regarding breakdown vehicles, traffic police mentioned that around 5 vehicles can be observed every day at not only uphill direction also downhill section.

TABLE 5.1-18 NUMBER OF VEHICLE INVOLVED IN ACCIDENTS ON NAGDHUNGA SECTION

	Truck	Bus	Car	Motor Cycle	Total
Num. of vehicle involved in accidents	87	51	66	37	241

Source: Nepal traffic office, Nagdhunga police station

TABLE 5.1-19 NUMBER OF PEOPLE INVOLVED IN ACCIDENTS ON NAGDHUNGA SECTION

	Death	Major injured	Minor injured	Total
Num. of people involved in accidents	10	20	101	131

Source: Nepal traffic office, Nagdhunga police station

Locals watching a site where a truck hit a house in Pipalmode on the Naubise-Nagdhunga road section along Prithvi Highway, killing a couple on the spot, on Sunday night.

Source: The Himalayan times, 1 July, 2014

FIGURE 5.1-39 NEWSPAPER ARTICLE THAT TELLS THE ACCIDENT AT NAGDHUNGA

Source: JICA Study Team

PHOTO 5.1-6 ACCIDENT VEHICLE AT NAGDHUNGA

5.1.9 Summary of Traffic Characteristics

Based on the traffic survey result, the main traffic characteristic, a traffic volume, a travel speed and OD pattern is summarized below.

Traffic Volume

- Annual average daily traffic of Nagdhunga section in 2014 was estimated 7,700 veh./day.
- Traffic volume of Nagdhunga is increasing with each passing year from 2007. The annual growth rate is 6.7%.

Traffic composition

- The high ratio of heavy vehicle ratio, which is 48%, of Nagdhunga section is a feature of the traffic of this road. (without motor cycle case).
- The ratio of freight vehicle shows 37% of total volume. It can be explained that this road plays role as major logistics network road.

Travel speed:

- It also became clear that vehicles are forced to a low-speed running on this section. Especially, the travel speed of loading truck to Kathmandu direction, around 10 km/hr. is very low. This is equivalent to a 35 minutes driving for 8 kilometers distance on existing road.

OD pattern:

- Main traffic that pass Nagdhunga section is trip between Kathmandu, the capital of Nepal, and Western region or south area of Central region.
- Main trip of Passenger car and bus is Pokhara direction. On the other hand, the main trips of freight, especially heavy truck, is direction of Birgunji where is gateway of logistics to / from India.

5.2 FUTURE TRAFFIC DEMAND FORECAST

5.2.1 Approach

In this section, the future traffic demand is estimated based on socio-economic framework in Nepal and traffic survey conducted by study team. Firstly, the socio-economic framework related to traffic demand is reviewed.

And next, traffic growth of year 2020 and 2030 is estimated using the socio-economic framework. At last, traffic volume of Nagdhunga tunnel section is predicted considering traffic assignment between Nagdhunga tunnel section and competitive road such as existing road or new construction road.

5.2.2 Socio-economic Framework

Predicting the future traffic demand, the socio-economic framework of related indicator is set based on the trend of past statistical data and on the plan by each authorities of Nepal government. Related indicators set are population, number of tourist, GDP, GDP of tertiary sector shown in Tables below.

TABLE 5.2-1 FRAMEWORK OF POPULATION

year	Central Region (million)	*Growth rate*	Western Region (million)	*Growth rate*
2001	8.0	-	4.6	-
2011	9.7	*1.9%*	4.9	*0.8%*
2020	11.4	*1.8%*	5.2	*0.5%*
2030	13.5	*1.5%*	5.5	*0.5%*
2035	14.6	*1.5%*	5.6	*0.5%*

Source: CBS, Study team estimation

TABLE 5.2-2 FRAMEWORK OF NUMBER OF TOURIST

year	Number of Tourist (thousand)	*Growth rate*
2001	343	-
2011	718	*7.7%*
2020	1,406	*7.7%*
2030	2,777	*7.0%*
2035	3,664	*5.7%*

Source: Ministry of culture, tourism and civil aviation and study team estimation

TABLE 5.2-3 FRAMEWORK OF GDP

year	GDP (billion)	*Growth rate*
2001	430	-
2011	636	*4.0%*
2020	920	*4.2%*
2025	1,066	*3.0%*
2030	1,177	*2.0%*
2035	1,237	*1.0%*

**At basic price (constant)*
Source: Economic survey (Ministry of finance), Study team estimation based on Nepal government

TABLE 5.2-4 FRAMEWORK OF GDP OF TERTIORY SECTOR

year	GDP of Tertiary Sector (billion)	*Growth rate*
2001	194	-
2011	322	*5.2%*
2020	516	*5.4%*
2025	643	*4.5%*
2030	764	*3.5%*
2035	907	*3.5%*

**At basic price (constant)*
Source: Economic survey (Ministry of finance), Study team estimation based on Nepal government

5.2.3 Estimation of Traffic Growth

It is known that economic activity and change such as population increasing generates traffic growth. In this section, the future traffic of Nagdhunga in case of business as usual is predicted based on regression analysis between traffic data and related indicators estimated in framework study on previous section. This estimation is conducted by vehicle type.

(1) Passenger vehicle

Intended vehicle is Car, Microbus, and Mini bus is Car, Micro bus, and Mini bus.

This type car is used for relatively short and middle distance trip. As an indicator related to the traffic increase, the total population of Central region and Western region is selected. The forecasting model estimated is below.

$$\textit{Number of passenger}\ \text{vehicle} = 603.52 * \textit{Population (million)} - 5932 \quad R^2 = 0.87$$

TABLE 5.2-5 ESTIMATION RESULT OF PASSENGER VEHICLE

year	Passenger vehicle	*Growth rate*
2011	2,900	-
2014	3,200	*3.3%*
2020	4,100	*3.6%*
2030	5,500	*3.2%*
2035	6,200	*2.5%*

Source: JICA Study Team

(2) Large size tourist bus

Intended vehicle is heavy bus calcified in traffic count survey. As an indicator related to the traffic increase of tourist bus, the number of tourist and GDP of tertiory sector is selected. The forecasting model estimated is below.

*Traffic of passenger car = 1.66*Number of tourist (thousand)* R^2*=0.88*

TABLE 5.2-6 ESTIMATION RESULT OF HEAVY BUS

year	Heavy Bus	*Growth rate*
2011	1,200	-
2014	1,400	*5.3%*
2020	1,900	*5.2%*
2030	2,800	*4.0%*
2035	3,300	*3.0%*

Source: JICA Study Team

(3) Freight vehicle

Intended vehicle is trucks including light truck and heavy truck. As an indicator related to the traffic increase of freight vehicle, GDP of Nepal is selected. The forecasting model estimated is below.

*Number of Freight Vehicle = 4.93*GDP (billion) – 768 R2=0.90*

TABLE 5.2-7 ESTIMATION RESULT OF FREIGHT VEHICLE

year	Freight Vehicle	*Growth rate*
2011	2,400	-
2014	2,800	*5.3%*
2020	3,700	*4.8%*
2030	5,000	*3.1%*
2035	5,600	*2.3%*

Source: JICA Study Team

5.2.4 Future Traffic Demand

(1) Traffic Growth Rate

Referring to the traffic modeling result based on socio-economic framework, Annual Traffic growth rate was set for short-term (2014-2020), mid-term (2020-2030), Long-term (2030-2035) in shown **Table 5.2-8**. Then, average annual growth rate that of short-term is 4.1%, that of mid-term is 3.2%, long-term is 2.4%. Future traffic demand is estimated by multiplying the traffic growth rate in traffic volume of 2014 observed in traffic count survey.

TABLE 5.2-8 TRAFFIC GROWTH RATE OF NAGDHUNGA SECTION

	AGR(2014-2020)	AGR(2020-2030)	AGR(2030-)
Passenger Car	3.5%	3.0%	2.5%
Micro Bus	3.5%	3.0%	2.5%
Mini Bus	3.5%	3.0%	2.5%
Heavy Bus	5.0%	4.0%	3.0%
Light Truck	4.5%	3.0%	2.0%
Heavy truck	4.5%	3.0%	2.0%
Average	4.1%	3.2%	2.4%

Source: JICA Study Team

(2) Effects of Toll Collection and tunnel utilization ratio

To identify the impact of toll collection to tunnel user, the opinion survey is conducted on Nagdhunga of existing road. This opinion survey consists of the questionnaire about a willing to pay of tunnel utilization in case of 30NPR for passenger vehicle. Samples of 300 per each direction are collected. The result is shown in **Table 5.2-9**.

According to the result of opinion survey, the user of passenger car more than 90% answered to accept this level of toll charge. Road user of east bound is more positive rather than westbound. This result is supposed that almost user has the will to choice the tunnel route to avoid the uphill section and long distance driving if 30NPR charged.

TABLE 5.2-9 OPINION SURVEY ABOUT TUNNEL UTILIZATION TO PASSENGER CAR USER

Response	Naubise to Kathmandu		Kathmandu to Naubise	
	Eastbound		Westbound	
Yes	293	98%	277	92%
No	7	2%	23	8%
Total	300	100%	300	100%

Source: JICA Study Team based on Opinion Survey

According to the interview to truck owner that is charge of transship between Kathmandu and Birganj that is town of border with India, they also mentioned to use positively the new tunnel route if 40 NPR of toll fee. Based on the result of opinion survey, tunnel utilization ration is set shown in **Table 5.2-10**. Ration is estimated less than survey result. And also, the ration of westbound is lower than that of eastbound. Some drivers will choice the existing road to save the toll fee.

TABLE 5.2-10 TUNNEL UTILIZATION RATIO FOR TOTAL TRAFFIC OF NAGDHUNGA SECTION

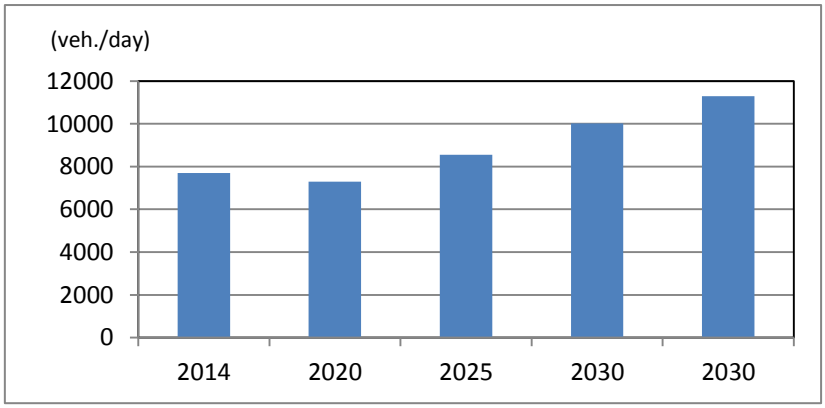
	AGR(2014-2020)		AGR(2020-2030)		AGR(2030-)	
	Eastbound	Westbound	Eastbound	Westbound	Eastbound	Westbound
Passenger Car	80%	70%	80%	70%	80%	70%
Micro Bus	80%	70%	80%	70%	80%	70%
Mini Bus	0%	0%	0%	0%	0%	0%
Heavy Bus	90%	80%	90%	80%	90%	80%
Light Truck	80%	70%	80%	70%	80%	70%
Heavy truck	90%	80%	90%	80%	90%	80%
Average	74%		74%		74%	

Source: JICA Study Team

(3) Future demand forecast in BAU case

In this section, the business as usual case which is not considered developments of competitive road such as fast truck, Sindhuli road. **Table 5.2-11** shows the result of future demand forecast in business as usual case. The traffic volume is calculated as the result of multiplication with traffic count survey and growth rate and tunnel utilization ratio. If there are no developments of competitive roads, it is clear that all traffic have to transit at Nagdhunga section.

The result of estimation indicated that traffic demand in 2020 is 7,301 veh./day, 8,552 veh./day in 2025, 10,021 veh/day in 2030.



Source: JICA Study Team

FIGURE 5.2-1 FUTURE TRAFFIC DEMAND ON TUNNEL SECTION IN BAU CASE (VEH/DAY)

TABLE 5.2-11 FUTURE TRAFFIC DEMAND (BUSINESS AS USUAL CASE)

Future Traffic Volume (Business as Usual Case) ①=②+③

	2014			2022			2025			2030			2035			AAGR* (2014-2020)		AAGR* (2020-2030)		AAGR* (2030-)	
	Eastbound	Westbound	Total	Eastbound	Westbound	Total	Eastbound	Westbound	Total	Eastbound	Westbound	Total	Eastbound	Westbound	Total	East	West	East	West	East	West
Passenger Car	959	1,036	1,996	1,263	1,365	2,628	1,367	1,477	2,844	1,585	1,712	3,297	1,793	1,937	3,730	3.5%	3.5%	3.0%	3.0%	2.5%	2.5%
Micro Bus	389	528	917	512	696	1,208	555	753	1,307	643	873	1,516	727	988	1,715	3.5%	3.5%	3.0%	3.0%	2.5%	2.5%
Mini Bus	227	344	571	299	453	752	324	490	814	375	568	944	425	643	1,068	3.5%	3.5%	3.0%	3.0%	2.5%	2.5%
Heavy Bus	639	715	1,354	944	1,057	2,001	1,042	1,166	2,208	1,268	1,419	2,686	1,470	1,645	3,114	5.0%	5.0%	4.0%	4.0%	3.0%	3.0%
Light Truck	444	127	571	631	181	812	670	192	862	777	223	1,000	858	246	1,104	4.5%	4.5%	3.0%	3.0%	2.0%	2.0%
Heavy truck	939	1,355	2,294	1,335	1,928	3,263	1,417	2,046	3,464	1,643	2,372	4,015	1,814	2,619	4,433	4.5%	4.5%	3.0%	3.0%	2.0%	2.0%
Total	3,597	4,107	7,704	4,985	5,679	10,664	5,375	6,125	11,499	6,291	7,167	13,458	7,086	8,077	15,164	4.1%		3.0%		2.4%	

Number of Vehicles on Tunnel Section ②

	2014			2022			2025			2030			2035			Tunnel utilization ratio (2014-2020)		Tunnel utilization ratio (2020-2030)		Tunnel utilization ratio (2035-)	
	Eastbound	Westbound	Total	Eastbound	Westbound	Total	Eastbound	Westbound	Total	Eastbound	Westbound	Total	Eastbound	Westbound	Total	East	West	East	West	East	West
Passenger Car	-	-	-	1,010	955	1,966	1,093	1,034	2,127	1,268	1,199	2,466	1,434	1,356	2,790	80%	70%	80%	70%	80%	70%
Micro Bus	-	-	-	410	487	897	444	527	971	514	611	1,125	582	691	1,273	80%	70%	80%	70%	80%	70%
Mini Bus	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0%	0%	0%	0%	0%	0%
Heavy Bus	-	-	-	850	845	1,695	938	933	1,871	1,141	1,135	2,276	1,323	1,316	2,638	90%	80%	90%	80%	90%	80%
Light Truck	-	-	-	505	127	632	536	135	671	621	156	777	686	172	858	80%	70%	80%	70%	80%	70%
Heavy truck	-	-	-	1,202	1,542	2,744	1,276	1,637	2,913	1,479	1,898	3,377	1,633	2,095	3,728	90%	80%	90%	80%	90%	80%
Total	-	-	-	3,977	3,957	7,933	4,287	4,265	8,552	5,023	4,998	10,021	5,658	5,631	11,288	74.4%		74.5%		74.4%	

Number of Vehicle on Existing road ③

	2014			2022			2025			2030			2035			Existing road ratio (2014-2020)		Existing road ratio (2020-2030)		Existing road ratio (2035-)	
	Eastbound	Westbound	Total	Eastbound	Westbound	Total	Eastbound	Westbound	Total	Eastbound	Westbound	Total	Eastbound	Westbound	Total	East	West	East	West	East	West
Passenger Car	-	-	-	253	409	662	273	443	716	317	514	831	359	581	940	80%	70%	80%	70%	80%	70%
Micro Bus	-	-	-	102	209	311	111	226	337	129	262	390	145	296	442	80%	70%	80%	70%	80%	70%
Mini Bus	-	-	-	299	453	752	324	490	814	375	568	944	425	643	1,068	0%	0%	0%	0%	0%	0%
Heavy Bus	-	-	-	94	211	306	104	233	337	127	284	411	147	329	476	90%	80%	90%	80%	90%	80%
Light Truck	-	-	-	126	54	181	134	58	192	155	67	222	172	74	245	80%	70%	80%	70%	80%	70%
Heavy truck	-	-	-	134	386	519	142	409	551	164	474	639	181	524	705	90%	80%	90%	80%	90%	80%
Total	-	-	-	1,009	1,722	2,731	1,088	1,859	2,947	1,267	2,169	3,436	1,429	2,447	3,876	25.6%		25.5%		25.6%	

**AGR: Annual average growth rate*

*** Eastbound (From Naubise to Kathmandu), Westbound (From Kathmandu to Naubise)*

Source: JICA Study Team

(4) Traffic Assignment

1) Road Network for Traffic Assignment

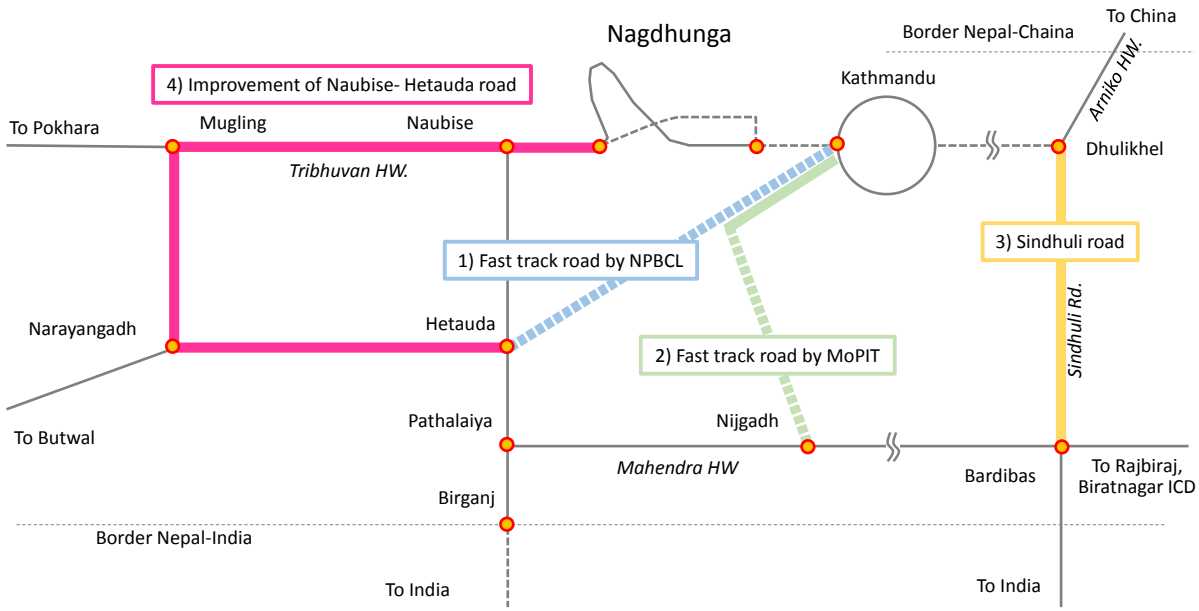
In this section, traffic assignment considering the competitive road is examined. Opening year of Nagdhunga tunnel is 2022. Traffic assignment is considered using future OD pattern based on current OD pattern passing Nagdhunga section.

The road considered for traffic assignment and the basic idea about traffic assignment, traffic diversion from Nagdhunga section to competitive road, is shown in **Table 5.2-12**. It have an assumption that other vehicle will use the tunnel section or existing road at Nagdhunga section.

TABLE 5.2-12 RELATED COMPETITIVE ROAD AND CONDITION OF ASSIGNMENT

Road	Development plan and impact to Nagdhunga section
1) Fast track road by NPBCL -Kathmandu Hetauda Tunnel Highway	This project is being developed by Nepal Purwadhar Bikash Company Ltd., (NPBCL) by BOOT schema. MoU between MoPIT and NPBCL is exchanged. Components: 3 tunnels 15 bridges. Road length: 59km. <Condition of assignement> - Opening year: 2031 - All traffic of zone 4, 12, 16 is shift to this road. - 20% of Traffic of zone 6 is shift to this road
2) Katumandu-Terai Fast track road by MoPIT	This road is a road that some parallel to the 1) Fast track road by NPBCL. In consideration of traffic assignment, is not taken into consideration as the road one) is preceded maintenance. This road is a road that some parallel to the 1) Fast track road by NPBCL. Road length: 76km.
3) Sindhuli road	This road connects between Kathmandu and Eastern-south area. In traffic assignment, it is considered that traffic of zone 13 (Eastern reagion_2) will be shift. Opening year: 2025
4) Improvement of Naubise-Hetauda road -Naubise-Mugling road -Mugling-Narayanghat road -Narayanghat- Hetauda road	This project is developed by World Bank finance. This road contributes to increase traffic of Nagdhunga section.

Source: Interview to DOR and existing report



Source: JICA Study Team

FIGURE 5.2-2 LOCATION OF RELATED ROAD NETWORK

2) Traffic Assignment Result

The result of traffic assignment is shown in **Table 5.2-13**. And traffic flow from 2022 to 2035 is illustrated in **Figure 5.2-3** – **Figure 5.2-6**. From result, the future traffic demand of Nagdhunaga tunnel section is estimated 7,900 veh./day in 2022, 8,100 veh./day in 2025, 9,500 veh./day in 2030, 8,300 veh./day in 2035.

TABLE 5.2-13 FUTURE TRAFFIC DEMAND (WITH COMPETITIVE ROAD CASE)

Future traffic volume (with Sindhuli Rd, Fast Track Rd.) ①=②+③

	2014			2022			2025			2030			2031			2035			AGR (2014-2020)		AGR (2020-2030)		AGR (2030-)	
	Eastbound	Westbound	Total	Eastbound	Westbound	Total	Eastbound	Westbound	Total	Eastbound	Westbound	Total	Eastbound	Westbound	Total	Eastbound	Westbound	Total	East	West	East	West	East	West
Passenger Car	959	1,036	1,996	1,263	1,365	2,628	1,326	1,433	2,759	1,537	1,661	3,199	1,405	1,518	2,922	1,550	1,675	3,226	3.5%	3.5%	3.0%	3.0%	2.5%	2.5%
Micro Bus	389	528	917	512	696	1,208	550	747	1,297	638	866	1,504	603	819	1,423	666	904	1,571	3.5%	3.5%	3.0%	3.0%	2.5%	2.5%
Mini Bus	227	344	571	299	453	752	306	462	768	354	536	890	302	458	760	334	505	839	3.5%	3.5%	3.0%	3.0%	2.5%	2.5%
Heavy Bus	639	715	1,354	944	1,057	2,001	972	1,087	2,059	1,182	1,323	2,505	1,026	1,148	2,174	1,154	1,292	2,447	5.0%	5.0%	4.0%	4.0%	3.0%	3.0%
Light Truck	444	127	571	631	181	812	616	177	793	715	205	920	585	168	752	633	182	814	4.5%	4.5%	3.0%	3.0%	2.0%	2.0%
Heavy truck	939	1,355	2,294	1,335	1,928	3,263	1,306	1,886	3,193	1,515	2,186	3,701	912	1,316	2,228	987	1,425	2,411	4.5%	4.5%	3.0%	3.0%	2.0%	2.0%
Total	3,597	4,107	7,704	4,985	5,679	10,664	5,076	5,793	10,869	5,941	6,778	12,719	4,833	5,427	10,259	5,325	5,983	11,308	4.1%		2.2%		-2.3%	

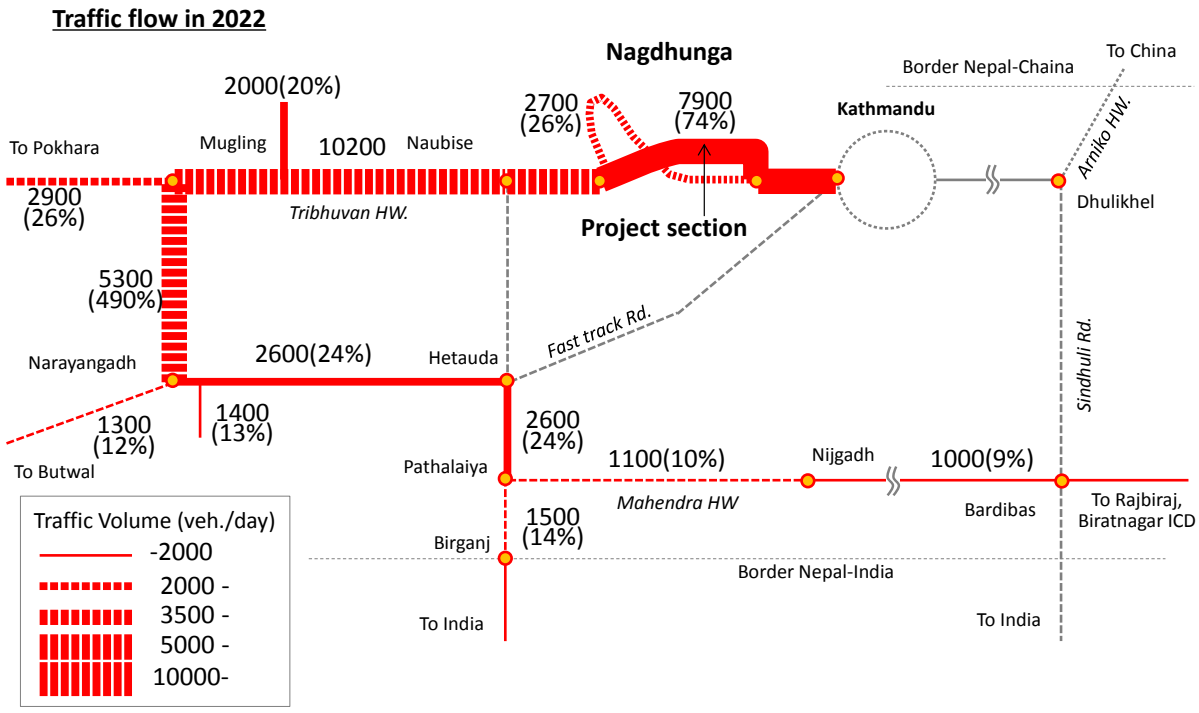
Number of Vehicles on Tunnel Section ②

	2014			2020			2025			2030			2031			2035			Tunnel utilization ratio (2014-2020)		Tunnel utilization ratio (2020-2030)		Tunnel utilization ratio (2035-)	
	Eastbound	Westbound	Total	Eastbound	Westbound	Total	Eastbound	Westbound	Total	Eastbound	Westbound	Total	Eastbound	Westbound	Total	Eastbound	Westbound	Total	East	West	East	West	East	West
Passenger Car	-	-	-	1,010	955	1,966	1,061	1,003	2,064	1,230	1,163	2,393	1,124	1,063	2,186	1,240	1,173	2,413	80%	70%	80%	70%	80%	70%
Micro Bus	-	-	-	410	487	897	440	523	963	510	606	1,117	483	574	1,056	533	633	1,166	80%	70%	80%	70%	80%	70%
Mini Bus	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%	0%	0%	0%	0%	0%
Heavy Bus	-	-	-	850	845	1,695	874	870	1,744	1,064	1,058	2,122	923	918	1,842	1,039	1,034	2,073	90%	80%	90%	80%	90%	80%
Light Truck	-	-	-	505	127	632	493	124	617	572	143	715	468	117	585	506	127	633	80%	70%	80%	70%	80%	70%
Heavy truck	-	-	-	1,202	1,542	2,744	1,176	1,509	2,685	1,363	1,749	3,112	820	1,053	1,873	888	1,140	2,028	90%	80%	90%	80%	90%	80%
Total	-	-	-	3,977	3,957	7,933	4,044	4,029	8,073	4,739	4,720	9,459	3,818	3,725	7,542	4,207	4,106	8,313	74%		74%		74%	

Number of Vehicle on Existing road ③

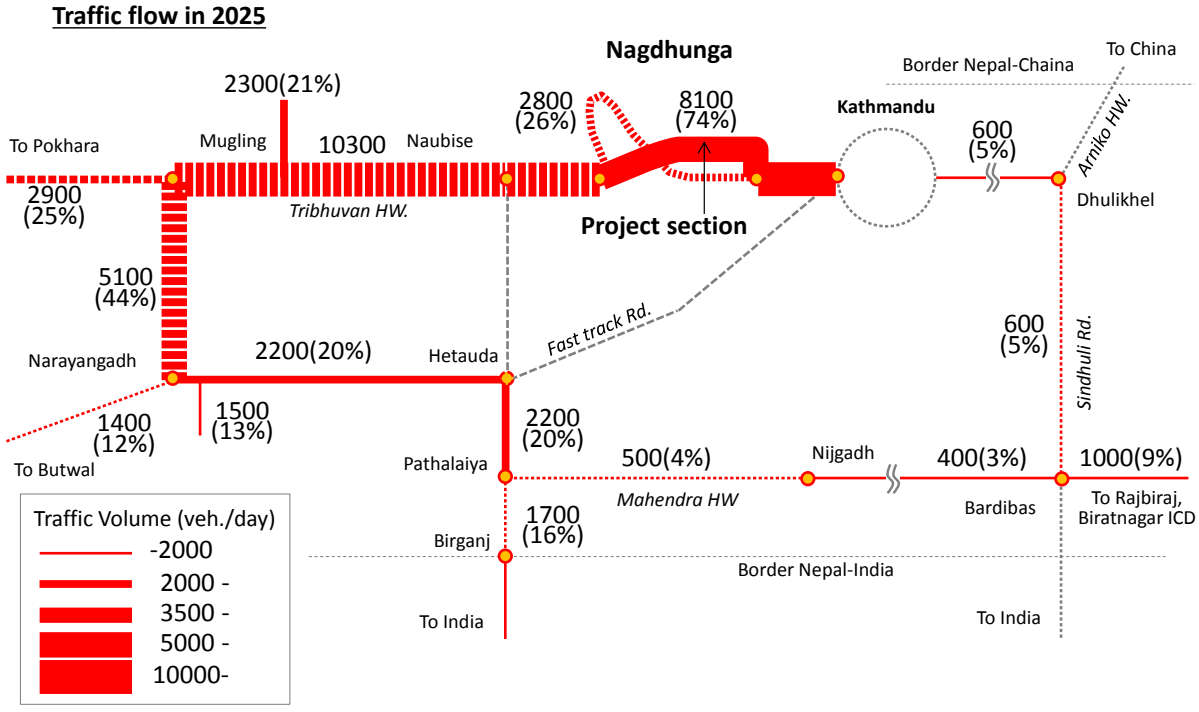
	2014			2020			2025			2030			2031			2035			Existing road ratio (2014-2020)		Existing road ratio (2020-2030)		Existing road ratio (2035-)	
	Eastbound	Westbound	Total	Eastbound	Westbound	Total	Eastbound	Westbound	Total	Eastbound	Westbound	Total	Eastbound	Westbound	Total	Eastbound	Westbound	Total	East	West	East	West	East	West
Passenger Car	-	-	-	253	409	662	265	430	695	307	498	806	281	455	736	310	503	813	20%	30%	20%	30%	20%	30%
Micro Bus	-	-	-	102	209	311	110	224	334	128	260	387	121	246	367	133	271	405	20%	30%	20%	30%	20%	30%
Mini Bus	-	-	-	299	453	752	306	462	768	354	536	890	302	458	760	334	505	839	100%	100%	100%	100%	100%	100%
Heavy Bus	-	-	-	94	211	306	97	217	315	118	265	383	103	230	332	115	258	374	10%	20%	10%	20%	10%	20%
Light Truck	-	-	-	126	54	181	123	53	176	143	61	204	117	50	167	127	54	181	20%	30%	20%	30%	20%	30%
Heavy truck	-	-	-	134	386	519	131	377	508	151	437	589	91	263	354	99	285	384	10%	20%	10%	20%	10%	20%
Total	-	-	-	1,009	1,722	2,731	1,032	1,764	2,796	1,202	2,058	3,260	1,015	1,702	2,717	1,118	1,877	2,995	26%		26%		26%	

Source: JICA Study Team



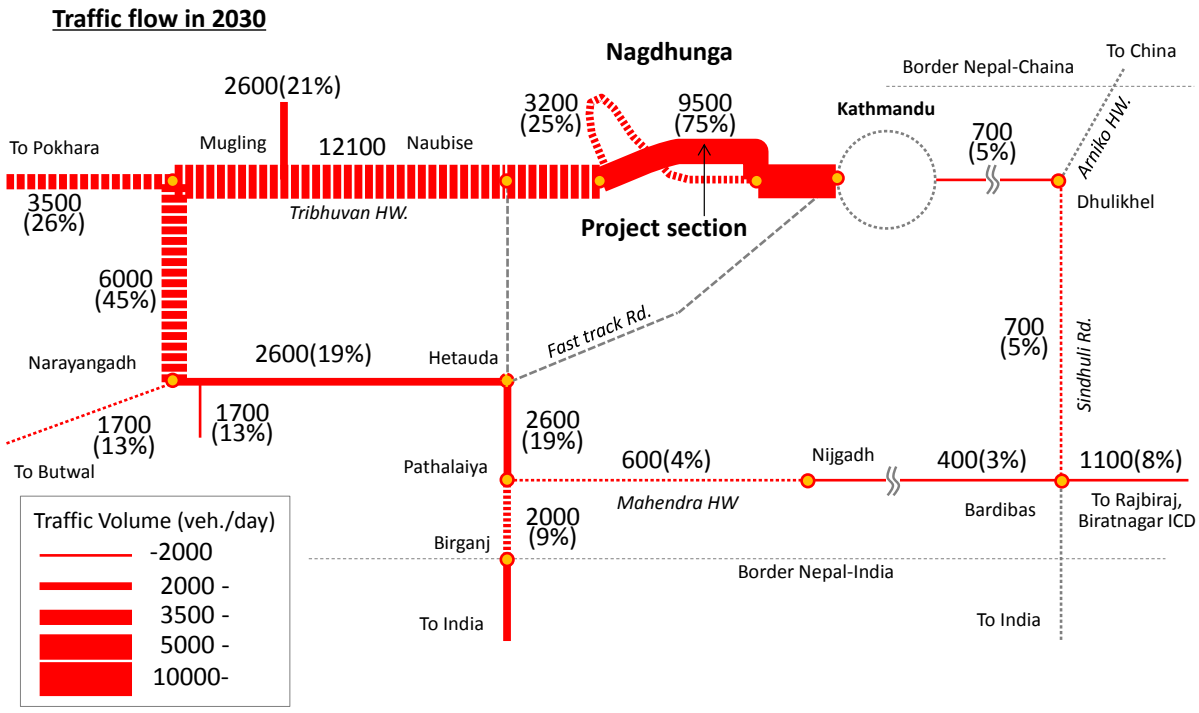
Source: JICA Study Team

FIGURE 5.2-3 TRAFFIC FLOW PASSING NAGDHUNGA IN 2022



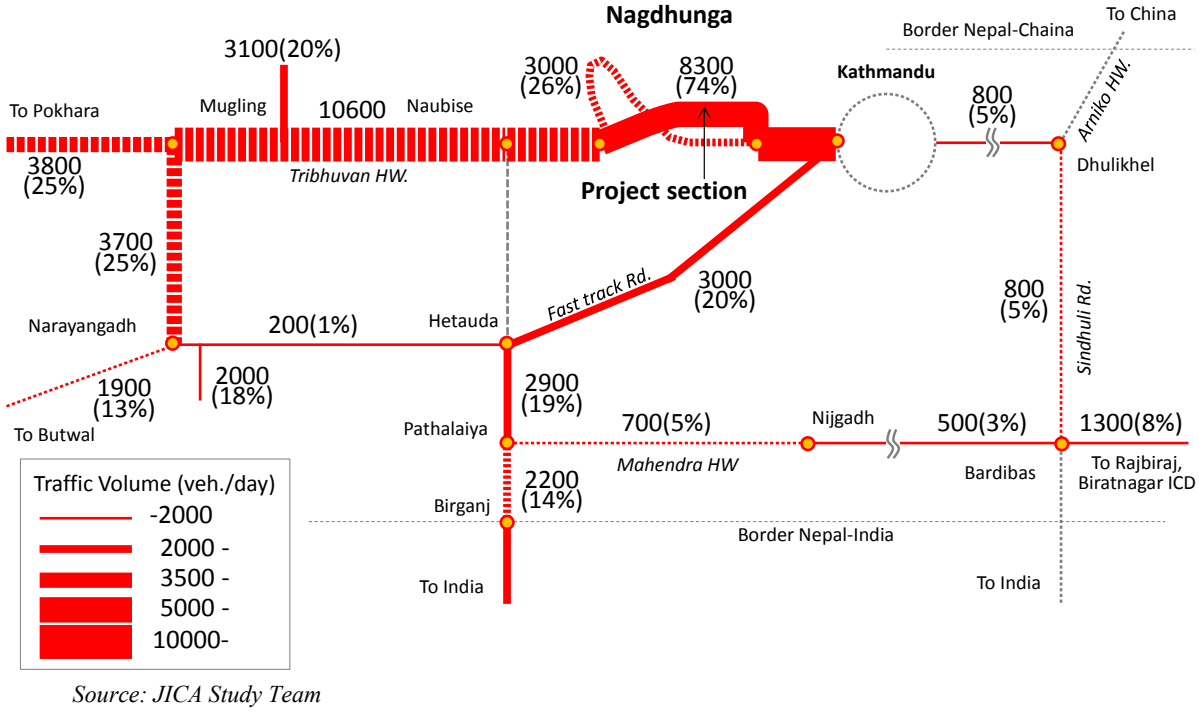
Source: JICA Study Team

FIGURE 5.2-4 TRAFFIC FLOW PASSING NAGDHUNGA SECTION IN 2025



Source: JICA Study Team

FIGURE 5.2-5 TRAFFIC FLOW PASSING NAGDHUNGA SECTION IN 2030



Source: JICA Study Team

FIGURE 5.2-6 TRAFFIC FLOW PASSING NAGDHUNGA SECTION IN 2035

CHAPTER 6

PRESENT CONDITION OF EXISTING ROAD

CHAPTER 6
PRESENT CONDITION OF EXISTING ROAD

6.1 FUNCTION AND ROLE OF EXISTING ROAD

As shown in **Figure 6.1-1**,the survey road is a part of Tribhuvan Highway, a National Highway which combines with Prithvi Highway at Naubise and is one of the only two roads connecting Kathmandu Capital with Pokhara and the Terai region. Pokhara is a tourist city located about 200km west of Kathmandu and Terai is the gateway to India where it presently shares the trade border at three locations with India. Sindhuli road, which is presently under construction under the Japanese assistance is another road that allows access from Kathmandu to India. However, the number of vehicles plying this road is only 659 vehicles per day and this is credited to the narrow width and the long and winding alignment. On the other hand, the current traffic on the survey road is about 7600 vehicles per day and is expected to increase in an approximate rate of 4%. As such, the survey road is expected to function as the life line or the vertebra of the economic activities inside the Kathmandu Valley until an alternative has been provided.

Major traffic along project road is heavy trucks transporting commodities from India, through Terai regions to Kathmandu and long trip buses from various parts of the country. As shown in **Figure 6.1-1**, the current routes are long detour route from Kathmandu via Kalanki, Naubise, Dharke, Mugling, Hetauda, Birganj. Naubise and Hetauda Section of Tribhuvan Highway are not used due to geographical constraint, bad road alignment and pavement condition. The project road has also the function of connecting between Kathmandu and Pokhara, which is the second largest city and long trip buses and trucks will use the project road.

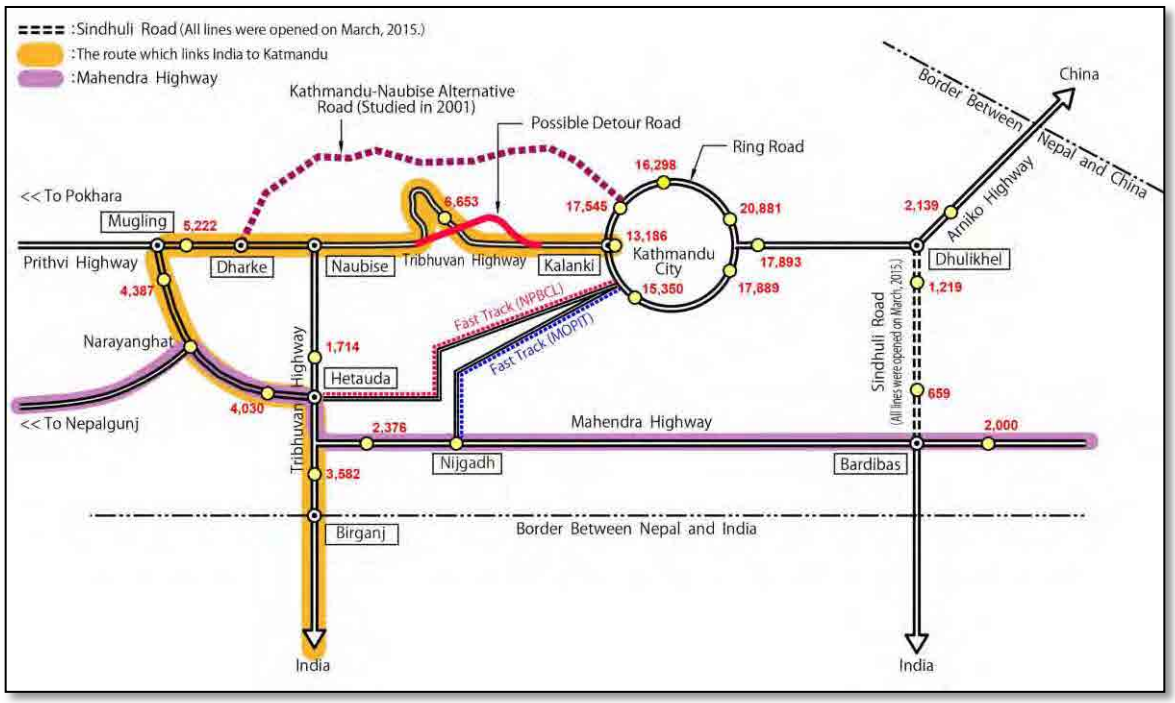


FIGURE 6.1-1 SCHEMATIC ROAD NETWORK AND PRESENT TRAFFIC VOLUME

6.2 ISSUES OF THE EXISTING ROAD

6.2.1 Poor Geometric Conditions

The existing road alignment has many small horizontal curves which climbs up and down the mountains with a steep gradient of 7~10%. Loaded trucks can only travel with a very low speed of 10 ~ 15 km/hr for climbing up direction.

TABLE 6.2-1 EXISTING ROAD ALIGNMENT

Horizontal Alignment	No. of Small Curve (R< 30m)	19 Curves
Vertical Alignment	The gradient length over 7%	10 % ℓ = 500m 8 % ℓ = 600m 7 % ℓ = 500m
		Total ℓ = 1,600m

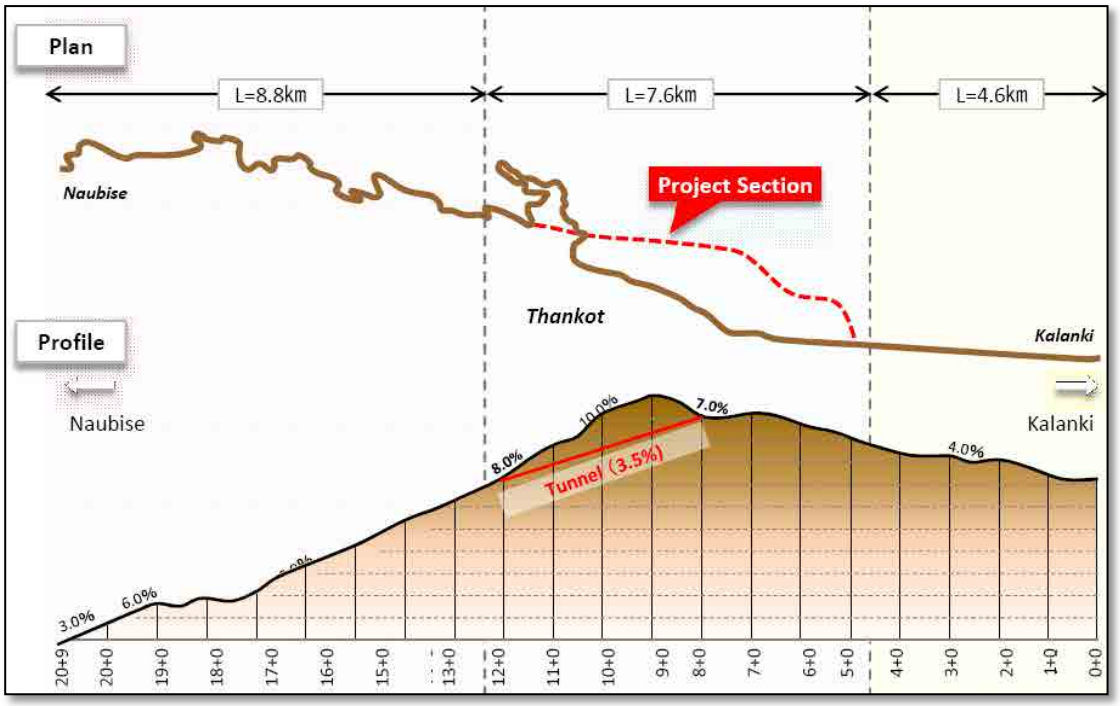


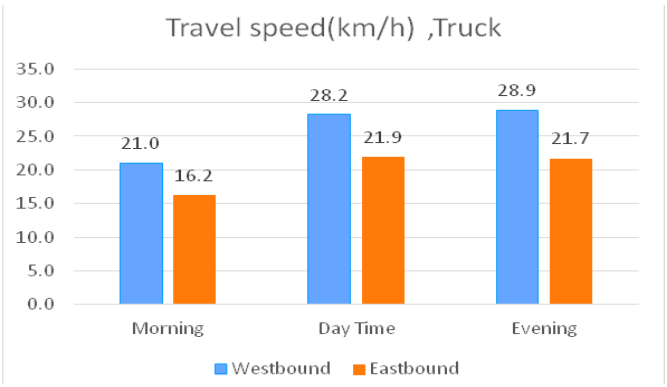
FIGURE 6.2-1 EXISTING ROAD ALIGNMENT

6.2.2 Transport Inefficiency

(1) Travel Speed and Time

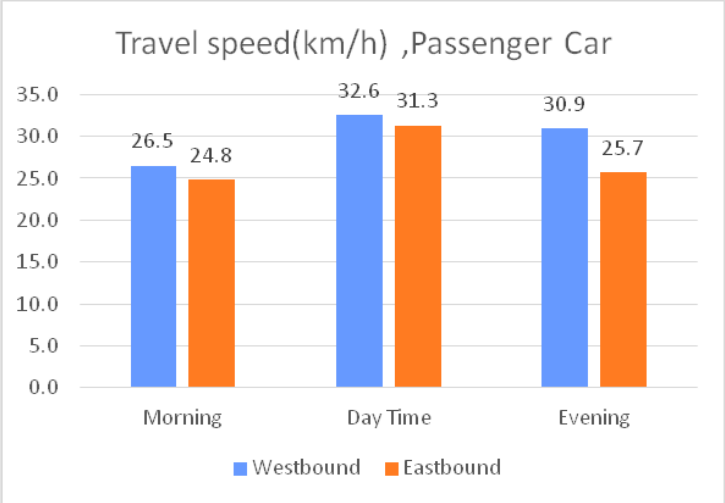
Based on the traffic survey result, traffic problems are identified (see section 5.1.4 Travel Time) Travel Survey for Nagdhunga Section (L = 8.8km) was conducted for two vehicle type (passenger car and truck). **Figure 6.2-2** shows the travel speed survey result for Truck. Travel speed of eastbound (from Naubise to Kathmandu) is lower than that of westbound (from Kathmandu to Naubise). Travel speed of eastbound at morning peak is only 16.9 km/h due to long steep up gradient (8%, L= 600 and 10% L=500m).

As shown **Figure 6.2-4**, travel time difference in the morning time between westbound and eastbound is ten (10) minutes. This means loss of time and money.



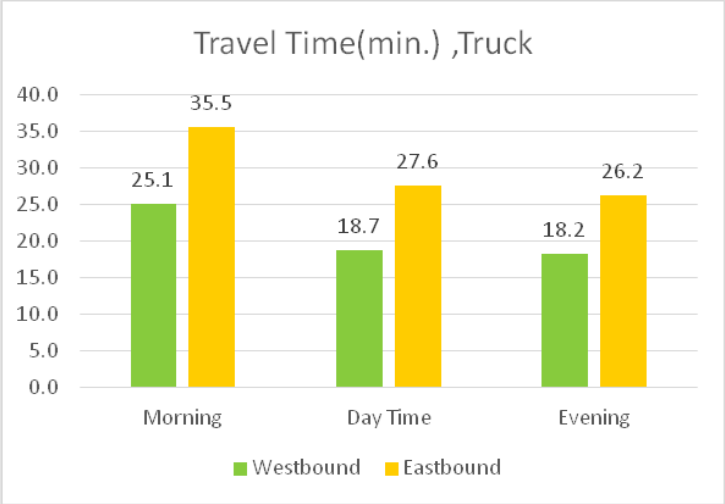
Note: 2014, July Survey

FIGURE 6.2-2 AVERAGE TRAVEL SPEED AT NAGDHUNGA SECTION BY TRUCK



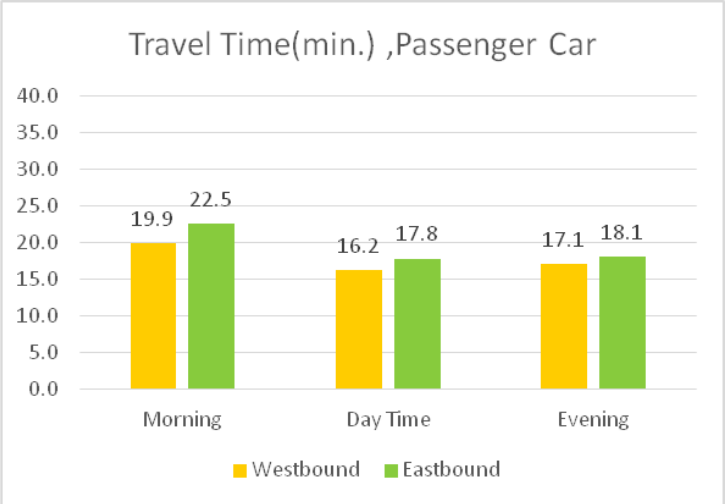
Note: 2014, July Survey

FIGURE 6.2-3 AVERAGE TRAVEL SPEED AT NAGDHUNGA SECTION BY PASSENGER CAR



Note: 2014, July Survey

FIGURE 6.2-4 AVERAGE TRAVEL TIME AT NAGDHUNGA SECTION BY TRUCK



Note: 2014, July Survey

FIGURE 6.2-5 AVERAGE TRAVEL TIME AT NAGDHUNGA SECTION BY PASSENGER CAR

(2) Transport Cost of the Existing Road

Based on the traffic survey result, transport cost of existing road was estimated. Transport cost consists of vehicle operating cost and travel time cost.

1) Vehicle Operating Cost

Daily total vehicle × km at Nagdhunga section is estimated as 66,000 vehicle km/day below. 7,500 vehicle/day ×8.8 km 66,000 vehicle/km. Based on unit vehicle operating cost, estimated VOC is 4.0 Million NRP / day.

TABLE 6.2-2 ESTIMATED TOTAL VEHICLE OPERATES COST (YEAR 2014)

	Vehicle*km	Unit VOC (NRP.km.veh)	VOC	
Pass. car	17,600	22.2	390,720	
S.Bus	7,920	29.5	233,640	
M.Bus	4,400	51.5	226,600	
L.Bus	11,440	82.5	943,800	
L.Truck	4,400	32.5	143,000	
H.Truck	20,240	102.4	2,072,576	
Total	66,000		4,010,336	NRP/day

2) Travel Time Cost

Daily Total Travel Time is 2,517 vehicle/hour. (see **Table 6.2-5**). Based on Unit Travel Time Cost, estimated TTC is 1.0 Million NRP/day.

TABLE 6.2-3 ESTIMATED TOTAL TRAVEL TIME COST (YEAR 2014)

	Vehicle*hour	TTC(NRP/hour/veh)	TTC	
Pass. car	599	235	140,863	
S.Bus	268	196	52,549	
M.Bus	148	549	81,401	
L.Bus	388	882	342,118	
L.Truck	223	375	83,675	
H.Truck	891	375	334,263	
Total	2,517		1,034,868	NRP/day

3) Transport Cost

Total Transport Cost of Nagdhunga Section is 5.0 (4.0+ 1.0) Million NRP/day. The Yearly Transport Cost is 1.8 Billion NRP. If these transport cost can be reduced by tunnel project, there will be huge amount of economic benefit for Nepal nationwide.

TABLE 6.2-4 TOTAL TRAILER KILOMETER AT NAGDHUNGA SECTION

Time	Direction	Length	Traffic Volume Year 2014					Total Vehicle * km				
			Pass. Car	Bus	L. Truck	H. Truck	Total	Pass. Car	Bus	L. Truck	H. Truck	Total
		km	vehicle	vehicle	vehicle	vehicle	vehicle	veh.* km	veh.* km	veh.* km	veh.* km	veh.* km
Morning	Westbound	8.8	200	300	20	280	800	1,760	2,640	176	2,464	7,040
	Eastbound	8.8	200	240	80	180	700	1,760	2,112	704	1,584	6,160
Day Time	Westbound	8.8	600	900	60	840	2,400	5,280	7,920	528	7,392	21,120
	Eastbound	8.8	600	720	240	540	2,100	5,280	6,336	2,112	4,752	17,480
Evening	Westbound	8.8	200	300	20	280	800	1,760	2,640	176	2,464	7,040
Total	Eastbound	8.8	200	240	80	180	700	1,760	2,112	704	1,584	6,160
	Westbound	8.8	1,000	1,500	100	1,400	4,000	8,800	13,200	880	12,320	35,200
	Eastbound	8.8	1,000	1,200	400	900	3,500	8,800	10,560	3,520	7,920	30,800
	Total		2,000	2,700	500	2,300	7,500	17,600	23,760	4,400	20,240	66,000

TABLE 6.2-5 TOTAL TRAVEL TIME AT NAGDHUNGA SECTION

Time	Direction	Travel Time, Year 2014				Traffic Volume, Year 2014					Total Vehicle * hour				
		Pass. Car	Bus	L. Truck	H. Truck	Pass. Car	Bus	L. Truck	H. Truck	Total	Pass. Car	Bus	L. Truck	H. Truck	Total
		min.	min.	min.	min.	vehicle	vehicle	vehicle	vehicle	vehicle	veh.*hour	veh.*hour	veh.*hour	veh.*hour	veh.*hour
Morning	Westbound	19.9	19.9	25.1	25.1	200	300	20	280	800	66	100	8	117	291
	Eastbound	22.5	22.5	33.5	33.5	200	240	80	180	700	75	90	45	101	310
Day Time	Westbound	16.2	16.2	18.7	18.7	600	900	60	840	2,400	162	243	19	262	686
	Eastbound	17.8	17.8	27.6	27.6	600	720	240	540	2,100	178	241	110	248	750
Evening	Westbound	17.1	17.1	18.2	18.2	200	300	20	280	800	57	86	6	85	234
Total	Eastbound	18.1	18.1	26.2	26.2	200	240	80	180	700	60	72	35	79	246
	Westbound					1,000	1,500	100	1,400	4,000	285	428	33	464	1,210
	Eastbound					1,000	1,200	400	900	3,500	313	376	190	428	1,307
	Total					2,000	2,700	500	1,300	7,500	599	804	223	891	2,517

6.2.3 Vulnerability to Disasters

Based on the study of existing topographic maps, aerial photographs, google earth Images and satellite images, it is found that the survey area east of the Nagdhunga is less hazardous to landslides. Most of the disastrous landslides affecting the stability of the existing roads are concentrated in the area between Nagdhunga in the east and the Sikre Khola in the west.

This part of the project area is characterized by many small to large landslides that once affected the passage of the vehicles in the road. The main cause of such high concentration of the landslides in this portion is attributed to the steep slopes, highly weathered, highly fractured and jointed, bedrocks composed of phyllite and phylltic sandstones with open joints. These landslides were active mainly during rainly season. However, most of these landslides now stable due to the construction of retaining structures though one can easily identify those landslides in the well preservation of the landslides scarps and the the body of the landslides .

The study area has also suffered some events of debris flow during past. Especially a recent event of debris flow has been identified from the Sisne Khola near the outlet of the proposed tunnel. According to the local people, the debris flow event was occurred in the august of 2007 creating obstacle to the passage vehicles for 7 hours. After this event 5 number of Sabo dams were constructed in the Sisne Khola so as to chase the flow of the debris into the road.

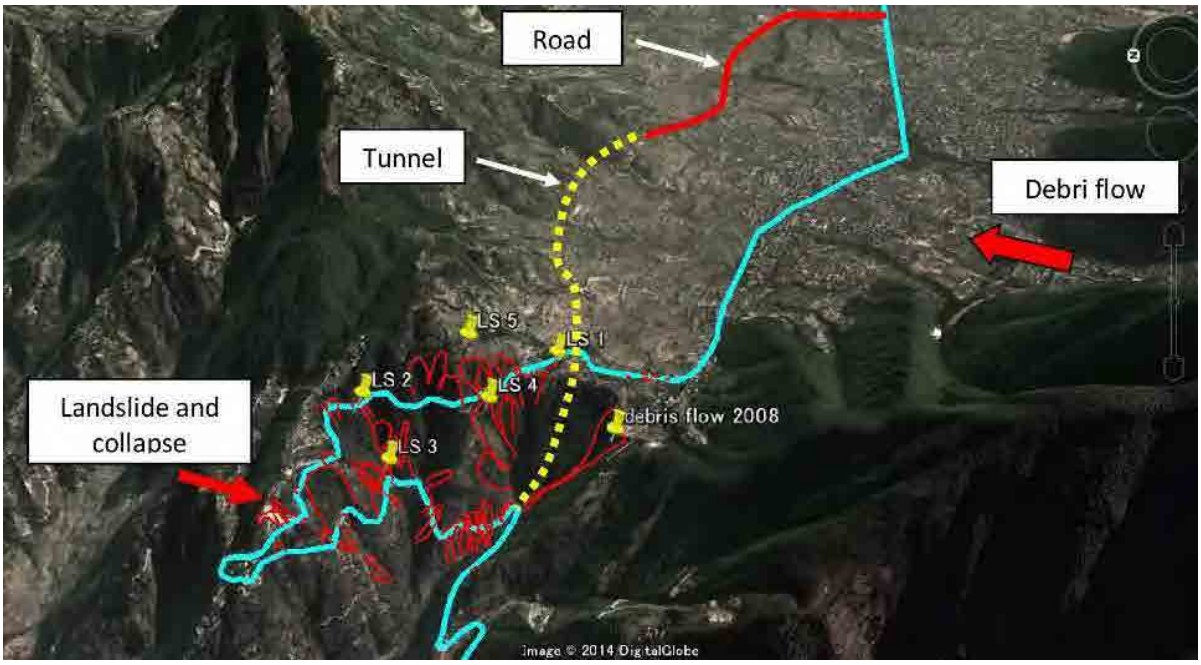


FIGURE 6.2-6 LANDSLIDE AND COLLAPSE DISTRIBUTION PROJECT AREA

Figure 6.2-6 shows the location of many landslide and collapse observed by topo-maps, aerial photos, field survey and google images.

Some of these landslide, we got more detail information as follows.

(1) LS 1 Near police check post at Nagdhunga

Around 2005, A new landslide started to move in the hillslope adjacent to the checkpost at Nagdhunga after the existing road was expanded to the present size during the conflict time. Though it did not create problem to the passage of the traffic, the cutslope was greatly unstable for the following years and even creat threat to the small houses on the upper part of the hillslope. Now a retaining structure has been constructed and the landslide is almost stable. The scarp and the body of the landslide can still be seen beside the large hoarding boards.

(2) LS 2 Near chisapanidhara

About 3 years ago, A big landslide was moved in this location after excavating the hillslope for expanding the Chisapani-Badbhanjyang road. The landslide was occurred after new cutslope was made for improving the existing gravel road. The landslide removed almost half part of the road. Later retaining wall was constructed on the hillside and gabion wall was constructed in the valley side to stabilze the road.

(3) LS 3 Location at Jhapre Khola

At the rainy season of 2008, the stream brought a huge amount of debris in the road and created problem for the passage of vehicles for about 7 hrs. The rain was persistent for the whole day and the sediments and the water were much beyond the capacity of the constructed surface drains. The traffic was stopped from about 4pm in the day and was opened for oneside after 7 hours. The similar event was repeated the following year but since then it has not caused any disturbances to the traffic.

(4) LS 4 At a small tributary with little water flowing

This is the place of another large landslide that caused problem to the road. Before construction of the retaining structures, about 10 years ago, there was a large landslide causing problem to the road. The landslide now seems stable with so many vegetations, however, still preserves the scarp of the landslide and its body. The landslide was active in rainy season.

(5) LS 5 In front of a big Landslide

According to the villagers, this landslide was very active and problematic about 15 to 20 years ago. The whole mass involving the road used to slide every year in the rainy season and created problem to the passage of the vehicles. The mass stopped to move after construction of the gabion walls in the foot of the landslide about 100m down the valley. It was constructed and strong concrete support and bolting was done to stabilize the road.

Some pictures concerned to slope failure from Nagdhunga pass to Sisne khola show in **Figure 6.2-7** shows a trace of large-scale landslide north of Nagdhunga police check post. Surface of landslide is now covered by forest. **Figure 6.2-8** shows a large scale collapse just north side of Sisne khola. Soil and rock blocks were continuously falling down during survey period also.

FIGURE 6.2-7 LARGE LANDSLIDE NORTH OF CHECK POST

FIGURE6.2-8 LARGE LANDSLIDE NORTH OF THE SISNE KHOLA

Figure 6.2-9 shows collapse of road shoulder due to steep gradient of slope, while **Figure 6.2-10** shows continuous collapse of cut slopes occurred after rainy season.(Photo by google earth)

FIGURE6.2-9 COLLAPSE OF ROAD SHOULDER

FIGURE 6.2-10 CUTSLOPE COLLAPSE AFTER HARD RAINFALL

These pictures below were taken on August 8 at Thankot. After a rainfall debris flow attacked a village house. Villagers brought their furniture at safe places. If a big debris flow occurred at Thankot area, Tribhuvan highway will be closed.

FIGURE 6.2-11 COMBINATION PICTURES OF DEBRIS FLOW

6.2.4 Traffic Accidents and Vehicle Breakdowns

As mention in section 5.1.7, annual traffic accident along Nagdhunga section occurrence is 241. Major traffic accident factors are bad horizontal and vertical alignment and narrow road width, as reported by the local traffic police. These are also manifested in many vehicle breakdowns along Nagdhunga section every time. As these vehicle breakdowns stopped on the carriage way many traffic was blocked by these breakdown. (see **Photo 6.2-1**)

PHOTO 6.2-1 VEHICLE BREAKDOWN ON THE CARRIAGEWAY

6.2.5 Traffic Capacity

Traffic Capacity of existing road and proposed tunnel section were estimated by Japan's road traffic capacity manual published by Japan Road Association.

If this project is implemented, the traffic capacity will drastically increase at this section.

Estimated Traffic Capacity	
-Existing Road Section	621vehicle/hour
-Proposed Tunnel Road Section	1,353 vehicle/hour

The calculation method and results describes as follows.

(1) Calculation Method

Traffic Capacity was calculated by base traffic capacity, road condition and traffic condition.

$$C_L = C_B \times \gamma_L \times \gamma_C \times \gamma_\ell \times \gamma_T \times \cdots.$$

1) C_B : Base Traffic Capacity (2,500 veh /h for two-way two-lane road, 2,200 veh/h for one lane of multi-lane road)

2) γ_L : Carriageway width (W_L [m]) Correction Factor

W_L [m]	γ_L
Over 3.25	1.00
3.00	0.94
2.75	0.88
2.50	0.82

3) γ_C : Side space width (W_L [m]) Correction Factor

Side space width, W_C [m]	γ_C	
	One side only	Both side
Over 0.75	1.00	1.00
0.50	0.98	0.95
0.25	0.95	0.91
0.00	0.90	0.81

4) γ_ℓ : Road side Development

Degree of urbanized area	γ_ℓ
Not urbanized area	0.95 ~ 1.00
Some urbanized area	0.90 ~ 0.95
Urbanized area	0.85 ~ 0.90

5) γ_T : Gradient and Heavy Vehicle Rate

E_T is applied based on **Table 6.2-6**.

TABLE 6.2-6 HEAVY VEHICLE'S PASSENGER CAR FACTOR (ER)

Gradient	Length (km)	Two-way Two-lane Road (Heavy Vehicle Rate, %)					Multi-lane Road (Heavy Vehicle rate, %)				
		10	30	50	70	90	10	30	50	70	90
3% less	−	2.1	2.0	1.9	1.8	1.7	1.8	1.7	1.7	1.7	1.7
4%	0.2	2.8	2.6	2.5	2.3	2.2	2.4	2.3	2.2	2.2	2.2
	0.4	2.8	2.7	2.6	2.4	2.3	2.4	2.4	2.3	2.3	2.2
	0.6	2.9	2.7	2.6	2.4	2.3	2.5	2.4	2.3	2.3	2.3
	0.8	2.9	2.7	2.6	2.5	2.4	2.5	2.4	2.4	2.3	2.3
	1.0	2.9	2.8	2.7	2.5	2.4	2.5	2.4	2.4	2.4	2.3
	1.2	3.0	2.8	2.7	2.5	2.4	2.6	2.5	2.4	2.4	2.4
	1.4	3.0	2.8	2.7	2.5	2.4	2.6	2.5	2.4	2.4	2.4
	1.6	3.0	2.9	2.8	2.6	2.5	2.6	2.5	2.5	2.4	2.4
5%	0.2	3.2	3.0	2.8	2.7	2.6	2.7	2.6	2.6	2.6	2.5
	0.4	3.3	3.1	2.9	2.8	2.7	2.9	2.7	2.7	2.7	2.6
	0.6	3.4	3.2	3.0	2.8	2.7	2.9	2.8	2.7	2.7	2.7
	0.8	3.5	3.2	3.0	2.9	2.8	3.0	2.9	2.8	2.8	2.7
	1.0	3.5	3.3	3.1	2.9	2.8	3.0	2.9	2.8	2.8	2.8
	1.2	3.6	3.4	3.1	3.0	2.9	3.1	3.0	2.9	2.9	2.8
	1.4	3.6	3.4	3.2	3.0	2.9	3.1	3.0	2.9	2.9	2.8
	1.6	3.7	3.4	3.2	3.1	2.9	3.2	3.0	3.0	2.9	2.9
6%	0.2	3.4	3.2	3.0	2.8	2.7	2.9	2.8	2.7	2.7	2.7
	0.4	3.5	3.3	3.1	3.0	2.9	3.1	2.9	2.9	2.8	2.8
	0.6	3.7	3.5	3.3	3.1	3.0	3.2	3.1	3.0	3.0	2.9
	0.8	3.8	3.6	3.4	3.2	3.1	3.3	3.2	3.1	3.0	3.0
	1.0	3.9	3.6	3.4	3.3	3.1	3.3	3.2	3.1	3.1	3.1
	1.2	4.0	3.7	3.5	3.3	3.2	3.4	3.3	3.2	3.2	3.1
	1.4	4.1	3.8	3.6	3.4	3.3	3.5	3.4	3.3	3.2	3.2
	1.6	4.1	3.9	3.7	3.5	3.3	3.6	3.4	3.3	3.3	3.3
7%	0.2	3.5	3.3	3.1	2.9	2.8	3.0	2.9	2.8	2.8	2.8
	0.4	3.7	3.5	3.3	3.1	3.0	3.2	3.1	3.0	3.0	2.9
	0.6	3.9	3.6	3.4	3.3	3.1	3.4	3.2	3.1	3.1	3.1
	0.8	4.0	3.8	3.5	3.4	3.3	3.5	3.3	3.3	3.2	3.2
	1.0	4.2	3.9	3.7	3.5	3.4	3.6	3.4	3.4	3.3	3.3
	1.2	4.3	4.0	3.8	3.6	3.5	3.7	3.5	3.5	3.4	3.4
	1.4	4.5	4.2	3.9	3.7	3.6	3.8	3.7	3.6	3.6	3.5
	1.6	4.6	4.3	4.0	3.8	3.7	3.9	3.8	3.7	3.7	3.6

$$\gamma_T = \frac{100}{(100-T) + E_T T}$$

γ_T :Gradient Correction Factor

E_T : Heavy Vehicle's Passenger Car Factor

6) Other Factors

Other factor to reduce traffic capacity is horizontal alignment, driver's characteristics and vehicle performance (especially curve section and tunnel section). There are still no quantitative correction factors to consider these influences.

(2) Existing Road Capacity

Based on the above method, the existing road capacity was estimated

$C_L = C_B \times \gamma_L \times \gamma_C \times \gamma_l \times \gamma_T$

$= 2,500 \times 1.00 \times 0.91 \times 0.95 \times 0.29 =$ <u>626 vehicle/hour</u>

$C_B = 2,500$

$\gamma_L = 1.00$ ($W_L > 3.25$m)

$\gamma_C = 0.91$ (Both side $W_C = 0.25$m)

$\gamma_l = 0.95$ (sub-urban area)

$\gamma_T = E_r$ 3.4 (7%, Heavy Truck Rate 50%, ℓ =0.5km) (see **Table 6.2-6**)

⇩

$= E_r$ 5.7 (Gradient 10%, Heavy Truck 50%, ℓ = 0.5 km) was estimated by the Study Team based on **Table 6.2-6**.

$$\gamma_T = \frac{100}{(100-50) + 5.7 \times 50} = 0.29$$

As the peak hour traffic volume at Nadhunga section was **<u>621vehicle/hour,</u>** the traffic volume has already reached the traffic capacity.

(3) Tunnel Section

As the same method, the proposed tunnel section's capacity was estimated.

$C_L = C_B \times \gamma_L \times \gamma_C \times \gamma_t \times \gamma_T$

$= 2,500 \times 1.00 \times 0.95 \times 0.95 \times 0.6$

$= 1,353$ vehicle/hour

The estimated traffic capacity is **<u>1,353 vehicle/hour</u>**. If this project is implemented, the traffic capacity will drastically increase at this section.

CHAPTER 7

NECESSITY OF THE PROJECT

CHAPTER 7
NECESSITY OF THE PROJECT

7.1 ITEMS TO BE CONFIRMED FOR PROJECT NECESSITY

Project necessity was confirmed from the following view points;

- Alignment Problems
  - Existing road have a steep gradient of 7~10% and many small horizontal curves (**Section 6.2.1**).
- Transport Efficiencies
  - Present average travel speed of westbound is 16.2km/h in the morning peak due to poor alignment condition (**Section 6.2.2**).
  - Traffic capacity will drastically increase at this section (**Section 6.2.5**).
- Risk of Traffic Closure
  - This part of the project area is characterized by many small to large landslides. There are risk of traffic closure due to landslide or collapse of cut section along existing road (**Section 6.2.4**).
- Effect of Future Road Network
  - DOR has confirmed that the improvement of the existing road from Mugling to the west portal of this project will be undertaken by DOR under the assistance of the WB. DOR has confirmed to incorporate the plan of Nagdhunga Tunnel Construction Project and assured that the improvement plan will be consistent with the plan of the tunnel.(**Section 7.6 (1), Section 6.1**)
- Effects on National/Regional Development
  - The project will be support the National and Regional Development Plan (**Chapter 2**)
- Economic Viability
  - Total transport cost of Nagdhunga section is approximately 5 million NPR/day. The project contribute the economic benefit for Nepal nationwide (**Section 6.2.2**).

7.2 NATIONAL PRIORITY PROJECT

In Nepal, the National Priority Projects are categorized as “Pride” “P1”, “P2” and “P3” in a priority order. As this project has a very important role as a national economic corridor, recognition has been given as “P1” and essential process has been initiated by DOR for approval by the National Planning Commission (NPC). The NPC has already announced inclusion of the project in the annual development program 2071/72 it has published. Given the documents are smoothly processed the designation of the project as “P1” will be approved and included in the Red Book for fiscal year 2072/73.

Presently, altogether 455 projects are entitled as the priority projects out of which 282 are categorized as P1 project.

Table 7.2-1 shows the number of National Priority Projects and **Table 7.2-2** shows the major pride projects and the budget allocated.

TABLE 7.2-1 NUMBER OF NATIONAL PRIORITY PROJECT

	MOPIT Project		Other Ministry Project	Total
	DOR	Others		
Pride	6	1	14	21
P1	50	4	228	282
P2	16	3	110	129
P3	1	0	22	23
Total	**67**	**7**	**374**	**455**

Source: Red book 2013 – 14, Ministry of Finance

TABLE 7.2-2 PRIDE PROJECT OF ROADS

No	Project Name	Allocated Budget (2013-2014) 1,000 NRP
1	Mid Hill Highway	1,922,716
2	Postal Highway	1,250,000
3	North South Koshi Highway	N/A
4	North South Karnali Highway	N/A
5	North South Gardaki Highway	N/A
6	Kathmandu Terai Fast Track	N/A

South: Redbook 2013-2014, Ministry of Finance

7.3 TRAFFIC IMPACT

(1) Overall Traffic Characteristics

Based on the traffic surveys undertaken in July 2014, traffic flow is estimated as shown in **Figure 7.3-1**.

Through Traffic: Traffic which has origin or destination of Nagdhunga is 400 vehicles/day. It shares only five (5%) of the entire traffic. The remaining ninety five (95%) of traffic is through traffic.

Kathmandu Traffic: Traffic which starts from or ends in Kathmandu is 6,900 vehicle/day. The share of this section is 90%.

Pokhara Traffic: Pokhara is the second largest city and is a famous tourist destination in Nepal. Daily Traffic between Kathmandu and Pokhara through Dhading district is about 3,000 vehicle/day. Pokhara Traffic is 1,500 vehicle/day (Passenger Car 42%, Bus 54% and Truck 3%).

Birganj Traffic: Though Birgunj and central south traffic is 1,330 vehicles/day, Birgunj traffic passing this road was 570 vehicle/day (Heavy truck 80% and others 20%)

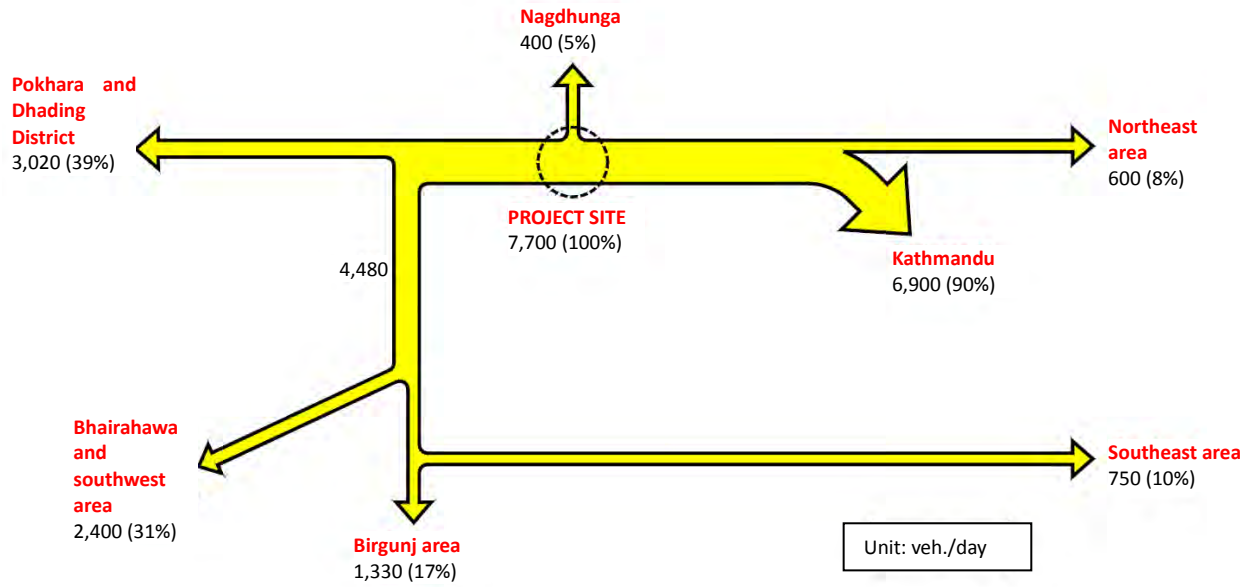


FIGURE 7.3-1 TRAFFIC CHARA CTERISTICS

7.4 ROAD IMPACT

As described in section 6.2, the road alignment of the objective existing road is in a very poor condition contributing to significant reduction of the traffic capacity.

Table 7.4-1 shows the road alignment factors and traffic capacity of the existing road and the proposed tunnel road. Since the proposed road section will be of high standard, and its geometric criteria such as the road width, horizontal curvature, vertical grades etc. will improve significantly, the traffic capacity in this section will increase. Consequently, the bottleneck situation of this road section will be alleviated, if not eliminated.

TABLE 7.4-1 ROAD ALIGNMENT FACTORS AND TRAFFIC CAPACITY OF EXISTING ROAD AND PROPOSED NEW TUNNEL ROAD

	Existing Road	Proposed Road
Road Length (km)	8.00 km	5.05 km (including tunnel, 2.45km)
Gradient	10%, L = 500m 8%, L = 600m 7%, L = 500m	3.22%, L = 2,450 m (Tunnel) 5.0%, L = 300 m
Minimum Radius Curve Section	19 curves (R<30m)	R = 200m
Road Width	8m	11m
Design Speed	20 kph (estimated based on curve radius)	40kph
Estimated Traffic Capacity	621 vehicle/hr	1,353 vehicle/hr (Tunnel Section)

Source: JICA Study Team

7.5 NECESSITY OF NAGDHUNGA TUNNEL

Nagdhunga Tunnel is necessary due to the following reasons;

- Traffic condition along Tribhuan highway at Nagdhunga section is chronic due to many sharp curves and hairpin curves (19 locations), and steep gradient(aggregate 1.6km section exceed a vertical gradient of 7%). As Nagdhunga Tunnel has no sharp curve section and steep gradient, the Tunnel project will contribute to reduce the traffic problem at

Nagdhunga area.

- Due to the above road condition, the current traffic volume is 7,704 vehicle/day in 2014 and it has reached its traffic capacity. Since traffic volume will increase by approximately 4%, the traffic condition will become more serious. To increase the traffic capacity at Nagdhunga section, the new tunnel road project is necessary.
- Strongly supports the economic activities not only in Kathmandu, but also nationwide as a whole, the road transport access to Birganj/Bhairahawa dry port of India must be strengthened. The share of truck is 37% of total traffic at Nagdhunga section. The Tunnel project will provide smooth access to Kathmandu and other areas.
- Most of the road sections have steep slope cutting and embankment sections and slope protection are minimal. In such case, heavy rains can trigger serious slope failures accounting to long and frequent road closures and/or raising chances of serious accidents. Traces of slope failures exist at Nagdhunga section even at present. The Nagdhunga Tunnel project will drastically reduce the risk of road closures as an alternative route.
- As estimated transport cost at Nagdhunga section is relatively high, which amounts to about 5 Million NRP/day (see Section 6.3). If the proposed tunnel road will be constructed, transport cost will be significantly reduced.
- Major commodities transported by trucks that pass the Nagdhunga section are construction materials (45%), agricultural products (20%), fuel (10%) and so on. These items are very important for the activities of daily living of Kathmandu's people.
- Even if Fast Track Project is implemented, the reduced traffic along Nagdhunga area is estimated to be only about 15% (converted).

7.6 ISSUES TO BE CONSIDERED

It is clear Nagdhunga Tunnel is a measure against the most critical section of the existing Tribhuvan Highway. The necessity of the tunnel is already justified in the preceding sections. However, in order to achieve maximum advantage of the tunnel, some other issues need to be resolved. Some of the major issues are as follows;

(1) Improvement of Existing Road beyond Tunnel Section

The road condition of the existing Tribhuvan Highway is poor all the way up to Naubise- the starting point of Prithvi Highway. The provision of the Nagdhunga Tunnel will improve only the most critical section of the stretch leaving behind the issue of improvement beyond the west side portal. It is no doubt that the best outcome of the improvement work is attainable if the entire section up to Naubise is improved.

In connection to this, DOR has confirmed that the improvement of the existing road from Mugling to the west portal of this project will be undertaken by DoR under the assistance of the WB. The DOR, Foreign Cooperation Branch has called for expression of interest (EOI) for the feasibility study and detailed design of improvement under the project name, "Nepal India Regional Trade and Transport Project". DOR has confirmed to incorporate the plan of Nagdhunga Tunnel Construction Project and assured that the improvement plan will be consistent with the plan of the tunnel.

(2) Maintenance of the Existing Road

From the opinion survey conducted during traffic count with the road users, about ninety percent of the traffic is estimated to use the tunnel. This means about ten percent of the traffic will continue using the existing road regardless of the geometric condition and other potential inconveniences and risks. Apart from these vehicles, vehicles that are barred from using the tunnel such as overloaded, oversized, and mechanically ill-functioning and those carrying hazardous and highly inflammable materials will also be using the existing road. Therefore,

maintaining the existing road adequately will be required. DOR has assured that the existing stretch will also be classified as the national highway and treat as a part of the SRN and maintain its condition in the same manner as it is being done at present.

(3) Measures to be taken when Existing Road is Impassable

The existing road beyond Sisnekhola (west side tunnel portal) is reported to have been closed frequently for traffic in the past due to landslides, slope failures and other natural causes. This is anticipated to occur again in the future. In such case, the only possible access to/from Kathmandu will be the tunnel way and such circumstances will raise a problem on whether to allow restricted vehicles from using the tunnel road or not. The Survey Team therefore proposes the following measures to be practiced during such time.

- The oversized vehicles shall not be allowed inside tunnel at all.
- The overloaded vehicles should be allowed inside only if/after it unloads the excess load
- The mechanically malfunctioning (defected) vehicles and other vehicles including tankers such as motorbikes, 3-wheelers should be allowed inside the tunnel only at a specified time, under controlled speed with proper escort and strict surveillance
- If necessary, limit the speed inside the tunnel.

CHAPTER 8

ALIGNMENT SELECTION

CHAPTER 8
ALIGNMENT SELECTION

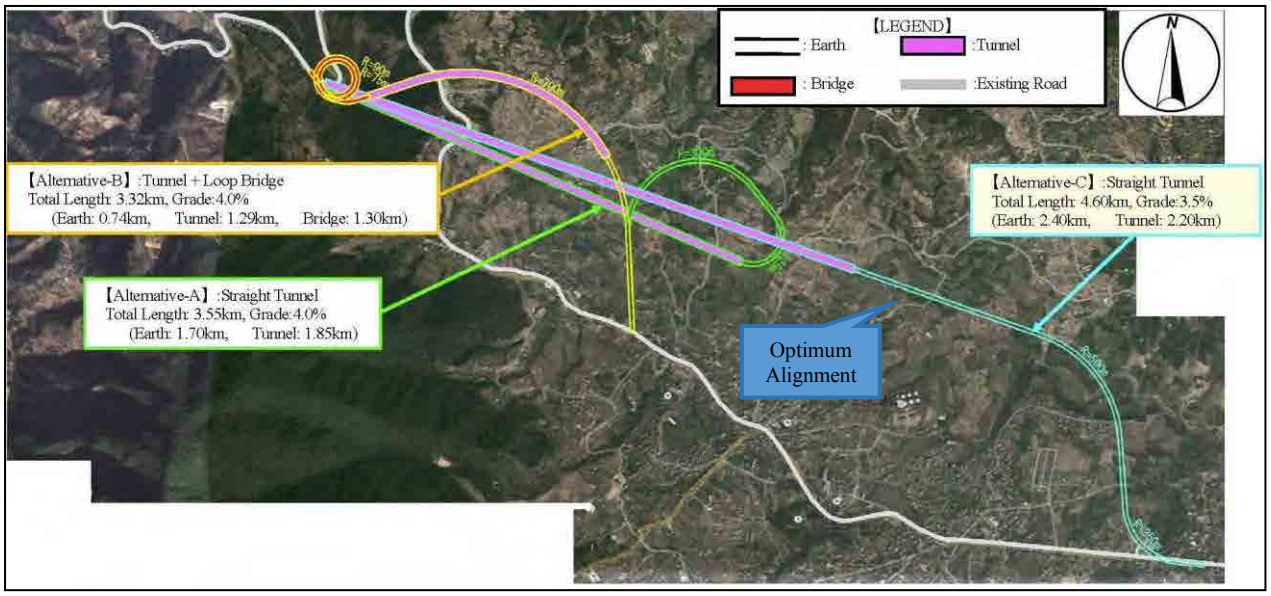
8.1 ALTERNATIVE ALIGNMENT STUDY BY JICA-ASSISTED "DATA COLLECTION SURVEY ON THANKOT AREA ROAD IMPROVEMENT IN NEPAL"

8.1.1 Background

Prior to this Survey, JICA had conducted the project, "Data Collection Survey on Thankot Area Road Improvement in Nepal" (Data Collection Survey) from January, 2014. Altogether five alternatives were studied in this project and comparison study was performed to select the optimum one from the three alternative alignments that passed the initial screening. These alternative alignments were reviewed as discussed hereunder.

8.1.2 Review of the Alternative Alignments

The alternative alignments selected from among the five alternatives for detailed comparison to select the optimum alignment proposed during the Data Collection Survey are shown in **Figure 8.1-1**.



Source: Data Collection Survey

FIGURE 8.1-1 ALTERNATIVE ALIGNMENTS

Though there is no specific mentioning about what the proposed alternatives are intended for, it can be assumed that the alignments proposed were from the following points of view.

1) Alternative-A: Emphasis on maximum utilization of existing road
2) Alternative-B: Emphasis on minimizing tunnel length
3) Alternative-C: Emphasis on geometric requirements

Out of the three alternative alignments, Alternative-C was selected as the optimum alignment in the Data Collection Survey. Alternate-B, which has the shortest tunnel, is the least attractive alternative. The spiral land bridge (looped bridge) is not only extremely expensive to construct, but also difficult and its maintenance cost is also the highest. The construction cost of Alternative-B is twice as much as that of Alternative-C. To add, the vertical gradient of the tunnel (4.0%) as well as that of the spiral bridge section (4.8%) are relatively higher to enable smooth and safe drive to the vehicles.

Alternate-A is attractive in terms of lowest construction cost, maintenance cost and land acquisition including relocation of houses. Impact on the groundwater during construction is considered to be high and the approach road at the east side is considered to require high fill

and high cut. However, the biggest concern is that there is high possibility of lowering the groundwater level of the surrounding area.

As mentioned in the Data Collection Survey, all alternatives have its own distinct advantages. This survey puts high emphasis on vertical grades. The vehicles plying on the objective road, particularly the trucks, are not only old and over loaded, but also lack in capacity. Measured record indicates that these trucks can run on an average of about 15-20km/h at sections inclined to 4.0%. This can create unfavorable situation inside the tunnel. Therefore, it is desirable to have a vertical gradient as small as possible.

From this aspect, Alternative-C, which has a vertical grade of 3.5% and was selected as optimum alignment is justifiable.

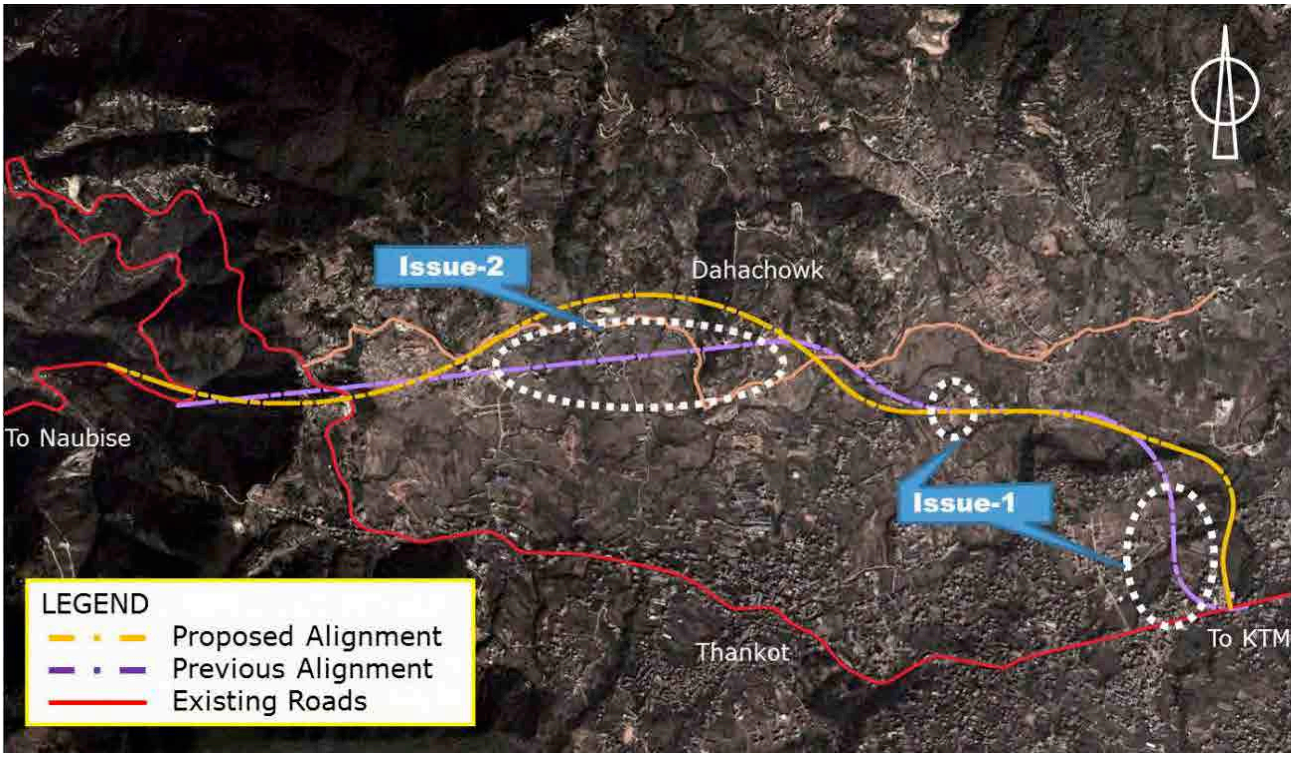
8.1.3 Suitability for Provision of Tunnel

The objective road is one of the most important trunk roads that support the economic and social activities of the country. The objective section of the project passes through Nagdhunga Pass, and consists of steep vertical grades exceeding 10% in combination to consecutive curves with small radius of curvature. This section is vulnerable to slope failures and other water-induced disasters, that often hamper traffic flow or sometimes even contributes to closure of the road. All combined, the section is being the biggest bottleneck of the road and immediate measures are required to deal with the situation. As have also been pointed out in pre-studies, the optimum measure to remedy the above situation is provision of a tunnel. The following reasons are considered to justify its suitability.

- Being a mountainous area, improvement of vertical grades and widening of the existing road is extremely difficult, if not virtually impossible.
- Other possible improvement measures are provision of land bridge, provision of spiral bridge etc. These methods were studied and compared and the results showed that provision of tunnel (as planned in this project) is the optimum measure.
- The proposed tunnel was studied from various aspects and has been planned to satisfy the requirements specified in the Japanese Guidelines for Planning and Design of Tunnels.
- This tunnel is potentially the first ever highway tunnel of its kind in Nepal. Various facilities have been planned to be installed inside the tunnel taking safety during and after construction into consideration. One of the programs planned is the capacity development (CD) of DOR during operation stage. The CD also includes enhancing safety awareness of road users through tunnel safety campaign program.

8.1.4 Issues of the Optimum Alignment

The Survey Team conducted site reconnaissance several times after the commencement of the project with an aim to verify the actual condition of the alignment at the site, as well as identify issues, if any, regarding the optimum alignment of the Data Collection Survey. **Figure 8.1-2** shows the optimum alignment (indicated by the violet line) and locations where issues were identified.



Source: Data Collection Survey

FIGURE 8.1-2 OPTIMUM ALIGNMENT MAP AND LOCATION OF ISSUES

(1) Social and Environmental Issues

1) Houses Near End Point of East Side of Approach Road

One of the major issues of the previous alignment was identified at the intersection with the existing Tribhuvan Highway. As shown in **Figure 8.1-3**, the alignment affects several big residential houses necessitating relocation of many households. In addition, there is development work being conducted at the open area. According to the hearing conducted by the Survey Team with the workers there, it was understood that 14 new houses will be constructed in no matter of time. All these houses will be affected by the alignment.

FIGURE 8.1-3 HOUSES NEAR END POINT OF EAST SIDE APPROACH ROAD

2) Impact on Brick Factories

The other issue is that the alignment almost bisects the brick kiln as is shown in **Figure 8.1-4**. In the Data Collection Survey, it is mentioned that the brick factories are not permanent structures. They move to different location once the material for making the bricks is no more available near its location. It also says that, being just a factory, where people commute to make bricks and not a place where people actually live, there is need for relocation of the factory only and does not require relocation of households. From such aspect it was concluded that alignment bisecting the brick factory is not a big issue.

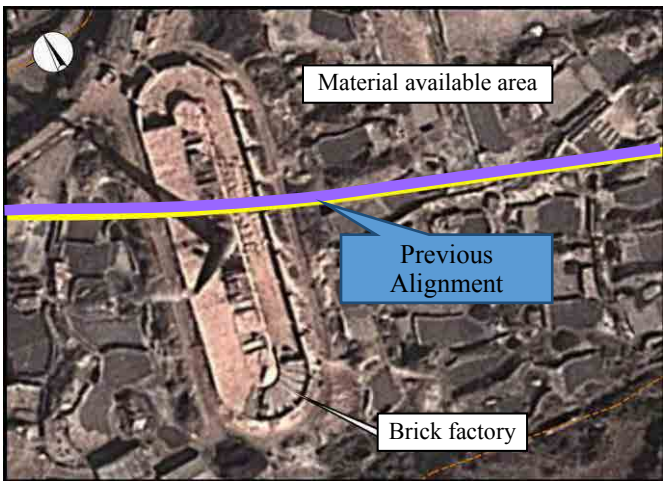


FIGURE 8.1-4 ALIGNMENT BISECTING BRICK FACTORY

The Survey Team met and discussed with the DOR and confirmed that there is less chance of any kind of objection in requiring the land belonging to the brick factory.

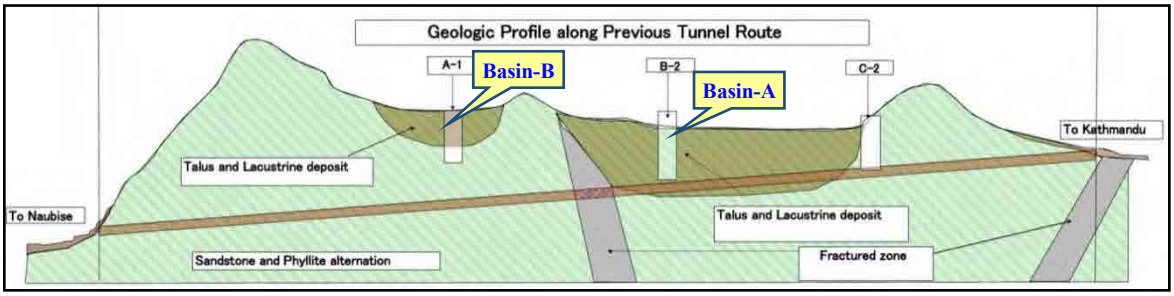
(2) Engineering Issue

As can be understood from **Figure 8.1-3**, the alignment near the intersection with the existing Tribhuvan Highway is curved. It is understood that doing so can secure smooth flow along the approach road. However, vehicles from Thankot headed for Kathmandu will have a hard time negotiating with the traffic to and from the approach road. This type of alignment is acceptable if the traffic volume from within Thankot area is significantly low. Otherwise, it is considered to lack traffic safety.

On the other hand, there is no specific plan for an approach road at the west side in the Data Collection Survey. There is also no detailed arrangement for securing connectivity between the approach road with the existing Tribhuvan Highway.

(3) Geological issue

The geological condition of the tunnel profile is shown in **Figure 8.1-5**. This figure depicts the soil type distribution along the tunnel. As shown in the figure, the area is basically composed of Sandstone and Phyllite, where excavation work for tunnel construction is relatively simple. However, the basin areas are composed of alternate layer of lacustrine and Talus deposited from the surrounding mountains such as Chandragiri and Badbhanjyang. These types of soil are considered weak and weathered. A portion of the previous tunnel alignment (Data Collection Survey) passes along this Lacustrine and talus soil deposit. Tunneling along this type of soil will require various auxiliary methods and is not only time-consuming but is also costly.



Source: Survey Team

FIGURE 8.1-5 GEOLOGICAL CONDITION ALONG TUNNEL SECTION

8.2 SELECTION OF TUNNEL PORTALS AND ALIGNMENT

Past study reports were reviewed and those alignments proposed and studied are reviewed in detail. As a result, the Survey Team has concluded that the locations of tunnel portals recommended in the Data Collection Survey are optimum. Due to the short period allowed for site investigations, field survey areas and quantities for geotechnical, topographical, hydrological and environmental survey have been fixed and started implementation in the very early stage.

8.2.1 Eastern portal

The Survey Team once studied of the adequate location of eastern portal aiming to reduce the vertical gradient of the tunnel section to reduce concentration of harmful gasses and particles inside the tunnel as much as possible. During the course, a candidate location of tunnel portal was determined. The location of this portal is shown in **Figure 8.2-2** as Alt 2 and the portal of recommended Alignment 1A is shown in the figure as indicated by Alt.1.

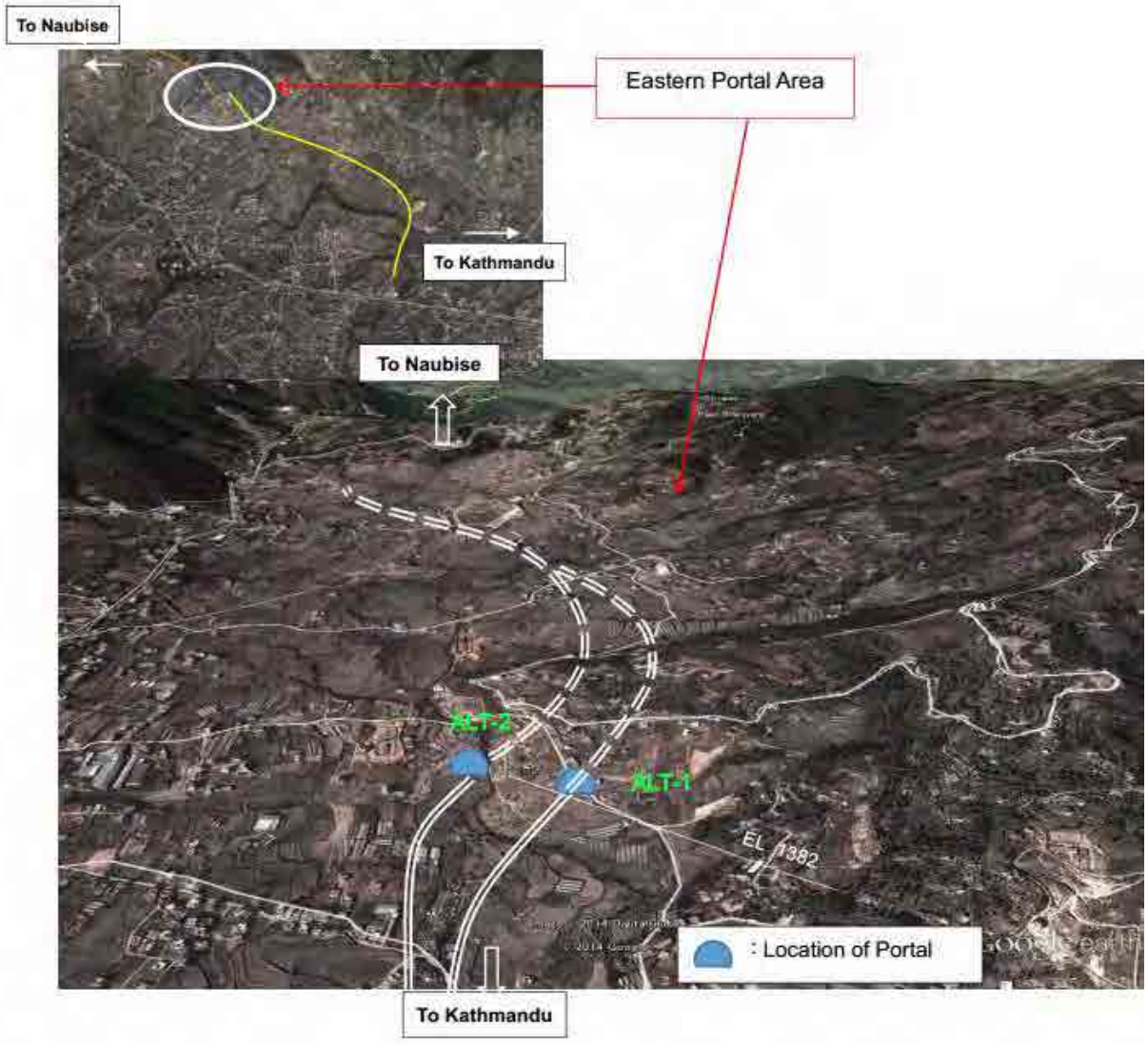


FIGURE 8.2-1 LOCATION OF EASTERN PORTAL AND ITS ALTERNATIVE

Site reconnaissance was carried out along the Alignment 1A and candidate portal Alt 2. After field survey on topography and geology, the eastern portal Alt 2 has been abandoned due to the following reasons.

- Alt 2 is located at the margin of a small ridge about 300m south from the alignment 1A.

This means it will be necessary to have a significant alignment change from alignment 1A and will also require provision of a large S-curve in the tunnel section. In addition, alignment of approach road should also be largely modified.

- There are some large cuttings in the ridge where complex geotechnical conditions are observed. Completely weathered basement rock mass is totally fractured and sheared and its structure is totally disturbed. There might have been a distribution of significant faults which could have caused such disturbance of geological settings.
- In the small ridge extending from north to south, saddle topography is observed and southern portion of this saddle structure is anticipated to be in totally disturbed ground.
- If the portal is fixed at Alt 2, the excavation of the tunnel will lie on this very difficult geotechnical condition. Tunneling may encounter serious difficulty and require longer construction period and higher cost.

8.2.2 Western portal

The western portal location was tentatively fixed at the foot point of the ridge behind a small shop by cutting the slope till the same elevation of that of existing road based on the site reconnaissance result and topographic survey result. There are two small streams at both sides of the portal. Thus it is extremely importance to manage the stream water to avoid any possible influence to the tunnel portal structure.

With adequate drainage system at the base of the streams, these small valleys are to be used for the temporary installment of various facilities for tunnel construction, such as stock yard for various materials and equipment for construction, water treatment facility for the waste water from the tunnel and so on.

It is of great importance for the alignment to adequately intersect with the existing road. Various alternative ideas are under study to safely intersect with existing road and new road. Meanwhile, the deep valley in front of the tunnel shall be filled up by material from slope cut and tunnel muck and utilized for new road access to the existing road. After topographical survey has been finished portal elevation was lowered by about 5m to intersect with the existing road at the same elevation because of the difficulty in approaching to the existing road in adequate gradient.

During the course due to the difficulty anticipated to construct the approach road connecting to the existing road in a safe manner and getting proper intersection there, our team started studying other candidate portal locations which are shown in the **Figure 8.2-2** as Alt-2 and Alt-3.

Alt-2 is located at about 30m below the existing road (elevation may be about 1290m). When tunnel portal is constructed here and connected to the existing road at the small ridge northwest of the curve of the existing road, wide area can be obtained for the intersection of new road and existing road.

Site reconnaissance was carried out and after field survey on topography and geology, Alt-2 has been abandoned due to the following reasons.

- Alt-2 situates just beneath the existing road at elevation of about 1290m and is friable to falling down of heavy vehicles.
- Approach to the portal needs long access within the sharp valley topography where slope stability shall be a key factor.
- Tunnel becomes longer and gradient is steeper than present alignment.
- It is difficult to obtain sufficient working area at portal.
- When the road goes out from the tunnel it requires very long and tall bridge which requires most advanced technique and higher cost.

Alt-3 is located at a tiny valley south of the existing road at elevation of about 1290m. When tunnel is constructed with large and wide cuttings of the slopes surrounding the portal, new road may easily approach to the existing road. And when the valley north of the portal is filled up for diversion of the existing road during tunneling, it can provide an intersection area.

Site reconnaissance was carried out and after field survey on topography and geology, the candidate portal Alt-3 has been abandoned due to the following reasons.

- To get sufficient space to start tunneling form here, wide area of slopes shall be cut to obtain sufficient working area for tunneling. It destructs the natural environment and requires permanent slope maintenance of wide areas.
- Length of the tunnel increases significantly and tunnel gradient also becomes steeper than the present alignment.
- New road at the tunnel outlet intersects with the existing road which has gradient of about 6% and traffic safety may be a serious problem.
- To fill the valley north of existing road to get road diversion materials for fill are not available in early stage.

FIGURE 8.2-2 WESTERN PORTAL LOCATION AND ITS ALTERNATIVES

8.2.3 Alignment of the tunnel

In the early stage after site reconnaissance survey and geological walk out survey, alignment of the tunnel section was shifted towards north as shown in **Figure 8.2-3**, in order to avoid the poor ground south of the saddle of the small ridge near eastern portal as well as to avoid the unconsolidated sediments in the valley area after passing the ridge. Thus, beneath the valley areas sufficient rock cover above the tunnel is safeguarded. By avoiding very poor geotechnical conditions tunnel construction can be done more economically and within shorter period. Following shifting of the initial alignment to the north, maintaining a straight alignment for the tunnel section was not possible and insertion of two reverse curves had to be done because the two portals (entrance and exit portal locations) are immobile. Therefore, the alignment proposed under this survey is curved. Being the first road tunnel, questions may be raised whether a curved alignment can be applied inside a tunnel. In general, drivers tend to speed up on long straight road. The long straight alignment can be monotonous under similar aesthetic like inside a tunnel and make the drivers sleepy or enhance driver errors. There is similar

practice in Japan also. The “Transport Engineering Handbook 2008” of Japan recommends a maximum length of 1000m for a road with design speed 50km/h. Therefore, from engineering approach, a tunnel with a big radius of curvature is rather better than a long straight alignment.

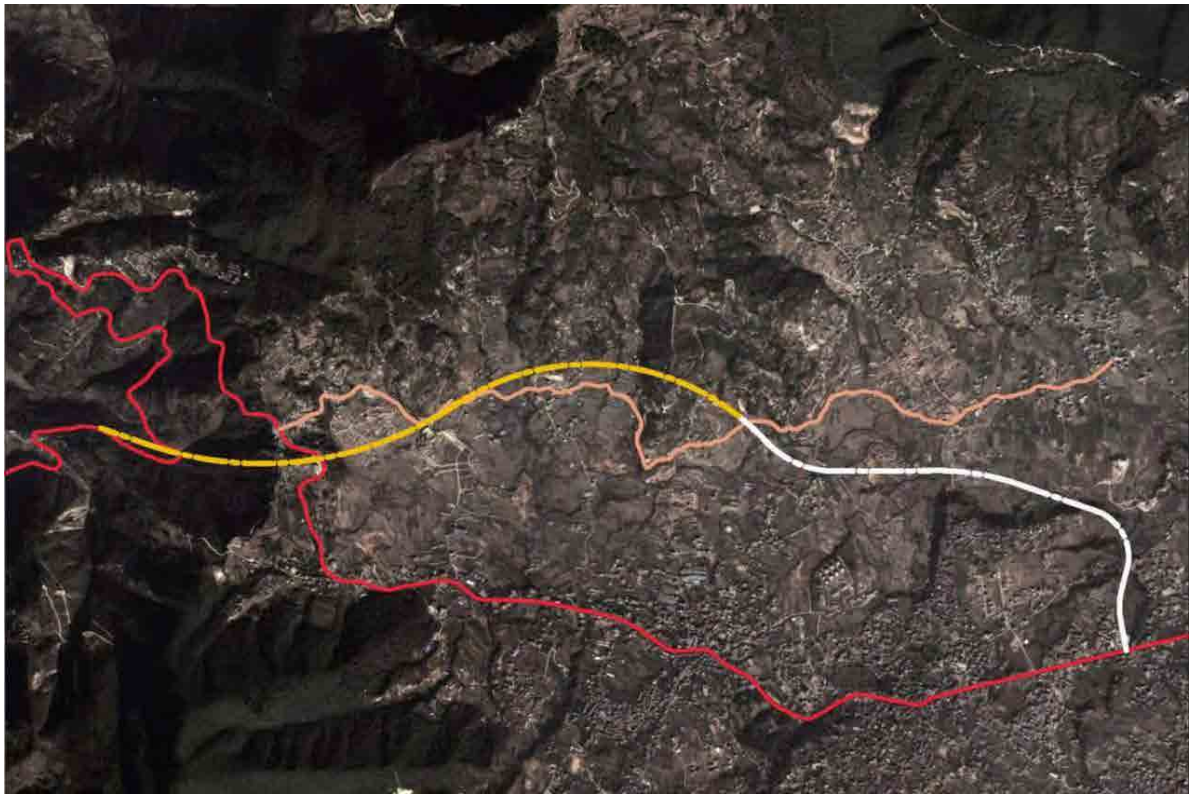


FIGURE 8.2-3 TENTATIVE ALIGNMENT

8.3 SELECTION OF APPROACH ROAD ALIGNMENT

The approach road is composed of two sections – one at the east side and the other at the west side. The east side approach road was selected from various alternatives during the Data Collection Survey. There was no selection of an approach road in the west side.

8.3.1 Basic Policy

Following policies were applied in selecting the alignment of the approach road.

(1) Meet the Engineering Requirements

(2) Minimize the length of the road

(3) Minimize adverse impact on natural and social environment

(4) Secure access appropriately to and from the community

(5) Secure safe flow during construction (construction efficiency)

(6) Economic feasibility

8.3.2 Requirements for Selection

Various requirements were applied in identifying the alternative alignments of the approach road. The major requirements taken into consideration are as follows.

(1) Overall Requirement

The approach road at the east side is relatively long with a length of about 2.6km. This

alignment was selected during the Data Collection Survey from among several alternatives. The Survey Team made a quick review and concluded that the selected alignment is justifiable for reasons mentioned below. (Some of these reasons are mentioned in Section 8.1.2 as well).

- The location of the tunnel portal is a precondition for an approach road. The location of the tunnel portal was determined such that lowest possible vertical grade can be applied. Therefore, it is fixed. On the other hand, the location where the approach road would meet with the existing road is desirable to be such that the houses that would be affected are minimal. The proposed alignment for the approach satisfies these conditions.
- There is a District Road running parallel north of the existing Tribhuvan Highway. The only proper connection between these two roads is in Nagdhunga. The proposed approach road alignment is such that it provides a new connecting point between these two roads allowing easy access from the District Road to not only to the tunnel, but also to the existing Trbhuvan Highway.
- The Outer Ring road, if implemented will run north-south about several hundred meters east from the proposed approach road. The approach road can be extended towards the east in the future to provide direct access to/from the Outer Ring Road.

(2) Engineering Requirement

The approach road is considered to become a part of the Tribhuvan Highway, which is functionally classified into Class II. As such, the approach road should meet the basic geometric requirements of the said class (Class II). **Table 8.3-1** shows the basic requirements for Class II roads based on Nepal Road Standard 2070 (July, 2013), but some of the requirements come from other standards such as Japan Road Ordinance and AASHTO.

TABLE 8.3-1 ENGINEERING REQUIREMENTS FOR SELECTION OF ROUTES

ITEMS	REQUIREMENTS	
1. Administrative Classification	National Highway	
2. Functional Classification	Class II	
3. Design Traffic (ADT)	10,000-11,000	
4. Design Speed	60km/h (40km/h in case of existing road)	
5. Design Vehicle	WB-15 AASHTO	
6. Horizontal Radius of Curvature	Desirable	150m
	Minimum	100m
	Unavoidable	90m
	Hair pin curves	15m
7. Vertical Gradient	0.5% - 7%	
8. Right of Way Reserve	50m (25m from centerline at each side)	

(3) Natural and Social Environmental Requirements

The following natural and social environmental concerns of existing land were taken into consideration in identifying the proposed approach road.

- National and community forests
- Rivers, streams and other sources of water
- Religious and social facilities (temples, holy trees, cremation area, graves, etc.)
- Cultivated lands/farms
- Important government facilities
- Residential houses/buildings

- Institutional and educational facilities
- Existing roads

(4) Access to Abutting Properties

The approach road at the east side will function as a bypass of the existing Tribhuvan Highway, emphasizing the mobility function of a road. However, there are communities alongside the approach road and the approach road should provide access to and from such communities.

8.3.3 Identification of Control Points

Control points for delineation of alignment were identified through review of relevant documents, thorough site reconnaissance and discussions with relevant organizations. Following are some major control points identified.

- Built-up areas
- Undergoing housing development plans
- Water channels (rivers, streams)
- Intersection with the existing roads
- Geologically weak areas (faults, land slide and slope failure prone area etc.)
- Topographically unsuitable areas (cliffs, mountains, soft ground etc.)

8.3.4 Delineation of Alternative Alignments

(1) East Side Alternative Alignment

As mentioned earlier, the alignment of east side approach road set during the Data Collection Survey is appropriate except for the issues mentioned in section 8.1. Therefore, instead of providing completely new and different alternative alignments, measures were taken to address the aforementioned issues and modify the optimum alignment determined in the previous Study. The control points mentioned above were also taken into consideration in modifying the alignment. The measures taken are;

1) Shifting of Alignment

Figure 8.3-1 shows the previous alignment (Data Collection Survey) and the newly delineated alignment. The new alignment runs almost in parallel with the previous alignment at about 200m to the east from the previous alignment. However, the intersecting point with the existing Tribhuvan Highway is almost at the same location. As depicted in the figure, in contrary to the previous alignment, which affects a number of houses, the newly delineated alignment allows avoidance of many houses that were affected by the previous alignment.

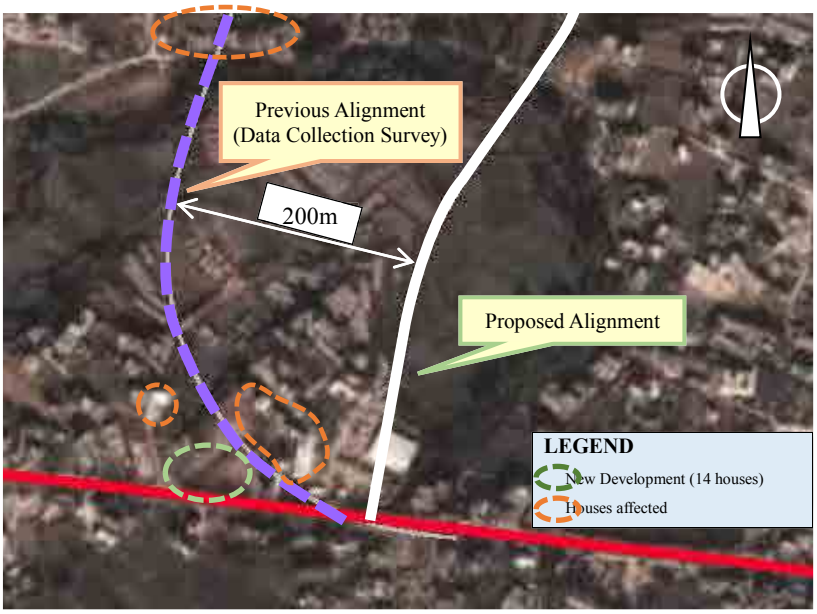


FIGURE 8.3-1 ALIGNMENT SHIFT AT END POINT OF EAST APPROACH ROAD

2) Provision of Intersection System

Signal controlled system will be planned at the intersection with the existing Tribhuvan Highway to control the traffic flow.

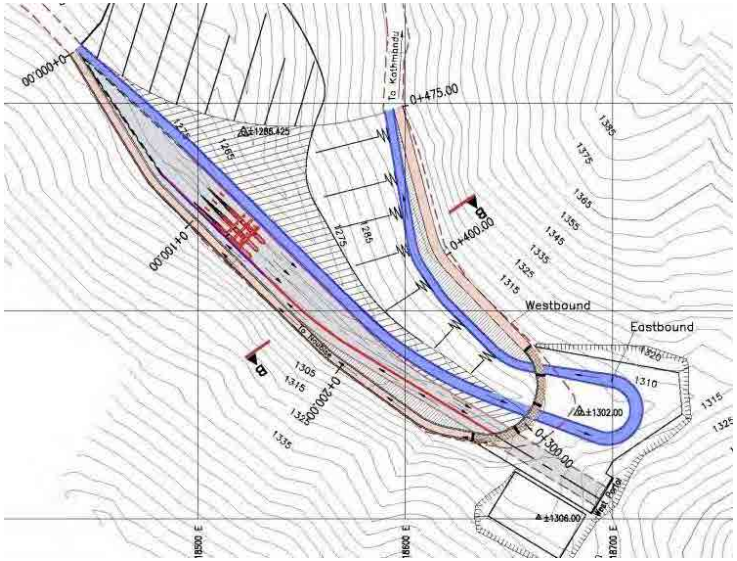
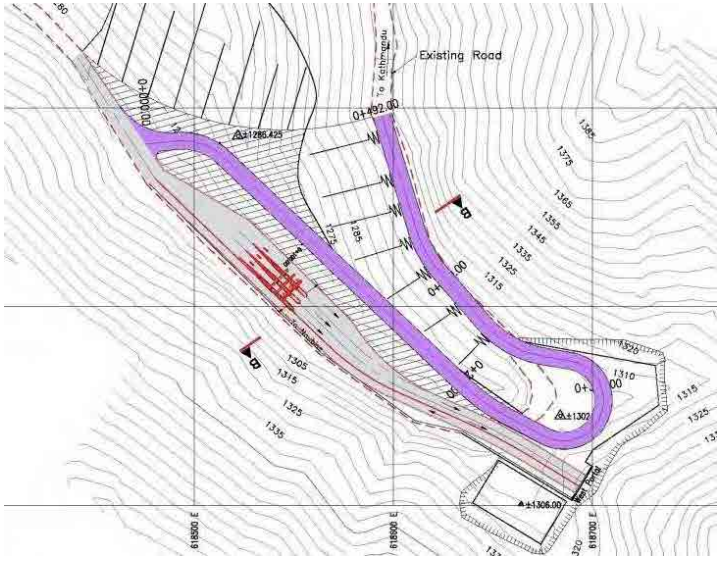
3) Change following Alteration of Tunnel Alignment

The tunnel alignment was altered tentatively based on the recommendation made in the Data Collection Survey and the findings of the preliminary results of geological investigations. The alignment of the approach road was then adjusted to meet with the modified alignment of the tunnel.

(2) West Side Alternative Alignment

The alignment of the approach road at the west side is dependent on how the connection with the existing road is provided. Many conceivable alternatives for connectivity between the approach road and the existing road were studied, among which two potential alternatives were ultimately selected. A simple comparison of these two alternatives was conducted with respect to the geometry, safety, drivability, and construction cost as summarized in **Table 8.3-2**.

TABLE 8.3-2 COMPARISON OF CONNECTIVITY BETWEEN APPROACH ROAD AND EXISTING ROAD

Alternatives		Alternative-1: Without Intersection		Alternative-2: With Intersection	
Illustration					
Concept		Traffic control: Merge/diverge Approach road: priority Existing road: Yield		Traffic control: Signalized Intersection (If possible, introduction of)	
Structures		Bridge L=60m (3-span, curved) Retaining walls		Traffic signals	✓
Evaluation Factors	**Geometry**	Min. horizontal radius=15m Max. grade=11.7% (westbound) =5.0% (eastbound)		Min. horizontal radius: 20m Max. grade= 5% (both direction)	✓
	Safety	Inferior to Alternative-2		No significant problem	✓
	Drivability (approach road)	Interruption to traffic is low (Approach road priority)	✓	Interruption to traffic could be high (stop at intersection) *(signal can be arranged to prioritize traffic flow on approach road)*	
	Construction Efficiency		✓		✓
	Cost and period	Expensive than Alternative-2		Cheaper than Alternative-1	✓
Evaluation				**RECOMMENDED**	

8.3.5 Verification at Site

Site reconnaissance was conducted to verify the established alignment at the site. The alignment was checked whether it meets with the actual condition of the site and satisfies the control points set. There were no particular contradictions nor issues identified during the site reconnaissance

8.3.6 Determination of the Alignment

A comparative study was conducted to determine the optimum alignment of the tunnel and its approach road. Table 8-2 shows the comparison and its result.

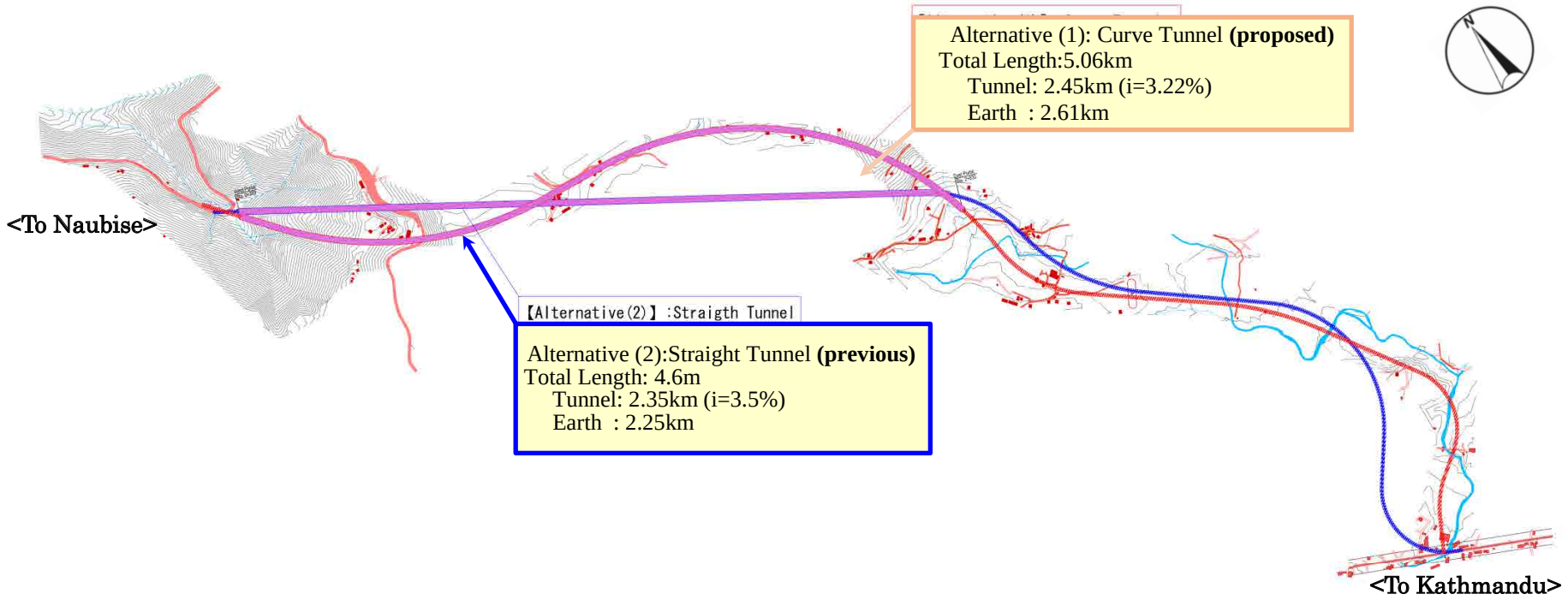
8.4 SELECTED ALIGNMENT OF TUNNEL AND APPROACH ROAD SECTION

Table 8.4-1 shows the comparison between the proposed and previous alignments. The horizontal alignment of tunnel including the approach section and the profile is shown in **Figure 8.4-1**.

Plan and Profile of the final alignment is shown in the **Sheets NO. 3 to 6 of the Preliminary Design Drawings**.

TABLE 8.4-1 COMPARISON BETWEEN PROPOSED AND PREVIOUS ALIGNMENTS

PLAN



Items	【Alternative(1)】:Proposed Alternative of This Project (Curve Tunnel)		【Alternative(2)】:Alternative of Data Collection Survey(Straight Tunnel)	
Drivability	Tunnel alignment is S-shaped curve.	△	Tunnel alignment is Straight.	○
Vertical Grade	Vertical grade is looser than "alternative (2)".(i=3.2%)	○	Vertical grade is steep. (i=3.5%)	○
Construction Difficulty(Tunnel)	Constructability of tunnel is better than “Alternative (2)” as the tunnel alignment pass through hard rock bed.	○	Construction of tunnel is difficult because the tunnel alignment pass through residual soil layer of basin in east area of tunnel.	△
Affected Houses	Number of relocated house is about half of "Alternative (2)"	○	Maximum number of relocated house is about 27.	△
Cost (Ratio)	1.00	○	1.40	△
Construction Period	42 months	○	59 months	△
Ranking Evaluation	Vertical grade, construction difficulty, affected house, construction cost and period are better than “Alternative (2)”. Traffic accident risk is lower than “Alternative (2)”.	1	Drivability is better than “Alternative (1)”. Traffic accident risk is high.	2

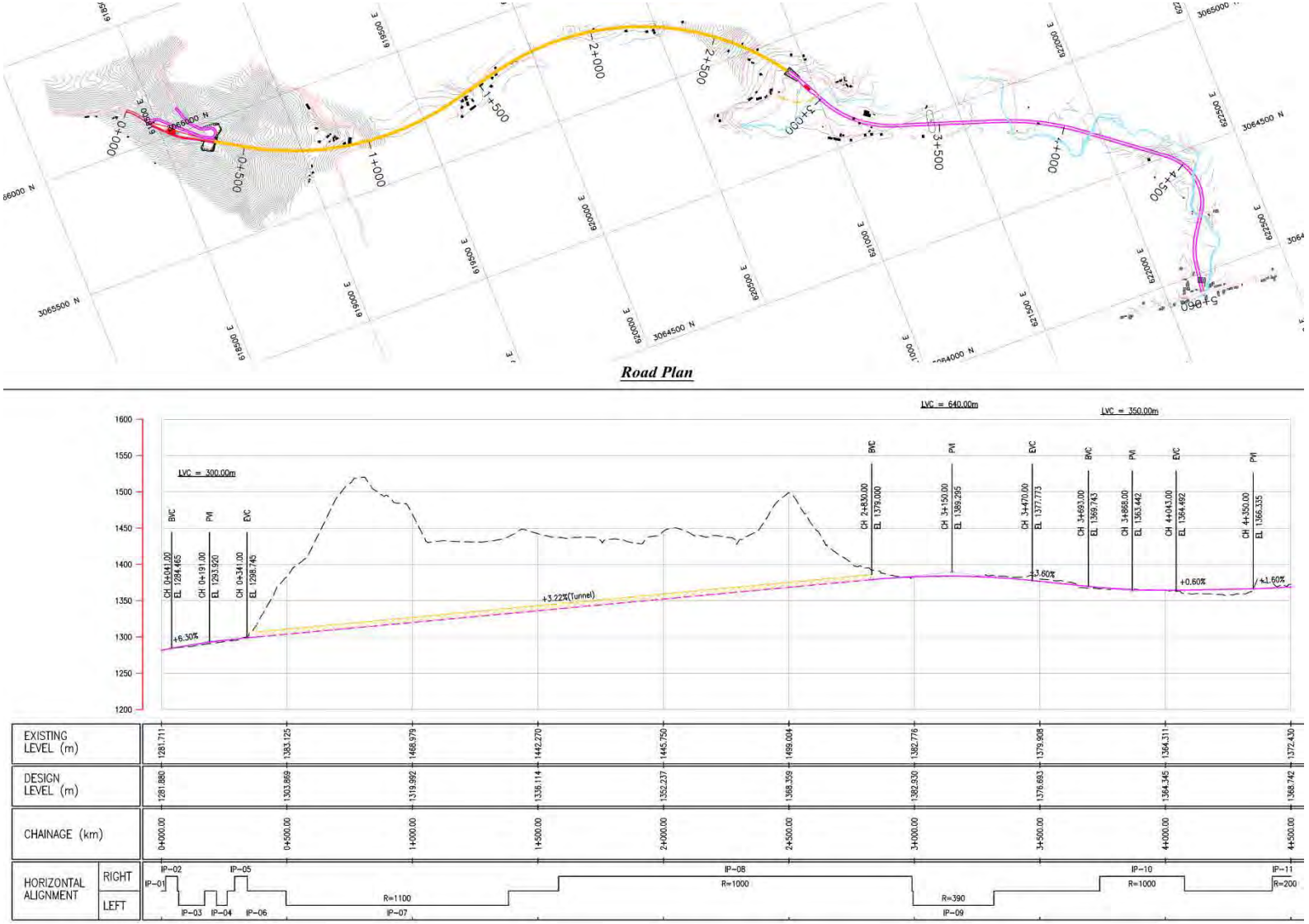


FIGURE 8.4-1 HORIZONTAL AND VERTICAL ALIGNMENT OF SELECTED ALIGNMENT (TUNNEL AND APPROACH ROAD)