Chapter 3

Data Collection and Organization for Environmental and Social Considerations

Chapter 3 Data Collection and Organization for Environmental and Social Considerations

3.1 Scope of Data Collection and Organization for Environmental and Social Considerations

3.1.1 Contents of Data Collection of Organization

The scope of collection and organization of data relevant to environmental and social considerations for the current project is:

1) Explore the aspects of environmental impact assessments to consider (scale of resettlement and land acquisition, development in national parks, etc.) as well as the content and method of field survey for the proposed Hanoi-Vientiane expressway.
2) Based on JICA Guidelines for Environmental and Social Considerations (April 2010), conduct a comparative study of environmental and social considerations in determining appropriate road plan, estimate and evaluate important aspects of environmental impact assessment, prepare adequate mitigation measures and monitoring plans.
3) Upon consultation with the counterparts, prepare a draft environmental checklist from JICA Guidelines for Environmental and Social Considerations (April 2010) to summarize the result of the survey.

The scope of this survey involves four different routes stretching across a wide area. Therefore, the area subject to environmental and social considerations encompasses all the area required for these routes; the proposed area for Pre-F/S route, for rehabilitation of National Road No.8 (NR 8) that runs parallel to Pre-F/S route, new expressway along NR8, and National Road 1D that connects the two roads.

In this Chapter, the data compiled and examined are organized in the following ways:

1) Review the laws and regulations in Laos and Vietnam regarding environmental and social dimensions of the project (see 3.2)
2) Summarize the baseline information regarding natural and social environment of the target study area. (see 3.3)
3) Outline systems and procedures of and calculate the estimated cost for land acquisition and resettlement. (see 3.4)
4) Carry out scoping to clarify and concentrate on significant aspects of environmental impact assessment, predict and evaluate likely effects, propose mitigation measures. Scoping was conducted only for the select routes. (see 3.5)
5) Clarify issues requiring further study and topics to address in the future. (see 3.6)
6) Environmental checklist is not included in this report because consultation with counterparts has not been implemented.

3.1.2 Study Area for Environmental and Social Considerations

The alternative routes to be examined in this study, as shown in the table below, connect Vientiane (Laos) to Vinh (Vietnam). The table below shows the routes. Refer to Chapter 6 for their details.

Table 3.1.1 Alternative Routes under Review

Alternative routes	Total distance
Route 1 Pre-F/S Route	400km
Route 2 NR 8 Route	403km
Route 3 Compound: NR13→NR8→1D→Pre-F/S Route	496km
Route 4 Compound: NR13→Pre-F/SRoute→1D→NR8	426km

The study area of this project is the area surrounded by the routes stretching between Vientiane in Lao PDR to Vinh in Vietnam. The figure below shows the target area enclosed by the routes under examination: Pre-F/S Corridor, Lao NR 13, Lao NR 8, Lao NR 1D, and Vietnam AH15.

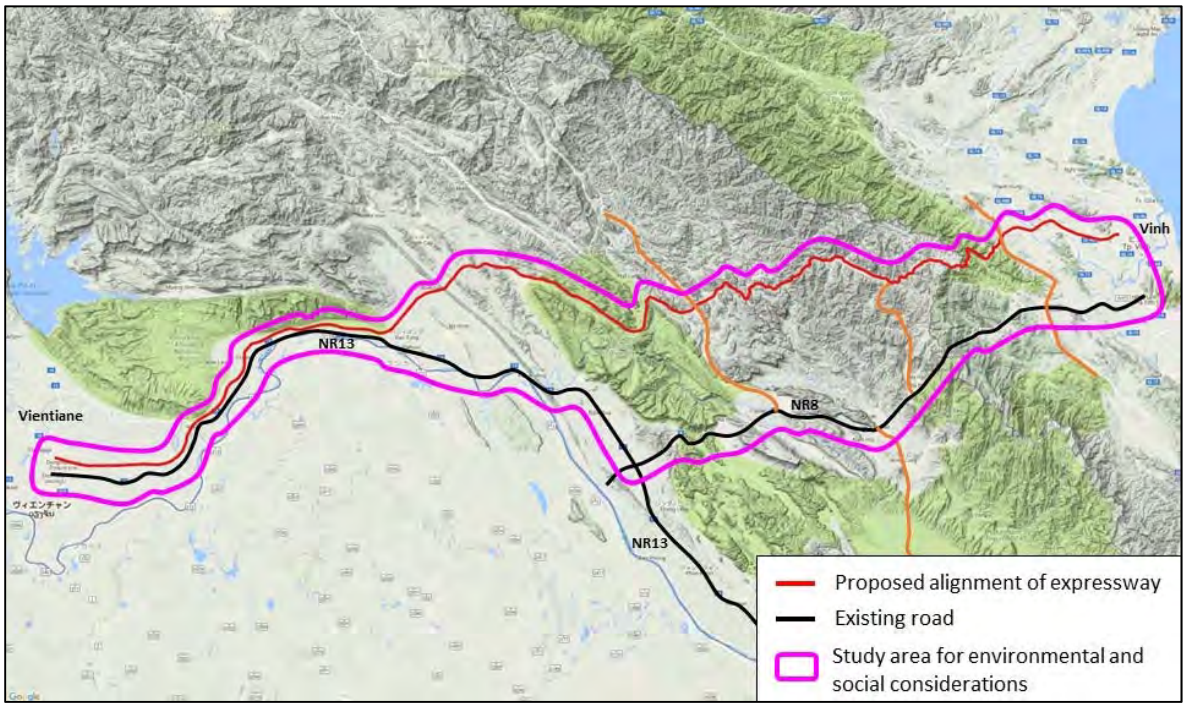


Figure 3.1.1 Study Area for Data Collection for Environmental and Social Considerations

In the following sections, the laws and regulations in Lao PDR and Vietnam pertaining to environmental and social considerations are reviewed. Next, the baseline information about environmental and social conditions in the study area are summarized.

3.2 Review of Laws and Regulations Relevant to Environmental and Social Considerations

3.2.1 Laws and regulations of Lao PDR relevant to environmental and social consideration

(1) Relevant legal frameworks in Lao PDR

The following is the summary of the laws and regulations in Lao PDR relevant to environmental and social considerations. The foundation of the environmental laws and regulations in the country is Environmental Protection Law (EPL), first enacted in 1999 and amended in 2012 is. The table below lists the major laws in Lao PDR.

Table 3.2.1 Major Laws Relevant to Environmental and Social Considerations in Lao PDR

No.	Title	Enacted Year	Enacted No.
1	Constitution	1991, amended in 2003, 2015	
2	Environmental Protection Law	1999, amended in 2012	No.29/NA
3	Law on Agriculture	1999	No.01/98/NA
4	Water and Water Resources Law	1996, amended in 2017	No.23/NA
5	Land Law	2003	No.04/NA
6	Forestry Law	2007	No.06/NA
7	Wildlife and Aquatic Resources Law	2008	No.07/NA
8	Law on National Heritage	2005, amended in 2013	No.44/NA
9	Public Roads Law	1999, amended in 2016	No.03/NA

Source: JICA Study Team

(2) Administrative frameworks in Lao PDR

This section summarizes the administrative frameworks of Lao PDR relevant to environmental and social considerations.

1) Ministry of Natural Resources and Environment: MONRE

In the administrative procedure of environmental and social consideration, the Ministry in charge of IEE and EIA reviews is MONRE. It was established as a result of 2011 merger between government agencies such as National Land Management Authority (NLMA) and Department of Geology, as well as the Department of Forest Conservation in the Ministry of Agriculture and Forestry (MOAF), Water Resources & Environment Administration (WREA).

Review of IEE and EIA is conducted in the Department of Environmental and Social Impact Assessment (ESIA) of MONRE.

2) Ministry of Public Works and Transport: MPWT

For road sector projects, administration related to environmental and social considerations is implemented by the Public Transportation Research Institute (PTRI) in MPWT. There is only one personnel dedicated to environmental and social considerations in Department of Road (DOR) as of December 2017, and the main function of the position is as coordinator for environmental and social considerations. The Environmental and Social Division (ESD) of PTRI also takes part and provides review and advice on ESIA for new road project prior to their submission to MONRE. In national roads projects, PTRI-ESD shall assist in the following aspects:

- Prepare and develop terms of reference for IEE, EIA, and RAPs for road projects
- Review bids and proposals for environmental and social works and assistance to be provided by consultants and/or consulting firms as appropriate.
- Reviews and endorse the IEEs, EIAs, and RAPs prepared by consultants and experts for the purpose of national road projects before their submission for review and approval by MONRE.

・Validate the IEE, EIA, and RAP reports and documents related to national road projects and ensure that they were prepared in accordance with the procedures described in the ESOM, including consultation of stakeholders and affected persons.
・Participate in monitoring and supervision mission of national road projects to ensure compliance with environmental and social requirements

3) Ministry of Agriculture and Forestry: MOAF

In the administrative procedure of environmental and social considertation, MOAF plays an important role in the management of nature preserved area and forest as well as in the procedure to calculate compensation for land acquisition and resettlement.

MOAF is a responsible agency for preserved area and forest, and the Department of Agriculture and Forestry (DOAF) is the main department within MOAF in charge of procedures regarding these environmentally designated areas, including application or authorization for the change of designation. In some projects MOAF conducts an environmental survey for EIA in cooperation with expert consultancy. Further, as for the calculation of land acquisition and resettlement cost, local (prefecture or district level) MOAF is responsible for deciding amount for compensation.

(3) Procedures of Environmental Compliance Certificate (ECC) in Lao PDR

1) Necessary study for Environmental Compliance Certificate (ECC)

Follow Environmental Protection Law, a project proponent is required to conduct Environmental Impact Assessment (EIA) or Initial Environmental Examination (IEE) to obtain Environmental Compliance Certificate (ECC). The types of study (EIA or IEE) required for each project category in road sector are as follows.

Table 3.2.2 Project Categorization in Road Sector

Category	Necessary Study	Categorization Criteria
Category 1	Applicable to small-scale projects and projects with no significant negative impact to environment is expected. Initial Environmental Examination (IEE) is required.	Road improvement project (national, provincial, district, extra road improvement) Road rehabilitation or upgrading project (national, provincial road rehabilitation)
Category 2	Applicable to large-scale development plans and projects. Environmental Impact Assessment (EIA) is required.	Road construction through national or provincial protected areas New road construction project (national, provincial, district, urban, extra construction)

Source: JICA Study Team

2) ECC process

Decree on Environmental Impact Assessment (2010) and Environmental Impact Assessment Guidelines (2010) describes the process of obtaining ECC. For road sector projects, Environmental and Social Operations Manual (2009) should be also consulted in conducting EIA.

A project proponent must submit ESIA (Environmental and Social Impact Assessment) report prepared in Lao language and ESMMP (Environmental and Social Management and Monitoring Plan) to MONRE. MONRE reviews the report within ten working days. If it is found adequate, the proponent submits fifteen copies of ESIA report to MONRE, which are then reviewed by other relevant authorities. If no further action is required, ECC is issued within 95 days. Assessment of the result of ESMMP implementation during construction phase is conducted within 6 month of commencement of operation.

ECC for ESIA is in principle valid throughout the project period. It expires if no activity is commenced within 2 years after issue of ECC.

Depending on the types of projects, valid period of ECC for ESMMP and permits for environmental contamination ranges from two to five years. The proponent must apply for extension of the ECC when it expires. If all environmental requirements are satisfied, extension of the ECC will be approved.

3) Road project categorization and safeguard requirements

Safeguard requirements for each category of road project in Laos are summarized in Table 3.2.3 and Table 3.2.4**.** Documents required for IEE, EIA, RAP, and other environmental and social safeguards for national road construction and maintenance projects are prepared by DOR.

Table 3.2.3 Road Project Categories and Safeguard Requirements in Lao PDR

Category	Level of Impact/Risk	Safeguard Requirements
A	**Significant:** The project area is of high site sensitivity or works are of such a magnitude that they can alter the natural environment, biodiversity, the economic organization, and/or cultural property.	- Detailed EIA/SIA including comprehensive EMP (and possibly social action plan [SAP], resettlement plan [RP], ethnic communities development plan [ECDP]) - Approval by MONRE - Environmental/social specifications to be developed for inclusion in contract documents - Manual for design & construction - Monitoring and evaluation system
B	**Moderate**: The project area is of moderate site sensitivity or the works will create effects less adverse than those of Cat. A; are reversible, and are easier to mitigate.	- IEE, ISA, land acquisition and compensation report (LACR), specific action for ethnic communities development - Approval by ESD (or MONRE or PEC) - Environmental/social specifications for contract documents - Manual for design & construction - Monitoring and evaluation system
C	**Low or minimal**: The project area is of low site sensitivity or the impacts are site specific or the works will create few, if any, impacts that cannot be mitigated.	- Screening and scoping forms - Guidelines for design and construction including generic EMP/SAP (modified to suit project activities and site)
Project Exclusions: - Projects that irreversibly impact rare, endemic, or endangered fauna and flora - Projects that are located in critical natural habitats or converted natural habitats (unless compensatory measures are provided) - Projects that negatively affect human health - Projects that cause irreparable harm or damage to cultural heritage or resources		

Source: Environmental and Social Operations Manual (ESOM, 2009)

Table 3.2.4 Genetic Project Types and Road Classification

Project Types	Road classification (hierarchy in Road Law)				
	National	Provincial	District	Rural	Special
New construction	A	A	A	A	A
Upgrading	A-B	A-B	A-B	B	B
Improvement	B	B	B	B	B
Rehabilitation	B-C	B-C	C	C	C
Maintenance	C	C	C	C	C

Source: Environmental and Social Operations Manual (ESOM, 2009)

(4) Gap analysis with international standards

World Bank (WB) carried out Safeguards Diagnostic Reviews (SDR) in 2008, revealing the gap between Lao system and World Bank Safeguard Policies. As a result, Environmental and Social Operations Manual (ESOM) was prepared to recognize the gap and recommend appropriate measures, which was adopted by MPWT.

The table below shows the gap between the current Lao system and JICA Guidelines for Environmental and Social Considerations (April 2010).

Table 3.2.5 Gap Analysis between JICA Guidelines and Lao National Laws

JICA	Lao PDR	Measures
Analyze alternatives, including "without project" situations.	No clear mention of analysing alternatives including "without project" scenarios. No requirements in analysis of alternatives from perspectives of regional situations, initial cost and ordinary expenses, establishment of systems, training, and monitoring. Only requires listing pros and cons of more than one alternatives	Same as for the gap with WB Safeguard Policies. ESOM, which MPWT adopted, recommends means to resolve the gap. Therefore, the gap in guidelines is resolved.

Source: JICA Study Team

(5) Laws and regulations related to land acquisition and resettlement in Lao PDR

Refer to 3.4.1 (1) Major laws and regulations regarding land acquisition and resettlement.

(6) Laws and regulations related to Protected Areas in Lao PDR

The table below shows major laws and regulations pertaining to protected areas in Lao PDR. In recent years, deforestation is exacerbating due to shifting cultivation and rubber plantation. To effectively tackle the issue, Ministry of Agriculture and Forestry is taking initiative to amend the current Forestry Law.

Table 3.2.6 Major Laws and Regulations Related to Protected Areas in Lao PDR

No.	Title	Enacted Year	Enacted No.
1	Decree on the establishment of the National Protected Areas for the whole country	1993	No.164/PM
2	Forestry Law	2007	No.06/NA
3	National Protected Area and Wildlife Regulations	2001	
4	Wildlife and Aquatic Law	2007	No.07/NA
5	Convention on Biological Diversity	1996	
6	National Biodiversity Strategy and Action Plan 2016-2025	2016	

Source: JICA Study Team

3.2.2 Laws and Regulations of Vietnam Relevant to Environmental and Social Considerations

(1) Relevant legal frameworks in Vietnam

The following is the summary of the laws and regulations in Vietnam relevant to environmental and social considerations. Law on Environmental Protection (LEP), first enacted in 1994 and amended in 2005 and 2014, is the foundation of environmental protection in Vietnam.

Table 3.2.7 Law and Regulations Related to Environmental and Social Considerations in Vietnam

Legal documents		Prepared by
Government Laws		
	Law 55/2014/QH13 on Environmental Protection approved by Assembly dated on June 23, 2014	National Assembly
	Law 17/2012/QH13 on Water Resources approved by Assembly dated on June 21, 2013	National Assembly
	Law 45/2013/QH13 on Land approved by Assembly dated on November 29, 2013	National Assembly
Government Decrees and Circulars		
	Decree 43/2014/ND-CP dated May 15, 2014 of Government on details of some articles of Law on Land	MONRE, MARD, and other ministries

	Legal documents	Prepared by
	Decree 19/2015/ND-CP dated February 14, 2015 on details of some articles of Law on Environmental Protection	MONRE and other ministries
	Decree 18/2015/ND-CP dated February 14, 2015 on regulating the Master Plan on environmental protection, strategy environmental assessment, environmental impact assessment and environmental protection plan	MONRE and other ministries
	Circular 27/2015/BTNMT dated July 17, 2015 of MONRE on strategy environmental assessment, environmental impact assessment and environmental protection plan	MONRE
	Decree 201/2013/ND-CP dated November 27, 2013 of Government on regulating details of some articles of Law on Water Resources	MONRE, MARD, and other ministries
	Decree 38/2015/ND-CP dated April 24, 2015 on Waste and Scrap management	MONRE and MOC
	Circular 51/2014/TT-BTNMT dated September 5, 2014 of MONRE on regulating Technical Regulations on Environment in Hanoi Capital	MONRE
Government Technical Regulations/Standards/Code on Environment		
	QCVN 50:2013/BTNMT _ National Technical Regulation on Hazardous Thresholds for Sluges from Water Treatment Process	MONRE
	QCVN 40:2011/BTNMT_National Technical Regulation on Industrial Wastewater	MONRE
	QCVN 14:2008/BTNMT_National Technical Regulation on Domestic Wastewater	MONRE
	QCVN 08-MT:2015/BTNMT_National Technical Regulation on Surface Water Quality	MONRE
	QCVN 09-MT:2015/BTNMT_National Technical Regulation on Underground water quality	MONRE
	QCVN 03-MT:2015/BTNMT_National Technical Regulation on the allowable limits of heavy metals in the soils	MONRE
	QCVN 05:2013/BTNMT_National Technical Regulation on Ambient Air Quality	MONRE
	QCVN 06:2009/BTNMT_National Technical Regulation on hazardous substances in ambient air	MONRE
	QCVN 26:2010/BTNMT_National Technical Regulation on Noise	MONRE

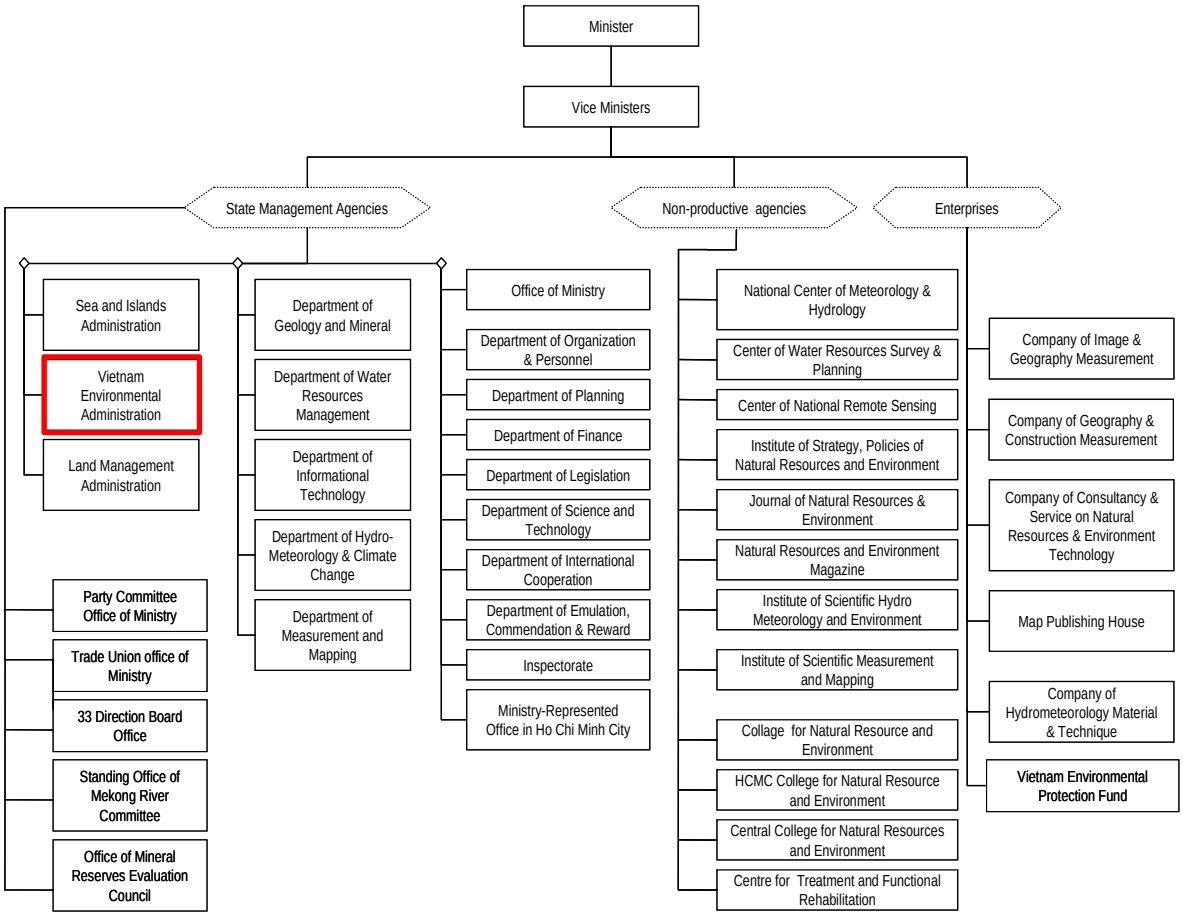
Source: JICA Survey Team

(2) Administrative framework in Vietnam

The following is the summary of administrative frameworks of Vietnam pertaining to environmental and social considerations for national projects.

1) Ministry of Natural Resources and Environment (MONRE)

MONRE takes on the central role in environmental and social considerations. It prepares and submits to the Government laws, national policy, strategy, and master plans, establishes and announces environmental standards, establishes and oversees environmental monitoring system, evaluates and approves strategic environmental assessment reports. The figure below is the organizational chart of MONRE.



Source: JICA Study Team

Figure 3.2.1 Organizational Chart of MONRE of Vietnam

2) Ministry of Transportation (MOT)

MOT cooperates with MONRE and other relevant agencies to establish laws and regulations related to environmental protection and transportation.

(3) Procedures of Environmental Compliance Certificate (ECC) in Vietnam

1) Projects that require EIA

Law on Environmental Protection enacted in 1994, amended in 2005 and 2015 stipulates on procedures of environmental compliance certificates in Vietnam. Projects that require EIA are as follows:

≪From Article 18, LED 2015≫

Projects that must implement EIA Report consist of:

a) Projects subject to the decision on investment policies made by National Assembly, Government, and the Prime Minister;

b) Projects that use land parcels situated in nature reserves, national parks, historical-cultural monuments, world heritage sites, biosphere reserves, scenic beauty areas that have been ranked;

c) Projects that is at risk of causing negative effects on the environment.

Type of transport projects that require implementation of EIA is stipulated as follows:

Table 3.2.8 Type and Scope of Projects that Require EIA

	Project	Scope
Transport Projects		
20.	Construction projects for automobile highways and automobile roads from class I to III; mountainous road class IV; railways, overhead railways	All, regarding automobile highways and automobile roads from class I to III: railways, overhead railways; Length of class IV mountainous roads: at least 50 km

Source: Decree No.18/2015/ND-CP Appendix II

2) Implementing Agency of EIA

Agency who carries out EIA is either a project proponent or a consultant employed by a project proponent. The project proponent must conduct consultation with relevant agencies, organizations, and communities that are directly affected. The project proponent incurs the cost and fees for EIA preparation and evaluation.

Vietnam Environmental Administration (VEA) under MONRE is in charge of review and evaluation of EIA for projects requiring approval of the National Assembly, Government, or Prime Minister. VEA reviews and evaluates EIA within 45 days after EIA is submitted.

(4) Gap analysis with international standards

The table below shows the gap between the current Vietnamese system and international standards regarding environmental and social considerations.

Table 3.2.9 Gap between Vietnamese System and International Standards Regarding Environmental and Social Considerations

Aspect	Major discrepancies	Measures
Disclosure	No provision regarding venues and methods of disclosing SEA, EIA, EPP reports and monitoring reports. No provision stipulating announcement of public consultation via Mass media and newspapers.	Verify that information is disseminated to PAPs.
Public consultation	No provision about public consultation at the stage of scoping Participants of public consultation are limited to the representatives of relevant organizations. Not all PAPs are allowed to participate in public consultation.	Implement public consultation at the stage of scoping. Verify that PAPs including socially vulnerable people and indigenous people are participating public consultation.
Compensation	Project approval process does not require Resettlement Action Plan or Indigenous People Plan Process of compensation for relocation takes place separate from EIA	Verify that Resettlement Action Plan and Indigenous People Plan are prepared along with EIA.

Source: Institute for Global Environmental Strategies

(5) Laws and regulations related to land acquisition and resettlement in Vietnam

Refer to 3.4.1 (1) Major laws and regulations regarding land acquisition and resettlement.

(6) Laws and decrees related to protected area in Vietnam

The table below shows laws and decrees related to protected areas in Vietnam.

Table 3.2.10 Laws and Decrees Related to Protected Areas in Vietnam

No	Regulations	Title & Details
1	Law No. 20/2008/QH12 dated 13/11/2008	On Biodiversity
2	Decree No.65/2010/ND-CP	Regulate in details and guides implementation of some articles in Biodiversity Law
3	Decision No. 1250/QD-TTg dated 31/7/2013 of Prime Minister	Approved National Strategy for Biodiversity to 2020, vision to 2030

4	Law No.29/2004/QH11 dated 3/12/2004	Law on Forest Protection and Development
5	Decree No. 1976/QD-TTg dated 12/11/2015	On approving the planning for special-use forest system across the country to the year 2020 and a vision to 2030
6	Decision 186/2006/QD-TTg	On promulgating the regulation on forest management (*Article 13, 18, 22*)

Source: JICA Study Team

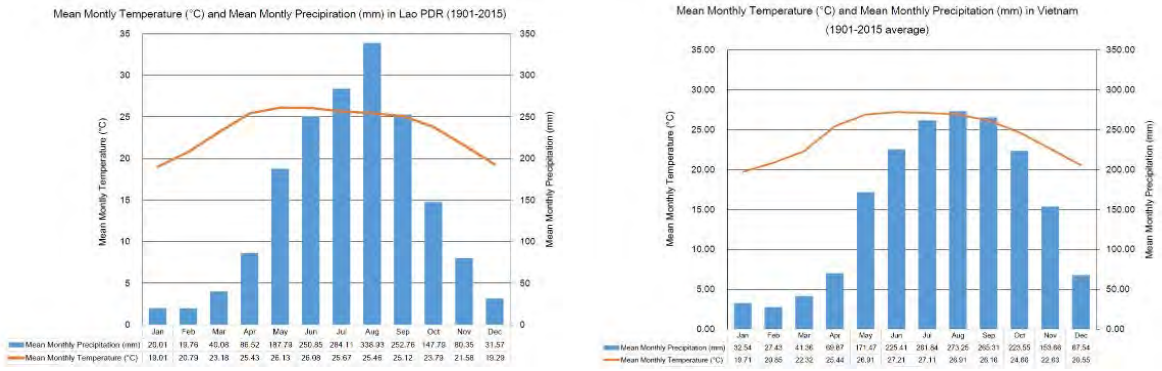
3.3 Items to be considered in Environmental Impact Assessment

Baseline information of the environmental items to be considered is compiled in order to minimize impacts from road construction. Particularly important factors to consider when examining alternative routes in the target project area are addressed following the list of items on JICA Guidelines (April 2010).

3.3.1 Climate

(1) Climate in Laos and Vietnam

Both Lao PDR and Vietnam belong to Tropical Monsoon Climate, showing clear rainy and dry seasons. The figures below show the monthly average temperature and monthly average rainfall from 1901 to 2015 in each country. In Lao PDR, majority of rain falls between May and October, whereas in Vietnam, between May and November.

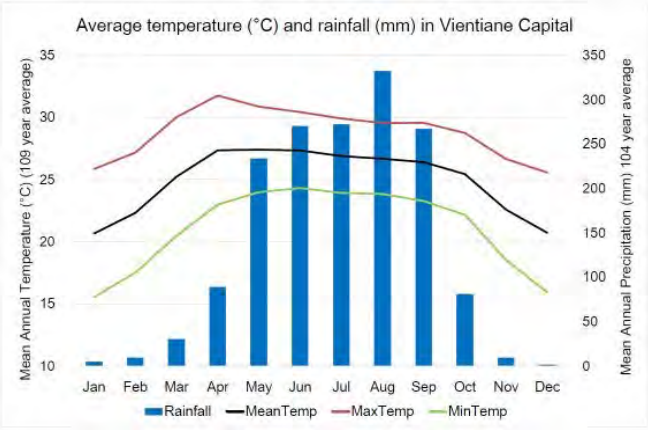


Source: JICA Study Team

Figure 3.3.1 Mean Monthly Temperature and Mean Monthly Precipitation in Lao PDR (left) and Vietnam (right)

(2) Climate in Vientiane city

Mean monthly temperature, mean minimum temperature, mean maximum temperature, and mean monthly rainfall in Vientiane City are shown in the figure below. Temperature is the average of 109 years between 1901 and 2009. Rainfall data is average of 104 years between 1901 and 2009 except the years with no data (1916, 1921, 1954, 1979, and 2003).



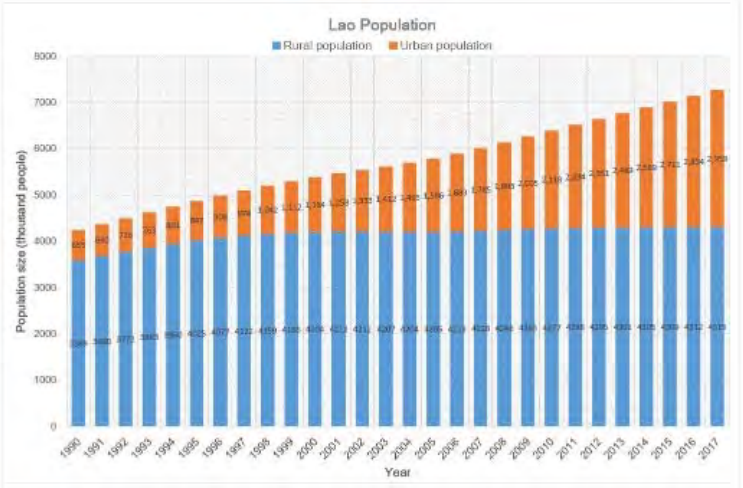
Source: Created by JICA Study Team based on World Bank Climate Change Knowledge Portal

Figure 3.3.2 Mean, minimum, and maximum monthly temperature and mean monthly rainfall in Vientiane Capital

3.3.2 Population

(1) Population by urban / rural areas in Lao PDR

The figure below shows the population trend in urban and rural areas of Lao PDR. In 2017 the total population in the country exceeded 7 million people. Although the total population has been rising from 1990 to 2017, the increase is predominantly confined to urban areas. The population in the rural areas has not changed much since 1997.



Source: JICA Study Team

Figure3.3.3 Population change in urban and rural areas in Lao PDR (1990-2017)

"Results of Population and Housing Census 2015" categorized areas in Lao PDR into three groups: urban, rural with roads, rural without roads. Urban areas must satisfy at least three conditions from below:

- Village is situated in a district or provincial center
- More than 70 percent of total households in the village use electricity
- More than 70 percent of total households in the village use piped water
- Village is accessible by road in two seasons
- Village has permanent market operating the whole day

Villages that do not satisfy at least 3 conditions from above are categorized as rural, and further categorized into two.

・Rural with roads: villages with roads accessible all year-round by four-wheeled motor vehicles
・Rural without roads: villages not accessible all year-round by four-wheeled motor vehicles

(2) Population by administrative division in target study area

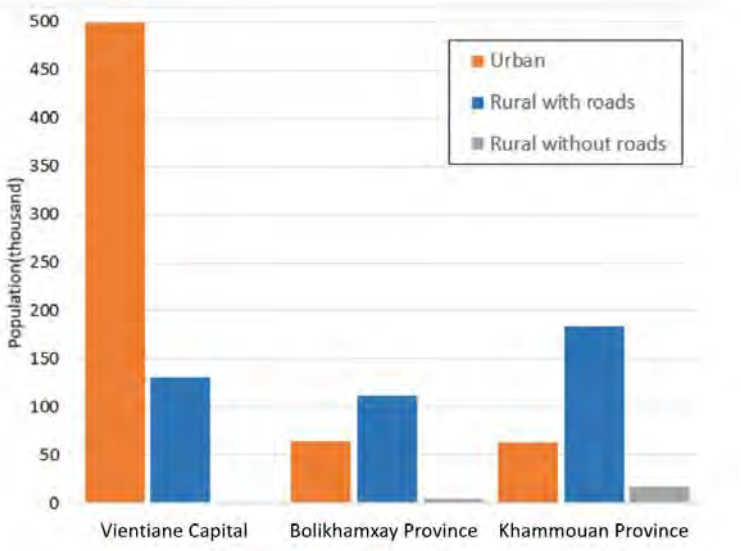
1) Laos PDR

The target area of this study in Laos side includes Vientiane City, Bolikhamsai Province, and Khammouan Province. The table below shows the population of each administrative division in 2015. Population density of Vientiane City stands out among the three.

Table 3.3.1 Population of the Provinces in the study area in Lao PDR (2015)

Administrative Division	Population (thousands)	Area (km2)	Population density (person/km2)	Population		
				Urban	Rural with roads	Rural without roads
Vientiane City	821	3,920	209	499,157	130,534	434
Bolikhamsai Province	274	14,863	18	64,864	112,448	4,953
Khammouan Province	392	16,315	24	63,258	184,031	17,342

Source: Results of Population and Housing Census 2015



Source: JICA Study Team

Figure 3.3.4 Population of each Administrative Division in the Study Area

2) Vietnam

The target area of this study in Vietnam side includes Nghe An Province and Ha Tinh Province. The table below shows the population of these provinces in 2016.

Table 3.3.2 Population of the Provinces in the study area in Vietnam (2016)

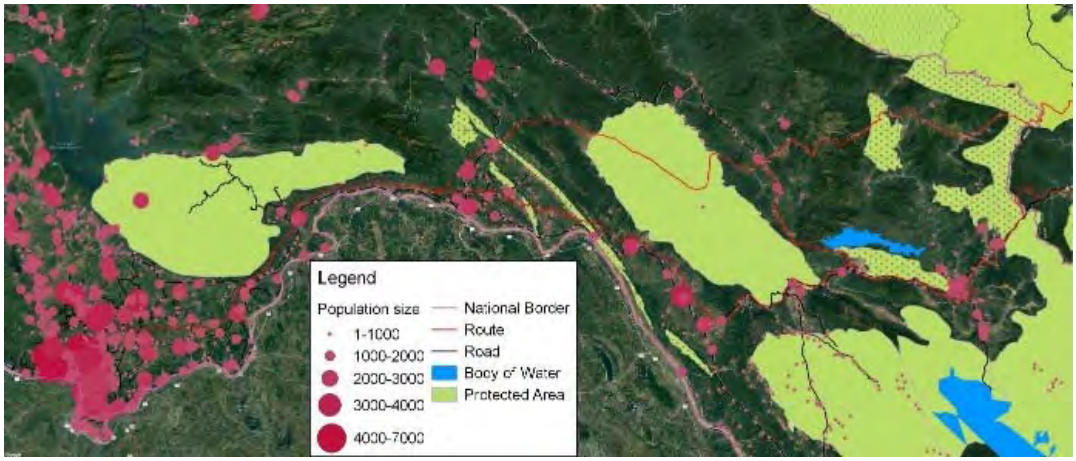
Province	Population (thousands)	Area (km^2)	Population density (person/km^2)
Nghe An	3,105.5	16,481.7	188
Ha Tinh	1,266.7	5,990.6	211

Source: Statistical Handbook of Viet Nam 2016

(3) Distribution of villages and population in target study area

The distribution of villages and population in the study area in Lao PDR is shown in the figure below. It clearly demonstrates that population density is the highest in Vientiane Capital, followed by Pac Xan, in which the intersection of NR 13 and Pre-F/S route sits. Population is also concentrated along NR 8, whereas population density is low along Pre-F/S route. Based on the distribution of population from

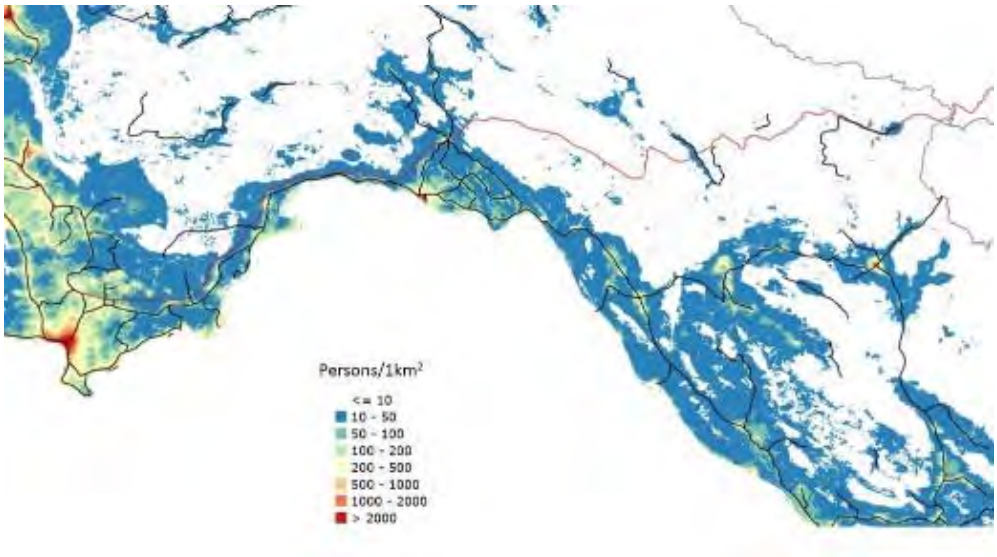
the map, the number of local residents who benefit from road construction is higher along NR 8 than along Pre-F/S route.



Source: JICA Study Team

Figure3.3.5 Distribution of Villages and Population in the Study Area in Lao PDR

The map below also depicts the estimated population density based on the census in Lao PDR. Local residents who would benefit are sparsely scattered along Pre-F/S route between Pac Xan and Thanh Thuy at the border.



Source: JICA Study Team

Figure3.3.6 Estimated population density in Lao PDR

3.3.3 Air Pollution, Noise and Vibration

(1) Environmental standards in Lao PDR

Neither Pre-F/S nor KOICA's F/S for NR 8 upgrade plans performed measurement of air quality, water quality, and noise and vibration levels in the project areas. Such measurements in the populated areas along the route will be necessary as baseline information before commencement of construction as the project moves forward upon determination of the route.

The table below summarizes the environmental standards related to air quality, noise and vibration in Lao PDR.

Table 3.3.3 Air Quality Standards in Lao PDR

Parameters	Symbol	Average Time Unit: mg/m3					Method of Measurement
		Hours			1 month	1 year	
		1 hr	8 hr	24 hr			
Carbon monoxide	CO	30	10.26	-	-	-	Non dispersive infrared detection
Nitrogen dioxide	NO_2	0.32	-	-	-	-	Chemiluminescene method
Sulphur dioxide	SO_2	0.78	-	0.30	-	0.10	UV Fluorescence (1hr, 24hr, 1yr) or Pararosaniline (1hr,4hr)
Total Suspended Particulate	TSP	-	-	0.33	-	0.10	Gravimetric
Particulate Matter less than 10 microns	PM-10	-	-	0.12	-	0.05	Gravimetric or Beta Ray or Taper Element Oscillating Microbalance or Dichotomous
Ozone	O_3	0.20	-	-	-	-	Chemiluminescence or UV Absorption Photometry
Lead	Pb	-	-	-	1.5	-	Atomic Absorption Spectrometer

Source: National Environmental Standards, 2009

Table 3.3.4 Noise and vibration standards in Lao PDR

Standards	Method of Measurement
Maximum Sound Level (L_{max}) should not exceed 115 dB(A)	Equivalent Sound Level (L_{eq}) from Fluctuating Noise
L_{eq} 24 hour not exceeding 70 dB(A)	Equivalent Sound Level (L_{eq}) from Steady Noise

Source: National Environmental Standards, 2009

(2) Environmental standards in Vietnam

Environmental standards in Vietnam are provided in the following provisions:

- Air quality: National technological standard QCVN 05: 2009/BTNMT
- Water quality: National technological standard QCVN 08:2008/BTNMT
- Noise: National technological standard QCVN 26:2010/BTNMT
- Vibration: National technological standard QCVN 26:2010/BTNMT

3.3.4 Ecosystems

Routes under examination runs through Bolikhamsai Province in which habitats for rare and endangered species exist. These areas are internationally considered significant from ecological point of view.

(1) Biology in Lao PDR

The table below shows groups of species found in Lao PDR.

Table 3.3.5 Species in Lao PDR

Species Groups	Estimated Number of Species		
	Total	Endemic	Threatened
Plants	412	41	21
Mammals	282	1	46
Reptiles	150	0	11
Amphibians	89	2	5
Insects[1]	597	7[2]	0
Birds	700	0	23
Freshwater Fish	468	106	6
Some Invertebrates[3]	3	0	3
TOTAL	2701	157	115

[1]only butterflies & dragonflies, [2]only butteflies, [3]not specified

Source: Fourth National Report to the Convention of Biological Diversity, 2010

Because not enough research on ecosystem in Lao PDR has been done, the extant information does not cover the entire range of species living in the country, especially for floral species. That being said, there are a number of endemic and endangered species in this biologically important area, as shown in the table above. Notably, a diversity of endangered species survive in the habitat in the Annamite Range that covers the area around the border between Lao PDR and Vietnam. In the process of determining the best route and points to cross borders, it is imperative to take into account that this region hosts these significant ecosystems.

(2) Endangered species in the study area based on IUCN Red List

The table below summarizes the following categories of species found in the study area listed on IUCN Red List: Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), and Data Deficient (DD).

Table 3.3.6 Endangered Species on IUCN Red List found in the Study Area

No.	Class	Scientific Name	Common Name	Status
1	mammals	*Manis javanica*	Sunda Pangolin	CR
2	mammals	*Muntiacus vuquangensis*	Large-antlered Muntjac	CR
3	mammals	*Nomascus leucogenys*	Northern White-cheeked Gibbon	CR
4	mammals	*Pseudoryx nghetinhensis*	Saola	CR
5	birds	*Asarcornis scutulata*	White-winged Duck	EN
6	birds	*Pavo muticus*	Green Peafowl	EN
7	birds	*Urocissa whiteheadi*	White-winged Magpie	EN
8	mammals	*Chrotogale owstoni*	Owston's Civet	EN
9	mammals	*Cuon alpinus*	Dhole	EN
10	mammals	*Elephas maximus*	Asiatic Elephant	EN
11	mammals	*Nomascus siki*	Southern White-cheeked Gibbon	EN
12	mammals	*Panthera tigris*	Tiger	EN
13	mammals	*Pygathrix nemaeus*	Douc Langur	EN
14	mammals	*Trachypithecus phayrei*	Phayre's Leaf Monkey	EN
15	reptiles	*Indotestudo elongata*	Elongated Tortoise	EN
16	reptiles	*Platysternon megacephalum*	Big-headed Turtle	EN

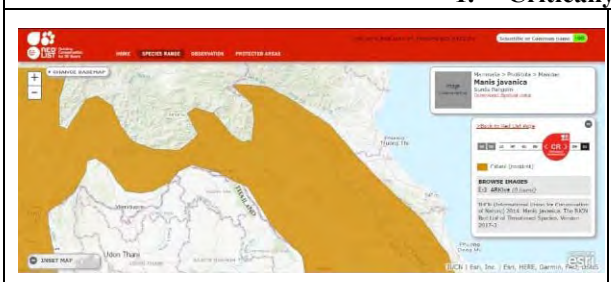
17	mammals	*Bos gaurus*	Gaur	VU
18	mammals	*Capricornis milneedwardsii*	Chinese Serow	NT
19	mammals	*Catopuma temminckii*	Asiatic Golden Cat	NT
20	mammals	*Negolagus timminsi*	Annamite Striped Rabbit	DD

Note: CR: Critically Endangered, EN: Endangered, NT: Near Threatened, DD: Data Deficient
Source: JICA Study Team

(3) Distribution of habitat of endangered species

The table below show the habitat ranges of some of the endangered species on IUCN Red List found in the study area.

1. Critically Endangered



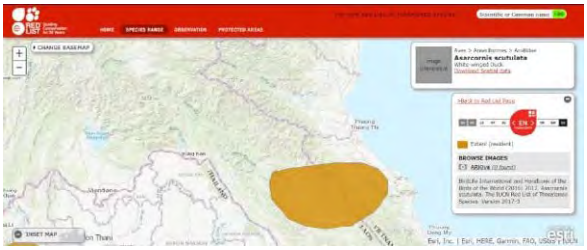
Sunda Pangolin
Manis javanica

Large-antlered Muntjac
Muntiacus vuquangensis

Northern White-cheeked Gibbon
Nomascus leucogynys

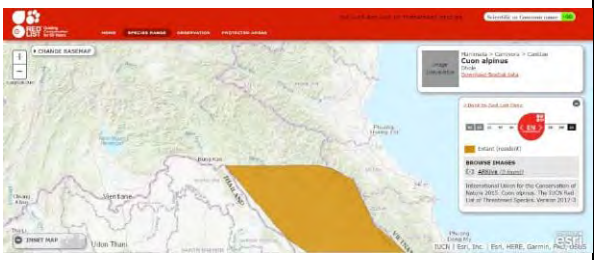
Saola
Pseudoryx nghetinhensis

2. Endangered



White-winged Duck
Asarcornis scutulata

Owston's Civet
Chrotogale owstoni



Dhole
Cuon alpinus

Asiatic elephant
Elephas maximus

Southern White-cheeked Gibbon
Nomascus siki

Douc Langur
Pygathrix nemaeus

3. Vulnerable

Gaur (Bos gaurus):
Bos gaurus

4. Near Threatened

Asiatic Golden Cat
Catopuma temminckii

5. Data Deficient

Annamite Striped Rabbit
Nesolagus timminsi

Source: Created by JICA Study Team based on IUCN Redlist

Figure3.3.7 Habitat Ranges of the Endangered Species Found in the Study Area

(4) Habitat of endangered species (Saola)

The critically endangered species worthy of special attention in this study area is Saola (*Pseudoryx nghetinhensis*), because of the facts that both Lao PDR and Vietnam have regulations to protect them and that the some routes under examination are passing through locations where saolas were spotted in the past.

1) Current situation of Saola

The major threat to survival of Saola is poaching and loss of habitat. Exisiting road construction made human access to the habitat area of Saola easier. As a result, subsistence hunting of Saola by local residents as well as poaching by outsiders became more prominent. At the same time, the road construction divided and/or destroyed their habitat.

Saola's habitat areas extend in the northern Annamite Ranges that coincide with the border between Lao PDR and Vietnam. Saola in Vietnam is considered extinct from hunting. In Lao PDR, some of them have been observed in and around Phou Sithone Endangered Species Conservation Area designated by Bolikamxay Province to protect them. It is now considered that saolas are surviving only in those areas and near the Vietnam border in Lao PDR.

Live capture of saola has been attempted in the past without any success, meaning it is unrealistic to consider mitigating measures involving protection of saola in the zoo and assisted reproduction.

In addition, Wildlife Conservation Society (WCS) has been active in raising awareness for saola protection, in which local residents participate as stakeholders. Another awareness program to local residents will not be an effective mitigation measures to counteract the impact of new road construction.

2) International agreements and domestic regulations

Saola is listed in Appendix I of CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora), commonly called as Washington Convention, which both Lao PDR and Vietnam are parties to (Table 3.2.7). Also, saola is designated as a species to be protected according to the regulations of both Lao PDR and Vietnam (Table 3.2.8).

Table 3.3.7 CITES Criteria and Exception

	Criteria	Exception
Appendix I	Threatened with extinction and CITES prohibits international trade in specimens of these species except when the purpose of the import is not commercial	Except for scientific research. In exceptional cases, trade may take place provided it is authorized by the granting of both an import permit and an export permit (or re-export certificate)

Source: CITES

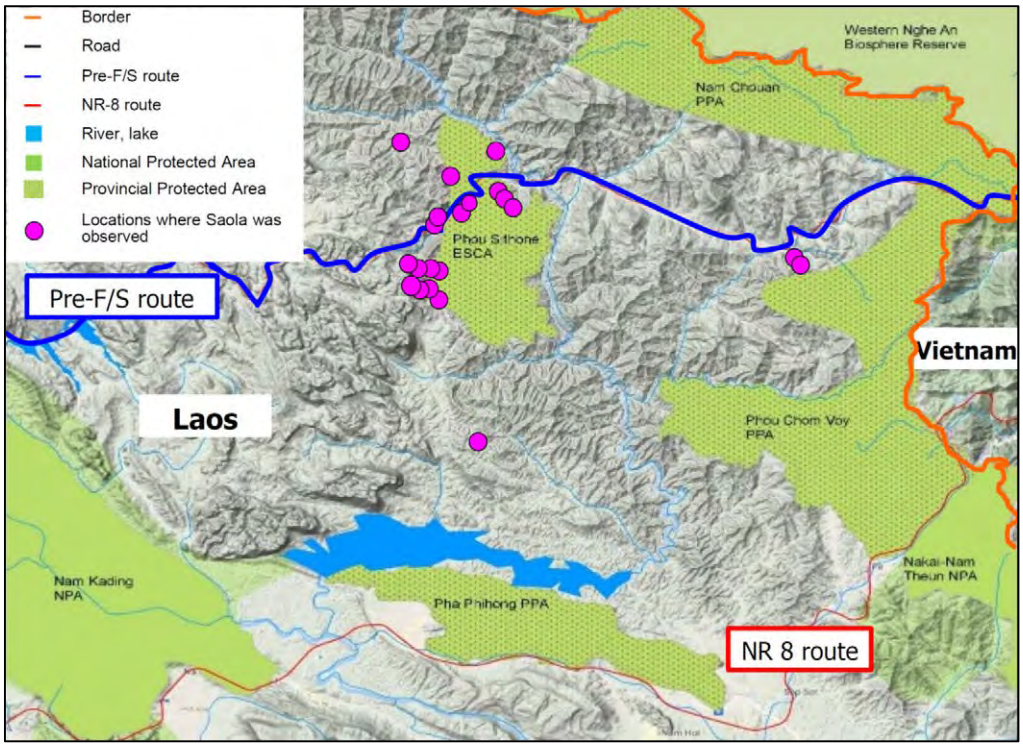
Table 3.3.8 Regulation in Lao PDR and Vietnam Related to Protection of Endangered Species

Nation	Regulation	Description
Lao PDR	Ministry of Agriculture and Forestry Regulation 360/AF. 2003 National Biodiversity Conservation Areas, Aquatic and Wild Life Management Regulations	Restricted wild and aquatic life (List I) : Rare and near extinct wild and aquatic life with high value and special socio-economic and environmental importance for the country. These species are strictly managed and any activity relating to them requires approval from the Ministry of Agriculture and Forestry
Vietnam	The Government Decree 32/2006/ND-CP on Management of Endangered, Precious, and rare Species of Wild Plants and Animals	IB Wild Animal Species: Group I: Prohibiting exploitation and use for commercial purposes, including wild plants, animals, which are especially valuable to science and the environment or have highly economical value, or for which populations are very small in the wild or are in high risk of extinction.

Source: JICA Study Team

3) Locations where Saolas were observed

Between 1996 and 2013, saolas were spotted and/or observed in 22 location shown in the Figure 3.3.8.



Source: Created by JICA Study Team based on Phommachanh et al. (2017) Tropical Conservation Science. vol. 10:1-15

Figure 3.3.8 Locations where Saolas were Observed and Pre-F/S Route

Due to extremely low saola population, most of the spots where saola was observed are concentrated along the existing roads. As shown in the map above, Pre-F/S route passes through the spots where saolas were found. It is concerned that road construction through this area will inevitably result in dividing saola habitat. It is likely that saola population will decrease further due to increase in poaching and traffic accidents during construction and after operation.

3.3.5 Protected Areas

All four routes under examination of this study pass through one to several protected areas in Lao PDR or Vietnam. Therefore, it is necessary to consider options to avoid, minimize, and/or mitigate negative impact on them from road construction.

(1) Designation of Protected Areas

1) Protected areas in Laos side

About 14% of land area of Lao PDR is designated as protected areas. As of 2018, 24 national protected areas have been established as well as many provincial protected areas.

Accroding to Ministry of Agriculture and Forestry, all of the protected areas in Lao PDR fall under Category VI: Managed Resource Protected Area of IUCN category. As of March, 2018, there is no National Park in Lao PDR. However, preparation is under way to change the designation of the following two national protected areas into category II (National Park) by 2020:

1. Nakai-Nam Theun NPA: Bolikhamsai Province, Khammouan Province
2. Nam Et-Phou Louey NPA: Luang Prabang Province, Xieng Khuoang Province, Houanphanh Province

All four routes under examination do not pass through the above national protected areas. Should the alignment of the route change or that the road construction is after 2020, there may be changes to legal procedures for development due to change in the categories of protected areas.

Protected areas in Lao PDR in the study area are as follows.

Table 3.3.9 Protected Areas in Lao PDR in the Study Area

No.	Name	Category
1	Phou Khao Khouay NPA	National Protected Area
2	Nam Kading NPA	National Protected Area
3	Phou Hin Boun NPA	National Protected Area
4	Nakai-Nam Theun NPA	National Protected Area
5	Corridor Nakai-Nam Theun and Phou Hin Poun	National Protected Area
6	Say Phou Ngou PPA	Bolikhamsai Provincial Protected Area
7	Pha Kouanchan PPA	Bolikhamsai Provincial Protected Area
8	Nam Chouan PPA	Bolikhamsai Provincial Protected Area
9	Phuo Sithone ESCA	Bolikhamsai Provincial Protected Area
10	Phou Chom Voy PPA	Bolikhamsai Provincial Protected Area

Note: NPA: National Protected Area; PPA: Provincial Protected Area; ESCA: Endangered Species Conservation Area
Source: JICA Study Team

2) Protected areas in Vietnam side

In Vietnam, aside from national parks, there are Biosphere Reserve. Protected areas in Lao PDR and Vietnam in the study area are as follows.

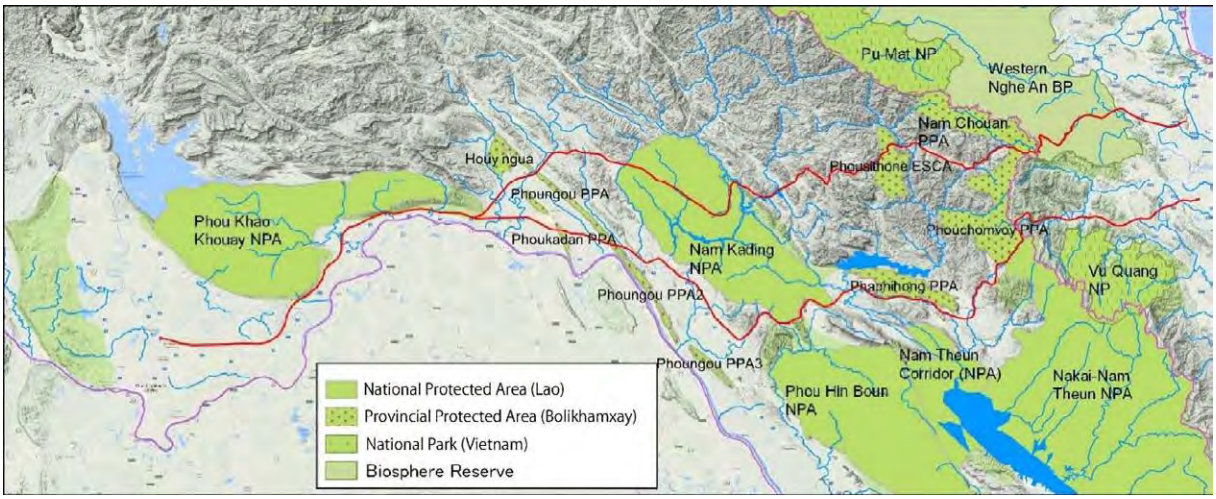
Table 3.3.10 Protected Areas in Vietnam in the Study Area

No.	Name	Category
1	Pu Mat National Park	National Park
2	Vu Quang National Park	National Park
3	Western Nghe An Biosphere Reserve	Biosphere Reserve

Source: JICA Study Team

3) Distribution of Protected Areas in Laos and Vietnam

Distribution of protected areas in Lao PDR and Vietnam is illustrated in the figure below.



Source: JICA Study Team

Figure 3.3.9 Distribution of Protected Areas in Lao PDR and Vietnam

(2) Distribution of Protected Areas along road plans

1) Protected Areas each alterative plan passes through

The table below is a summary of Protected Areas each alternative plan passes through. Pre-F/S route passes through one national and two provincial protected areas in Lao PDR, and transition zone of the biosphere reserve in Vietnam. NR 8 route, on the other hand, passes through one national and one provincial protected area in Lao PDR but it doesn't pass through any protected area in Vietnam.

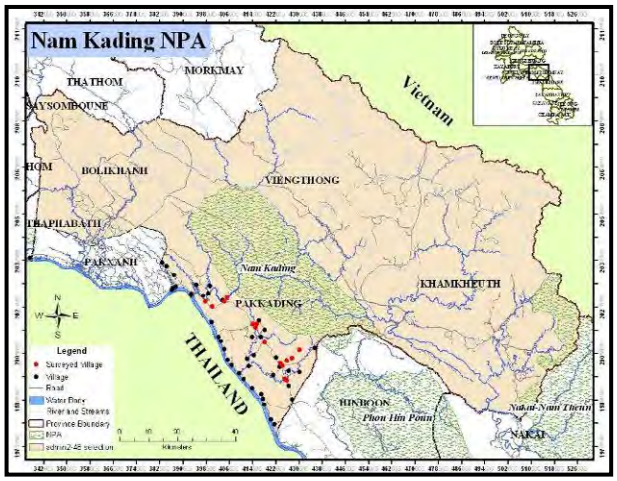
Table 3.3.11 Protected Areas and Alternative Routes

	Lao PDR			Vietnam
	Vientiane Capital	Bolikhamsai Province	Near the border	
Alternative 1 (Pre-F/S Route)	-	Nam Kading NPA Phou Sithone ESCA	Nam Chouan PPA	Transition zone of Western Nghe An BP
Alternative 2 (NR 8 Route)	-	-	Nam Theun (Ext.) NPA Phou Chom Voy PPA	-
Alternative 3 (Composite： NR 13→NR 8→1D→Pre F/S Route)	-	Phou Sithone ESCA	Nam Chouan PPA	Transition zone of Western Nghe An BP
Alternative 3B (Composite： Pre F/S Route→1D→NR 8)	-	Nam Kading NPA	Nam Theun (Ext.) NPA Phou Chom Voy PPA	-

Note: NPA: National Protected Area, PPA: Provincial Protected Area, BP: Biosphere Reserve
Source: JICA Study Team

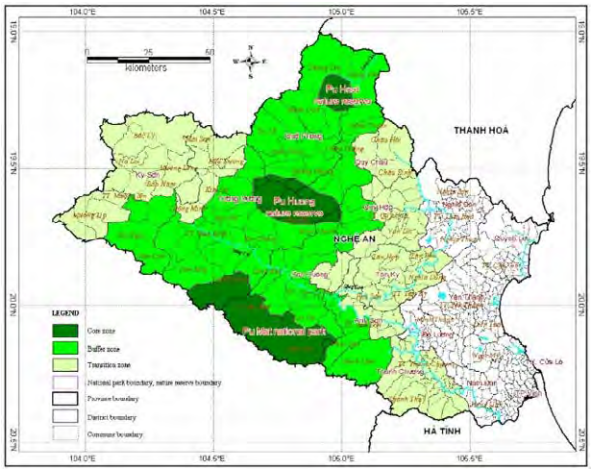
2) Map of Protected Area

Nam Kading National Protected Area (Lao PDR) and Western Nghe An Biosphere Reserve (Vietnam) are the protected area through which Pre-F/S route passes. Maps of these protected areas are shown below.



Source: Ministry of Agriculture and Forestry

Figure 3.3.10 Map of Nam Kading National Protected Area



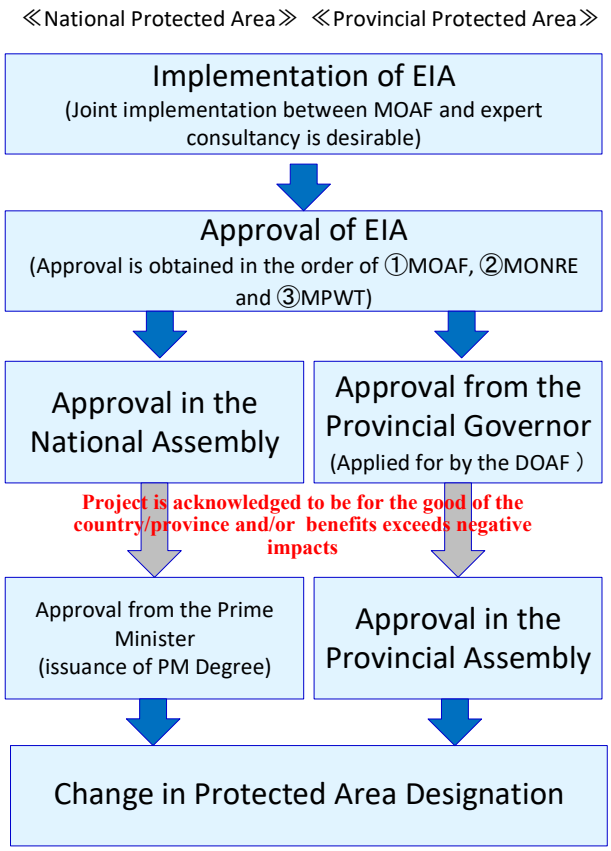
Source: UNESCO

Figure 3.3.11 Map of Western Nghe An Biosphere Reserve

(3) Legal procedures for development in Protected Areas in Lao PDR

1) Procedure to change designation of Protected Area

For road construction in a National Protected Area, protected area designation of the target land must be reversed. The process is described in the following figure:



Source: Prepared by JICA Study Team based on interviewing with MOAF and MONRE

Figure 3.3.12 Procedure to Change Designation of Protected Area

2) Procedure to change designation of forest

Similarly to the above, road construction in forest areas (Protection Forest, Conservation Forest and Production Forest) in Lao PDR also necessitates procedure to reverse the forest designation of the target land. For the details of forest designation, please refer to 3.3.6 (2) Forest designation in Lao PDR.

(4) Legal procedure for development in Protected Areas in Vietnam

Pre-F/S route passes through Biosphere Reserve (BP)'s Transition zone in Vietnam. However, According to Biodiversity Law (No. 20/2008/QH12), road construction in Transition Zone is not prohibited.

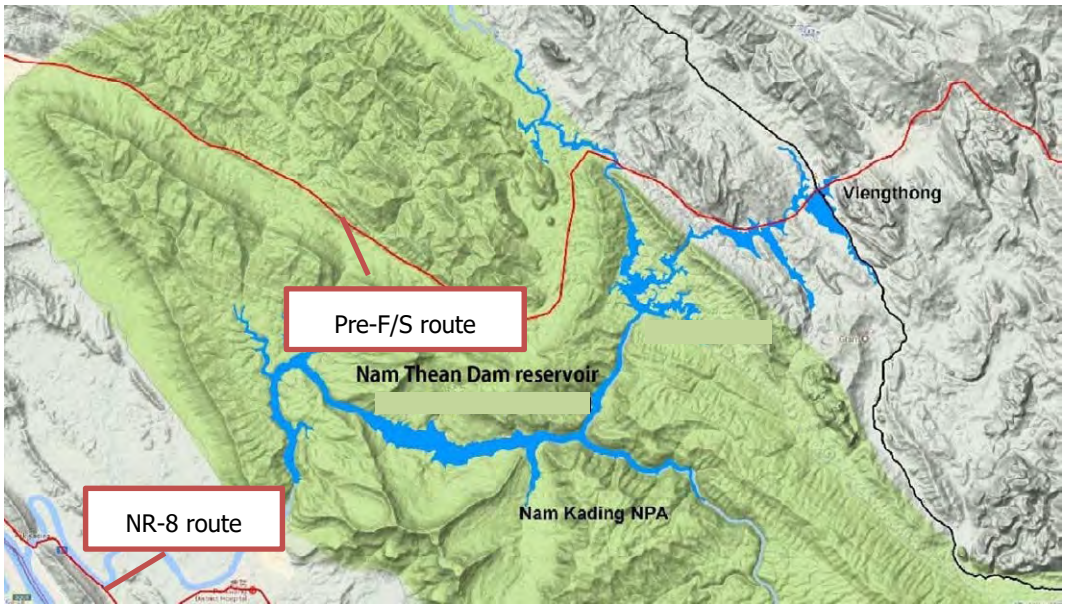
≪From Biodiversity Law (2008), Article No.7 "Prohibited actions regarding biodiversity"≫
" Public Transportation Construction Project is not prohibited in transition zone of Biosphere Reserve area " .

Unlike the legal procedure in Laos outlined earlier, specific procedure to reverse designation of protected area or forest is not necessary. However, a project proponent is required to prepare EIA in Pre-F/S and submit to MONRE. The approved EIA is then submitted to the Prime Minister together with Pre-F/S report and approved by him.

(5) On-going development project in Nam Kading National Protected Area in Lao PDR

In Nam Kading National Protected Area, through which Pre-F/S route passes, a dam construction project (Nam Thean dam) is now underway. According to the Department of Agriculture and Forestry of Bolikhamsai Province, Nam Thean dam is 50 to 60% complete as of February 2018. Locations of Nam Thean dam's water area and alignment of Pre-F/S route are illustrated in the figure below.

This map shows that Pre-F/S route runs through water area of Nam Thean dam.



Source: Prepared by JICA Study Team based on data provided by Bolikhamsai province DOAF

Figure 3.3.13 Nam Thean Dam under Construction and Alternative Routes

According to the DOAF of Bolikhamsai Province, Viengthong initially would submerge with the estimated high water level. Due to a large number of relocation that would result, the dam plan has been modified so that the water level would reach up to the boundary of Viengthong and that 1D would not submerge.

However, as of July 2018, the map or data of the latest Nam Thean dam plan with modified water level has not been able to be obtained. Thus, it is necessary to obtain latest and detailed information regarding this construction project during the coming survey in the future, and to check whether and how the Nam Thean dam plan would affect the road plan examined in this study.

3.3.6 Land Use

(1) Land use categories in Lao PDR

Land Law of Lao PDR categorizes all lands into eight categories as follows.

Table 3.3.12 Land use categories in Lao PDR

No.	Land use	Example
1	Agricultural land	Agriculture, livestock industry, agricultural research, irrigation, etc.
2	Forest land	Forests as defined in Forestry Law
3	Water area land	Rivers, lakes, islands, etc.
4	Industrial land	Plants, research institutions, water treatment facilities, etc.
5	Communication land	Roads, bridges, stations, railroads, etc.
6	Cultural land	Historical and archaeological sites, temples, etc.
7	Land for national defense and security	Military facilities
8	Construction land	Residential places, public facilities, etc.

Source: JICA Study Team

(2) Forest designation in Lao PDR

1) Forest categories according to Forestry Law

Categories of forests as defined in Forestry Law in Lao PDR are as shown in Table 3.3.13. The Law further specifies zoning for Protection Forest and Conservation Forest. Protection Forest consists of Totally Protected Zone and Controlled Use Zone, while Conservation Forest consists of Totally Protected Zone, Controlled Use Zone, Corridor Zone, and Buffer Zone. In none of the zones road construction is permitted.

Table 3.3.13 Forest Categories in Lao PDR

Forest Categories	Definition
Protection Forest	For protection of water resources, preventing soil erosion, environmental protection, etc.
Conservation Forest	For conserving nature, preserving plants and animals, etc.
Production Forest	For production, wood and forest products, for socio-economic development of people's living
Regeneration Forest	Forest areas in degraded condition and has been designated for regeneration
Degraded Forest	Forest areas that have been heavily damaged such as land without forest or barren forestland, allocated for tree replanting, agriculture-tree products, permanent animal husbandry areas

Source: Prepared by JICA Survey Team based on Forestry Law

2) Procedure for forestland conversion

For construction projects, forest land must be converted to Communication land for road. Article 70 and 71 of Forestry Law stipulates on conversion of forestland as follows:

1. Conversion of forestland is possible if it brings a high level of benefits to the nation and to livelihoods of the people and it is included in the national socio-economic development plan, and able to be undertaken only in the designated areas.
2. Entities that have been approved to convert land shall be responsible for paying fees for technical services, royalties and conversion fees.
3. If the State needs to convert forestland allocated to individual or organization, the State shall compensate the individual or organization.
4. Conversion of forestland into transportation land for road construction requires the permanent type of conversion of forestland.

The required process for the conversion of forestland is based on the procedures explained in the previous section; see 3.3.5 (3) Legal procedures for development in Protected Areas in Lao PDR.

3) Other forest category rules set by a village

Villages may designate certain portion of forest as communal assets including burial ground and spirit forest.

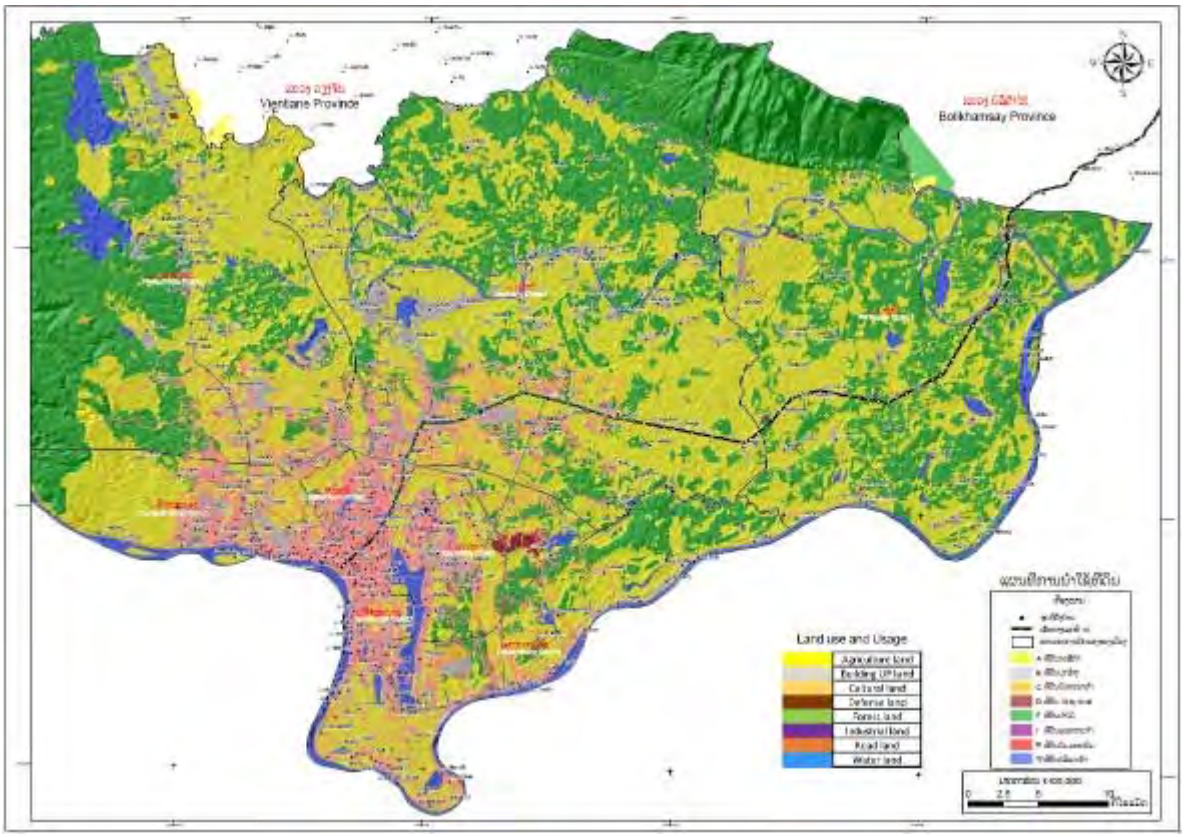
In Lao PDR, agricultural land has been allocated to villagers and forest management has been devolved to villages since 1996 based on Land Forest Allocation. Although forest categories and land categories do exist as framework, their boundaries and management is not universally accurate across villages.

(3) Land use patterns in Lao PDR

Land use patterns in the study area is shown in the figure below as a baseline information.

1) Land use patterns in Vientiane city

Below is the land use pattern in Vientiane city. Agricultural land and forest land are prevalent in Vientiane City except in the core urban area.



Source: Housing and Urban Planning Department

Figure 3.3.14 Land Use Patterns in Vientiane City

2) Changes in the land use patterns in Vientiane city

Changes in land use patterns in Vientiane City from 1995 to 2005 are shown in the table below. In 1995, majority of land use fell under forest with 70% of total and paddy fields with 16.7%, as oppose to only 3% dedicated to built-up area as urban and development areas. The land use pattern had changed by 2005, with double the size of built-up area and decreased land for forest (65 km2 decrease) and vacant land (108km2 decrease).

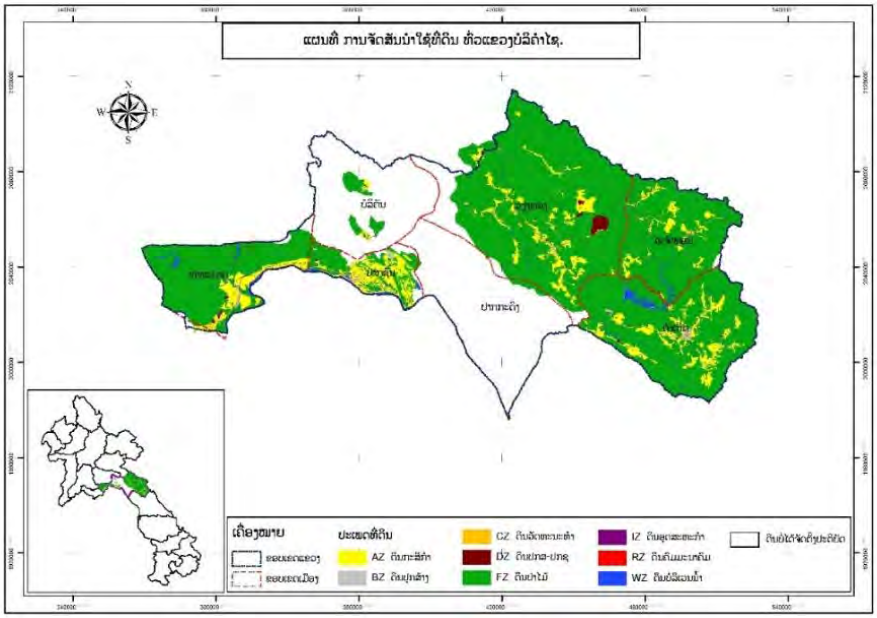
Table 3.3.14 Changes in the Land Use Patterns in Vientiane City

	1995			2005			Difference
	Area(km2)	(%)		Area(km2)	(%)		(2005-1995)
Buit-up Area	132.84	3.4%		220.66	5.6%		87.82
Paddy Field	655.11	16.7%		659.93	16.8%		4.82
Upland Cropland	52.86	1.3%		65.17	1.7%		12.31
Forest	2,710.88	69.2%		2,645.56	67.5%		-65.32
Vacant Land	221.08	5.6%		113.01	2.9%		-108.07
Water Body	147.23	3.8%		215.67	5.5%		68.44
Total	3,920.00			3,920.00			0.00

Source: JICA Study Team

3) Land use patterns in Bolikhamsai Province

The land use pattern in Bolikhamsai Province is shown below.



No.	legend /color	Land Use	Area (ha)	Percentage
1	AZ	Agriculture Land	121,324.13	7.77
2	BZ	Building Up Land	10,544.89	0.67
3	CZ	Culturally Land	1,617.40	0.1
4	DZ	Soldiers and police Land	5,548.59	0.35
5	FZ	Forest land	936,679.43	60.03
6	IZ	Industrt Land	1,092.17	0.06
7	RZ	Road Land	5,487.49	0.35
8	WZ	Water Land	27,574.70	1.77
9		Unvegetated Lands	450,450.63	28.9
		Sum	**1,560,319.43**	**100**

Source: Ministry of Natural Resources and Environment (Converted from ArcGIS by TEDI)

Figure 3.3.15 Land Use Pattern in Bolikhamsai Province

(4) Land use pattern in Vietnam

1) Land use pattern in Nghe An Province

According to Statistics of Land (2016), area size per person in Nghe An province is 0.54ha/person, which is 1.5 times as big as the national average (0.36ha/person). Area size by land type in Nghe An province is summarized below.

Table 3.3.15 Land Use Pattern in Nghe An Province

Land Type	Area Size	Ratio
Agricultural Production Land	303,919 ha	16.4%
Forestry Land	1,148,453 ha	69.7%
Specially Used Land	74,916 ha	45.5%
Homestead Land	22,593 ha	1.4%
Other	120,874 ha	7.3 %
Total	1,648,162 ha	100%

Source：Prepared by JICA Study Team based on Statistics of Land, 2016

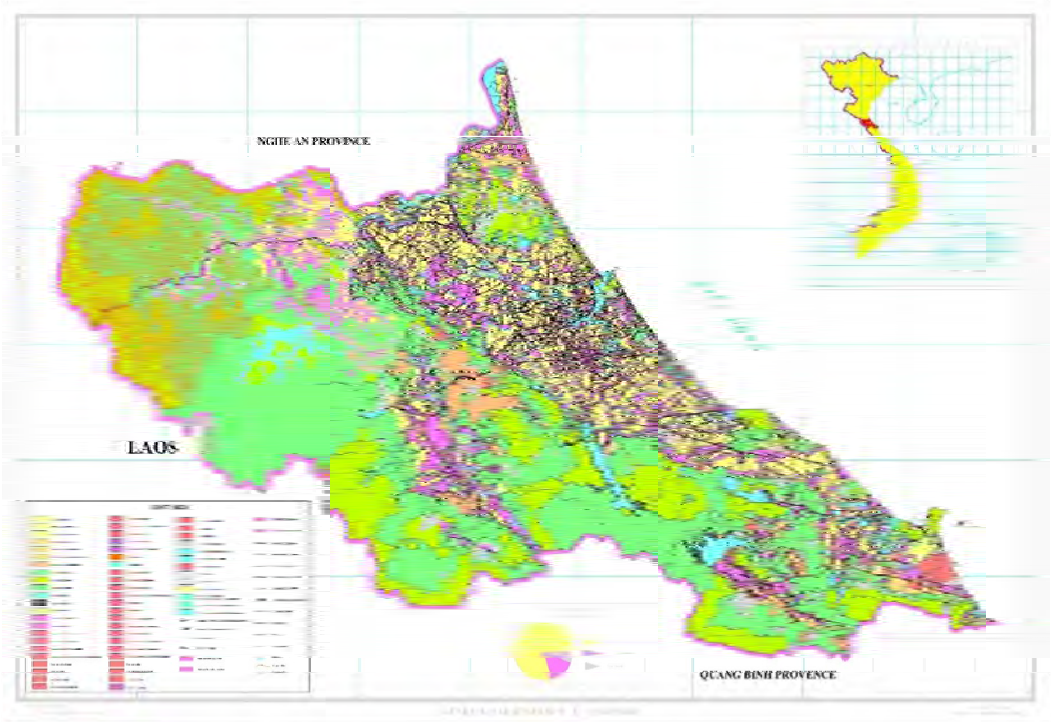
2) Land use pattern in Ha Tinh Province

The land use patterns of Ha Tinh Province according to Statistics of Land (2016) is shown below.

Table 3.3.16 Land Use Pattern in Ha Tinh Province

Land Type	Area Size	Ratio
Agricultural Production Land	152,219 ha	25.4%
Forestry Land	321,957 ha	53.7%
Specially Used Land	41,688 ha	7.0%
Homestead Land	11,804 ha	2.0%
Other	120,874 ha	11.9%
Total	599,067 ha	100%

Source：Prepared by JICA Study Team based on Statistics of Land, 2016



Source: Ha Tinh Department of Natural Resources and Environment

Figure 3.3.16 Land Use Patterns of Ha Tinh

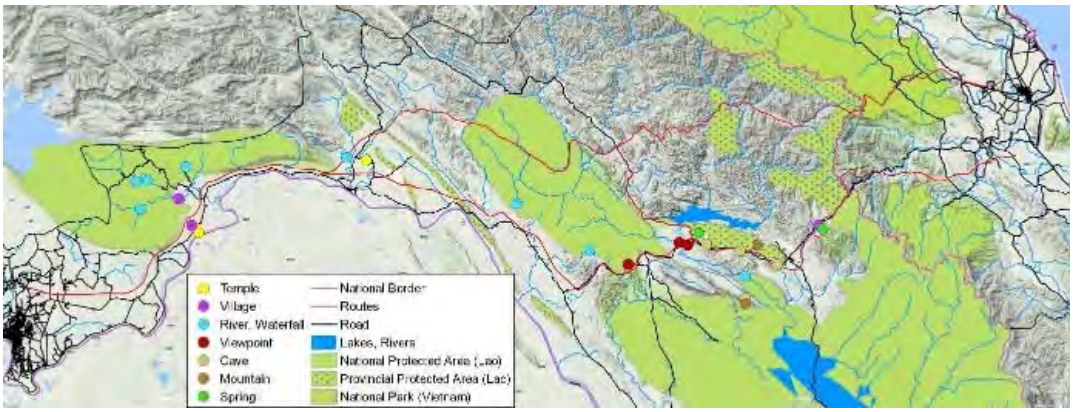
3.3.7 Landscape and Tourism Resources

The figure below shows major tourist destinations in Phou Khao Khouay National Protected Area and in Bolikhamsai Province.

There are tourist resources sparsely located along the NR 8. Most of them are picturesque places with natural landscape, including viewpoints such as caves and waterfalls. When planning a construction of road or tunnel, possible negative impacts on these sites need to be taken into account.

Source: Phou Khao Khouay National Protected Area Leaflet

Figure 3.3.17 Tourist Map in Phou Khao Khouay National Protected Area



Source: JICA Study Team

Figure 3.3.18 Distribution of Tourist Destination in Bolikhamsai Province

Table 3.3.17 List of Tourism Resources in Bolikhamsai Province

No.	Name	Category	No.	Name	Category
1	Taenchao Mountain	Mountain	2	Pha Phi Hong Mountain	Mountain
3	Tad Yong Rapids	River, Waterfall	4	Tad Leuk	River, Waterfall
5	Tad Yong	River, Waterfall	6	Tad Xai	River, Waterfall
7	Nampa Waterfall	River, Waterfall	8	Tad Van Fong	River, Waterfall
9	Tad Thone	River, Waterfall	10	Kaeng Laeng Rapids	River, Waterfall
11	Hot Spring	River, Waterfall	12	Cool Pool	River, Waterfall
13	Dragon Cave	Cave	14	Pha Kong Cave	Cave
15	Damdin Cave	Cave	16	Hospital Cave	Cave
17	Sala Viewpoint	Viewpoint	18	Limestone Forest Viewpoint	Viewpoint
19	Vat Phabath	Temple	20	Vat Phonsane	Temple
21	Vat Dan Soung	Temple	22	Ban Na	Village
23	Ban Yang Khuea	Village	24	Ban Nong Or	Village

Source: JICA Survey Team

3.3.8 Disasters

(1) Major disasters and their scale

The table below shows the past natural disasters that Lao PDR suffered between 1966 and 2005. Flooding is the most prevalent disasters in the country.

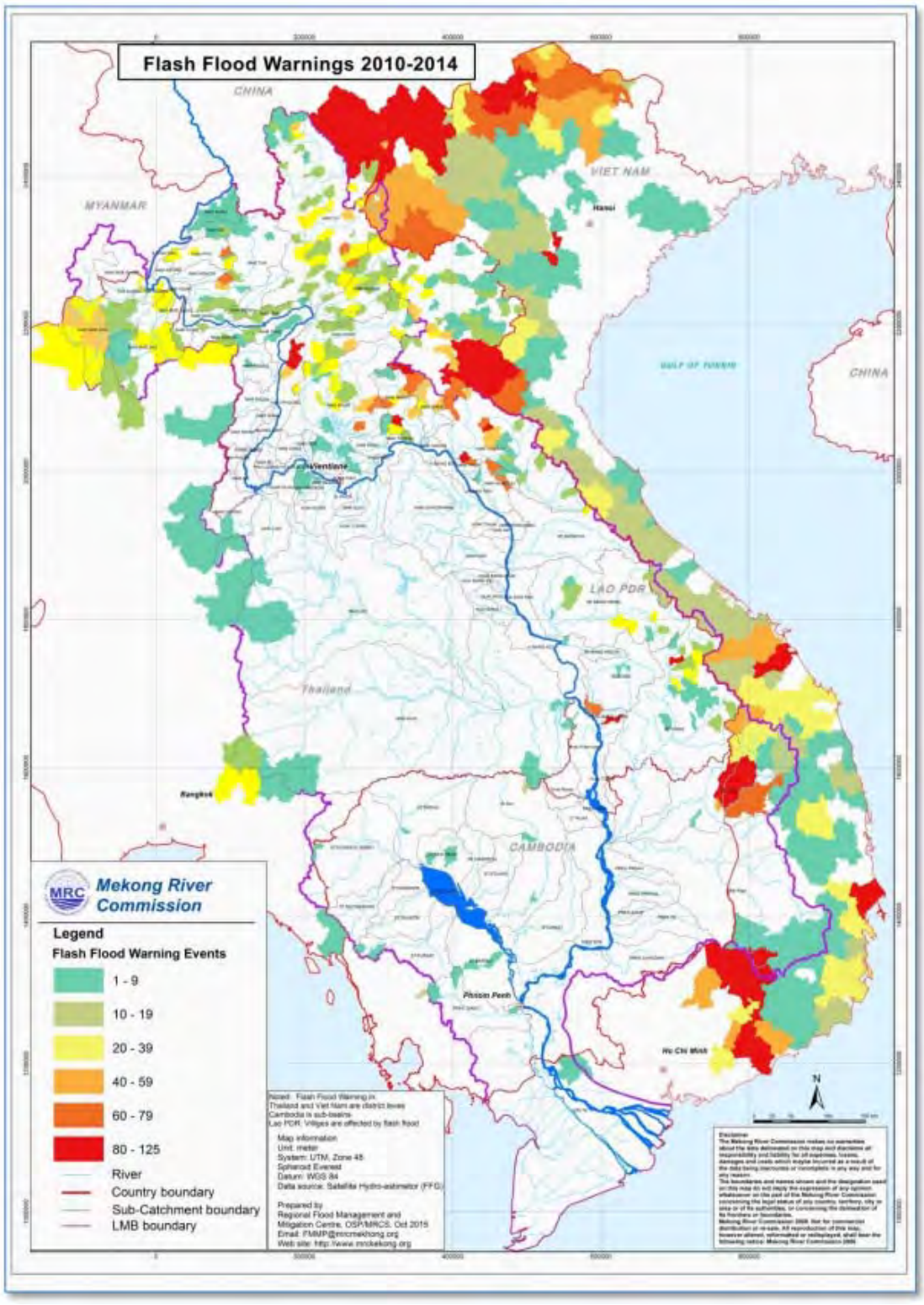
Table 3.3.18 Past Disasters and Damages in Lao PDR

Damage caused by flood in Lao PDR in 1966-2005			
Year	Types of Disasters	Total of damage in US$ (thousand)	Flood area
2005	flood and landslides	1,316.58	Central and South
2004	flood	750.399	South
2002	Big flood, flood and landslides	14,170	North, Central and South
2001	flood	808.5	Central and South
2000	flood	6,684.23	Central and South
1999	flood	7,450	Central
1997	flood and drought	1,860.30	South
1996	Big flood and drought	10,500	Central
1995	flood	15,000	Central
1994	flood	21,150	Central and South
1993	Big flood and drought	21,827.93	Central and South
1992	flood, drought and forest fires	302,151.20	Central and North
1991	flood and drought	3,650	Central
1990	flood	100	Central
1986	flood and drought	2,000	Central and South
1985	Big flood	1,000	North
1984	flood	3,430	Central and South
1981	flood	682	Central
1980	flood	3,000	Central
1979	flood and drought	3,600	North and South
1978	Big flood	5,700	North and South
1976	flood	9,00	Central
1774	flood	180	
1973	flood	3.7	Central
1972	flood and drought	40	Central
1971	Big flood	3,573	Central
1970	flood	30	Central
1969	flood	1,020	South
1968	flood	2,830	Central and South
1966	Big flood	13,800	Central

Source: National Disaster Reduction Plan 2016-2020

(2) Flood

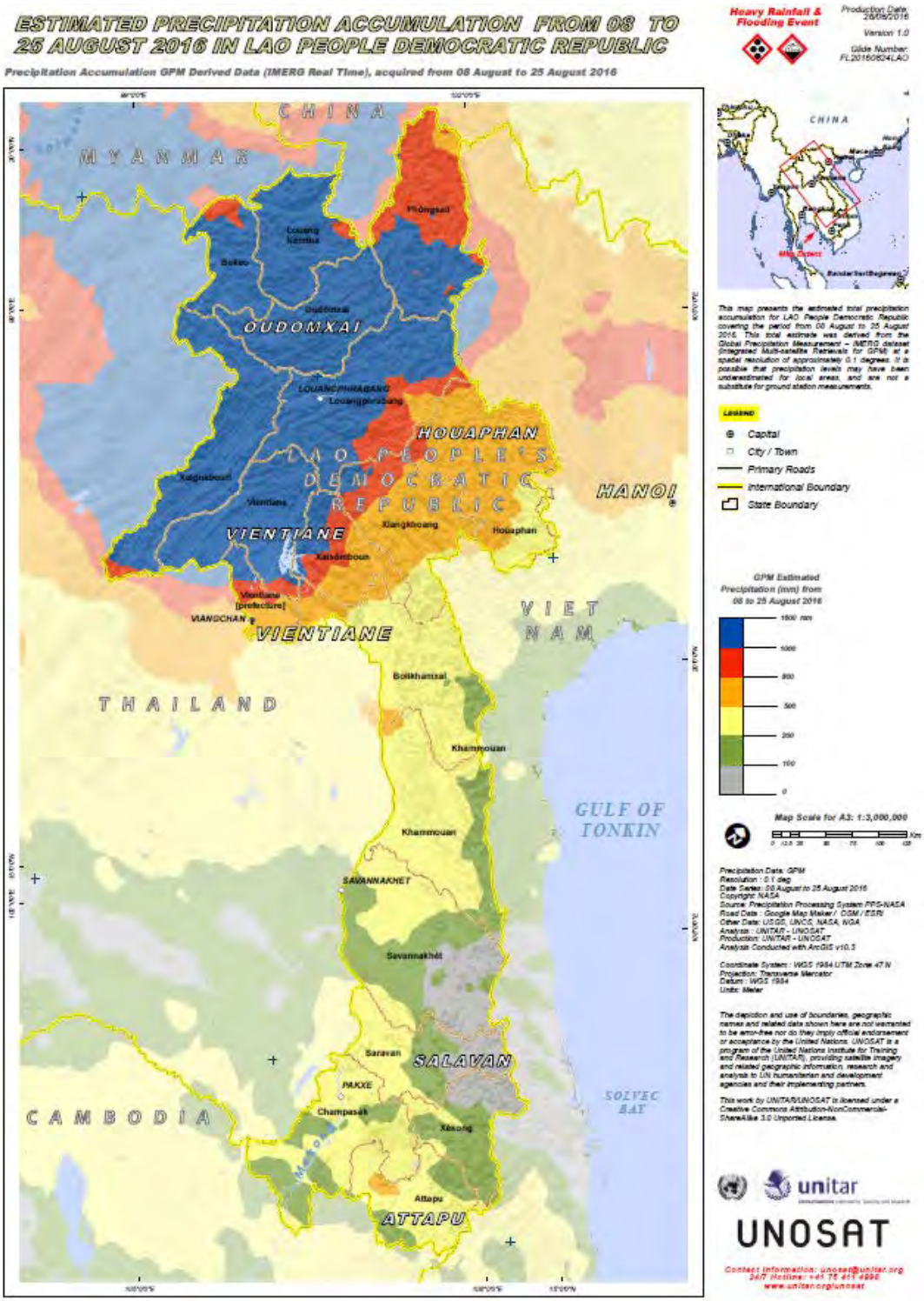
The figure below shows the regions with Flash Flood Warnings issued between 2010 and 2014. Several areas in the study area experienced frequent warnings. Because Flash Flood is a localized, rapid flood, further study is required to identify vulnerable sites along a planned route to consider the impact during road construction and after operation.



Source: Annual Mekong Flood Report 2014, Mekong River Commission

Figure 3.3.19 Regions where Flash Flood Warning was issued（2010-2014）

The latest heavy rainfall occurred between 8 and 11 of August, 2016, causing floods in the northern region of Lao PDR. However, it did not leave a significant impact in the study area.



Source: reliefweb (https://reliefweb.int/disaster/ff-2016-000093-lao)

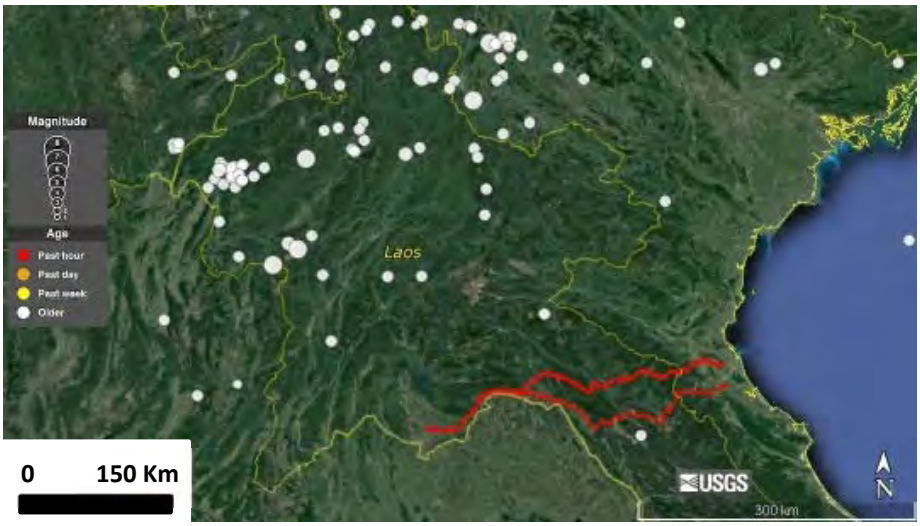
Figure 3.3.20 Precipitation between 8th and 25th of August, 2016

(3) Earthquake

1) Distribution of past earthquake

In Lao PDR, small- to medium-scale earthquakes have been recorded in the north and the south. However, there is only one recorded earthquake above Magnitude 7. Further, the nation suffered no large-scale damage from earthquakes. The figure below shows the distribution of the epicenters of earthquakes above Magnitude 1 that occurred in the northern and central Lao PDR and the northern Vietnam between January 1st, 1990 and January 30th, 2018.

The figure above demonstrates that the routes under examination in this report do not overlap with earthquake epicenters. One exception is the earthquake with Magnitude 4.7 that occurred on October 18th, 1985, epicenter of which is about 20km to the closest route.

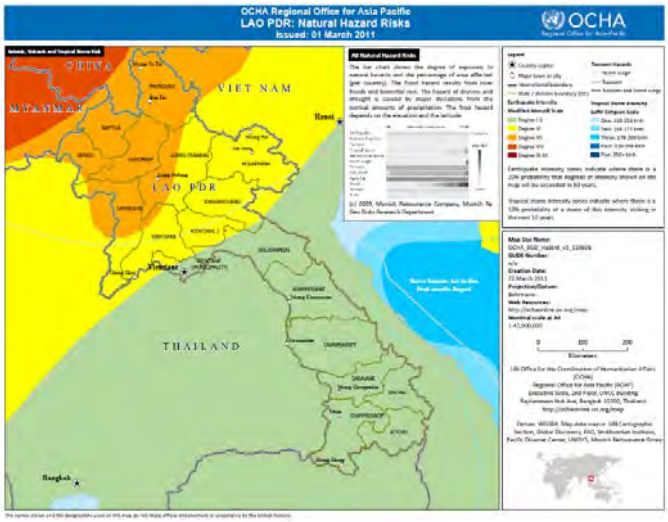


Source; Prepared by JICA Study Team based on USGS Earthquake Hazards Program

Figure 3.3.21 Epicenters of earthquakes in the northern and central Lao PDR and the northern Vietnam

2) Degree of exposure to natural hazards

The figure below shows the degree of exposure to natural hazards and modified Mercalli Scale to show earthquake intensity in Lao PDR and Vietnam. It reveals that the study area does not belong to the area with higher degree of exposure to earthquakes.



Source: OCHA

Figure 3.3.22 Degree of Exposure to Natural Disasters in Lao PDR and Vietnam

Intensity	Shaking	Description
I-V	Not felt	Not felt
II	Weak	Felt only by a few persons at rest
III	Weak	Felt quite noticeably by persons indoors
IV	Light	Felt indoors by many
V	Moderate	Felt by nearly everyone
VI	Strong	Felt by all. Slight damage
VII	Very strong	Slight to moderate in well-built ordinary structures
VIII	Severe	Considerable damage in ordinary substantial buildings

Source: USGS

Figure 3.3.23 Modified Mercalli Scale

3.3.9 UXO Distribution

(1) UXO in Lao PDR

Lao PDR is per capita the most bombed nation. Even to this day nearly a quarter of all villages in the nation are contaminated by UXO (Unexploded Ordnance). Over 2 million tons of ordnance were dropped between 1964 and 1973. Most of them were clustered bombs. It is estimated about 30% out of 270 million submunitions were unexploded. The ordnance took more than 50,000 lives since 1964. In 2015, 42 individuals lost their lives due to UXO. As many as 40% of the casualties in the 10 years up to 2015 were children. A number of agencies and organizations are taking on the mission to clear UXOs in Lao PDR.

Table 3.3.19 Number of UXO found and destroyed from 2010 to 2015

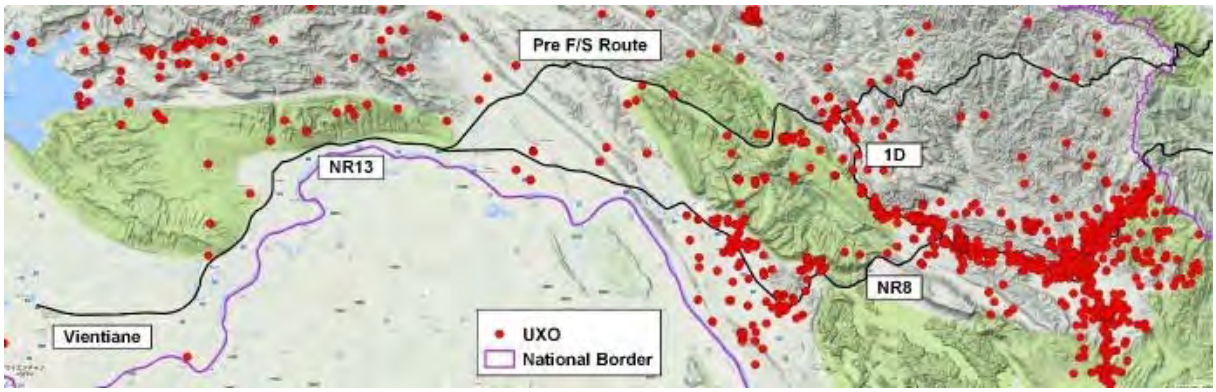
Humanitarian clearance operators - UXO Found and Destroyed through Area Clearance 2010-2015							
Year	Hectares Cleared	Bomb	Bombies/ CM	Landmines	Other UXO	Total UXO	CM/ha
2010	2,996	39	19,740	18	14,506	34,303	6.6
2011	3,692	22	19,088	96	19,683	38,889	5.2
2012	3,823	60	26,011	18	17,318	43,407	6.8
2013	3,228	28	22,847	48	20,626	43,549	7.1
2014	3,662	36	26,566	78	17,697	44,377	7.3
2015	2,961	55	49,497	108	13,162	62,822	6.7

Source: Unexploded Ordnance Sector Annual Report 2015

Table 3.3.20 UXO Accidents and Casualties

Year	Accidents	Injuries				Deaths				Total Casualties
		Male	Female	Boys	Girls	Male	Female	Boys	Girls	
2008	186	99	22	67	15	66	8	20	5	302
2009	77	50	8	25	3	25	1	6	2	120
2010	75	33	8	47	7	9	1	9	5	119
2011	64	32	9	34	4	6	0	14	0	99
2012	36	17	11	11	2	6	1	6	2	56
2013	18	9	2	12	5	5	0	7	1	41
2014	22	8	5	9	7	4	0	12	0	45
2015	27	15	1	16	1	6	1	2	0	42

Source: Unexploded Ordnance Sector Annual Report 2015



Source: JICA Survey Team

Figure 3.3.24 Distribution of UXO in Study Area in Lao PDR

As shown in the figure above, significant concentrations of UXO have been found along NR 8. It is imperative to clear existing UXO and/or verify that the land for road construction is clear of UXO.

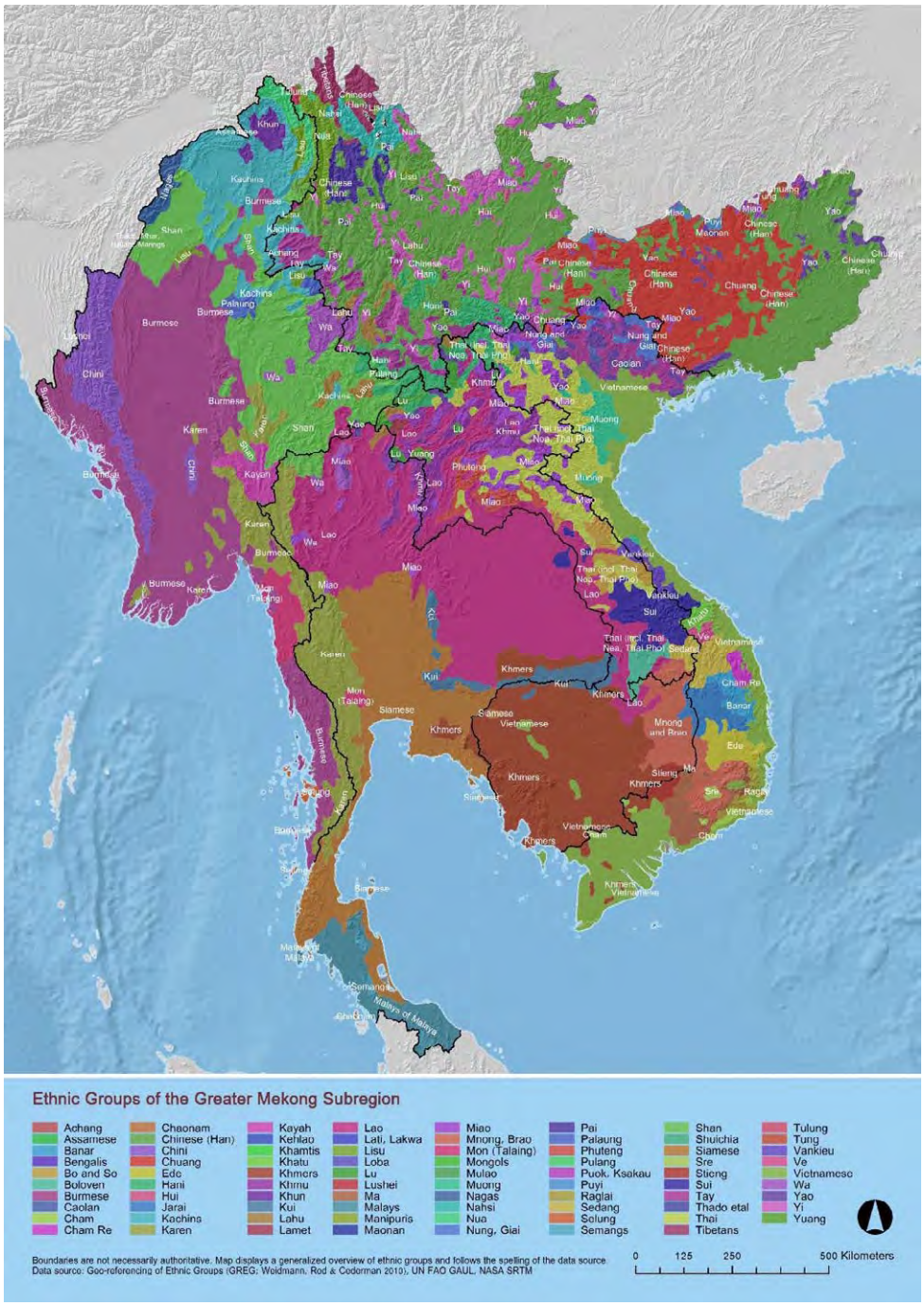
(2) UXO in Vietnam

The status and distribution of UXO in Vietnam could not be obtained from Vietnam National Mine Action Centre and other organizations dealing with UXO because it is a matter of national security.

3.3.10 Ethnic Minorities

(1) Distribution of major ethnic groups in Lao PDR and Vietnam

Figure below shows the distribution of ethnic groups in Lao PDR and Vietnam.

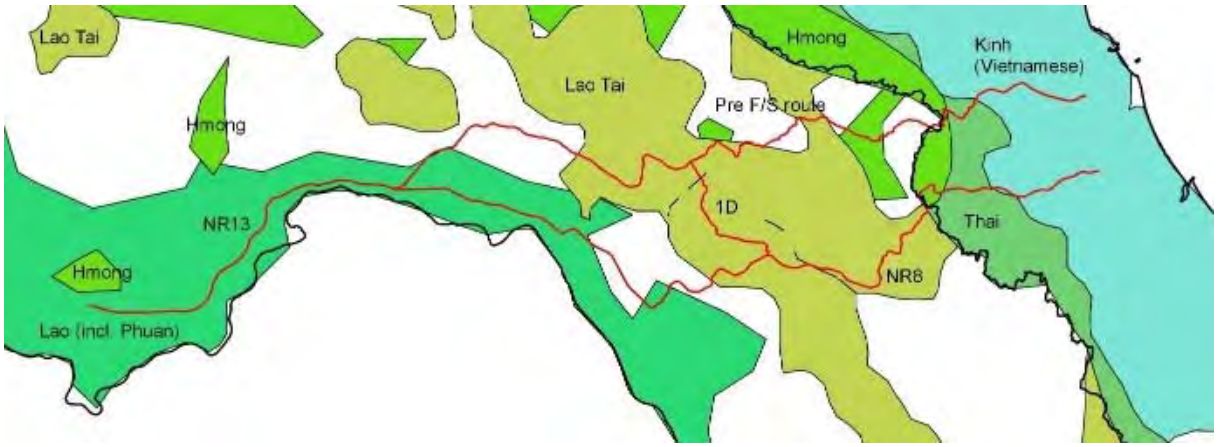


Source: FAO

Figure 3.3.25 Ethnic Groups of the Greater Mekong Subregion

(2) Distribution of ethnic group in the study area

The Lao is the main ethnic group found between Vientiane to the western end of NR 8, the Lao-Tai between NR 8 in Bolikhamsai Province to the border of Vietnam, the Hmong around the border, the Thai in the mountainous regions in AH15 in Vietnam, and the Kinh (major ethnic group in Vietnam) in the flatland in Vietnam.



Source: JICA Survey Team

Figure 3.3.26 Distribution of Ethnic Group in the Study Area

(3) Ethnic groups of Bolikhamsai Province, Lao PDR

There are 24 ethnic groups currently residing in Bolikhamsai Province. The majority of them belong to the Lao and the Tai. The table below shows the breakdown of the 24 ethnic groups and their populations. Further study is necessary to accurately identify where ethnic minorities reside around the routes under examination, then to consider the scale of impact on them.

Table 3.3.21 Demography of ethnic groups in Bolikhamsai Province

No.	Name of Ethnic Group	Bolikhamsai Province		
		# of Household	Total Population	Female
1	Lao	21,278	114,191	57,409
2	Tai	13,347	74,412	36,641
3	Mong	7,345	52,748	26,101
4	Kaemu	1,837	11,233	5,561
5	Phong	1,518	8,675	4,106
6	Tom	824	4,743	2,344
7	Thainea	222	1,177	666
8	Phouthai	1,642	9,441	4,775
9	Katang	28	152	81
10	Chack	177	1,131	589
11	Leu	57	295	148
12	Yue	23	116	64
13	Phounoy	20	109	60
14	Makong	10	51	21
15	Yae	1	6	4
16	Taouy	3	15	5
17	Samtao	2	10	7
18	Couy	12	71	35
19	Yu	18	105	57
20	Aiwmain	35	229	120
21	Aca	27	154	85
22	Chee	225	1,439	705
23	Vienkiew	21	81	43
24	Chin	12	50	29
Total		48,684	280,634	139,656

Source; Labour and Social Welfare Department of Bolikhamsai Province

(4) Ethnic groups of Nghe An Province, Vietnam

Breakdown of ethnic groups in Nghe An Province in Vietnam is shown in the table below. There are many ethnic minorities in the mountainous areas of Nghe An Province. Further study is necessary to identify if and which ethnic minorities would be affected by the routes under examination and figure out the scope and scale of the impact.

Table 3.3.22 Ethnic Minorities in Mountainous areas of Nghe An Province, Vietnam

No.	Ethnic Minority	No. of People	Ratio compared to population in mountainous areas (%)	Population distribution
1	Thai	299,490	26.7	Ky Son, Tuong Duong, Con Cuong, Que Phong, Quy Chau, Quy Hop, Tan Ky, Nghia Dan, Thanh Chuong, Anh Son và Quynh Luu
2	Tho	62,751	5.6	Nghia Dan, Quy Hop, Tan Ky, Thai Hoa commune
3	Kho Mu	45,890	4.1	Ky Son, Tuong Duong, Que Phong
4	Mong	30,433	2.7	Ky Son, Que Phong, Tuong Duong
5	O Du	1,085	0.1	Xop Pot, Kim Hoa, Com, Pung and Cha Cong hamlets of Kim Da commune and some inhabit in Kim Tien, Luong Minh, Luong, Thac Giam and Tam Dinh communes of Tuong Duong district and My Ly commune of Ky Son district.
6	Others	3,128	0.3	Scatter in mountainous districts
	Total	442,777	39.5	

Source: Committee for Ethnic Affairs in Nghe An, 2016

3.4 Land Acquisition and Resettlement

This section outlines legal systems and procedures for land acquisition and resettlement, and then estimates approximate compensation cost for each section/route.

3.4.1 Legal System of Land Acquisition and Resettlement

(1) Major laws and regulations regarding land acquisition and resettlement

1) Lao PDR

The table below shows the list of major laws and regulations regarding land acquisition and resettlement in Lao PDR.

Table 3.4.1 Laws and Regulations for Land Acquisition and Resettlement in Laos PDR

No.	Title	Enacted Year	Enacted No.
1	Land Law	October 2003	No. 04/NA
2	Decree on the Compensation and Resettlement of the Development Project	October 2000	No. 1770/STEA
3	Decree on the Compensation and Resettlement of the Development Project	July 2005	No. 192/PM
4	Decree on Compensation and Resettlement Management in Development Projects	April 2016	No. 84
5	Regulation for Implementing Decree No. 192/PM on Compensation and Resettlement of People Affected by Development Projects	November 2005	No. 2432/STEA
6	Technical Guidelines on Compensation and Resettlement in Development Projects	November 2005	
7	Technical Guidelines on Compensation and Resettlement in Development Projects	February 2011	Prime Minister's Office STEA
8	Technical Guidelines on Compensation and Resettlement in Development Projects	2016	Prime Minister's Office STEA
9	Degree on the Implementation of the Land Law	June 2008	No. 88/PM

Source: JICA Survey Team

2) Vietnam

The table below shows the list of major laws and regulations regarding land acquisition and resettlement in Vietnam.

Table 3.4.2 Laws and Regulations for Land Acquisition and Resettlement in Vietnam

No	Regulations	Details
1	Land Law, 2003	Ratified by the National Assembly on 26/11/2003, came into effect as of 01/07/2004
2	Decree No.17/2006/ND-CP	On revising some contents in the Decrees guiding the implementation of Land Law
3	Decree No.84/2007/ND9-CP	On the additional regulations on issuance of land use right certificate, land repossession, exercising the land use right, the procedures of compensation, support and resettlement upon land repossession by the Government and adjustment of land claims
4	Decree No. 69/2009/ND-CP	On land use planning, land prices, land acquisition, compensation, assistance and resettlement

Source: JICA Survey Team

(2) Procedures for land acquisition and resettlement

1) Lao PDR

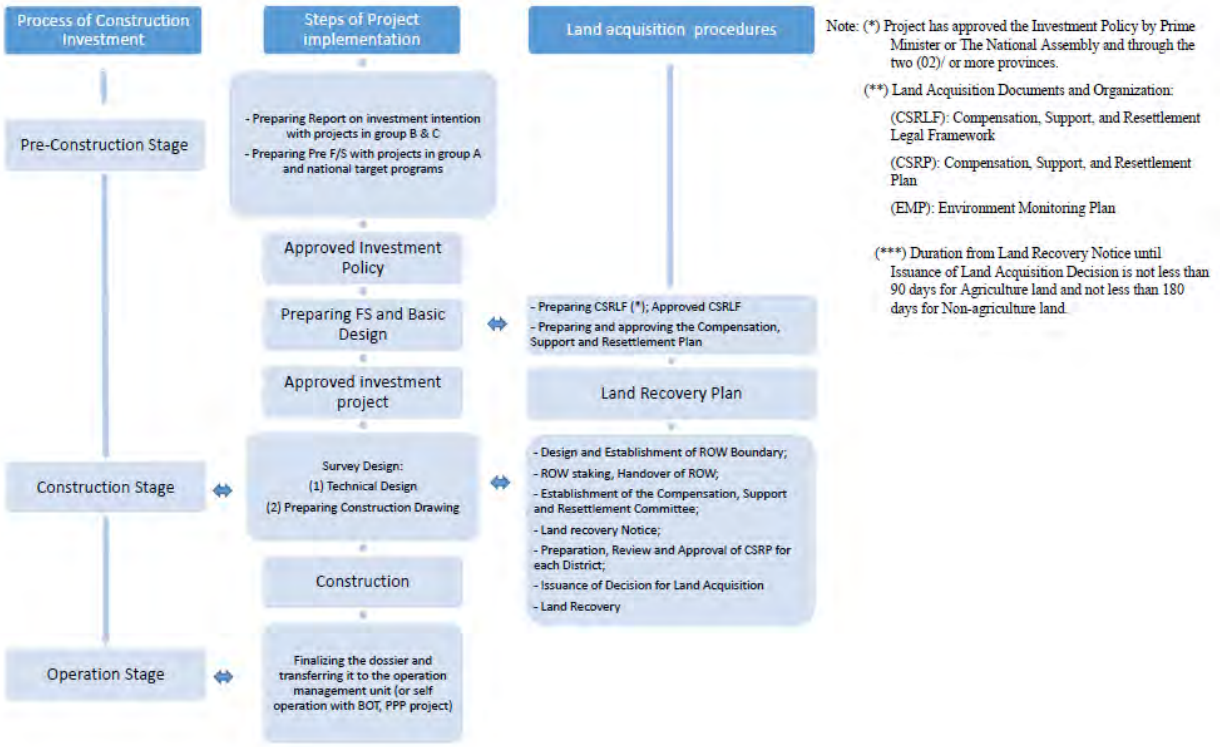
If land acquisition and/or resettlement is necessary for a project in Lao PDR, complying the above-mentioned laws and regulations, a project proponent must prepare and submit Resettlement Plan (RP) and Land Acquisition and Compensation Report (LACR) along with IEE or EIA.

For road projects, after the centerline and ROW are clarified, the proponent must identify Project Affected Peoples (PAPs) if involuntary resettlement is necessary. If land acquisition is necessary, the proponent must identify land owners and carry out census.

The proponent then organizes consultation with relevant government agencies, community leaders, and land owners to explain the project, obtain agreement, and address compensation.

2) Vietnam

If land acquisition and/or resettlement is necessary for a project in Vietnam, complying the above-mentioned laws and regulations, a project component must prepare and submit Compensation, Support, and Resettlement Plan (CSRP) and Land Recovery Plan (LRP) and obtain approval. Procedural flow in Vietnam is illustrated in Figure 3.4.1.



Source: Prepared by JICA Survey Team based on Vietnam laws and re

Figure 3.4.1 Procedural Flow regarding Land Acquisition and Resettlement

(3) Method for calculating compensation

1) Lao PDR

Objects covered for compensation in Lao PDR are categorized into three groups, that is, 1) structure, 2) production and 3) land. A local government has a responsibility in deciding unit price of compensation cost. As for a standard for calculating compensation, the Prime Minister's Decree on Compensation and Resettlement Management in Development Projects (Enacted No. 84, issued in April, 2016) stipulates that it should be average prices based on prices set by the state and market prices. However, in reality, unit prices are calculated as a result of detailed survey by a committee for

compensation and resettlement, which is formed for each project at a local level. The unit prices for compensation decided by the committee are the officially approved by local assembly and reported to MPWT.

Table 3.4.3 Method for Calculation of Compensation regarding Land Acquisition and Resettlement

Item	Method for Calculation
Object for compensation	(1) structure, (2) production, (3) land
Agency for setting compensation prices	Local government. Responsible governmental agencies with their corresponding compensation objects are as follows; (1) structure： local MPWT (2) production： local MOAF (3) land： local MONRE (Department of Land)
Method for calculating compensation prices	・ Committee for Compensation and People's Resettlement is formed and it decides unit prices for compensation ・ MONRE is in charge of coordination for setting up the above committee ・ The committee members usually include the head of target municipality (i.e. Provincial Governor) as a chairman, representatives from related municipalities, a project proponent and affected local residents etc. ・ Unit compensation prices set by the committee are officially approved by the local assembly (Article No.35 in Land law) and reported to MPWT
Standard for calculating compensation prices	・ According to the Prime Minister's Decree No.84, compensation prices are in principle average prices of prices set by the state and market prices. ・ In reality, there is no widely-used formula for calculating compensation. The above-mentioned committee decides prices on case-by-case basis.

Source: Prepared by JICA Survey Team based on on-site interviews with Department of Land (MONRE), Department of Agriculture and Forestry (MOAF)

2) Vietnam

Similarly to Lao PDR, compensation for land acquisition and resettlement is calculated for each project individually in Vietnam. Specifically, Provincial People's Committee conducts a survey according to which it then decides unit compensation prices in reference to market prices. Meanwhile, measurement for scale of objects covered for compensation is conducted by each commune and final compensation prices are thus determined.

≪From Land Law (2013), Article No. 114 Clause 4 ≫

"Specific land price shall be used as a basis for calculation of compensation amount upon land recovery by the State"）

≪From Land Law (2013), Article No. 114 Clause 3 ≫

"Provincial-level People's Committees shall decide on specific land prices. The determination of specific land prices must be based on the investigation, collection of information about land parcels, market land price and information on land price in the land database, and based on suitable valuation methods." （Land law, 2013）

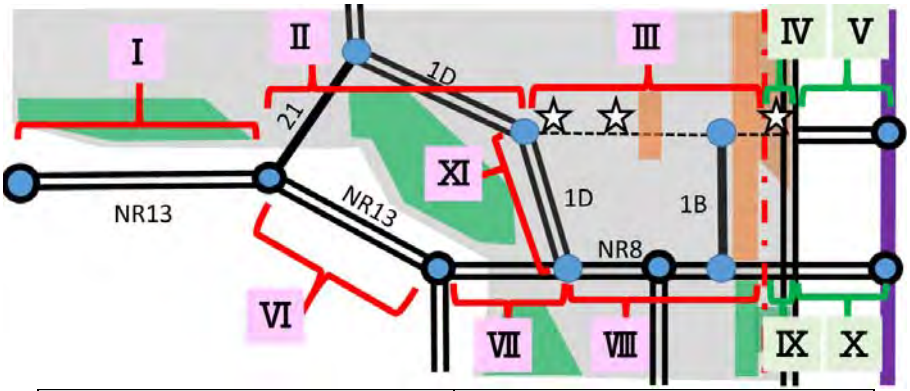
3.4.2 Preconditions for Estimation of Land Acquisition and Resettlement Cost

(1) Target routes

All four routes examined in this survey, as shown in the table below, are the target of calculating estimated cost for land acquisition and resettlement. For the calculation by section, road is segmented into sections as shown in Figure 3.4.2.

Table 3.4.4 Target Routes for Calculating Compensation for Land Acquisition and Resettlement

Target Routes	Length
Alternative 1 (Pre-F/S route)	400km
Alternative 2 (NR 8 route)	403km
Alternative 3A (Composite: NR13→NR8→1D→Pre-F/S)	496km
Alternative 3B (Composite NR13→Pre-F/S→1D→NR8)	426km



Section		Section	
I.	Vientiane – Pac Xan	**VII.**	Vieng Kham - Phontan
II.	Pac Xan - Viengthong	**VIII.**	Phontan - Namphao
III.	Viengthong – Nam On	**IX.**	Namphao - HCM road
IV.	Nam On - HCM road	**X.**	HCM(South) - Vinh
V.	HCM road (North) - Vinh	**XI.**	Phontan - Viengthong
VI.	Pac Xan – Vieng Kham		

Figure 3.4.2 Road Segmented into Sections

(2) Setting of ROW

For the calculation of compensation in this study, the ROW is set as 60m all along every route, regardless of the terrain. This assumption is considered reasonable because the Article No.22 of Road Law in Laos stipulates that the standard ROW for a newly constructed road should be between 40m and 60m.

ROW= 60m

(3) Method for calculating compensation

In this study, compensation cost is estimated in the method described in Table 3.4.5.

Table 3.4.5 Method for Calculating Compensation for Land Acquisition and Resettlement

Type of compensation	Method for Calculation
Land Acquisition	・Data of road alignment (ROW=60m) examined in Chapter 6 of this report is reflected on Google earth ・Land use pattern is visually checked and categorized into three patterns (1. Residential, 2. Agricultural, 3. Mountainous/Forest) for every 1km length of road ・Compensation amount is estimated according to the following formula; unit price for land by land use (USD/㎡) × road length (m) × ROW 60 (m)
Resettlement	・Data of road alignment (ROW=60m) examined in Chapter 6 of this report is reflected on Google earth ・The number of structure located within ROW is visually checked and counted ・Compensation amount is estimated according to the following formula; ・unit compensation price for each structure (USD/building) × the No.of resettled structure)

(4) Setting unit prices

Unit prices for compensation is set as per Table 3.4.6.

Table 3.4.6 Setting Unit Prices for Compensation

Country			Laos (※1)	Vietnam (※2)
Land Acquisition			Unit Price (US$/㎡)	Unit Price (US$/㎡)
	Land Use Patterns	①Residential	14.45	17.34
		②Agricultural	0.87	1.04
		③Mountainous or Forestland	0.36	0.43
			Unit Price (US$/building)	Unit Price (US$/building)
	Structure (house, shop, etc.)		4,725.4	5,670.5

※1: prices drawn from KOICA (2018), *"Detailed Feasibility Study for Upgrading National Road No.8 on the Asian Highway(AH15) Network in the Lao PDR"* (p.58)

※2: Considering the price difference between two countries, unit prices of Vietnam are assumed to be 1.2 times as much as those of Laos.

3.4.3 Estimation Result of Compensation Cost

(1) Compensation for land acquisition

1) Compensation by road section

Area size acquired for the project and the compensation for land acquisition by section are estimated as shown in the figure below. Section I (Vientiane – Pac Xan section) on Laos side and Section V (HCM road north – Vinh section) on Vietnam side require high land acquisition cost because they pass through residential areas and agricultural land relatively longer than mountainous areas.

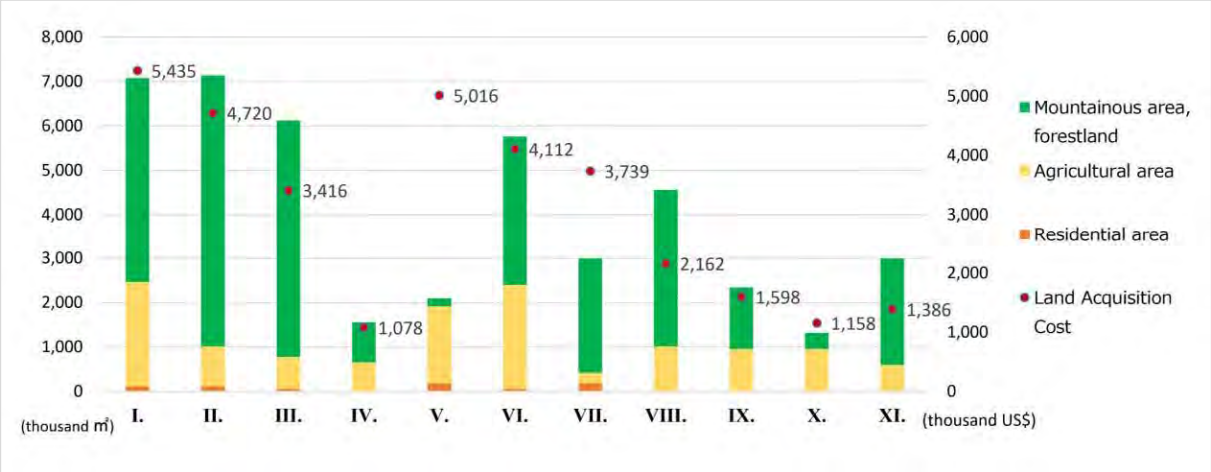


Figure 3.4.3 Area Size Acquired and Compensation for Land Acquisition by Section

2) Compensation by routes

Compensation for land acquisition by route is estimated as shown in the figure below. Alternative 3A shows the highest compensation cost as it passes through mountainous terrain the least. No significant difference can be observed for the rest.

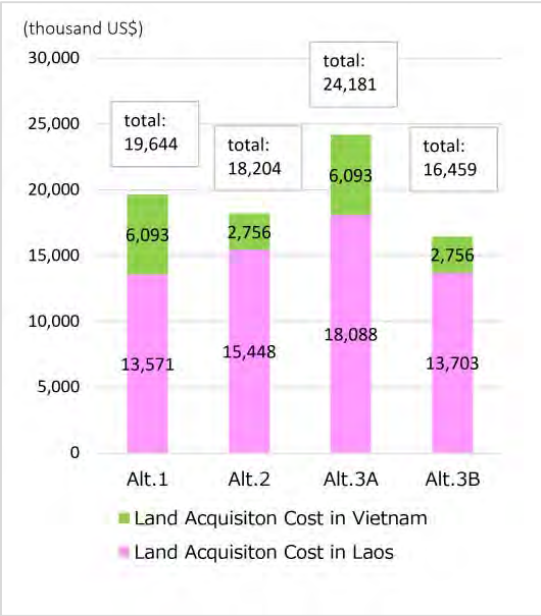


Figure 3.4.4 Land Acquisition Cost by Route

(2) Compensation for resettlement

1) Compensation by road section

The number of resettled structure and the compensation for resettlement by section are estimated as shown in the figure below. Section V (HCM road north – Vinh section) on Vietnam side requires by far the highest resettlement cost because it passes through several residential areas and thus the number of structures to be resettled is considerably large.

Figure 3.4.5 Resettlement Cost by Section (thousand USD)

2) Compensation by routes

Compensation for resettlement by route is estimated as shown in the figure below. Alternative 1 and Alternative 3A show particularly high compensation cost as it passes the Section V (HCM road north – Vinh), along which a large number of resettled structures are situated. The cost for resettlement in Alternative 1 and 3A is more than double of that of Alternative 2 and 3B.

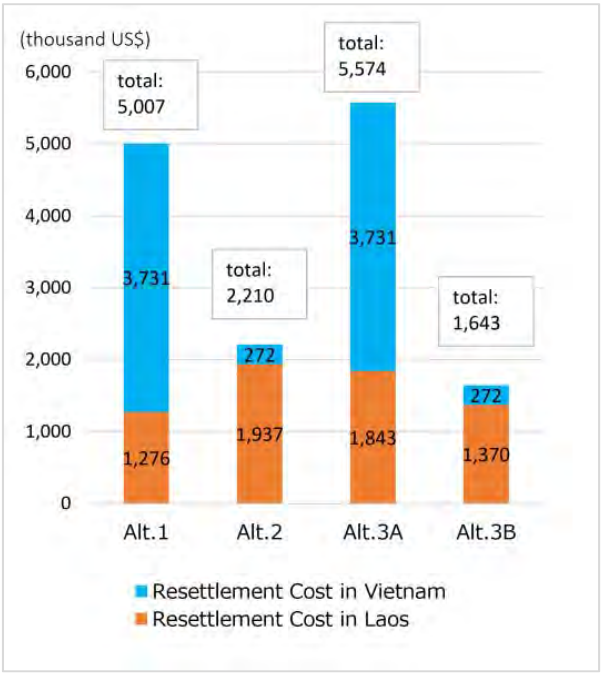


Figure 3.4.6 Resettlement Cost by Route (thousand USD)

3.5 Impact Assessment and Mitigation Measures

3.5.1 Scoping and Terms and Reference for Environmental and Social Consideration

The Chapter 9 of this study report demonstrates that, of all four alternative routes examined and compared in this study, "Alternative route 2" (route parallel to NR 8) is found to be most desirable.

In this section, scoping of environmental and social impact expected from the expressway development along this NR 8 route was carried out first, and then, possible measure to mitigate negative impact are outlined. Subsequently, scoping of other non-expressway sections included in the target area is conducted whenever possible.

Regarding the expressway development along Alternative 2, the route is divided into three sections; namely (1) Vientiane – Pac Xan section, (2) Pac Xan - Vieng Kham section and (3) Vieng Kham and NSE section. For each section, scoping result and possible mitigation measures are summarized in TOR format.

As for the non-expressway development sections, the result of (1) Viengthong – Nam On section (filling of missing link) is summarized in TOR format, but for the (2) NR 8 bottleneck, only particularly important topics are summarized. The section for (3) Provincial Road 1B improvement is not considered due to lack of existing data.

1. Expressway development along Alternative 2 (NR 8 route)		Scoping and Mitigation Measures
	1. Vientiane – Pac Xan section (NR 13 bypass)	Results summarized in TOR format
	2. Pac Xan – Vieng Kham section (NR 13 bypass)	
	3. Vieng Kham – NSE section (NR 8 bypass)	
2. Other non-expressway development sections proposed in the target area		Scoping and Mitigation Measures
	1. Viengthong – Nam On (filling of missing link)	Results summarized in TOR format
	2. Bottleneck section in NR 8	Particularly important topics summarized
	3. Improvement of Provincial Road 1B	Not considered due to lack of existing data

3.5.2 Expressway development along Alternative 2 (NR 8 route)

(1) Section between Vientiane and Pac Xan (NR 13 bypass)

1) Scoping result (Vientiane – Pac Xan section)

Category	No.	Environmental Factor	Evaluation		Reason for evaluation
			BC DC	OP	
Pollution Control	1	Air pollution	B-	B-	**DC :** Exhaust gases discharged from construction machines may have temporary adverse impact on air quality in the surrounding area. **OP :** As no decrease in traffic of NR13 is predicted, exhaust gases from the traffic on the new road may have negative impact on air quality in the surrounding area.
	2	Water pollution	B-	D	**DC :** Water runoff and discharge from construction sites, construction machines and vehicles as well as worker base camp may cause water pollution. **OP :** No negative impact is expected.
	3	Waste	B-	C-	**DC :** Surplus construction soil and waste would be generated. **OP :** Illegal damping of waste with adverse environmental impact brought in from outside may increase.
	4	Noise and vibrations	B-	C-	**DC :** Construction noise and vibration from operation of construction machines and vehicles is expected. **OP :** Noise and vibration may increase due to increase in traffic.
	5	Ground subsidence	D	D	No construction work that could induce ground subsidence is expected.

Category	No.	Environmental Factor	Evaluation		Reason for evaluation
			BC DC	OP	
Natural Environment	6	Protected areas	D	D	Although a section of the route passes an area 1km from the boundary of Phou Khao Khouay National Protected Area, significant adverse impact is not expected as it is sufficiently away.
	7	Ecosystem	D	D	No significant adverse impact is expected as the alignment does not pass habitats of rare species.
	8	Hydrology	C-	C-	**DC：** Because some sections of the alignment cross rivers, attention needs to be paid to changes in hydrology and river bed. **OP：** In case bridge structures such as piers be constructed in the river, hydrological regime may be altered.
	9	Topography and geology	D	D	No negative impact on topography and geology is expected.
Social Environment	10	Resettlement	C-	C-	**BC：** Involuntary resettlement would be necessary for land acquisition for road and construction. However, the estimated numbers of Project Affected Households (PAHs) and Projected Affected People (PAPs) are unknown at this stage.
	11	The Poor	B+/-	B+	**BC：** PAHs and PAPs may include the poor. If they are eligible for compensation, their standard of living may improve through livelihood restoration and/or enhancement program. **OP：** Increase in employment opportunity is expected from job creation, improved inter-regional accessibility, and increase in tourists.
	12	Ethnic minorities and indigenous peoples	C	C	It is not clear yet whether the road right of way and the surrounding areas overlap with settlements of ethnic minorities and/or indigenous peoples. Further survey is necessary.
	13	Local economy such as employment and livelihood	B-	B+	**BC：** If PAPs' livelihood relies on agriculture, they may temporarily lose their livelihood through relocation. **OP：** Road construction would bring positive impact by improved access to urban areas and increased number of tourists to visit.
	14	Land use and utilization of local resources	C-	D	**DC：** Land acquisition for road ROW and/or lease would be necessary. Further survey is required to identify the scale of impact. **OP：** No significant negative impact is expected.
	15	Water usage	C-	D	**DC：** If river water sources are being used, turbid water generated by construction may have adverse impact. **OP：** No change in water usage is expected.
	16	Existing social infrastructure and services	B-	C	**DC：** Traffic control may be necessary. **OP：** Further survey is required to identify sensitive receptors (residence, educational, health, and religious facilities) along the route.
	17	Social institutions such as social infrastructure and local decision-making institutions	D	D	**DC/OP**：Although no impact that would divide social institutions is expected, attention should be paid to avoid unfair compensation when evaluating for land acquisition and resettlement.
	18	Misdistribution of benefits and damages	D	D	Although no misdistribution of benefits and damages is expected at this stage, attention should be paid to avoid unfair compensation when evaluating for land acquisition and resettlement.
Social Environment	19	Local conflicts of interest	C	C	Further survey is required.

Category	No.	Environmental Factor	Evaluation		Reason for evaluation
			BC DC	OP	
Social Environment	20	Cultural heritage	C	C	At this stage no cultural heritage designated internationally or by local government was identified in the target project area. However, upon determination of detailed alignment, it is necessary to accurately map sacred sites and burial grounds in the surrounding areas.
	21	Landscape	B-	B-	**DC/OP：** Existing landscape may be changed by the road construction in urban/residential areas.
	22	Gender	B+	B+	Increased employment opportunity is expected from job creation for all gender and improved inter-regional accessibility.
	23	Children's rights	C	B+	Better access to educational facilities in a distant area would provide improved opportunity to education.
	24	Infectious diseases such as HIV/AIDS	B-	D	**DC：** Infectious diseases may spread because of the inflow of outside workers.
	25	Working conditions including occupational safety	B+/-	C	**DC：** Consideration for working conditions will be necessary. Employment opportunity for residents along the route is expected. **OP：** Employment opportunity such as light maintenance work is expected for residents along the route.
	26	Accidents	B-	B-	**BC**：UXO clearance is necessary. **DC**：Consideration for accidents during construction is necessary. **OP**：Ensuring safe passage through the new road is necessary.
	27	Transboundary impact and climate change	D	D	No significant transboundary impact or negative impact on climate change is expected.

Note: BC: Before Construction, DC: During Construction. OP: Operation Phase
A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown (Further examination is needed, and the impact could be clarified as the study progresses).
D: No impact is expected.

2) Mitigation measures (Vientiane – Pac Xan section)

Category	No.	Factor	Mitigation measures and agenda
Pollution Control	1	Air pollution	1. Identify sensitive receptors around the project area (residences, educational, health, and religious facilities) 2. Measure current air quality 3. Consider mitigation measures against air pollution from construction by preparing a monitoring plan, etc. 4. Vehicle emissions prediction
	2	Water pollution	1. Measure water quality of relevant rivers 2. Figure out water usage patterns at relevant rivers 3. Consider mitigation measures against water pollution from construction by preparing a monitoring plan, etc.
	3	Waste	1. Research standards regarding waste management 2. Consider waste management strategy 3. Explore monitoring program to control illegal damping of waste by outsiders
	4	Noise and vibrations	1. Identify sensitive receptors around the project area (residences, educational, health, and religious facilities) 2. Measure current noise and vibration levels 3. Prepare a monitoring plan and mitigation measures against noise and vibrations during construction from construction equipment and vehicles.
	8	Hydrology	1. Figure out the locations of river crossings 2. Consider monitoring changes in water flow and river bed
Social Environment	10	Resettlement	1. Upon deciding detailed alignment, consider the extent of land to acquire. 2. Identify the scale of resettlement in detail 3. Survey of affected assets
	11	The Poor	1. Identify the poor in the project area 2. Confirm the status by hearing
	12	Ethnic minorities and indigenous peoples	1. Identify the residential areas of project affected ethnic minorities and indigenous peoples 2. Obtain data based on population census, socio-economic survey, and interviews
	13	Local economy such as employment and livelihood	Identify Project Affected Peoples and Project Affected Assets
	14	Land use and utilization of local resources	Survey of land use of the affected area
	15	Water usage	Study the water usage patterns in the affected rivers
	16	Existing social infrastructure and services	Survey of social infrastructure such as educational and health facilities
	19	Local conflicts of interest	Study differences in benefits and impacts to local residents due to road construction
	20	Cultural heritage	Identify local sacred sites and cemeteries and consider the extent of impact on them
	21	Landscape	1. Closely study existing landscape resources especially in urban or residential areas 2. Consider road design (i.e. color, configuration) harmonious with existing landscape
	22	Gender	Survey detailed social conditions of the project area
	23	Children's rights	Identify educational facilities near the route and consider impact on children
	24	Infectious diseases such as HIV/AIDS	Prepare training program for construction workers
	25	Working conditions including occupational safety	Consider monitoring of working conditions of construction workers
Others	26	Accidents	1. Figure out the status of UXO clearance in the project area 2. Consider accident prevention during construction

(2) Section between Pac Xan and Vieng Kham (NR 13 bypass)

1) Scoping result (Pac Xan – Vieng Kham section)

Category	No.	Environmental Factor	Evaluation		Reason for evaluation
			BC DC	OP	
Pollution Control	1	Air pollution	B-	B-	**DC：** Exhaust gases discharged from construction machines may have temporary adverse impact on air quality in the surrounding area. **OP：** As no decrease in traffic of NR13 is predicted, exhaust gases from the traffic on the new road may have negative impact on air quality in the surrounding area.
	2	Water pollution	B-	D	**DC：** Water runoff and discharge from construction sites, construction machines and vehicles as well as worker base camp may cause water pollution. **OP：** No negative impact is expected.
	3	Waste	B-	C-	**DC：** Surplus construction soil, wood and waste would be generated. **OP：** Illegal damping of waste with adverse environmental impact brought in from outside may increase.
	4	Noise and vibrations	B-	C-	**DC：** Construction noise and vibration from operation of construction machines and vehicles is expected. **OP：** Noise and vibration from passing traffic is expected.
	5	Ground subsidence	D	D	No construction work that could induce ground subsidence is expected.
Natural Environment	6	Protected areas	D	D	No impact is expected.
	7	Ecosystem	D	D	No significant adverse impact is expected as the alignment does not pass habitats of rare species.
	8	Hydrology	C-	C-	**DC：** Because some sections of the alignment cross rivers, attention needs to be paid to changes in hydrology and river bed. **OP：** In case bridge structures such as piers be constructed in the river, hydrological regime may be altered.
	9	Topography and geology	D	D	No negative impact on topography and geology is expected.
Social Environment	10	Resettlement	C-	C-	**BC：** Involuntary resettlement would be necessary for land acquisition for road and construction. However, the estimated numbers of Project Affected Households (PAHs) and Projected Affected People (PAPs) are unknown at this stage.
	11	The Poor	B+/-	B+	**BC：** PAHs and PAPs may include the poor. If they are eligible for compensation, their standard of living may improve through livelihood restoration and/or enhancement program. **OP：** Increase in employment opportunity is expected from job creation, improved inter-regional accessibility, and increase in tourists.
	12	Ethnic minorities and indigenous peoples	C	C	It is not clear yet whether the road right of way and the surrounding areas overlap with settlements of ethnic minorities and/or indigenous peoples. Further survey is necessary.
	13	Local economy such as employment and livelihood	B-	B+	**BC：** If PAPs' livelihood relies on agriculture, they may temporarily lose their livelihood through relocation. **OP：** Road construction would bring positive impact by improved access to urban areas and increased number of tourists to visit.

Category	No.	Environmental Factor	Evaluation		Reason for evaluation
			BC DC	OP	
Social Environment	14	Land use and utilization of local resources	C-	D	**DC :** Land acquisition for road ROW and/or lease would be necessary. Further survey is required to identify the scale of impact. **OP :** No negative impact is expected.
	15	Water usage	C-	D	**DC :** If river water sources are being used, turbid water generated by construction may have adverse impact. **OP :** No change in water usage is expected.
	16	Existing social infrastructure and services	B-	C	**DC :** Traffic control may be necessary. **OP :** Further survey is required to identify sensitive receptors (residence, educational, health, and religious facilities) along the route.
	17	Social institutions such as social infrastructure and local decision-making institutions	D	D	**DC/OP** : Although no impact that would divide social institutions is expected, attention should be paid to avoid unfair compensation when evaluating for land acquisition and resettlement.
	18	Misdistribution of benefits and damages	D	D	Although no misdistribution of benefits and damages is expected at this stage, attention should be paid to avoid unfair compensation when evaluating for land acquisition and resettlement.
	19	Local conflicts of interest	C	C	Further survey is necessary.
	20	Cultural heritage	C	C	At this stage no cultural heritage designated internationally or by local government was identified in the target project area. However, upon determination of detailed alignment, it is necessary to accurately map sacred sites and burial grounds in the surrounding areas.
	21	Landscape	B-	B-	**DC/OP :** Existing landscape may be changed by the road construction in urban/residential areas.
	22	Gender	B+	B+	Increased employment opportunity is expected from job creation for all gender and improved inter-regional accessibility.
	23	Children's rights	C	B+	Better access to educational facilities in a distant area would provide improved opportunity to education.
	24	Infectious diseases such as HIV/AIDS	B-	D	**DC :** Infectious diseases may spread because of the inflow of outside workers.
	25	Working conditions including occupational safety	B+/-	C	**DC :** Consideration for working conditions will be necessary. Employment opportunity for settlements along the route is expected. **OP :** Employment opportunity such as light maintenance work is expected for residents along the route.
Others	26	Accidents	B-	B-	**BC** : UXO clearance is necessary. **DC** : Consideration for accidents during construction is necessary. **OP** : Traffic accident is expected.
	27	Transboundary impact and climate change	D	D	No significant transboundary impact or negative impact on climate change is expected.

Note: BC: Before Construction, DC: During Construction. OP: Operation Phase

A+/-: Significant positive/negative impact is expected.

B+/-: Positive/negative impact is expected to some extent.

C+/-: Extent of positive/negative impact is unknown (Further examination is needed, and the impact could be clarified as the study progresses).

D: No impact is expected.

2) Mitigation Measures (Pac Xan – Vieng Kham section)

Category	No.	Factor	Mitigation measures and agenda
Pollution Control	1	Air pollution	1. Identify sensitive receptors around the project area (residences, educational, health, and religious facilities) 2. Measure current air quality 3. Consider mitigation measures against air pollution from construction by preparing a monitoring plan, etc 4. Vehicle emissions prediction
	2	Water pollution	3. Measure water quality of relevant rivers 4. Figure out water usage patterns at relevant rivers 5. Consider mitigation measures against water pollution from construction by preparing a monitoring plan, etc
	3	Waste	1. Research standards regarding waste management 2. Consider waste disposal strategy 3. Explore monitoring program to control illegal damping of waste by outsiders
	4	Noise and vibrations	1. Identify sensitive receptors around the project area (residential area, educational, health, and religious facilities) 2. Measure current noise and vibration levels 3. Prepare a monitoring plan and mitigation measures against noise and vibrations during construction from construction equipment and vehicles.
	8	Hydrology	1. Figure out the locations of river crossings 2. Consider monitoring changes in water flow and river bed
Social Environment	10	Resettlement	3. Upon deciding detailed alignment, consider the extent of land to acquire. 4. Identify the scale of resettlement in detail 5. Survey of affected assets
	11	The Poor	1. Identify the poor in the project area 2. Confirm the status by hearing
	12	Ethnic minorities and indigenous peoples	1. Identify the residential areas of project affected ethnic minorities and indigenous peoples 2. Obtain data based on population census, socio-economic survey, and interviews
	13	Local economy such as employment and livelihood	Identify Project Affected Peoples and Project Affected Assets
	14	Land use and utilization of local resources	Survey of land use of the affected area
	15	Water usage	Study the water usage patterns in the affected rivers
	16	Existing social infrastructure and services	Survey of social infrastructure such as educational and health facilities
	19	Local conflicts of interest	Study differences in benefits and impacts to local residents due to road construction
	20	Cultural heritage	Identify local sacred sites and cemeteries and consider the extent of impact on them
	21	Landscape	1. Closely study existing landscape resources especially in urban or residential areas 2. Consider road design (i.e. color, configuration) harmonious with existing landscape
	22	Gender	Survey detailed social conditions of the project area
	23	Children's rights	Identify educational facilities near the route and consider impact on children
	24	Infectious diseases such as HIV/AIDS	Prepare training program for construction workers
	25	Working conditions including occupational safety	Consider monitoring of working conditions of construction workers
Others	26	Accidents	1. Figure out the status of UXO clearance in the project area 2. Consider accident prevention during construction

(3) Section between Vieng Kham and NSE (NR 8 bypass)

1) Scoping result (Vieng Kham – NSE section)

Category	No.	Environmental Factor	Evaluation		Reason for evaluation
			BC DC	OP	
Pollution Control	1	Air pollution	B-	B-	**DC：** Exhaust gases discharged from construction machines may have temporary adverse impact on air quality in the surrounding area. **OP：** As no decrease in traffic of NR8 is predicted, exhaust gases from the traffic on the new road may have negative impact on air quality in the surrounding area.
	2	Water pollution	B-	D	**DC：** Water runoff and discharge from construction sites, construction machines and vehicles as well as worker base camp may cause water pollution. Water discharge from tunnel excavation is expected. **OP：** No negative impact is expected.
	3	Waste	B-	C-	**DC：** Surplus construction soil, waste, and excavated soil from tunnel would be generated. **OP：** Illegal damping of waste with adverse environmental impact brought in from outside may increase.
	4	Noise and vibrations	B-	C-	**DC：** Construction noise and vibration from operation of construction machines and vehicles is expected. Noise and vibration is expected to be generated while excavating tunnel near the entrance or surface. **OP：** In case sensitive receptors (residences, educational, health, and religious facilities) are located around the route, noise from increased traffic volume may negatively impact them.
	5	Ground subsidence	C-	C-	If tunnel excavation causes groundwater level to be lowered, ground subsidence and/or surface subsidence may occur.
Natural Environment	6	Protected areas	A-	A-	The route under consideration passes Nam Chom Voy Provincial Protected Area near the border with Vietnam. Legal procedures to undo protected area designation and forest license are necessary. Road construction would divide the protected area reduce the total area of the protected area.
	7	Ecosystem	A-	A-	The route passes through habitats for diversity of endangered species internationally and domestically designated for protection. **DC：** Construction is expected to involve forest clearance, loss, disturbance, and division of habitats for plants and animals. Due to construction noise and human intervention, animals sensitive to environmental change would temporarily shift their habitat ranges. The population of animals may decrease due to traffic accidents during construction. **OP：** It is expected that reduction in forest area leads to loss and division of animal and plant habitats. Disturbance to animal habitats and increase in poaching may occur due to improved access by humans through road construction. There may be negative cumulative impact derived from development project triggered by road construction. The population of animals may decrease due to traffic accidents.
	8	Hydrology	C-	C-	**DC：** Because some sections of the alignment cross rivers, attention needs to be paid to changes in hydrology and river bed.

Category	No.	Environmental Factor	Evaluation		Reason for evaluation
			BC DC	OP	
Natural Environment					**OP：** In case bridge structures such as piers be constructed in the river, hydrological regime may be altered.
	9	Topography and geology	B-	B-	Negative impact is expected where cutting and tunnels are considered.
Social Environment	10	Resettlement	C-	C-	**BC：** Involuntary resettlement would be necessary for land acquisition for road and construction. However, the estimated numbers of Project Affected Households (PAHs) and Projected Affected People (PAPs) are unknown at this stage.
	11	The Poor	B+/-	B+	**BC：** PAHs and PAPs may include the poor. If they are eligible for compensation, their standard of living may improve through livelihood restoration and/or enhancement program. **OP：** Increase in employment opportunity is expected from job creation, improved inter-regional accessibility, and increase in tourists.
	12	Ethnic minorities and indigenous peoples	C	C	It is not clear yet whether the road right of way and the surrounding areas overlap with settlements of ethnic minorities and/or indigenous peoples. Further survey is necessary.
	13	Local economy such as employment and livelihood	B-	B+	**BC：** If PAPs' livelihood relies on agriculture, they may temporarily lose their livelihood through relocation. **OP：** Road construction would bring positive impact by improved access to urban areas and increased number of tourists to visit.
	14	Land use and utilization of local resources	C-	D	**DC：** Land acquisition for road ROW and/or lease would be necessary. The scale of impact requires further survey. **OP：** No negative impact is expected.
	15	Water usage	C-	D	**DC：** If river water sources are being used, turbid water generated by construction may have adverse impact. **OP：** No change in water usage is expected.
	16	Existing social infrastructure and services	B-	C	**DC：** Traffic control may be necessary during construction. **OP：** Further survey is required to identify sensitive receptors (residence, educational, health, and religious facilities) along the route.
	17	Social institutions such as social infrastructure and local decision-making institutions	D	D	**DC/OP**：Although no impact that would divide social institutions is expected, attention should be paid to avoid unfair compensation when evaluating for land acquisition and resettlement.。
	18	Misdistribution of benefits and damages	D	D	Although no misdistribution of benefits and damages is expected at this stage, attention should be paid to avoid unfair compensation when evaluating for land acquisition and resettlement.
	19	Local conflicts of interest	C	C	Further survey is necessary.
	20	Cultural heritage	C	C	At this stage no cultural heritage designated internationally or by local government was identified in the target project area. However, upon determination of detailed alignment, it is necessary to accurately map sacred sites and burial grounds in the surrounding areas.
	21	Landscape	B-	B-	**DC/OP：** Landscape may be negatively impacted because tunnels, cutting, construction of structures are considered as well as the route passes through forests and near the viewpoints for tourism.
	22	Gender	B+	B+	Increased employment opportunity is expected from job creation for all gender and improved inter-regional accessibility.

Category	No.	Environmental Factor	Evaluation		Reason for evaluation
			BC DC	OP	
Social Environment	23	Children's rights	C	B+	Better access to educational facilities in a distant area would provide improved opportunity to education.
	24	Infectious diseases such as HIV/AIDS	B-	D	**DC：** Infectious diseases may spread because of the inflow of outside workers.
	25	Working conditions including occupational safety	B+/-	C	**DC：** Consideration for working conditions will be necessary. Employment opportunity for settlements along the route is expected. **OP：** Employment opportunity such as light maintenance work is expected for residents along the route.
Others	26	Accidents	B-	B-	**BC**：UXO clearance is necessary. **DC**：Consideration for accidents during construction is necessary. **OP**：Traffic accident is expected.
	27	Transboundary impact and climate change	C	A+/C-	Increase in transboundary traffic will have positive impact by enhancing interactions and economy between two countries. Reduction of carbon pools is expected depending on the scale of forest felling and development along the route involved and induced by construction.

Note: BC: Before Construction, DC: During Construction. OP: Operation Phase

A+/-: Significant positive/negative impact is expected.

B+/-: Positive/negative impact is expected to some extent.

C+/-: Extent of positive/negative impact is unknown (Further examination is needed, and the impact could be clarified as the study progresses).

D: No impact is expected.

2) Mitigation Measures (Vieng Kham – NSE section)

Category	No.	Factor	Mitigation measures and agenda
Pollution Control	1	Air pollution	1. Identify sensitive receptors around the project area (residences, educational, health, and religious facilities) 2. Measure current air quality 3. Consider mitigation measures against air pollution from construction by preparing a monitoring plan, etc 4. Vehicle emissions prediction
	2	Water pollution	1. Measure water quality of relevant rivers 2. Figure out water usage patterns at relevant rivers 3. Consider mitigation measures against water pollution from construction by preparing a monitoring plan, etc
	3	Waste	1. Research standards regarding waste management 2. Explore waste disposal strategy 3. Explore monitoring program to control illegal damping of waste by outsiders
	4	Noise and vibrations	1. Identify sensitive receptors around the project area (residential area, educational, health, and religious facilities) 2. Measure current noise and vibration levels 3. Prepare a monitoring plan and mitigation measures against noise and vibrations during construction from construction equipment and vehicles.
Natural Environment	6	Protected areas	1. Need to consider alternative alignment that does not run through protected areas 2. Check whether going through Provincial Protected Area violates JICA Guidelines for Environmental and Social Considerations 3. Undo protected area designation and obtain forest license 4. Identify and confirm stakeholders, conduct consultation, and reach agreement 5. Consider monitoring program of negative impact 6. Consider biodiversity offsets by designating new land as protected area with comparable in size and quality to the area lost to the Right of Way
	7	Ecosystem	1. Identify and confirm stakeholders 2. Upon stakeholder consultation, identify the habitat ranges of endangered species 3. Consider alternative alignment that does not pass important natural habitats for ecosystems 4. Cooperate with stakeholders in considering adverse impacts on wildlife including diverse endangered species and planning periodic monitoring 5. Consider mitigation measures such as constructing dedicated wildlife crossings, installing fences and road signs, more presence of on-site management, more frequent patrols, incentives for public participation in ecosystem preservation
	8	Hydrology	1. Figure out the locations of river crossings 2. Consider monitoring changes in water flow and river bed 3. Examine impact of tunnel excavation on surface and ground water
	9	Topography and geology	With more detailed plan, analyze impact of tunnel excavation and cutting on topography and geology
Social Environment	10	Resettlement	1. Upon deciding detailed alignment, consider the extent of land to acquire. 2. Identify the scale of resettlement in detail 3. Survey of affected assets
	11	The Poor	1. Identify the poor in the project area 2. Confirm the status by hearing
	12	Ethnic minorities and indigenous peoples	1. Identify the residential areas of project affected ethnic minorities and indigenous peoples 2. Obtain data based on population census, socio-economic survey, and interviews
	13	Local economy such as employment and livelihood	Identify Project Affected Peoples and Project Affected Assets

Category	No.	Factor	Mitigation measures and agenda
Social Environment	14	Land use and utilization of local resources	1. Survey of land use of the affected area 2. Consider appropriate countermeasures against illegal logging
	15	Water usage	Study the water usage patterns in the affected rivers
	16	Existing social infrastructure and services	Survey of social infrastructure such as educational and health facilities
	19	Local conflicts of interest	Study differences in benefits and impacts to local residents due to road construction
	20	Cultural heritage	Identify local sacred sites and cemeteries and consider the extent of impact on them
	21	Landscape	With more detailed plan, evaluate the impact on landscape from tunnel excavation, cutting, structures, as well as road constructed in the forestland and mountainous areas.
	22	Gender	Survey detailed social conditions of the project area
	23	Children's rights	Identify educational facilities near the route and consider impact on children
	24	Infectious diseases such as HIV/AIDS	Prepare training program for construction workers
	25	Working conditions including occupational safety	Consider monitoring of working conditions of construction workers
Others	26	Accidents	1. Figure out the status of UXO clearance in the project area 2. Consider accident prevention during construction
	27	Transboundary impact and climate change	1. Monitor changes in traffic volume 2. Figure out the scale of forest felling required and consider mitigation measures such as replanting

3.5.3 Other Non-Expressway Development Sections Proposed in Phased Approach

(1) Section between Viengthong – Nam On (filling of missing link)

1) Scoping Result (Viengthong – Nam On section)

Category	No.	Environmental Factor	Evaluation		Reason for evaluation
			BC DC	OP	
Pollution Control	1	Air pollution	B-	B-	**DC :** Exhaust gases discharged from construction machines may have temporary adverse impact on air quality in the surrounding area. **OP :** Exhaust gases from the traffic on the new road may have negative impact on air quality in the surrounding area.
	2	Water pollution	B-	D	**DC :** Water runoff and discharge from construction sites, construction machines and vehicles as well as worker base camp may cause water pollution. Water discharge from tunnel excavation may have adverse impact on water quality. **OP :** No adverse impact is expected.
	3	Waste	B-	C-	**DC :** Surplus construction soil, waste and excavated soil from tunnel would be generated. **OP :** Illegal damping of waste with adverse environmental impact brought in from outside may increase due to improved accessibility.
	4	Noise and vibrations	B-	C-	**DC :** Construction noise and vibration from operation of construction machines and vehicles is expected. Noise and vibration is expected to be generated while excavating tunnel near the entrance or surface. **OP :** In case sensitive receptors (residences, educational, health, and religious facilities) are located around the route, noise from increased traffic volume may negatively impact them.
	5	Ground subsidence	C-	C-	If tunnel excavation causes the water table to be lowered, ground subsidence and/or surface subsidence may occur.
Natural Environment	6	Protected areas	A-	A-	Because the section passes through Phou Sithone ESCA, legal procedures to undo designation of the protected area will be necessary. The protected area will be divided and its total area decrease due to road construction.
	7	Ecosystem	A-	A-	The route passes through habitats for diversity of endangered species internationally and domestically designated for protection. **DC :** Construction is expected to involve forest clearance, loss, disturbance, and division of habitats for plants and animals. Due to construction noise and human intervention, animals sensitive to environmental change would temporarily shift their habitat ranges. The population of animals may decrease due to traffic accidents during construction. **OP :** It is expected that reduction in forest area leads to loss and division of animal and plant habitats. Disturbance to animal habitats and increase in poaching may occur due to improved access by humans through road construction. There may be negative cumulative impact derived from development project triggered by road construction. The population of animals may decrease due to traffic accidents.

Category	No.	Environmental Factor	Evaluation		Reason for evaluation
			BC DC	OP	
Natural Environment	8	Hydrology	C-	C-	**DC :** It is necessary to pay attention to changes in water flow and river bed because some sections of the route run along and cross rivers. Proposed tunnels may impact hydrology of surface and groundwater. **OP :** In case bridge structures such as piers be constructed in the river, hydrological regime may be altered.
	9	Topography and geology	B-	B-	Cutting and tunnels are proposed in some sections, which would negatively impact topography and geology.
Social Environment	10	Resettlement	C-	C-	**BC :** Involuntary resettlement would be necessary for land acquisition for road and construction. However, the estimated numbers of Project Affected Households (PAHs) and Projected Affected People (PAPs) are unknown at this stage.
	11	The Poor	B+/-	B+	**BC :** PAHs and PAPs may include the poor. If they are eligible for compensation, their standard of living may improve through livelihood restoration and/or enhancement program. **OP :** Increase in employment opportunity is expected from job creation, improved inter-regional accessibility, and increase in tourists.
	12	Ethnic minorities and indigenous peoples	C	C	It is not clear yet whether the road right of way and the surrounding areas overlap with settlements of ethnic minorities and/or indigenous peoples. Further survey is necessary.
	13	Local economy such as employment and livelihood	B-	B+	**BC :** If PAPs' livelihood relies on agriculture, they may temporarily lose their livelihood through relocation. If PAPs are utilizing forest resources, they may lose livelihood due to forest felling during construction. **OP :** Road construction would bring positive impact by improved access to urban areas and increased number of tourists to visit.
	14	Land use and utilization of local resources	B-	B-	**DC :** Reduction in currently utilized forest resources is expected due to forest felling during construction. **OP :** Improved access to forest by unknown outsides may lead to deforestation from illegal logging.
	15	Water usage	C-	D	**DC :** If river water sources are being used, turbid water generated by construction may have adverse impact. **OP :** No change in water usage is expected.
	16	Existing social infrastructure and services	B-	C	**DC :** Traffic control may be necessary. **OP :** Further survey is required to identify sensitive receptors (residence, educational, health, and religious facilities) along the route.
	17	Social institutions such as social infrastructure and local decision-making institutions	D	D	**DC/OP** : Although no impact that would divide social institutions is expected, attention should be paid to avoid unfair compensation when evaluating for land acquisition and resettlement.
	18	Misdistribution of benefits and damages	D	D	Although no significant misdistribution of benefits and damages is expected at this stage, attention should be paid to avoid unfair compensation when evaluating for land acquisition and resettlement.
	19	Local conflicts of interest	C	C	Further survey is necessary.

Category	No.	Environmental Factor	Evaluation		Reason for evaluation
			BC DC	OP	
Social Environment	20	Cultural heritage	C	C	At this stage no cultural heritage designated internationally or by local government was identified in the target project area. However, upon determination of detailed alignment, it is necessary to accurately map sacred sites and burial grounds in the surrounding areas.
	21	Landscape	B-	B-	**DC/OP：** Landscape may be negatively impacted because tunnels, cutting, construction of structures are considered as well as the route passes through forests and mountains.
	22	Gender	B+	B+	Increased employment opportunity is expected from job creation for all gender and improved inter-regional accessibility.。
	23	Children's rights	C	B+	Better access to educational facilities in a distant area would provide improved opportunity to education.。
	24	Infectious diseases such as HIV/AIDS	B-	D	**DC：** Infectious diseases may spread because of the inflow of outside workers.。
	25	Working conditions including occupational safety	B+/-	C	**DC：** Consideration for working conditions will be necessary. Employment opportunity for settlements along the route is expected.。 **OP：** Employment opportunity such as light maintenance work is expected for residents along the route.
Others	26	Accidents	B-	B-	**BC**：UXO clearance is necessary. **DC**：Consideration for accidents during construction is necessary. **OP**：Increase in traffic volume may lead to increase in traffic accidents.
	27	Transboundary impact and climate change	C	B+/C-	Although increase in transboundary traffic will have positive impact by enhancing interactions and economy between two countries, the scale of impact is considered minimal due to low population density along the route. Reduction of carbon pools is expected depending on the scale of forest felling and development along the route involved and induced by construction.

Note: BC: Before Construction, DC: During Construction. OP: Operation Phase

A+/-: Significant positive/negative impact is expected.

B+/-: Positive/negative impact is expected to some extent.

C+/-: Extent of positive/negative impact is unknown (Further examination is needed, and the impact could be clarified as the study progresses).

D: No impact is expected.

2) Mitigation Measure (Viengthong – Nam On section)

Category	No.	Factor	Mitigation measures and agenda
Pollution Control	1	Air pollution	1. Identify sensitive receptors around the project area (residences, educational, health, and religious facilities) 2. Measure current air quality 3. Consider mitigation measures against air pollution from construction by preparing a monitoring plan, etc 4. Vehicle emissions prediction
	2	Water pollution	1. Measure water quality of relevant rivers 2. Figure out water usage patterns at relevant rivers 3. Consider mitigation measures against water pollution from construction by preparing a monitoring plan, etc
	3	Waste	1. Research standards regarding waste management 2. Consider waste disposal strategy 3. Explore monitoring program to control illegal damping of waste by outsiders
	4	Noise and vibrations	1. Identify sensitive receptors around the project area (residential area, educational, health, and religious facilities) 2. Measure current noise and vibration levels 3. Prepare a monitoring plan and mitigation measures against noise and vibrations during construction from construction equipment and vehicles.
	5	Ground subsidence	Examine the possibility of ground and surface subsidence due to lowered water table from tunnel excavation
Natural Environment	6	Protected areas	1. Need to consider alternative alignment that does not run through protected areas 2. Check whether going through Provincial Protected Area violates JICA Guidelines for Environmental and Social Considerations 3. Undo protected area designation and obtain forest license 4. Identify and confirm stakeholders, conduct consultation, and reach agreement 5. Consider monitoring program of negative impact 6. Consider biodiversity offsets by designating new land as protected area with comparable in size and quality to the area lost to the Right of Way
	7	Ecosystem	1. Identify and confirm stakeholders 2. Upon stakeholder consultation, identify the habitat ranges of endangered species 3. Consider alternative alignment that does not pass important natural habitats for ecosystems 4. Cooperate with stakeholders in considering adverse impacts on wildlife including diverse endangered species and planning periodic monitoring 5. Consider mitigation measures such as constructing dedicated wildlife crossings, installing fences and road signs, more presence of on-site management, more frequent patrols, incentives for public participation in ecosystem preservation
	8	Hydrology	1. Figure out the locations of river crossings 2. Consider monitoring changes in water flow and river bed 3. Examine impact of tunnel excavation on surface and ground water
	9	Topography and geology	With more detailed plan, analyze impact of tunnel excavation and cutting on topography and geology
Social Environment	10	Resettlement	1. Upon deciding detailed alignment, consider the extent of land to acquire. 2. Identify the scale of resettlement in detail 3. Survey of affected assets
	11	The Poor	1. Identify the poor in the project area 2. Confirm the status by hearing
	12	Ethnic minorities and indigenous peoples	1. Identify the residential areas of project affected ethnic minorities and indigenous peoples 2. Obtain data based on population census, socio-economic survey, and interviews
	13	Local economy such as employment and livelihood	Identify Project Affected Peoples and Project Affected Assets

Category	No.	Factor	Mitigation measures and agenda
Social Environment	14	Land use and utilization of local resources	1. Survey of land use of the affected area 2. Consider appropriate countermeasures against illegal logging
	15	Water usage	Study the water usage patterns in the affected rivers
	16	Existing social infrastructure and services	Survey of social infrastructure such as educational and health facilities
	19	Local conflicts of interest	Study differences in benefits and impacts to local residents due to road construction
	20	Cultural heritage	Identify local sacred sites and cemeteries and consider the extent of impact on them
	21	Landscape	With more detailed plan, evaluate the impact on landscape from tunnel excavation, cutting, structures, as well as road constructed in the forestland and mountainous areas.
	22	Gender	Survey detailed social conditions of the project area
	23	Children's rights	Identify educational facilities near the route and consider impact on children
	24	Infectious diseases such as HIV/AIDS	Prepare training program for construction workers
	25	Working conditions including occupational safety	Consider monitoring of working conditions of construction workers
Others	26	Accidents	1. Figure out the status of UXO clearance in the project area 2. Consider accident prevention during construction
	27	Transboundary impact and climate change	1. Monitor changes in traffic volume 2. Figure out the scale of forest felling required and consider mitigation measures such as replanting

(2) NR 8 bottleneck section

The NR8 bottleneck section and the proposed road section to be rehabilitated by the Lao government with construction equipment grant are too small a scale for the scope of this project to be considered adequately for scoping and mitigation measures. Therefore, only the particularly important aspects to address in further survey are discussed in the table below.

Category	Factor	Particularly important aspects to address
Natural Environment	Protected areas	The alignment runs along the southern boundary of Nam Kading National Protected Area. Given detailed alignment, verify that the project area and the protected area do not overlap.
	Ecosystem	Consult with stakeholders to verify that no endangered species is found near the southern boundary of Nam Kading National Protected Area.
Social Environment	Resettlement	1. Upon deciding detailed alignment, consider the extent of land to acquire. 2. Identify the scale of resettlement in detail 3. Survey of affected assets
	The Poor	Interview PAPs, conduct hearings involving other stakeholders, and review existing literature to identify the poor in the project area
	Ethnic minorities and indigenous peoples	Identify ethnic minorities and indigenous peoples in the project area through hearings and literature reviews
	Local economy such as employment and livelihood	Identify PAPs and affected assets through hearings and existing documents
	Land use and utilization of local resources	1. Figure out the exact land use of the project area through hearings with relevant parties and cadasters 2. Conduct interview survey of local residents to identify local resources such as traditionally used forest
	Existing social infrastructure and services	Identify social infrastructure such as educational and health facilities in the project area
	Cultural heritage	Map the distribution of temples, cemeteries, local burial grounds and spirit forest
	Landscape	Verify that there is no negative impact on tourist viewpoints
	Gender	Figure out the detailed social conditions through hearings and literature review

3.6 Issues to Consider in Examining Alternative Routes

From environmental and social considerations perspective, particularly important issues to consider in examining alternative routes for the current project are studied in this section based on the information compiled.

3.6.1 Protected Areas

(1) Road construction in protected area

All four alternative routes considered in this study will pass protected areas in Lao PDR or Vietnam (see Table 3.3.11).

If a planned road passes through a protected area in Laos, a process to reverse the designation of protected area must be followed and the decision needs to be approved in the National/Provincial Assembly. During the third survey trip in June 2018, meetings with the concerned governmental agencies of Laos were held to check their opinions regarding this issue. The concerned agencies of Laos expressed no objection towards the planned expressway passing through protected areas, saying that it does not pose a problem as long as the required process is duly followed.

Meanwhile in Vietnam, the zone through which some alternative routes are running is "Transition zone" in Biosphere reserve. In the Transition Zone, road construction is not prohibited and a procedure to change designation is not required.

Table 3.6.1 Summary of Situation regarding Road Construction and Protected Area

	Laos	Vietnam
Affected Protected Area	All alternative routes pass protected areas	Alt.1 and 3A : BP Alt 3 and 3B : No
Laws and Regulation	・ Procedure to change NPA/PPA designation and approval from National/Provincial Assembly are necessary	・ Road construction in Transition Zone in BP is not prohibited ・ Change of BP designation is not necessary
Opinion of Concerned Governmental Agencies	・ No objections/concerns were expressed by MPWT, MONRE or MOAF as long as the required process is duly followed	・ Needs to be checked in the next survey

(2) Point to note regarding Protected Area

The fact that road alignment inevitably passes through protected area might violate JICA Guidelines for Environmental and Social Considerations (April 2010), especially the following item.

> **Compliance with Laws, Standards, and Plans**
>
> 2. Projects must, in principle, be undertaken outside of protected areas that are specifically designated by laws or ordinances for the conservation of nature or cultural heritage (excluding projects whose primary objectives are to promote the protection or restoration of such areas). Projects are also not to impose significant adverse impacts on designated conservation areas.

To achieve the project objectives, undoing protected area designation for road construction is inevitable. Because the protected areas that will be affected are designated as such for conservation of natural habitat, it is necessary to explore alignments that would minimize the magnitude and area of negative impact. The criteria that follows should be adopted to identify particularly vulnerable areas for ecosystem.

3.6.2 Habitats for Endangered Species

As mentioned previously, protected areas and their surrounding areas dissected by alternative routes considered in this study coincide with habitats for a diversity of endangered species. Therefore, all alternatives considered may have adverse impact on the critical natural habitats (see Figure3.3.7). This may violate JICA Guidelines for Environmental and Social Considerations (April 2010), especially the following item.

Ecosystem and Biota
1. Projects must not involve significant conversion or significant degradation of critical natural habitats and critical forests.

To achieve the project objectives, impact on ecosystem is inevitable because especially the section near the border of two countries traverses the Annamite Mountain Range, which hosts habitats for a diversity of endangered species. It is necessary to conduct consultation involving relevant agencies and organizations (Ministry of Forestry and Agriculture, Department of Forestry, and Forest Resources Conservation Unit) and other stakeholders (local residents, indigenous peoples, Wildlife Conservation Society in Lao, IUNC). Consultation should aim to identify the critical natural habitats of endangered species and migratory animals by mapping distribution of breeding grounds, nesting sites, and core foraging areas. Based on the mapped information, alignment that could minimize adverse impact on ecosystems should be considered. In addition, new road to be constructed will inevitably divide habitat areas, it is desirable to explore mitigation measures including installing wildlife crossings, fences and road signs.

3.6.3 Nam Thean Dam Construction

In Nam Kading National Protected Area in Laos, Nam Thean Dam is now under construction. According to the data obtained during the survey trip, the alignments of Alternative 1 and Alternative 3B are likely to traverse portions of land that will submerge underwater upon completion of the dam (see Figure 3.3.13). The section between Pac Xan and Viengthong may require a substantial modification to the alignment.

According to DOAF of Bolikhamsai Province, the dam plan has been changed and the size of affected area was reduced, although the latest map or data to confirm this information has not been obtained yet. Thus, it is imperative to obtain the latest plan and map of the planned water level of the dam and check whether and how the Nam Thean dam would affect the road plan examined in this study.

3.6.4 Impact on Cultural Heritage

In the target study area for this project no World Heritage sites or cultural heritages designated by the governments was found. Future survey should identify locally important cultural and sacred sites in the study area such as temples, cemeteries, forestlands for burial grounds and spirit forests traditionally used by each village, and should consider detailed alignment to avoid such identified areas.

3.6.5 Impact on Land Use and Settlement of People

(1) Impact on forestland

Given that 70% of the total land of Laos is covered by forest, all the alternatives routes considered in this study must unavoidably pass through forestland. To construct a road in a forest land, conversion of forest land is required. Laws and regulations in Lao PDR do not stipulate mandatory offsets to restore natural resources when converting forest land to another. However, “Forestry Strategy to the Year 2020 of the Lao PDR”, issued in 2005, prepared a plan to restore national forest cover to 70% by 2020. In the same Forest Strategy 2020, following methods are proposed to achieve the objective of eradicating extreme poverty and hunger and ensuring environmental sustainability:

1) Sustain healthy forest as regional production system

2) Ensure and expand villagers income base from forest and national revenue stream

3) Ensure that forest function towards environmental and biodiversity conservation

A route should minimize the magnitude and range of area subject to forest felling in accordance with the objective and methods of Forest Strategy.

(2) Impact on agricultural and residential areas

All the alternative routes considered in this study more or less run through agricultural and residential areas. Depending on the alignment or section, this necessitates a number of people, buildings (houses, shops, etc.) or agricultural production to be resettled. Since resettlement might cause a considerable impact on people's livelihood and a delay of project schedule due to negotiations with affected people, it is desirable to avoid an alignment that traverses agricultural land and residential land wherever possible.

Chapter 4
Map Preparation Using Satellite Image Analysis and Correction

Chapter 4 Map Preparation Using Satellite Image Analysis and Correction

4.1 Map Preparation Range and Procedure

4.1.1 Map Preparation Range

The digital topographic map of target area prepared in this study is shown in Figure 4.1.1.

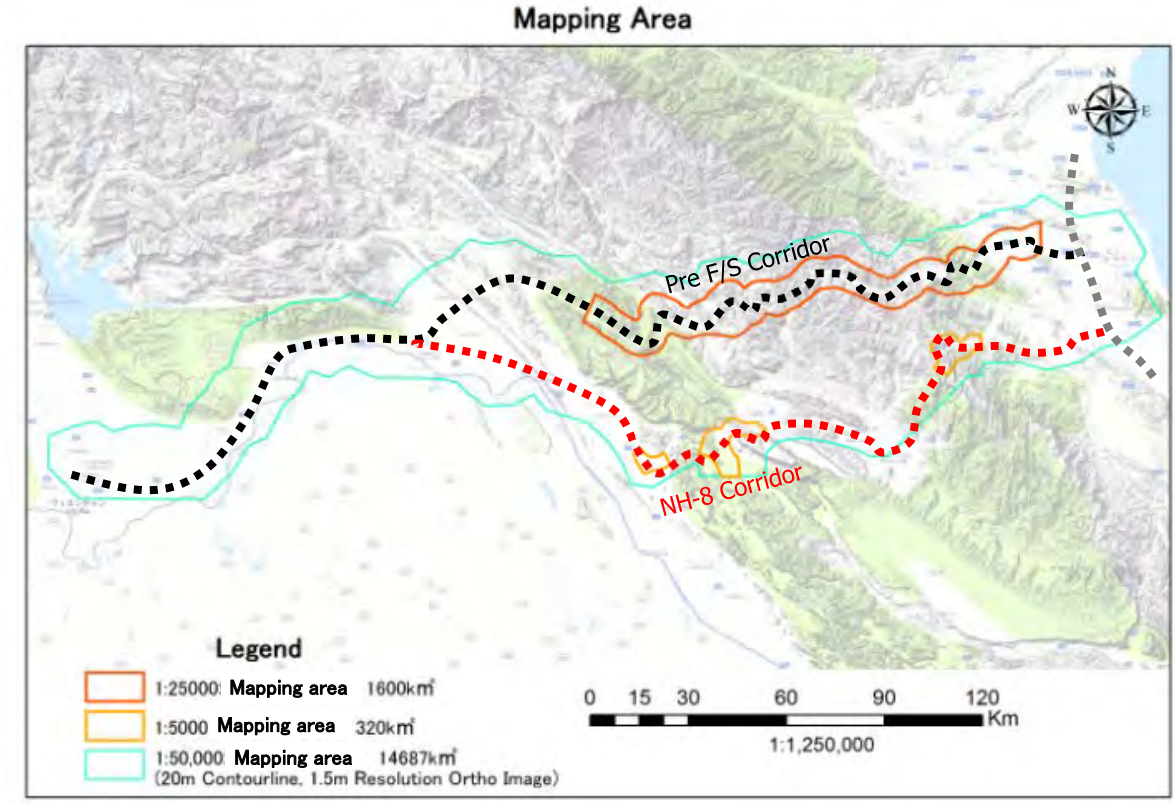


Figure 4.1.1 Topographic Map Preparation Range

4.1.2 Work Procedure

A GCP survey (Ground Control Point Survey) is implemented in order to correct the horizontal positions and height of the satellite images (ortho-images) and DSM data in this study. The positions of satellite images (ortho-images) are corrected based on these results in order to guarantee the precision according to the scale of the maps that are prepared.

In addition, tree height measurement work is performed in order to correct the height of trees when preparing the contour lines from the procured DSM (AW3D) elevation data. The existing AW3D DSM data are used for the topographic data in order to dramatically shorten the work period. Furthermore, the Geo7X made by the Trimble Inc., which is capable of independently performing measurement in real time, is utilized in order to drastically reduce GCP survey time. The map preparation procedure is shown in Figure 4.1.2.

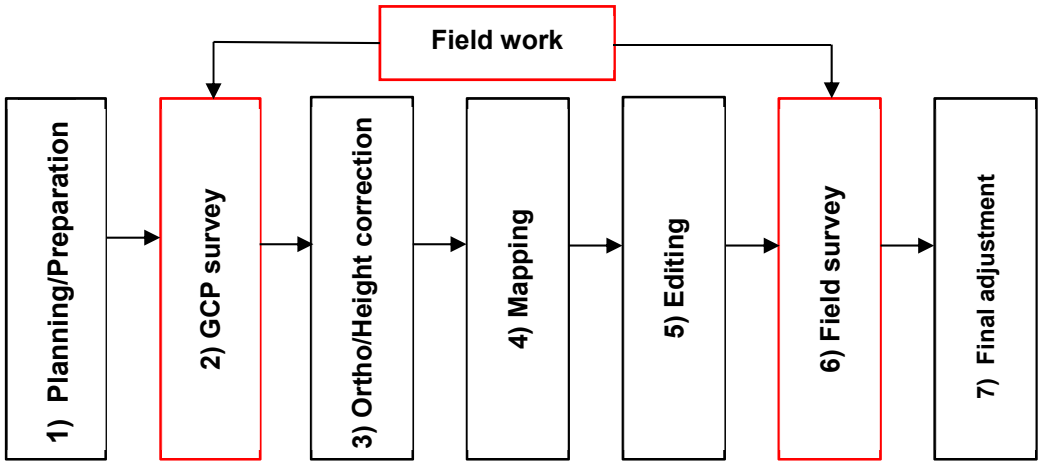


Figure 4.1.2 Topographic Map Preparation Procedure

(1) Planning/Preparation

A plan is formulated, using the satellite images and old maps as reference.

(2) GCP Survey

Survey equipment is used in the field to create the GCP points. Geo7X is used this time.

(3) Ortho-correction/ Height correction

Aerial triangulation is done using the Ground Control Points (GCP) acquired through field work, and ortho-images are prepared using the AW3D height data after correcting the positions of the satellite images.

(4) Mapping

Mapping work is conducted using the ortho-images as a reference. ArcGIS is used for mapping each feature.

(5) Editing

AW3D height data is used to create the contour lines with ArcGIS. Contour lines for forests in the mountainous areas are created after correcting the elevation using the results of the tree height survey as references. Locations that are automatically generated[1] and not satisfactory are manually corrected after checking them. In particular, many corrections were required for the contour lines of rivers, lakes and other water areas.

(6) Field survey

Locations which are found difficult to make judgment and use the satellite images to produce maps, and location which have changed over time are verified in the field. In addition, the vegetation and other details of the mapped data are verified.

(7) Final adjustment

The edited data was corrected based on the data verified during the field survey. Data for 1:5,000 scale and 1:25,000 scale topographic maps are prepared in A3 size .

[1] Create a surface model from Dem data and generate contour lines. ArcGIS 3D Analyst is used in this study.

4.2 Field Survey Correction Content

4.2.1 GCP Survey

This study consisted of a GCP survey to correct the position and height of satellite images. The Geo7X made by the Trimble Company was used for the survey work. Geo7X can perform sub-meter precision surveying independently in real time by using the RTK (Real Time Kinetic) correction service of the Trimble Company. This enabled the work period to be dramatically shortened for this survey compared to the method used in the past (GNSS survey using multiple receivers). The results of survey work were compiled in the Reference Point Details. The Ground Control Point Index Map prepared during this study is shown in Figure 4.2.1.

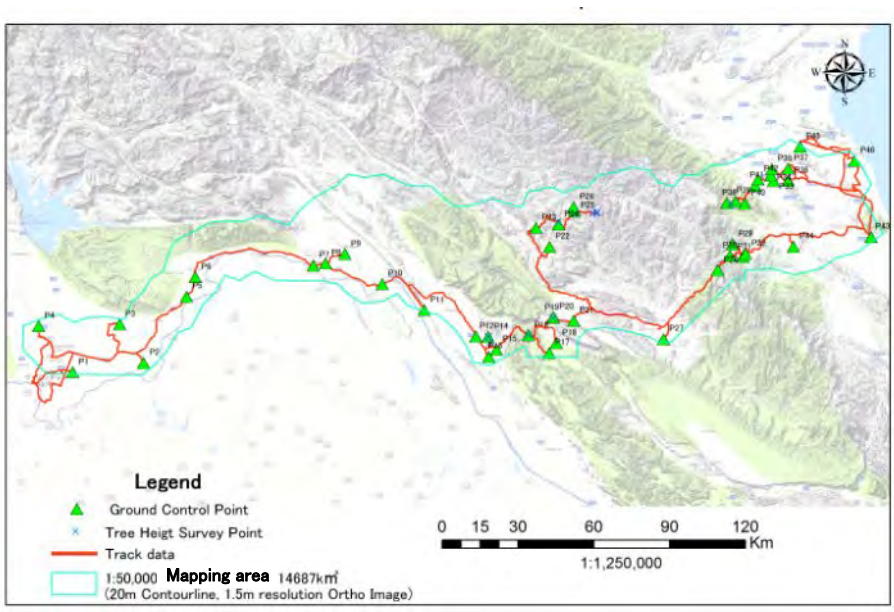


Figure 4.2.1 GCP Index Map

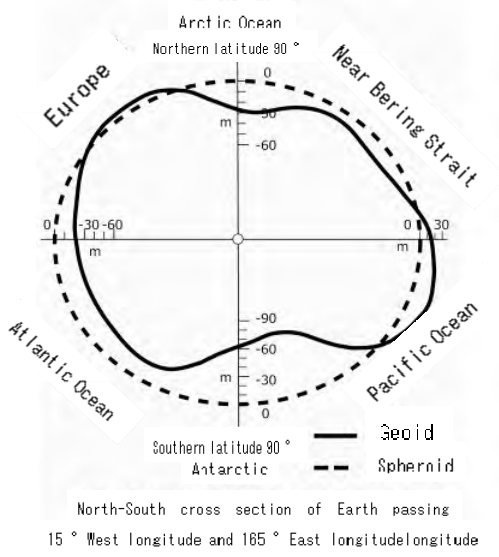
Figure 4.2.2 Trimble Geo7X

Figure 4.2.3 Reference Point Details

The specifications of the survey results are described below.

(1) Ellipsoid and datum: WGS84

Various spheroids or ellipsoids have been devised to simplify the surface model of the Earth. A spheroid is a three-dimensional shape created from a two-dimensional ellipse. The ellipse is an oval with a major axis (the longer axis) and a minor axis (the shorter axis). If the ellipse is rotated, the shape of the rotated figure will be spheroid. In this study, WGS 84, which is used in global geodetic GPS and others, is used.

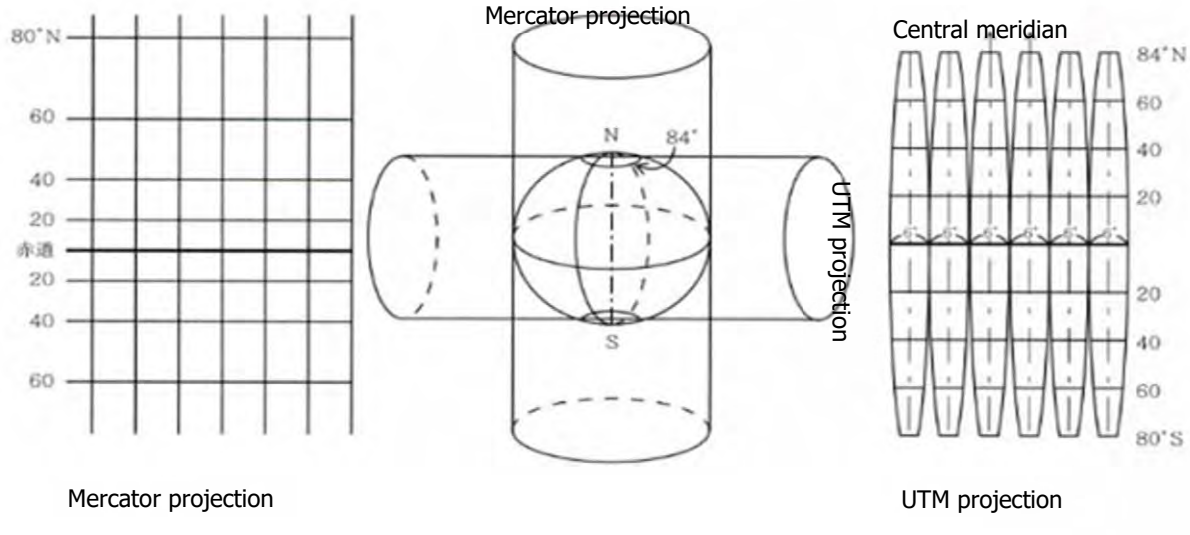


Source: GSI HP

Figure 4.2.4 Approximate Shape of the Geoid

(2) Projection: UTM Zone 48 North

Map projection is a method of expressing the three-dimensional earth surface on a two-dimensional plane. The Universal Transverse Mercator (UTM for short) is a kind of internationally standardized map projection method. It is primarily used for medium-scale maps.

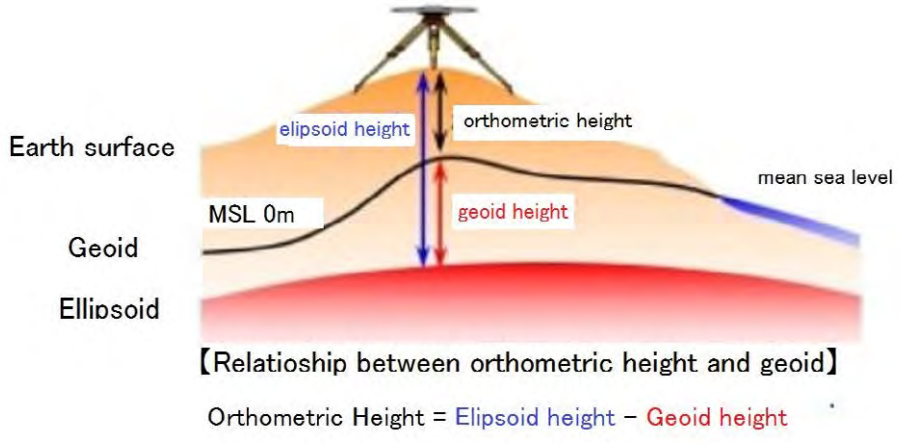


Source: Japan map center HP

Figure 4.2.5 Conceptual Diagram of Mercator Projection and UTM Projection

(3) Height reference: EGM2008 (WGS84)

Height required by GNSS observation is ellipsoidal height. It is necessary to correct the geoid height by using a geoid model in order to make this altitude (sea level height is 0 m). In this study, EGM 2008, the latest geoid model corresponding to the whole world, is used.



Source: GSI HP

Figure 4.2.6 Relation of Ellipsoid, Geoid and Altitude

Table 4.2.1 GCP Results

Name	X (East)	Y (North)	Elevation (EGM2008)	Name	X (East)	Y (North)	Elevation (EGM2008)
P1	261404.49	1992128.94	176.30	P25	460079.33	2055860.81	1090.48
P1-1	261419.68	1992094.30	174.84	P26	459697.65	2057454.09	1064.80
P2	289436.10	1995777.41	164.99	P27	495262.47	2005175.77	496.24
P2-1	289442.53	1995773.98	164.38	P27-1	495231.14	2005157.49	495.21
P3	279943.99	2011113.89	171.24	P28	516693.93	2032529.31	712.46
P3-1	279948.48	2011041.10	171.43	P28-1	516687.91	2032531.28	711.71
P4	247874.80	2010333.86	170.17	P29	522566.34	2042771.10	86.51
P4-1	247847.41	2010321.00	170.64	P30	521531.77	2038192.88	119.84
P5	306412.31	2022039.51	181.98	P30-1	521521.36	2038195.84	120.18
P5-1	306393.32	2022032.69	182.32	P31	526746.27	2037761.36	36.25
P6	309860.36	2029665.15	161.02	P32	527784.06	2038997.43	27.18
P7	356592.85	2034316.76	166.78	P33	538794.61	2067829.08	10.48
P7-1	356598.05	2034305.94	165.58	P33-1	538794.55	2067825.33	10.52
P8	361481.36	2035204.11	158.16	P34	537757.98	2069940.06	14.40
P8-1	361461.54	2035209.35	158.02	P34-1	537722.19	2069916.61	14.27
P9	369207.35	2038871.49	160.29	P35	538175.10	2072550.15	12.69
P9-1	369231.78	2038820.48	159.03	P35-1	538179.27	2072555.92	12.61
P10	383950.98	2027003.16	162.46	P36	544581.15	2067883.47	13.52
P10-1	383966.20	2027007.59	160.59	P36-1	544582.69	2067872.16	13.05
P11	400494.13	2016666.60	151.94	P37	544619.90	2072795.42	12.79
P12	420950.72	2006283.17	160.78	P37-1	544627.11	2072800.01	11.72
P12-1	420957.17	2006282.69	160.09	P38	520339.75	2059064.28	663.18
P13	426132.31	1998236.58	157.12	P39	523850.81	2059767.04	340.83
P14	425862.72	2006161.31	179.35	P39-1	523849.08	2059755.58	340.93
P15	429181.18	2001111.43	165.01	P40	527535.95	2058880.84	122.14
P16	441768.77	2006767.23	187.24	P41	531562.87	2065971.31	32.89
P16-1	441747.48	2006782.45	187.70	P41-1	531591.41	2065935.03	33.07
P17	449979.59	1999773.82	156.94	P42	532684.90	2068442.23	20.15
P17-1	449983.85	1999751.48	156.56	P42-1	532681.09	2068436.80	20.98
P18	452855.13	2003672.81	164.10	P43	577490.25	2045615.56	4.22
P18-1	452857.46	2003685.05	164.34	P43-1	577475.24	2045627.54	4.41
P19	451526.04	2013654.46	229.07	P44	546743.50	2041808.08	20.61
P20	451644.79	2013982.86	322.29	P44-1	546740.46	2041859.41	21.69
P21	459637.40	2012429.79	421.48	P45	549358.53	2081332.26	18.02
P22	450079.40	2041802.88	367.38	P45-1	549406.83	2081324.80	16.46
P23	444835.45	2049297.27	343.97	P46	570957.31	2075763.43	6.76
P23-1	444866.86	2049301.41	343.59	P46-1	570951.98	2075779.91	7.33
P24	453778.75	2050503.44	628.56				
P24-1	453778.98	2050525.60	629.66				

Source: JICA Study Team

4.2.2 Tree Height Survey

Since the DSM data include tree heights, accurate ground surface heights cannot be acquired using only DSM data in mountainous areas with many trees like the target area for this survey. Therefore, the position and height of average trees were measured in the field in order to correct for the tree height in each area. A Rangefinder attachment capable of a measurement of up to a maximum height of 120 meters was attached to the Geo7X without a reflector to perform this tree height survey. The survey results were compiled as a tree height survey.

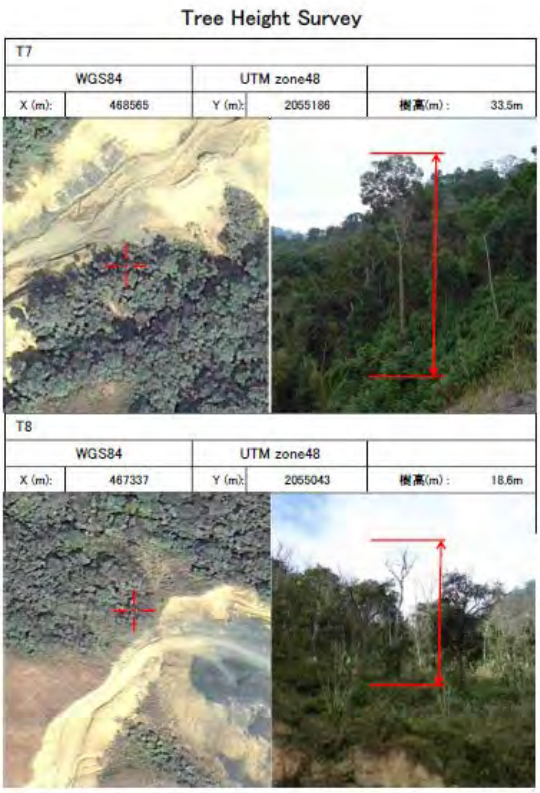


Figure 4.2.7 Tree Height Survey

4.3 Types and Precision of Results

4.3.1 Scale 1:50,000 Maps

In order to review the overall planned route of the expressway, ortho-contour line maps at a scale of 1:50,000 were prepared. The map format consists of displaying an ortho-image prepared from SPOT 6 & 7 satellite images, with the contour lines prepared from the DSM data superimposed. The contour line spacing was 20 m, and the ground resolution of the ortho-images was 1.5 m.

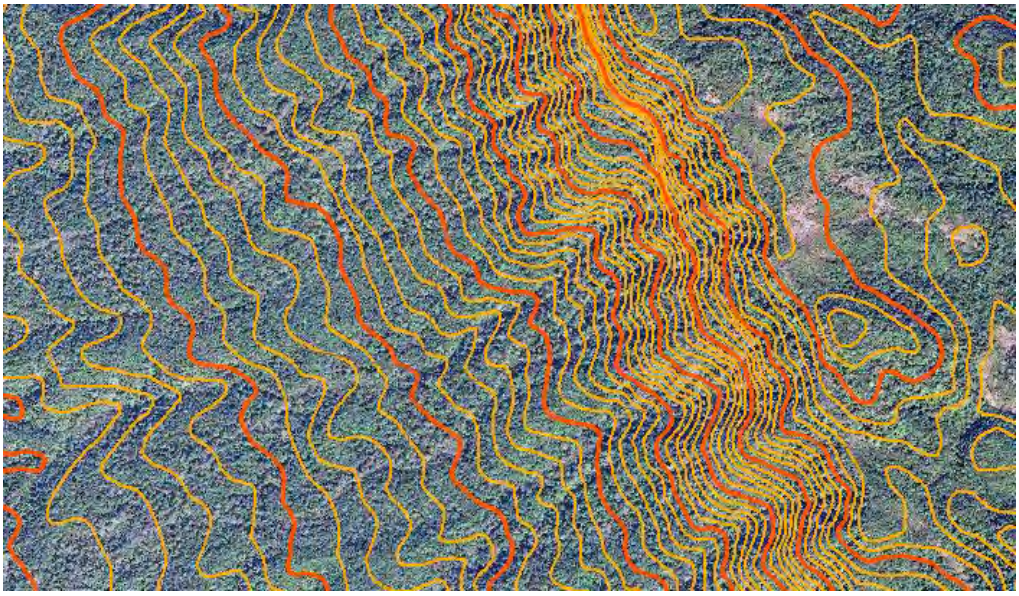


Figure 4.3.1 Scale 1:50,000 Topographic Map (Ortho Map)

4.3.2 Scale 1:25,000 Maps

Simplified topographic maps at a scale of 1:25,000 were prepared in order to review the access roads that connect existing roads to the planned expressway route and verify candidate routes that were surveyed during the F/S. The spacing of contour lines prepared from DSM data was 10 m. In addition, the roads, buildings and other features were mapped using the ortho-images with a ground resolution of 1.5 m as a reference. The administrative boundaries were entered using the GIS data obtained from the National Geographic Department of Lao PDR and topographic maps obtained from the Vietnam Department of Survey and Mapping.

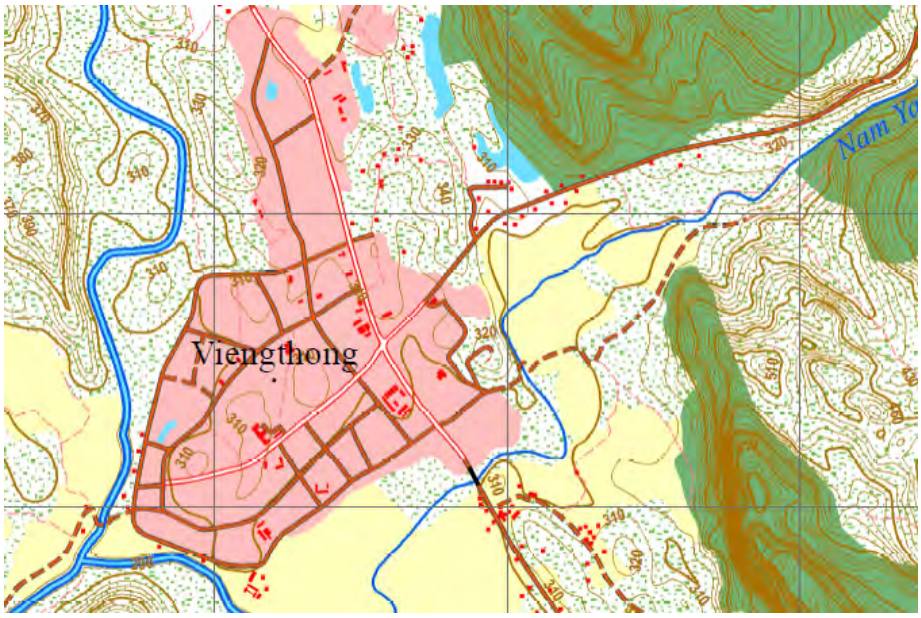


Figure 4.3.2 Scale 1:25,000 Topographic Map

4.3.3 Scale 1:5,000 Maps

Simplified topographic maps at a scale of 1:5,000 were prepared in order to review the detours, elevated portions, and tunnels necessary due to steep topography, as well as the bridges needed for rivers and other required structures. Contour lines with a spacing of 5 m were prepared from the AW3D (DSM) data for which the tree heights were corrected, and roads, buildings and other features were mapped from the World View satellite ortho-images (with ground resolution of 0.5 m). The administrative boundaries were entered using the GIS data obtained from the National Geographic Department of Lao PDR and topographic maps obtained from the Vietnam Department of Survey and Mapping.

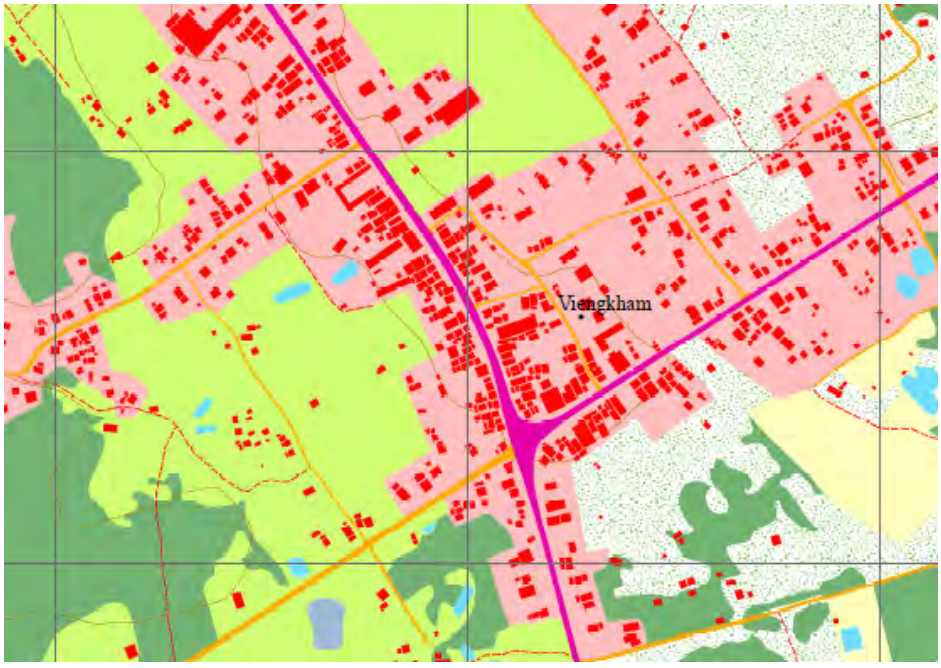


Figure 4.3.3 1:5,000 Topographic Map

4.3.4 Checking with Track Data

The precision of road positions on the simplified topographic maps (prepared by superimposing the track data acquired in the field with a handheld GNSS onto the prepared map data) was verified. There were no large errors in the position accuracy other than locations where the GNSS precision was extremely bad, such as in deep ravines.

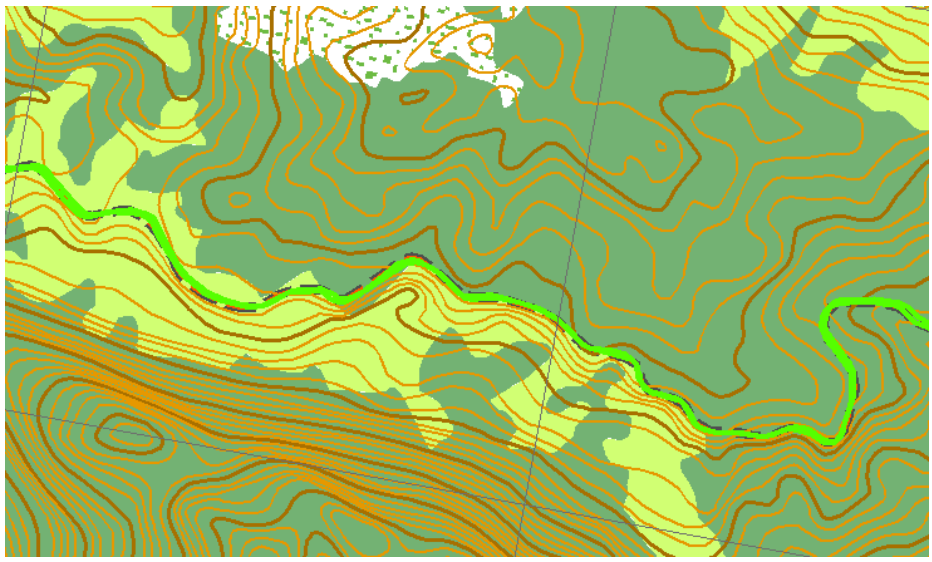


Figure 4.3.4 Checking Map Created with Track Data

4.3.5 Checking Elevation of GCP and AW3D DSM Points

The elevation of GCP and DSM points obtained using AW3D that were acquired with this work was checked. Checking was performed for 57 points, excluding 19 points for which there was thought to be change over time (COT) and locations where GCP survey conditions were bad. The overall error was an average of -0.64 m, and the standard deviation was 2.04 m. There was no problem in creating figures of each scale. When creating contour lines, areas with altitude problems are checked and corrected.

Table 4.3.1 Comparison of AW3D and GCP Points

Name	EGM2008	AW3D	GCP-AW3D	Remark	Name	EGM2008	AW3D	GCP-AW3D	Remark
P1	176.30	178.00	-1.70		P25	1090.48	1091.00	-0.52	Ind. Meas.
P1-1	174.84	177.00	-2.16		P26	1064.80	1062.00	2.80	Ind. Meas.
P2	164.99	166.00	-1.01		P27	496.24	499.00	-2.76	Tree shadow
P2-1	164.38	166.00	-1.62		P27-1	495.21	498.00	-2.79	Tree shadow
P3	171.24	172.00	-0.76		P28	712.46	719.00	-6.54	Chg. OT
P3-1	171.43	171.00	0.43		P28-1	711.71	717.00	-5.29	Chg. OT
P4	170.17	170.00	0.17		P29	86.51	93.00	-6.49	Chg. OT
P4-1	170.64	169.00	1.64		P30	119.84	127.00	-7.16	Chg. OT
P5	181.98	182.00	-0.02		P30-1	120.18	127.00	-6.82	Chg. OT
P5-1	182.32	182.00	0.32		P31	36.25	42.00	-5.75	
P6	161.02	158.00	3.02		P32	27.18	36.00	-8.82	
P7	166.78	173.00	-6.22	Chg. OT	P33	10.48	12.00	-1.52	
P7-1	165.58	174.00	-8.42	Chg. OT	P33-1	10.52	12.00	-1.48	
P8	158.16	157.00	1.16		P34	14.40	16.00	-1.60	
P8-1	158.02	157.00	1.02		P34-1	14.27	15.00	-0.73	
P9	160.29	159.00	1.29		P35	12.69	10.00	2.69	
P9-1	159.03	158.00	1.03		P35-1	12.61	16.00	-3.39	
P10	162.46	160.00	2.46		P36	13.52	15.00	-1.48	
P10-1	160.59	159.00	1.59		P36-1	13.05	15.00	-1.95	
P11	151.94	154.00	-2.06	Ind. Meas.	P37	12.79	14.00	-1.21	
P12	160.78	160.00	0.78		P37-1	11.72	14.00	-2.28	
P12-1	160.09	160.00	0.09		P38	663.18	669.00	-5.82	Chg. OT
P13	157.12	154.00	3.12		P39	340.83	345.00	-4.17	Tree shadow
P14	179.35	179.00	0.35		P39-1	340.93	348.00	-7.07	Tree shadow
P15	165.01	163.00	2.01		P40	122.14	129.00	-6.86	Ind. Meas.
P16	187.24	186.00	1.24		P41	32.89	32.00	0.89	
P16-1	187.70	186.00	1.70		P41-1	33.07	33.00	0.07	
P17	156.94	158.00	-1.06		P42	20.15	26.00	-5.85	
P17-1	156.56	158.00	-1.44		P42-1	20.98	26.00	-5.02	
P18	164.10	163.00	1.10		P43	4.22	7.00	-2.78	
P18-1	164.34	164.00	0.34		P43-1	4.41	7.00	-2.59	
P19	229.07	229.00	0.07		P44	20.61	24.00	-3.39	
P20	322.29	315.00	7.29	Chg. OT	P44-1	21.69	25.00	-3.31	
P21	421.48	424.00	-2.52		P45	18.02	18.00	0.02	
P22	367.38	367.00	0.38		P45-1	16.46	19.00	-2.54	
P23	343.97	342.00	1.97		P46	6.76	11.00	-4.24	
P23-1	343.59	344.00	-0.41		P46-1	7.33	11.00	-3.67	
P24	628.56	630.00	-1.44	Ind. Meas.	**Average Value**			**-0.64**	**Excl. UP**
P24-1	629.66	631.00	-1.34	Ind. Meas.	**Standard Deviation**			**2.04**	**Same**

Source: JICA Study Team

Chapter 5
Overview of Geology of the Subject Area

Chapter 5 Overview of Geology of the Subject Area

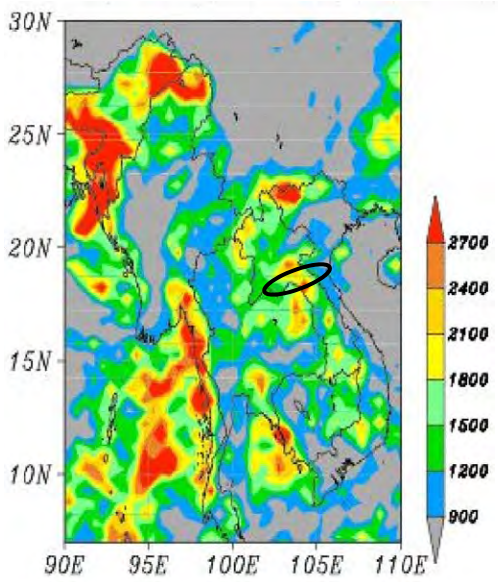
5.1 Topography

The Indochina Peninsula contains complex and diverse topography including the Annamese Cordillera (border of Vietnam, Lao PDR, and Cambodia), the Xiangkhoang Plateau (Lao PDR), the Bolaven Plateau (Lao PDR), Kravanh Mountains (Cambodia), the Khorat Plateau (Thailand), the Shan Plateau (Myanmar), and the Rakhine Mountains (Myanmar), spreading in a fan shape (Figure 5.1.1). The Lao PDR is land-locked in the Indochina Peninsula. The northern and central parts of the country consist of mountains, whereas the southern region consists of the Mekong delta. As the project under this study involves the area in the central Laos to the central Vietnam, Laos is mainly characterized as mountainous, while Vietnam mainly is plain.

Figure 5.1.1 Geography of Lao PDR and Vietnam

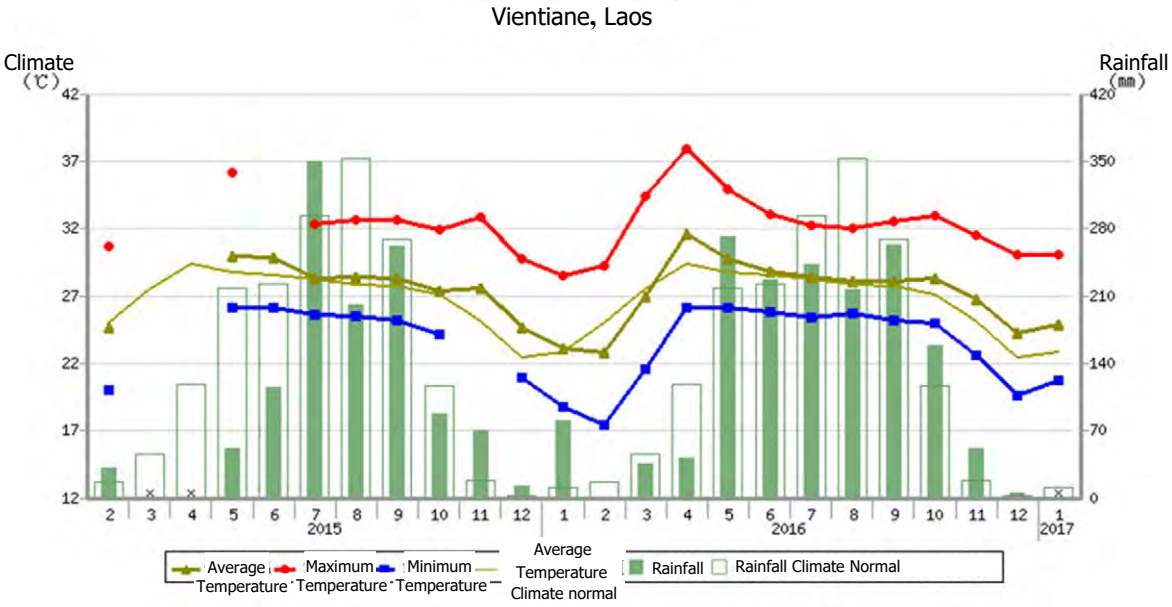
5.2 Climate

Laos and Vietnam belong to the tropical monsoon climate where the rainy season and the dry season appear alternately. With its high temperature and abundant rainfall, the region is suitable for rice farming, popular in deltas of major rivers such as The Hong River (Red River), the Mekong River, the Chao Phraya River, the Thanlwin River, and the Irrawaddy River. With regards to crops in the project area, double- and triple-cropping are practiced in the flat area with abundant water in Lao PDR and Vietnam. As shown in Figure 5.2.1, the target area has abundant rainfall.



Source: Ikeda, Yuichi. 2007 “Research on precipitation characteristics in east part of Indo-China peninsula.” Master’s thesis. Graduate School of Frontier Sciences, University of Tokyo.

Figure 5.2.1 Precipitation Distribution in the Indochina Peninsula（1997–2000）



Source: ClimateView, Japan Meteorological Agency

Figure 5.2.2 Climate of Vientiane, Lao PDR

5.3 Geological Features and Structure

5.3.1 Geological Features

Figure 5.3.1 below shows the geological feature of Lao PDR. This 1:1,000,000 scale map as well as that shown in Figure 5.3.3 was originally created by the British Geological Survey (BGS) in 1991.

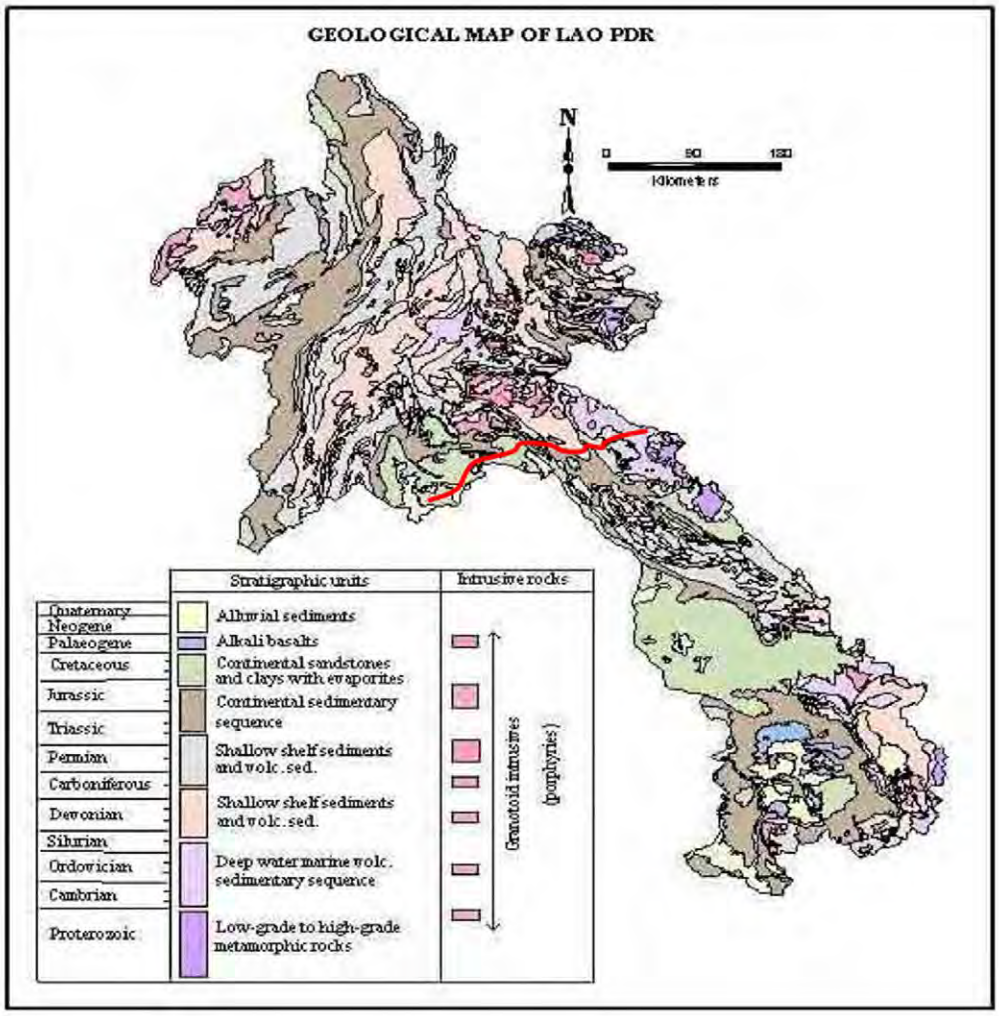


Figure 5.3.2 Geological Map of Lao PDR

In the central Laos, thin and superimposed strata from the Cretaceous Period of the Mesozoic Era to Precambrian Period of the Paleozoic Era stretch along the Indochina Peninsula in north-northwest to south-southeast direction, which can be clearly seen in satellite images.

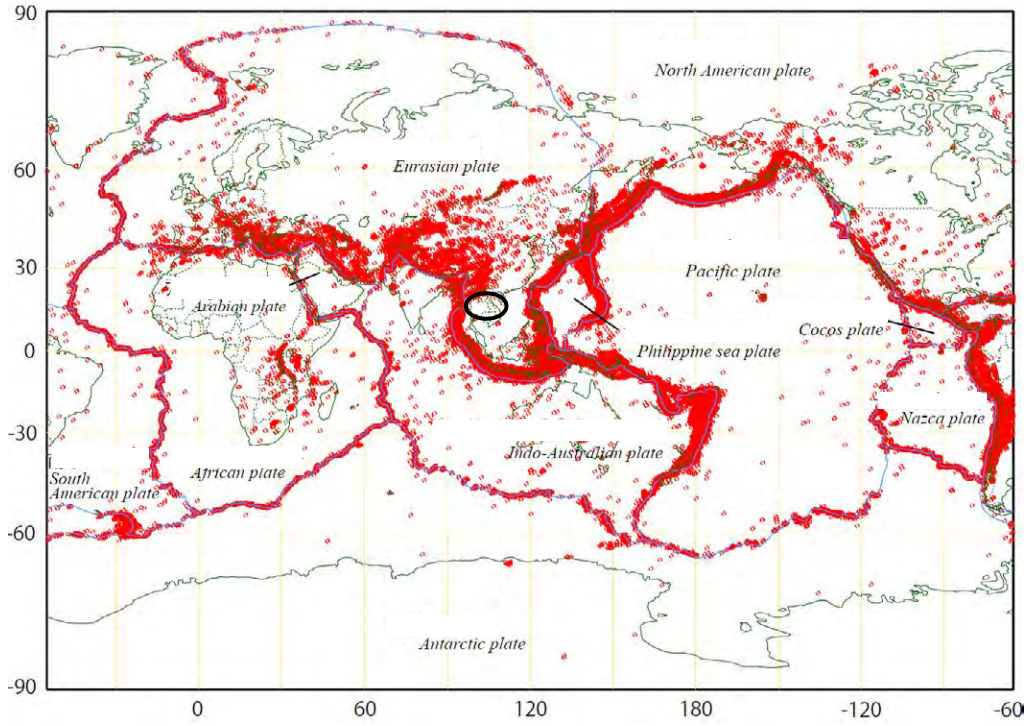
Precambrian strata are remaining slightly in the east and newer strata from Cretaceous Period of the Mesozoic Era are distributed towards the west. Along the road to Huong Son hydropower plant near the international border on National Road No. 8, biotite schistose gneiss, quartz-biotite granite, weathered biotite schist and strong weathered bare rock turned into brick-red clay from Precambrian Proterozoic Era.

At around 245 km point (of the Pre-F/S route) where topographic variation is significant, geologic features consist of marine deposit of shale, sandstone and limestone from the Permian and Carboniferous Periods. This strata of marine deposit was uplifted as a result of subduction of the Indian Plate. Rocks such as shale metamorphosed by pressure of a plate tend to develop fissures along stratum and vertical fissures.

In the northern and eastern Laos, limestone forms karst features. However, karst features are presumed to exist to a lesser extent in the current study area.

5.3.2 Geological Structure

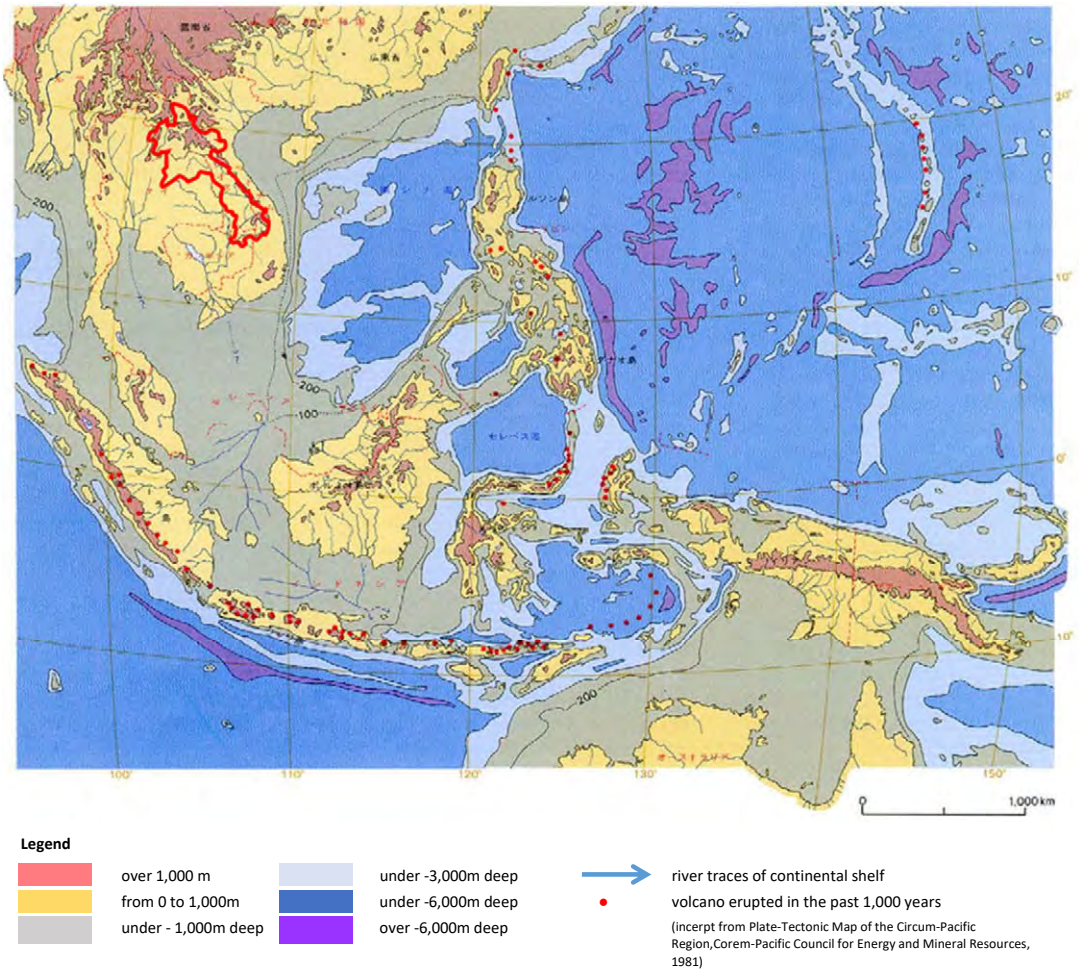
The target area is located between the Indian Plate and the Philippine Sea Plate. In particular, the Indian Plate has a strong influence on the area. However, since the area is sufficiently far away from the subduction zone of the Indian Plate, occurrence of earthquake is infrequent (Figure 5.3.3).



Source Japan Meteorological agency

Figure 5.3.3 Plates and Occurrence of Earthquakes (Red dots indicate earthquake epicenters)

Same can be said about volcano. The distribution of volcano is similar to that of plate boundaries as shown in Figure 5.3.4. There are no active volcanoes in the study area in Laos and Vietnam at present. The boundary between Laos and Vietnam is marked by mountains over 1000 m.



Source: Takaya, Yoshikazu. Geography and geology of Southeast Asia. URBAN KUBOTA no.25/10)

Figure 5.3.4 Elevation and Distribution of Volcanoes

Plate activities have been taking place in the Precambrian Proterozoic bedrock since the collision with the Indian Continent (from Paleozoic Permian period to Mesozoic Triassic period) until now. These Precambrian bedrock went through pressure metamorphism that generated faults in the Indochina Peninsula, which resulted in formation of conspicuous fissures in the rocks. In the current study area, mountains with conspicuous vertical fissures in very hard quartz and slate were observed (Figure 5.3.5). These very hard Precambrian and Paleozoic bedrocks with conspicuous fissures pose significant risks (in terms of safety, construction cost and maintenance cost) when excavation and cutting works are underway.

Figure 5.3.5　Conspicuous Vertical Fissures in Metamorphosed Slate and Quartzite

Figure 5.3.6　Block of Very Hard Quartzite and Metamorphosed Slate (Area in red dots)

The block of land mass shown in エラー! 参照元が見つかりません。 indicates the distribution of these steep cliffs of very hard bedrocks with many conspicuous vertical fissures. When planning tunnels in the target area, it is necessary to consider rockfalls and bedrock collapses (due to toppling and overhangs) at the tunnel entrances as well as the collapse of ceiling of the inner section of the tunnel.

5.4 Geology and Structures

5.4.1 Geology and Tunnels

There are several tunnel options being considered in the current study area. The table below shows items that are particularly challenging (Table 5.4.1).

Table 5.4.1 Types of Grounds that Need Attention

	Ground types to pay special attention to	Main characteristics of grounds	Problematic phenomenon
Generic part of tunnel	Swelling rock	・ Solfataric soil ・ Serpentinite ・ Weak mudstone ・ Clay in fault ・ Low competence ratio	・ Squeezing an heaving towards hole wall ・ High earth pressure ・ Long-term modification and increase in earth pressure ・ Deformation of support and lining
	Ground with possible high pressure and big springwater	・ Groundwater cut by fault clay ・ Water contained in bedding planes and fractures ・ Water contained in cavity of limestone and lava	・ Huge amount of springwater ・ High pressure springwater ・ Collapse of cutting face from springwater ・ Submerged tunnel ・ Degraded function of support
	Unconsolidated ground	Under groundwater table, ・ Sediment formed between late Tertiary Period and Quaternary Period ・ Pyroclastic material ・ Weathering crust ・ Crush zone	・ Flow of soil and cutting face collapse from springwater ・ Degraded function of support due to weakened soil ・ Groundwater depletion ・ Ground subsidence
	Grounds with high geothermal temperature, hot spring, toxic gas, etc.	・ Hydrothermal alteration zone ・ Crush zone ・ Intrusive rock ・ Coal and metal bearing sediment	・ Hot spring eruption ・ Toxic gas eruption ・ Spontaneous ignition of dynamite ・ Deteriorated working conditions
	Grounds with potential rock burst	・ Grounds composed of hard rocks with deep overburden ・ Rocks with high brittleness (ratio of unconfined compression test and tensile strength σc/σt)	・ Rock burst (cutting face and bedrocks collapse rapidly with explosion and violent spalling of rocks)
shallow overburden	Grounds where landslides and collapse may occur at a tunnel entrance and valley side	・ Thick colluvial and creeping talus deposits ・ Weak consolidated pyroclastic material ・ Terrace deposit ・ Strong weathered rocks ・ Crush zone ・ Schist, shale, slate with developed schistosity and fractures ・ Solfataric soil ・ Mudstone, shale, and tuff of Tertiary Period ・ A lot of springwater	・ Unsymmetrical pressure ・ Deformation of support and lining ・ Subsidence of support ・ Landslide and collapse
	Ground with shallow overburden	・ Ground composed of sediment and soft rock with shallow overburden ・ Presence of other structures on the surface and/or underground near the tunnel	・ Ground subsidence and collapse ・ Deformation of other structures ・ Substantial soil pressure ・ Deformation of support and lining

Source: Standard Design Specifications Vol. 3 Tunnels. (2009) P.48. by NEXCO

Anticipated challenges in road tunnel in general in the current study area are “Unconsolidated ground” and “Ground where rock burst is expected” outlined in Table 5.4.1.

(1) Unconsolidated ground

A site visit revealed strong weathered biotite schist, slate, phyllite, biotite gneiss, quartz-biotite granite (Precambrian Proterozoic, Paleozoic) around the international border on National Road No. 8. Folded through metamorphosis, these rocks are strong weathered into light yellow brown, brick-red to reddish brown cohesive soil, and sandy clay with many quartz grains.

In this type of bedrock, even NATM may require auxiliary method to prevent ceiling collapse at the tunnel entrance and other tunnel parts in general. For the bottom of the tunnel, it is necessary to consider lining and complete closure. When excavating the tunnels, it is necessary to pay attention to constructability and safety because, within quartz-biotite granite, weathered reddish brown cohesive soil with many quartz grains (Figure 5.4.1) and relatively fresh biotite granite cobbles coexist.

Figure 5.4.1 Weathered Quartz-biotite Granite and Biotite Schist Turning Reddish Brown
(White grains in the left photo are quartz)

(2) Ground where rock burst is expected

Many vertical cracks have been observed at about 24 km east from Vieng Kham on National Road No. 8. The rocks at this location form 300 m-high very hard mountains with ultramafic rocks (peridotite, pyroxenite, etc.) and metamorphosed slate on a flat ground. The rocks are hard and resilient to weathering, and development of fissures marks weathering even though these are old rocks from Precambrian (540 million years old) to Paleozoic era. Accordingly, vertical fissures are deep, raising possibility of “rock burst” and “ceiling collapse” (Figure 5.4.3).

It is desirable that the possibility of constructing tunnels at the target area be explored through high-density seismic survey and/or horizontal boring.

Figure 5.4.2 Rock Mass Located 24 km East of Vieng Kham

Source: JSCE Kanto Branch Niigata working group April 2011

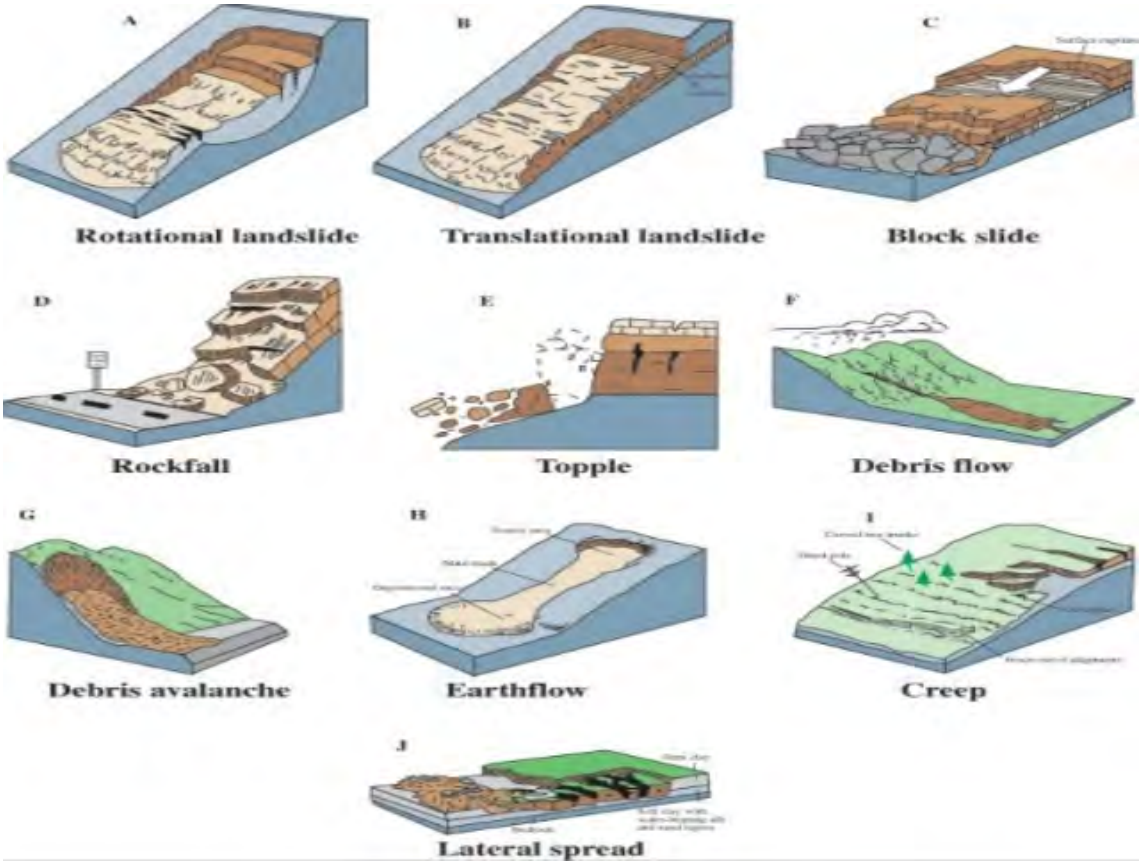
Figure 5.4.3 Rock Burst during Construction of Kan-etsu Tunnel

Note: "Rock burst" is a violent fracture of rocks with rumbling of a mountain, and happens when pressure from neighboring rocks concentrates on a tunnel face plane created by excavating hard bedrock. Above photographs were from 1977 when the main tunnel was being excavated (with full face tunneling with steel support). "Rock burst" happens where overburden was more than 750m, disrupting tunnel excavation repeatedly.

5.4.2 Entrance of Tunnel

Generally, colluvial deposit, slope failure and landslide must be paid attention to at tunnel entrances. Around the area ca. 24 km east of Vieng Kham on NR8, attention must be paid to toppling (Figure 5.4.5 Topple) and block slides (Figure 5.4.5 Block slide).

Figure 5.4.4 Rocks at ca. 24 km East of Vieng Kham



Source: PROTOCOL FOR INVENTORY MAPPING OF LANDSLIDE FEPOSITS FROM LIGHT DETECTION AND RANGUNG IMAGERY by William J. Burns and Ian P. Madin SPECIAL PAPER 42 2009

Figure 5.4.5 Types of Sediment Movement

5.4.3 Geology and Earthwork (Cutting and Filling)

Regarding cutting and filling for road construction, it is necessary to note the following aspect. There are steep mountains in the east of Viengthong on Pre F/S route, that are composed of strong weathered very hard slate (weak metamorphic, Paleozoic) and very hard shale that turned into reddish brown or brick-red cohesive soil. They are brittle and susceptible to water from rainfall, leading to slope failure and cut slope collapse (Figure 5.4.6).

Figure 5.4.6 Conspicuous Slope Failure along Existing Road in the Mountainous Area (at 245 km point of Pre F/S route)

Weathered slate and shale (Paleozoic) tend to slide along their bedding planes, forming a dip slope and a slope opposite to that of the road. A dip slope is prone to slope failure (Figure 5.4.7)

Figure 5.4.7 A dip Slope Structure of Slate and Shale and Slope Failure (at 260 km point of Pre F/S route)

Chapter 6
Evaluation of the Route in the Proposed Expressway Development Plan

Chapter 6 Evaluation of the Route in the Proposed Expressway Development Plan

6.1 Review of Pre-Feasibility Study

6.1.1 Routes Planned in the Pre-Feasibility Study

(1) Route selection process

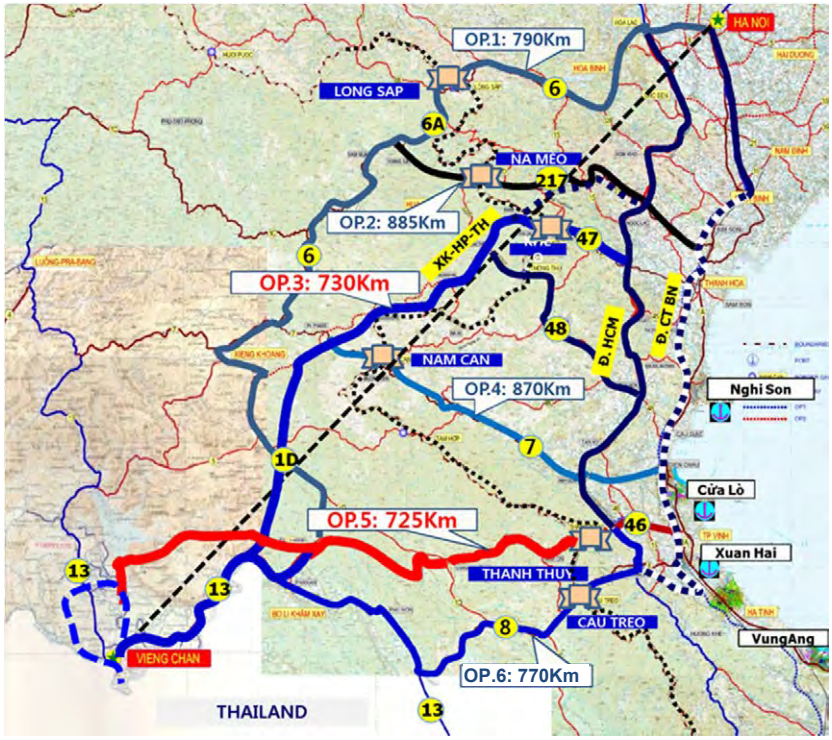
In the Pre-F/S, six routes are compared for the expressway plan to connect the Laotian capital, Vientiane, with the Vietnamese capital, Hanoi. The plan is formulated on the precondition that a 4-lane road between Hanoi and Ha Tinh, called the North-South expressway (NSE), will be completed by 2020.

The outline of the six routes compared is shown in Table 6.1.1. In the first round of comparison of Options 3 and 5, Option 5 scored higher in terms of the road length, road speed, investment amount, contribution to Laotian regional development, land acquisition, and other factors. In the second round, Option 5 was again selected as the recommended route over Option 6 due to road length, topographical conditions, and connection with ASEAN regions.

Table 6.1.1 Routes Planned in the Pre-Feasibility Study

OP	Border Crossing	Route Length (km)			Connected Roads	
		Laos	Vietnam	Total	Laos	Vietnam
1	Long Sap (Son La) – Pa Hang (Hua Phan)	590	200	790	13, 4B, 1D, 6, 6A	6
2	Na Neo (Thanh Hoa) – Nam xoi (Hua Phan)	580	305	885	13, 4B, 1D, 6	217, NSE
3	Kheo (Than Hoa) – Ta Lau (Hua Phan)	475	255	730	13, 4B, 1D, XK-HP-TH	47, HCM
4	Nam Cam (Nghe An) – Nam Can (Xieng Khoang)	400	470	870	13, 4B, 1D, 7	NSE
5	Thanh Thuy (Nghe An) – Nam On (BolyKhamxay)	355	370	725	13, 4B, PX-TT	46, NSE
6	Cau Treo (Ha Tinh) – Nam Phao (BolyKhamxay)	345	425	770	13, 4B, 1D, 8	8, NSE

Source: Prepared by JICA Study Team based on Hanoi-Vientiane Expressway Project Pre-feasibility Study by TEDI

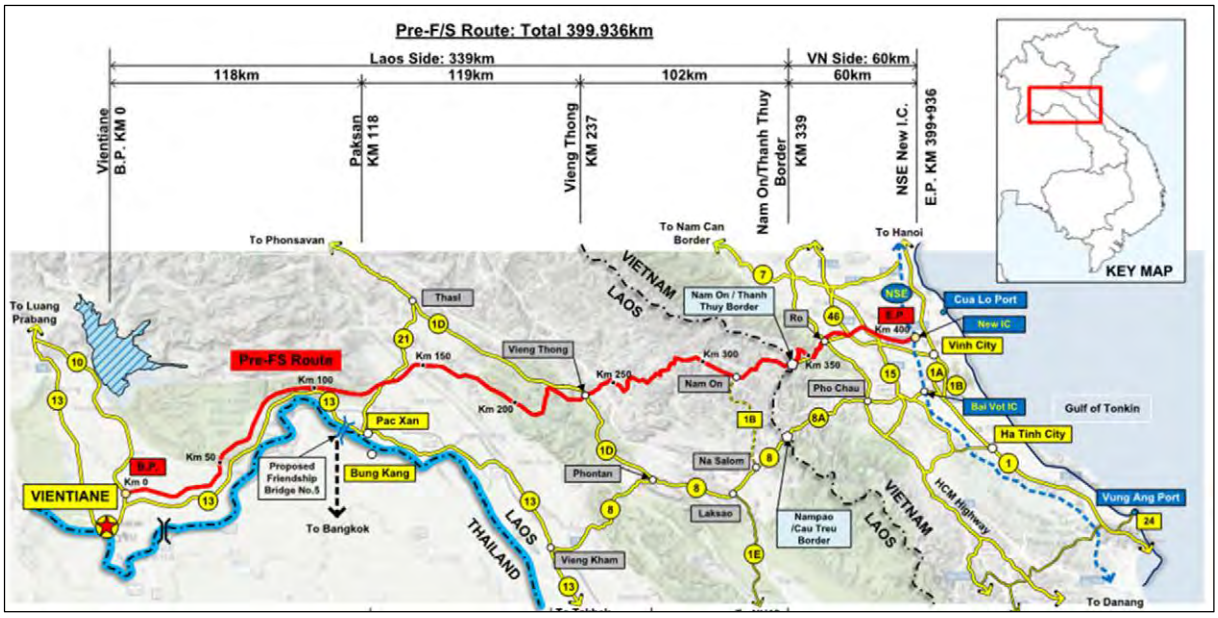


Source: Hanoi-Vientiane Expressway Project Pre-feasibility Study by TEDI

Figure 6.1.1 Routes Planned in the Pre-Feasibility Study

(2) Selected route

Option 5, the recommended route in the Pre-F/S, connects Vientiane and Vinh City and is approximately 400 km[1] long. The route passes through Thanh Thuy–Nam On border crossing. This route is hereinafter referred to as the "Pre-F/S route".



Source: Prepared by Study Team based on Hanoi-Vientiane Expressway Project Pre-feasibility Study

Figure 6.1.2 Diagram of Pre-F/S Expressway Plan

[1] The Pre-F/S indicates that the road length in Laos side is 355km, as shown in Table 6.1.1. However, the plan drawing was reviewed by JICA Study Team and it is confirmed that the length is 339 km to be exact.

6.1.2 Review of the Pre-F/S Expressway Plan

(1) Applicable design standards

The applicable design standards according to the Pre-F/S are described below. With no detailed design standards presented by the Laotian side, those from the Vietnamese side are mostly applied. The standards for expressway development in the Pre-F/S are based on the primary class standards from ASEAN Highway Standards (4 lanes or more, access-controlled):

- Specifications for highways of ASEAN
- Expressway - Specifications for design TCVN 5729-2012
- Design instruction and traffic organization in the investment phasing for highways issued by Decision No. 5109/QD-BGTVT dated 31/12/2014 of Ministry of Transport of Vietnam
- Highway - Specifications for design TCVN 4054-05
- Urban roads - Specifications for design TCXDVN 104:2007
- Design specifications for highways of Laos public works and transport
- Soft dressing - Requirements and design instructions 22TCN 211-06
- National technical regulations on expressway guidance signs QCVN 83:2014/BGTVT
- National technical regulations on road signs and signals QCVN 41:2012/BGTVT
- Design standards for bridges 22TCN 272-05
- Design standards of AASHTO.

(2) Geometric standards

The main road alignment factors for the Pre-F/S Expressway Plan are shown in the table below. The plan satisfies all reference values for a primary class highway according to the ASEAN Highway Standards.

Table 6.1.2 Road Alignment Factors for Pre-F/S Expressway Plan

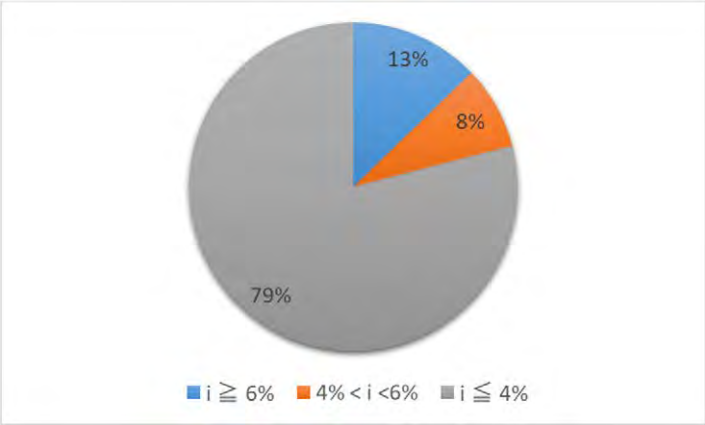
Item	ASEAN Highway Standards Primary Class (4 or more lanes, access-controlled)			TEDI Pre-F/S route (Expressway plan)			
Terrain classification	Level	Rolling	Mountainous	Vientiane-Pac Xan, HCM road-NSE		Pac Xan-(Border)-HCM road	
Design speed (km/h)	120-100	100-80	80-60	120	100	80	60
Minimum curve radius (m)	390	230	120	650	450	250	150
Steepest profile gradient (%)	4.0	5.0	6.0	5.5		6.0	-

Source: JICA Study Team

(3) Road gradient

Road gradient in the Pre-F/S plan is as per Figure 6.1.3: 4% or less for approximately 316 km (79% of the entire length), 4–6% for approximately 33 km (8%), and 6% or greater for approximately 51 km (13%).

As the planned road passed through steep mountainous terrain, the cumulative length with the steepest profile gradient (6%) becomes approximately 51 km. This could hinder the travel speed of large-sized vehicles such as trailer trucks. In this case, normal passenger vehicles following the slow large-sized vehicle also have to slow down. While construction of climbing lanes is normally considered as an appropriate means to avoid this situation, such measures are not considered in the Pre-F/S.

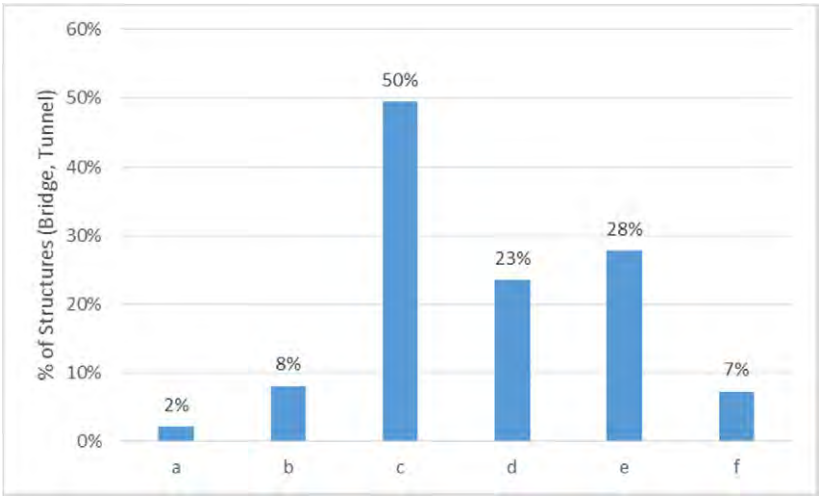


Source: JICA Study Team

Figure 6.1.3 Profile Gradient and Distribution for the Pre-F/S Expressway

(4) Structural length and ratios

Figure 6.1.4 summarizes the percentage of the structures (bridges and tunnels) in terms of length of different sections of the expressway in the Pre-F/S plan (also shown in Table 6.1.3). In the descending order, the length is 36.6 km (accounting for 50% of the total length) on the Viengthong - Nam On section, it is 7.2 km (28%) on the Thanh Thuy - Ro section, and 6.6 km (23%) on the Nam On-Thanh Thuy section. The Viengthong-Nam On section, which has the longest total length as well as the highest total length percentage of the structures, is of particular concern. That is, it requires 14 tunnels with a total length of 12.8 km. This would push up construction cost and pose serious challenges in terms of workability, including construction period and disaster measures.



Source: JICA Study Team

Figure 6.1.4 Percentage of Structures of the Pre-F/S Expressway

Table 6.1.4 Breakdown of Structure Lengths/Ratios for the Pre-F/S Expressway Plan

	Section		Length (km)	Bridge		Viaduct		Tunnel		Total	
	From	To		Qty.	Length (m)	Qty.	Length (m)	Qty.	Length (m)	Length	%
a	Vientiane	Pac Xan	118	29	2,557	0	0	0	0	2,557	2%
b	Pac Xan	Vieng Thong	119	41	3,816	14	5,775	0	0	9,591	8%
c	Vieng Thong	Nam On	74	11	1,163	34	22,731	14	12,750	36,644	50%
d	Nam On	Thanh Thuy	28	6	749	5	4,323	4	1,500	6,572	23%
e	Thanh Thuy	Ro (HCM Road)	26	5	573	7	6,150	1	500	7,223	28%
f	Ro (HCM Road)	NSE	35	12	2,545	0	0	0	0	2,545	7%
Total			400	104	11,403	60	38,979	19	14,750	65,132	16%
Remarks				Max. 1.6km				Max. 2.4km			

Source: JICA Study Team

(5) Reduced travel speed for logistics vehicles

Focusing on the traveling speed of large-sized trailers that fulfill region-wide logistical function of the expressway, a close review was conducted in this study on their speed reduction to less than 30 km/h in the steep gradient sections of the expressway route recommended in the Pre-F/S study.

The number of sections where the speed drops below 30 km/h was 28 (31.3 km or 7.6% of the total) in the eastbound direction, all in Laos; and there are 35 (34.3 km or 8.6% of the total) similar sections in the westbound lanes connecting Vietnam and Laos, 4 sections or 10.1 km in Vietnam. The minimum travel speed becomes as low as 22 km/h.

Table 6.1.5 Reduced Travel Speed for Logistics Vehicles

Eastbound: Laos to Vietnam				
Sections below 30 km/h	Max continuous length (km/section)	Cumulative length (km)	Ratio (of total 400 km) (%)	Minimum speed (km/h)
28 (0 in Vietnam)	8.7 (in Laos)	31.3 (0 km in Vietnam)	7.8%	22
Westbound: Vietnam to Laos				
Sections below 30 km/h	Max length (km/section)	Cumulative length (km)	Ratio (of total 400 km) (%)	Minimum speed (km/h)
35 (4 in Vietnam)	8.7 (in Vietnam)	34.3 (10.1km in Vietnam)	8.6%	22

(Study conditions) Target vehicles: semi-trailer, fully loaded (7 PS/t), Design speed: 80 km/h, minimum allowable speed: 30 km/h

Source: JICA Study Team

There are steep uphill gradient sections with speeds below 30 km/h extending 8.7 km in both the eastbound (Laos to Vietnam) and westbound (Vietnam to Laos) directions (Figure 6.1.5).

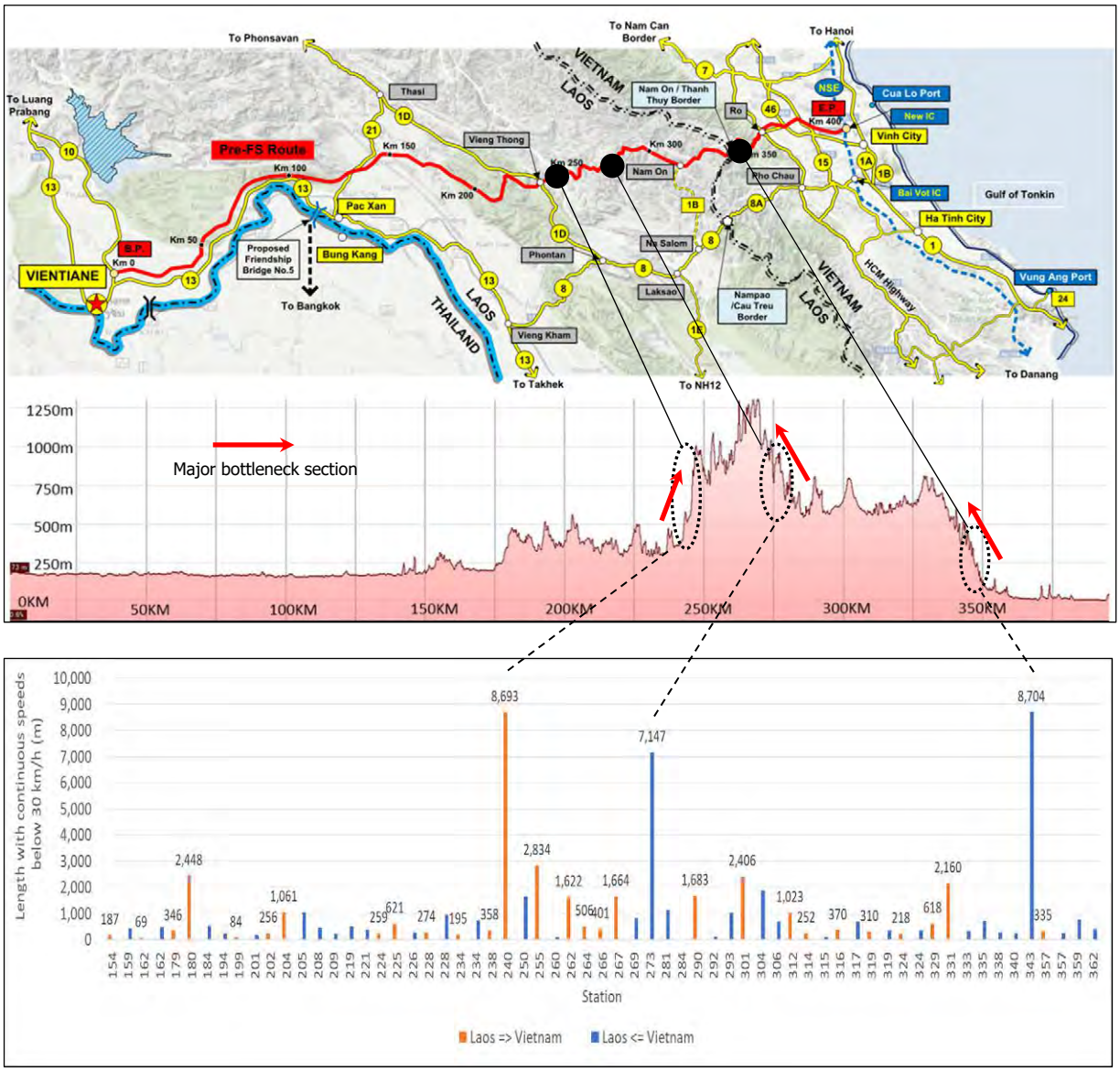


Figure 6.1.5 Low Speed Sections for Trailer Trucks on the Pre-F/S Expressway (bottlenecks)

Figure 6.1.6 Trailer Trucks Traveling on NR 8

Table 6.1.6 Sections and Lengths below 30 km/h of Large-Sized Vehicles

Laos to Vietnam

	Section below 30 km/h			Length (m)
1	154	+	463	187
	154	+	650	
2	162	+	942	69
	163	+	11	
3	179	+	481	346
	179	+	828	
4	180	+	932	2,448
	183	+	380	
5	199	+	509	84
	199	+	593	
6	202	+	714	256
	202	+	970	
7	204	+	61	1,061
	205	+	122	
8	224	+	607	259
	224	+	867	
9	225	+	471	621
	226	+	91	
10	228	+	438	274
	228	+	712	
11	234	+	246	195
	234	+	441	
12	238	+	964	358
	239	+	322	
13	240	+	998	8,693
	249	+	691	
14	255	+	365	2,834
	258	+	199	
15	262	+	597	1,622
	264	+	219	
16	264	+	768	506
	265	+	274	
17	266	+	241	401
	266	+	642	
18	267	+	798	1,664
	269	+	462	
19	290	+	529	1,683
	292	+	212	
20	301	+	834	2,406
	304	+	240	
21	312	+	724	1,023
	313	+	746	
22	314	+	914	252
	315	+	167	
23	316	+	972	370
	317	+	342	
24	319	+	202	310
	319	+	512	
25	324	+	495	218
	324	+	712	
26	329	+	361	618
	329	+	979	
27	331	+	253	2,160
	333	+	412	
28	357	+	602	335
	357	+	937	
Length (m)				31,256

Legend

Major bottleneck

Section where 6+% grade continues for 600+ m. requires climbing lane or other measures.

Vietnam to Laos

	Section below 30 km/h			Length (m)
1	362	+	791	399
	362	+	392	
2	360	+	11	780
	359	+	231	
3	358	+	161	254
	357	+	906	
4	352	+	238	8,704
	343	+	534	
5	340	+	950	259
	340	+	690	
6	338	+	958	284
	338	+	675	
7	335	+	839	731
	335	+	108	
8	333	+	705	328
	333	+	376	
9	325	+	35	354
	324	+	681	
10	319	+	836	355
	319	+	481	
11	318	+	11	703
	317	+	308	
12	315	+	236	100
	315	+	136	
13	307	+	398	685
	306	+	713	
14	306	+	100	1,891
	304	+	209	
15	294	+	736	1,039
	293	+	697	
16	292	+	395	111
	292	+	284	
17	284	+	491	26
	284	+	465	
18	283	+	106	1,144
	281	+	962	
19	280	+	365	7,147
	273	+	218	
20	270	+	661	811
	269	+	850	
21	260	+	986	109
	260	+	877	
22	252	+	331	1,650
	250	+	682	
23	235	+	158	751
	234	+	408	
24	229	+	626	948
	228	+	679	
25	226	+	329	272
	226	+	57	
26	222	+	286	385
	221	+	900	
27	219	+	586	509
	219	+	77	
28	210	+	206	229
	209	+	977	
29	208	+	686	469
	208	+	217	
30	206	+	383	1,052
	205	+	331	
31	201	+	556	185
	201	+	371	
32	195	+	98	230
	194	+	869	
33	184	+	536	526
	184	+	10	
34	163	+	468	483
	162	+	985	
35	159	+	721	440
	159	+	281	
Length (m)				34,342

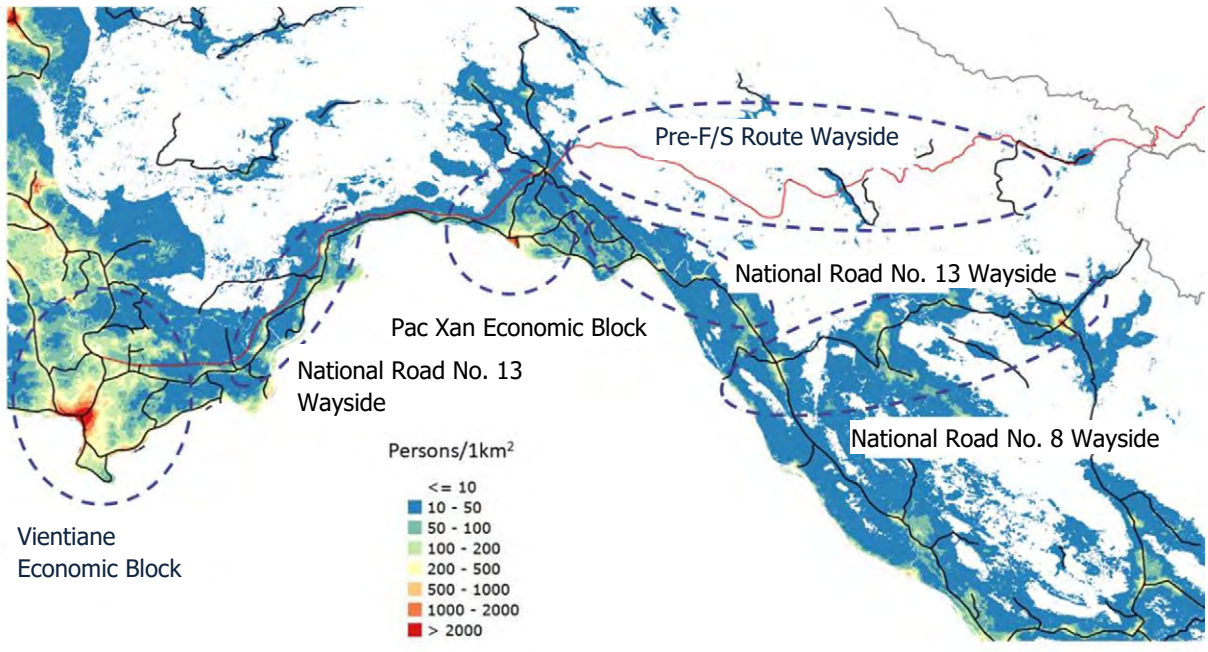
6.2 Basic Policy to Examine Alternative Routes

Although the route selected in the Pre-F/S connects Hanoi and Vientiane through the shortest path as described in the previous section, over 60% of the total length in Laos runs through the mountainous `area, and large trailer trucks may face difficulty in climbing the continuous steep slopes. Moreover, regional development along the route or service provision to roadside residents can hardly be expected. As a result, some alternative routes are proposed in this study taking into account the following items:

- Services to densely populated areas
- Development along the route
- Connections with other transport projects
- Connection with general roads
- Avoidance of effects on natural reserves
- Access to ports

6.2.1 Services to Densely Populated Areas

It is essential that road development be carried out with the purpose of improving the traffic condition and solving current traffic issues. To that end, it is important that people are able to access to the existing populated areas. Figure 6.2.1 demonstrates distribution of population in the target area, and it clearly shows that there is almost no population concentration along the Pre-F/S route, but along the National Road 13 (NR 13) and the National Road 8 (NR 8).



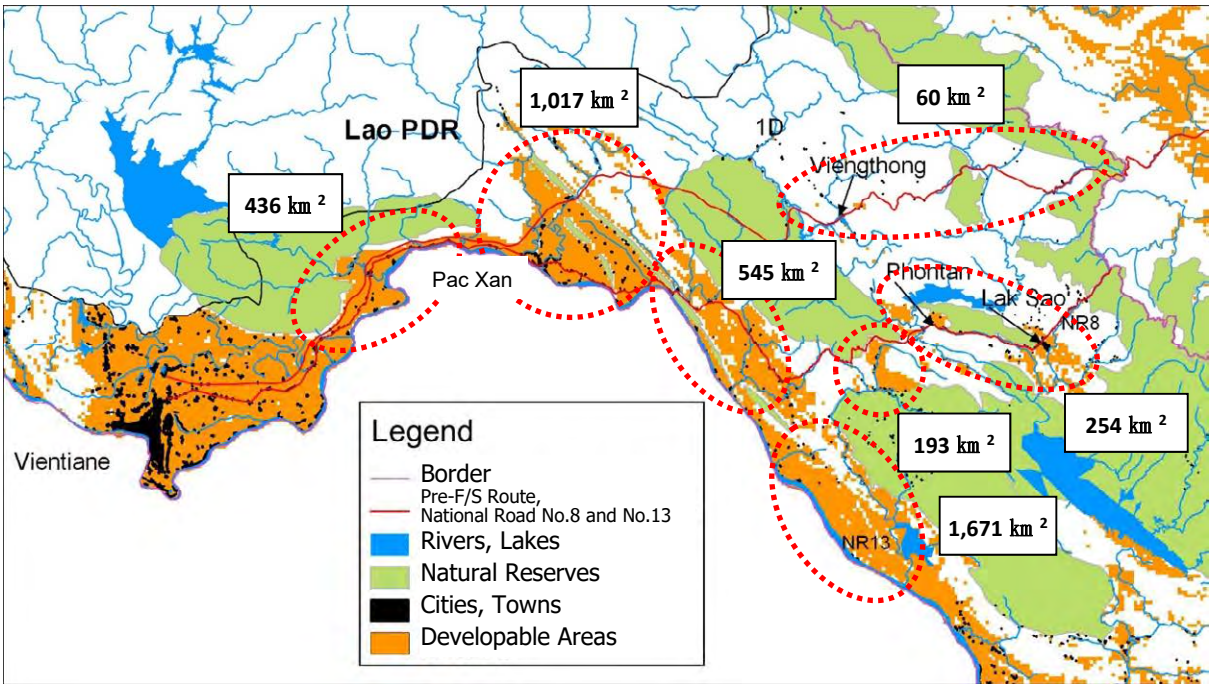
Source: JICA Study Team

Figure 6.2.1 Population Distribution of Target Area

6.2.2 Contribution to Roadside Regional Development

As described above, roadside development is not expected if a route mostly passes through mountains. Therefore, it is desirable to study distribution of developable or unutilized areas first, and then select a route accessible to these areas based on the result. Figure 6.2.2 illustrates the distribution of developable areas, i.e. plain area or gently undulating hills. It shows that most of the lands suitable for development are spread along NR 13, and around Phontan and Laksao of the wayside of NR 8. However, as for the Pre-F/S route, although the developable area is spread along Provincial Road No.

21 (PR 21) near Pac Xan, there is almost no developable land from Viengthong to the border with Vietnam.



Source: JICA Study Team

Figure 6.2.2 Distribution of Developable Area

6.2.3 Coordination with Other Transportation Projects

In Laos, besides the target road of this study, there are some other roads and railways planned. In order to maximize the effectiveness of each project, coordination with other transport projects is important and this should be taken into consideration when planning the route in this study. In particular, coordination with Vientiane-Pakse expressway plan may be especially significant since some sections in the plan overlap with the plan studied here.

The following projects are currently planned in Laos:

- China - Kunming Railway Construction Project
- Vientiane - Vung Ang Port Railway Construction Project
- Vientiane - Pakse Expressway
- Vientiane - Boten Expressway
- Fifth Thailand - Laos Friendship Bridge

6.2.4 Connection with General Roads

An expressway cannot provide the required service by itself, and general roads to access the expressway are essential. In addition, since general roads are also necessary as construction roads, the expressway should be adjacent to the general roads.

6.2.5 Avoidance of Effects on Natural Reserves

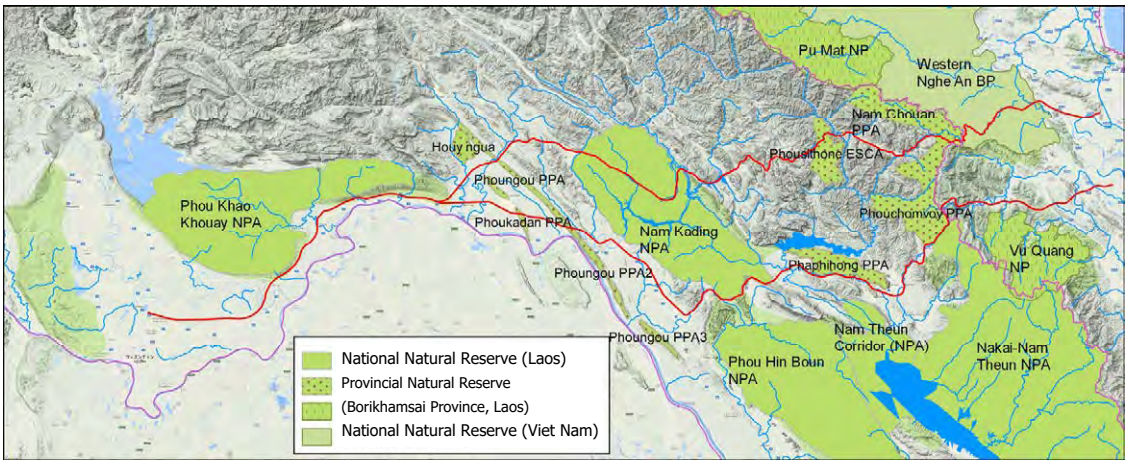
Figure 6.2.3 shows the distribution of nationally and provincially designated protected areas in the target area. In Bolikhamsai Province, there are many creatures[2] designated as endangered species by IUCN (International Union for Conservation of Nature and Natural Resources), and others protected by Laos Domestic Act (MAF 0360); most of them are supposed to inhabit in the natural reserves. Figure

[2] Mammals, birds, reptiles including elephants, tigers, giant monkeys, gaurs and saolas

6.1.4 shows the spots where saolas were observed. It goes without saying that the route has to be planned avoiding the negative impacts on these natural reserves.

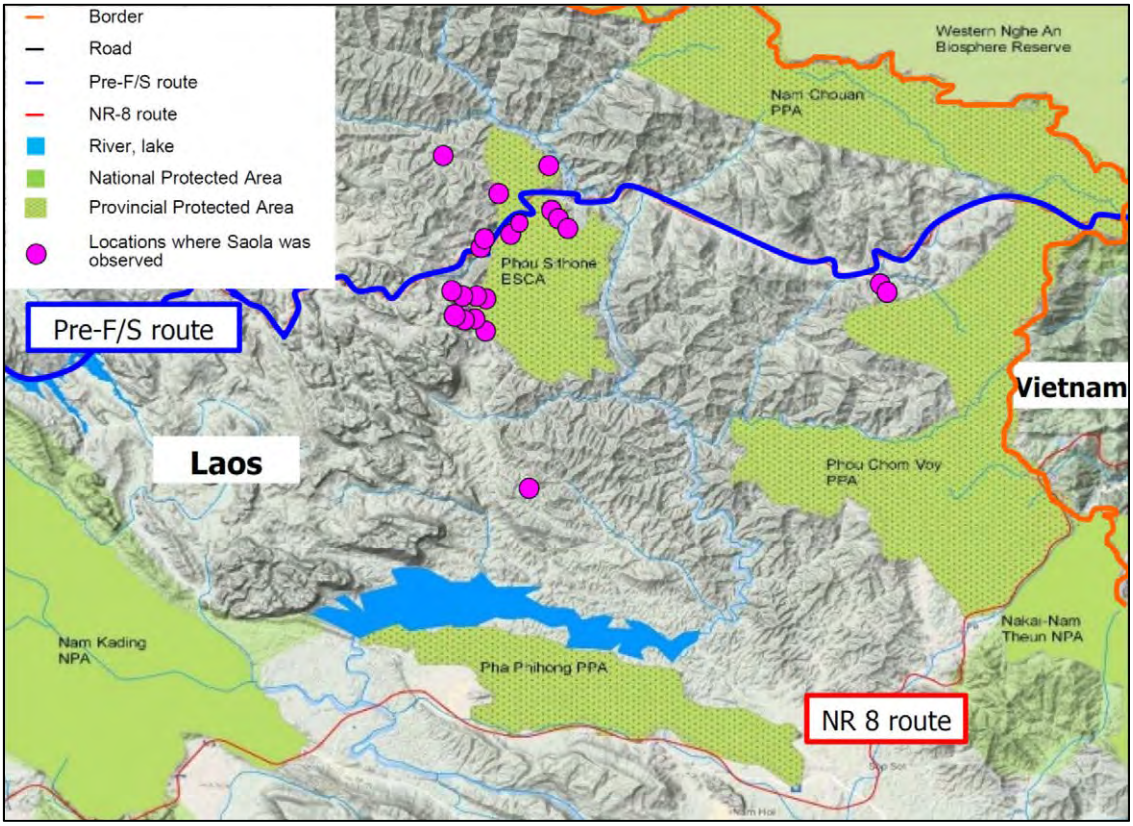
6.2.6 Improvement of Access to the Port

As an inland country, securing import and export gates is extremely important for Laos. Although currently Laos mainly uses Bangkok Port, it will be a great advantage for Laos if starts to use the Vietnamese ports alternatively since they are closer. In fact, the Government of Lao PDR has invested 20% in Vung Ang Port of Vietnam, and improvement of access to the Port is one of the objectives of this project.



Source: Prepared by JICA Study Team based on the interview survey

Figure 6.2.3 Conditions of Natural Reserves



Source: Prepared by JICA Study Team based on Phommachanh et al. (2017) Tropical Conservation Science. vol. 10:1-15

Figure 6.2.4 Saola Observation Sites

6.3 Proposed Alternative Route Plans

As discussed in Section 6.1, while the route set in the Pre-F/S (hereinafter the Pre-F/S route) is the shortest possible route connecting Hanoi and Vientiane, there are almost no prospects for roadside usage or regional development as more than 60% of the Laos side length is through mountainous areas. Also, as discussed in Section 6.2, there will be speed issues for large-sized vehicles in some sections. Thus, this section will discuss the possibility of alternate routes to the Pre-F/S route according to the basic policy given in Section 6.1. First, two basic route options are proposed: the Pre-F/S route plan as recommended by TEDI; and the NR 8 route plan, a route parallel to the NR 8 (part of Asia Highway AH15) running about 50 km to the south of the Pre-F/S route. Next, another two routes are proposed by combining sections of the above two routes (the compound plans), and in total, four alternatives are proposed.

6.3.1 Development Standards for Expressway Plan

Development standards for expressway plan in this study comply with the standards established in the TEDI Hanoi-Vientiane Expressway Project Pre-F/S, which the Vietnamese and Laotian governments accepted in early 2016. The Pre-F/S development standards for the expressway are set to satisfy the primary class requirements of the ASEAN Highway Standards (4 lanes or more, access-controlled).

Table 6.3.1 Road Alignment Factors for the Study of Expressway Plan

Item	ASEAN Highway Standards Primary Class (4 or more lanes, access-controlled)			Study route (Expressway plan)			
Terrain classification	Level	Rolling	Mountainous	Level		Rolling + Mountainous	
Design speed (km/h)	120-100	100-80	80-60	120	100	80	60
Minimum curve radius (m)	390	230	120	650	450	250	150
Steepest profile gradient (%)	4.0	5.0	6.0	4.0	5.0	6.0	6.0

Source: JICA Study Team

6.3.2 Development Alternatives for the Expressway Plan

(1) Alternative 1: Pre-F/S route plan

This route plan adheres to the TEDI-recommended Pre-F/S route for development of a Vientiane-Hanoi expressway. This route passes through downtown Vientiane and Bolikhamsai Province on the Laotian side and Nghe An Province on the Vietnam side.

In the Pre-F/S, the alignment of Pre-F/S route is studied with a 1:50,000 scale topographic map. In this study, on the other hand, a 1:25,000-scale map is created for the160 km-long mountainous section, and thus road alignment for this section is adjusted using the 1:25,000-scale map.

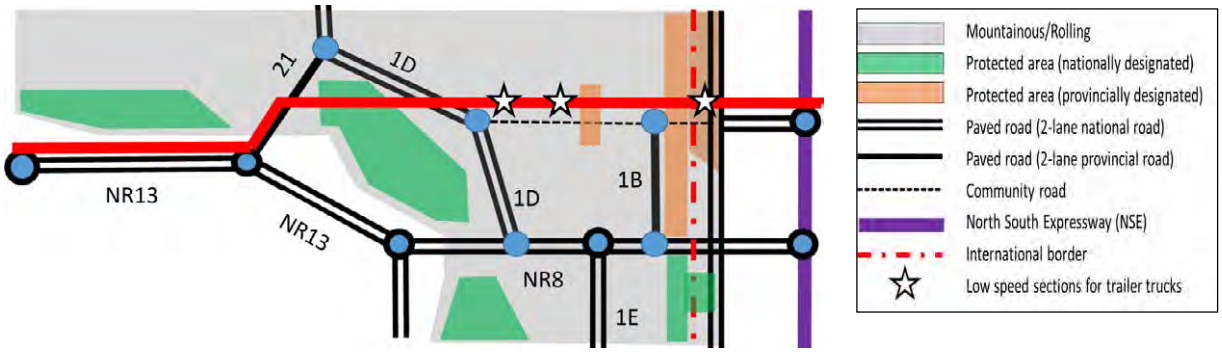


Figure 6.3.1 Route Map for Alternative 1

(2) Alternative 2: NR 8 route plan

This route is parallel to the existing NR 8, passes through downtown Vientiane, Bolikhamsai Province, and Khammouane Province (for 30 km) on the Laotian side and Ha Tinh Province on the Vietnam side. This route has less mountainous terrain than the Pre-F/S route, and passes mostly through a relatively flat terrain, and is also expected to be better in terms of both habitability and industrial development potential.

At present, there is a plan to upgrade the existing NR 8, consisting of a widening and partial road realignment (KOICA performed the feasibility study for this upgrade project in 2017). The plan is expected to be implemented shortly.

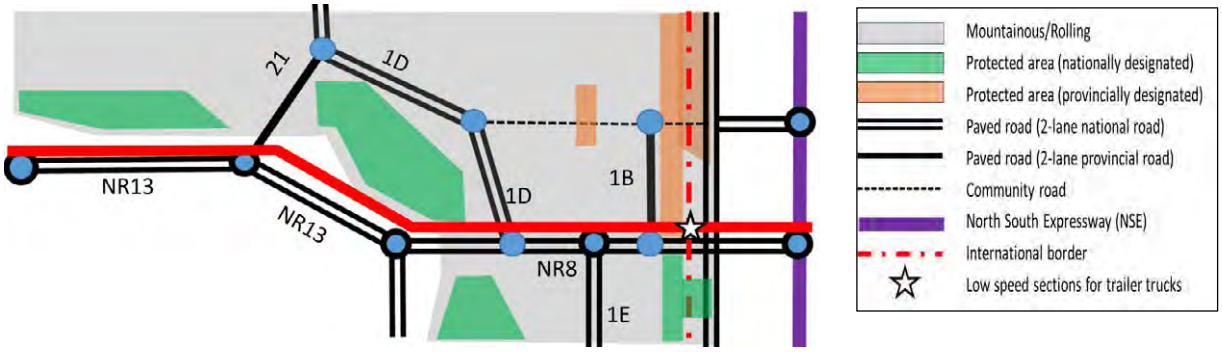


Figure 6.3.2 Route Map for Alternative 2

It should be noted here that the KOICA study used alignment factors meeting Class II ASEAN Highway Standards for the NR 8 upgrade plan.

Table 6.3.2 Alignment Factors for National Road 8 Upgrade Plan

Item	ASEAN Highway Standards Class II (2-lane highway)			KOICA feasibility study road (NR8 upgrade plan)		
Terrain classification	Level	Rolling	Mountainous	Level	Rolling	Mountainous
Design speed (km/h)	80-100	60-80	40-60	80-100	60-80	40-60
Minimum curve radius (m)	200	110	50	200	110	50
Steepest profile gradient (%)	6.0	7.0	8.0	6.0	7.0	8.0

Source: Detailed Feasibility Study for Upgrading National Road No.8, 1st Workshop, KOICA

(3) Alternatives 3A and 3B: Compound plans

Two compound plans are also proposed by combining sections of the Pre-F/S route and NR 8 route. The first one, Alternative 3A, bypasses the environmentally protected area (Nam Kading NPA) in Laos which the Pre-F/S route passes through, and is diverted partly to the NR 8 route. The second one, Alternative 3B, partly reroutes to the NR 8 route to strengthen its service to Laksao, a major city in Blikhamsai Province expected to be developed.

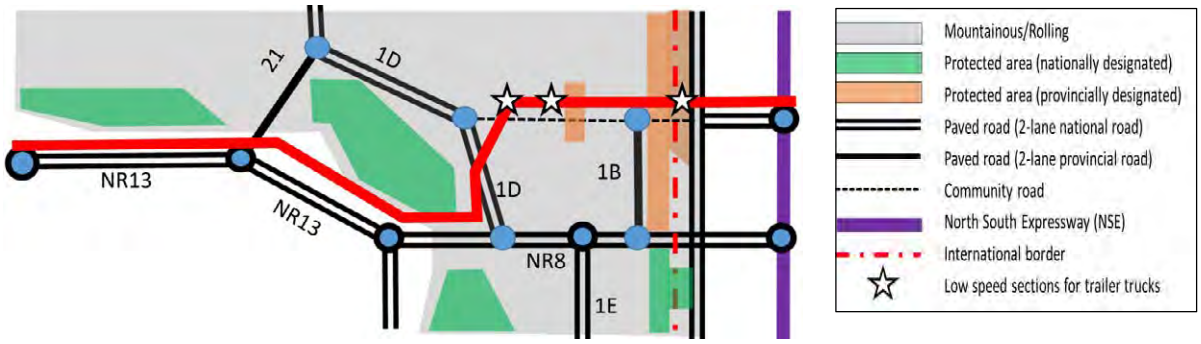


Figure 6.3.3 Route Map for Alternative 3A

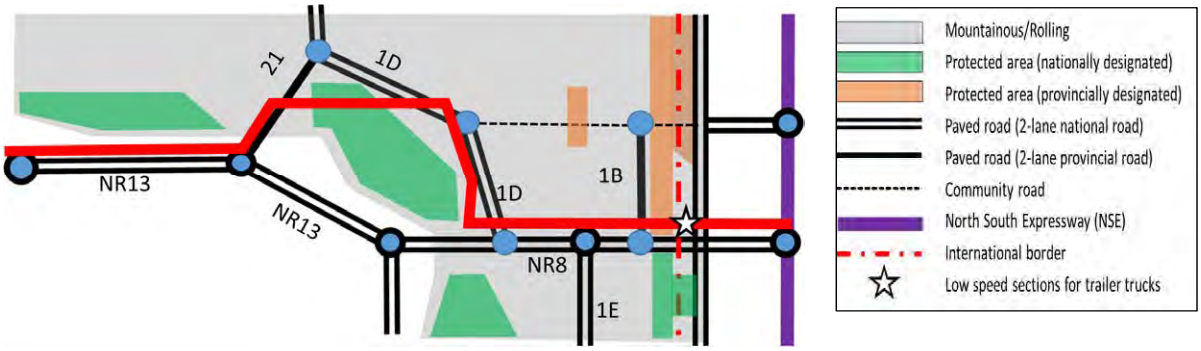


Figure 6.3.4 Route Map for Alternative 3B

Chapter 7
Traffic Demand Forecast

Chapter 7 Traffic Demand Forecast

7.1 Characteristic of the Target Area

7.1.1 Traffic Volume and Origin & Destination

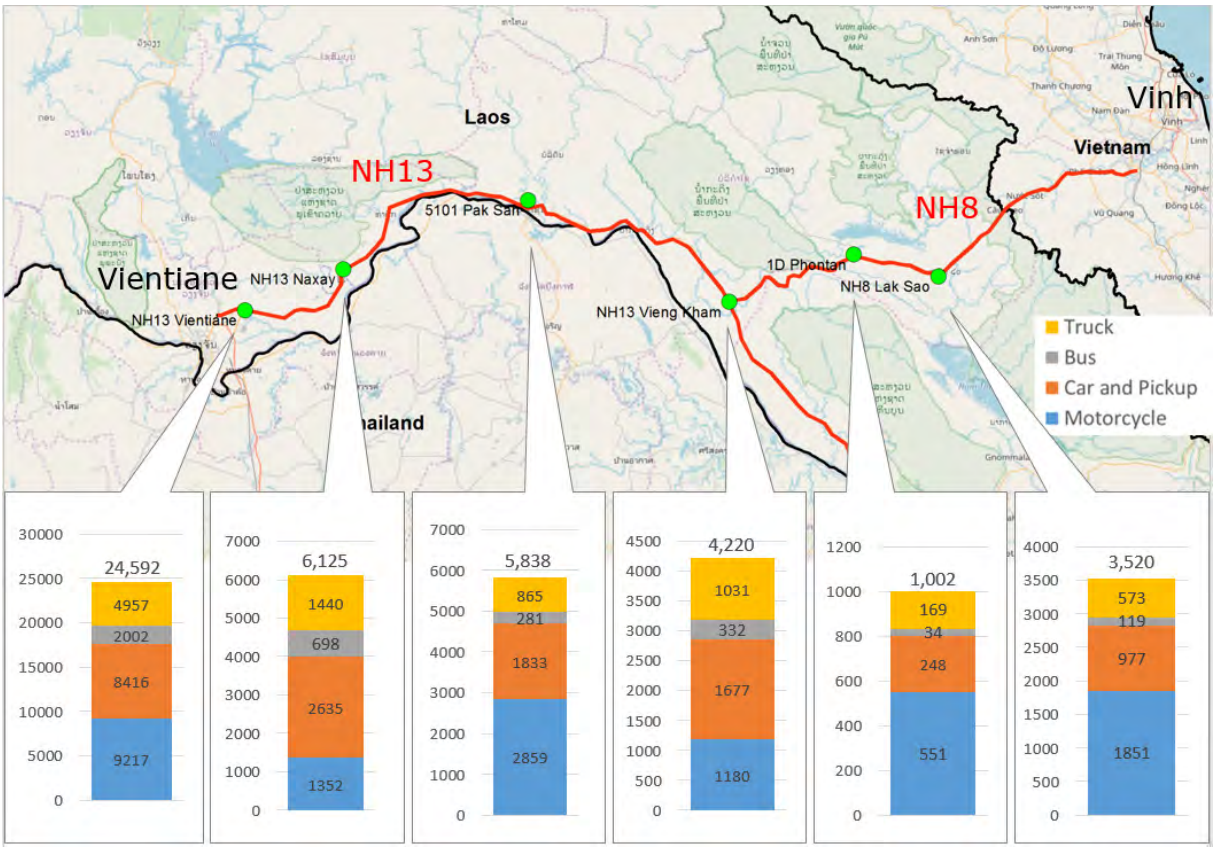
To analyze the traffic flow on the Hanoi-Vientiane expressway, traffic survey is conducted on the NR 8, NR 13 and their connected roads. There are two components in the traffic survey, which are traffic volume survey and roadside interview survey. The survey was conducted at six locations in January, 2018.

Table 7.1.1 Outline of the Traffic Survey

Traffic Volume Survey	Objective	To grasp possible user of Hanoi-Vientiane expressway by counting traffic volume of the NR8, NR13 and their connected roads.
	Methodology	Traffic counting by mode (Motorcycle, Passenger Car, Van & Small Bus, Medium Bus, Large Bus, 2 or 3 axles Truck, 4 axles truck, 5 or 6 axles Truck, More Axle Truck, Others) 24 hours in one weekday, 14 hours in one weekend
	Survey date	5 January 2018 – 8 January 2018
Roadside Interview Survey	Objective	To grasp possible user of Hanoi-Vientiane expressway by analyzing traffic flow on NR8 and NR13 and their connected roads.
	Methodology	Interview to car drivers by type of vehicle for 14 hours 5 January 2018 – 8 January 2018
	Questionnaire	- General Attribution : Age, Gender, Monthly income - Trip Information : Trip purpose, Origin, Destination, Trip mode, Cost, travel time - Freight information : Type of freight, weight, Container size, Place of custom clearance, Place of loading and unloading - Willing to pay by several comparisons among fare setting and travel time

Source: JICA Study Team

The result of the traffic volume survey shows especially high traffic on NR13 and routes using NR13. In particular, high traffic volume was observed at the survey location near Vientiane, the capital city of Laos. Regarding the type of vehicle, motorcycles and passenger cars accounted for a high proportion at every survey location. At the survey location along the NR8, a prominently high proportion of motorcycles was observed.



Source: JICA Study Team

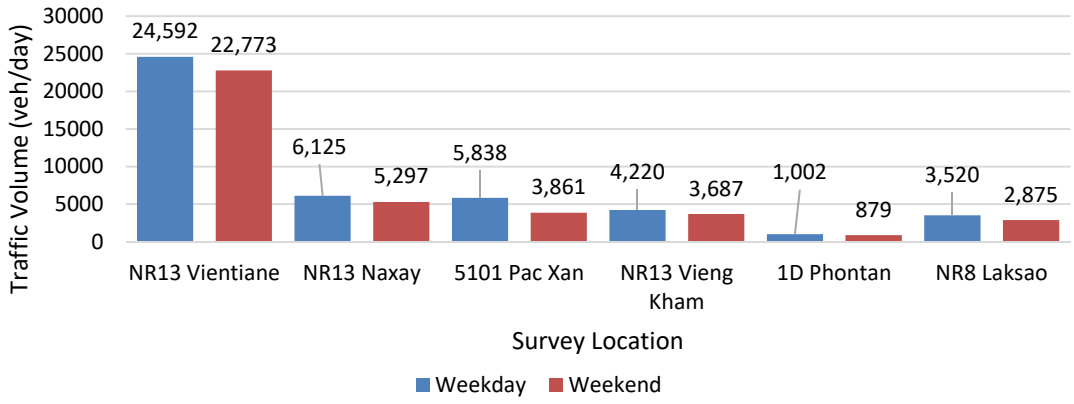
Figure 7.1.1 Survey Location of Traffic Survey (Traffic volume in 24 hours volume/day)

Regarding the difference of traffic volume between weekend and weekdays, the ratio of weekend/weekday is found to be between 0.82 and 0.91. The ratio in the center of Pac Xan is 0.66, which means weekend traffic is much lower than weekday traffic when compared with the ratios of other survey locations. Traffic count was conducted over a period of 14 hours in the weekend, and thus total traffic volume was calibrated to 24 hours volume by using ratio of daily traffic to daytime traffic in a weekday.

Table 7.1.2 Ratio of Daily Time Traffic to Daytime Traffic

Survey Location	Ratio (24hour/12h traffic)	Weekend/Weekday Ratio
NR13 Vientiane	1.17	0.92
NR13 Naxay	1.31	0.86
5101 Pac Xan	1.15	0.66
NR13 Vieng Kham	1.30	0.87
1D Phontan	1.12	0.88
NR8 Laksao	1.17	0.82

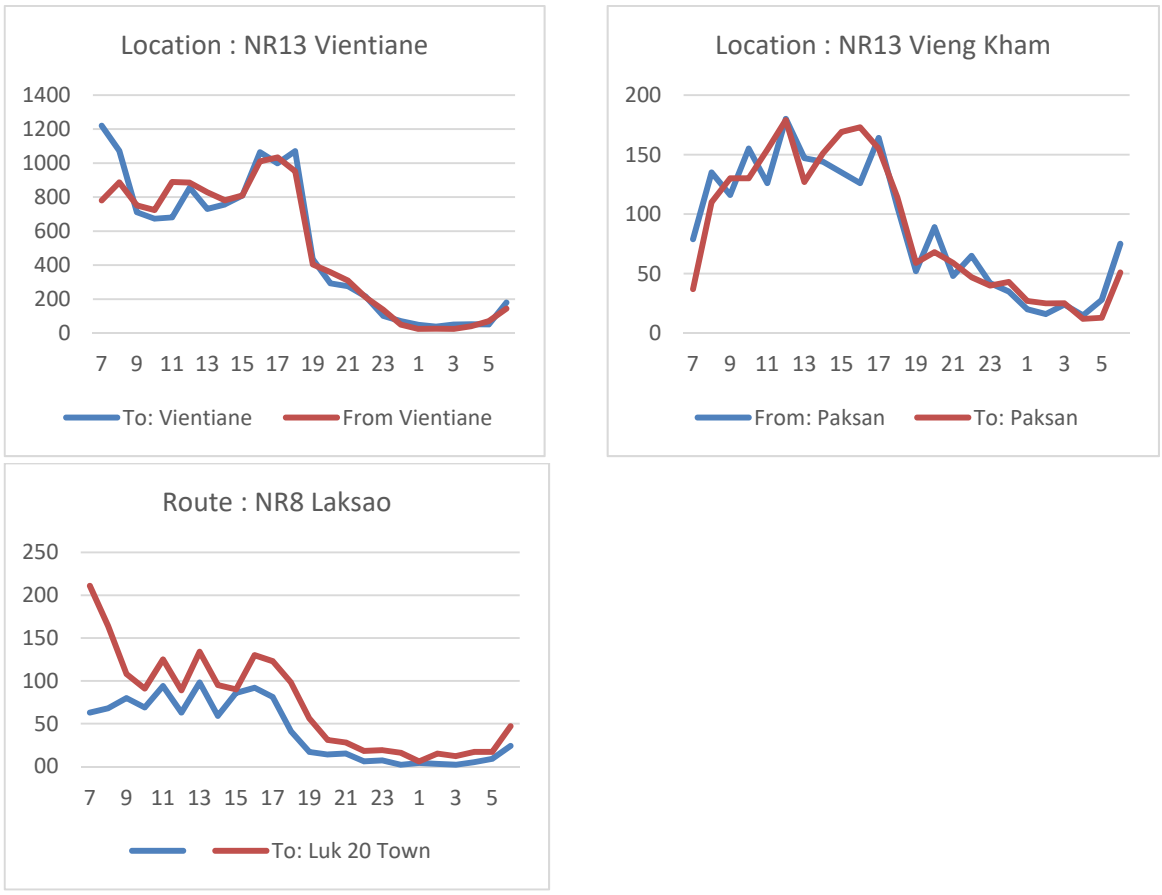
Source: JICA Study Team



Source: JICA Study Team

Figure 7.1.2 Result of Traffic Volume Survey

With regard to the time variation, two peak times are observed on NR13 near Vientiane and on NR8 near Laksao: between 7:00 and 8:00 and between 16:00 and18:00. Figure 7.1.3 shows traffic variation by time at major survey locations. Some survey locations have different peak hour for different directions. Peak hour ratios range from 8% to 10% at each survey location.



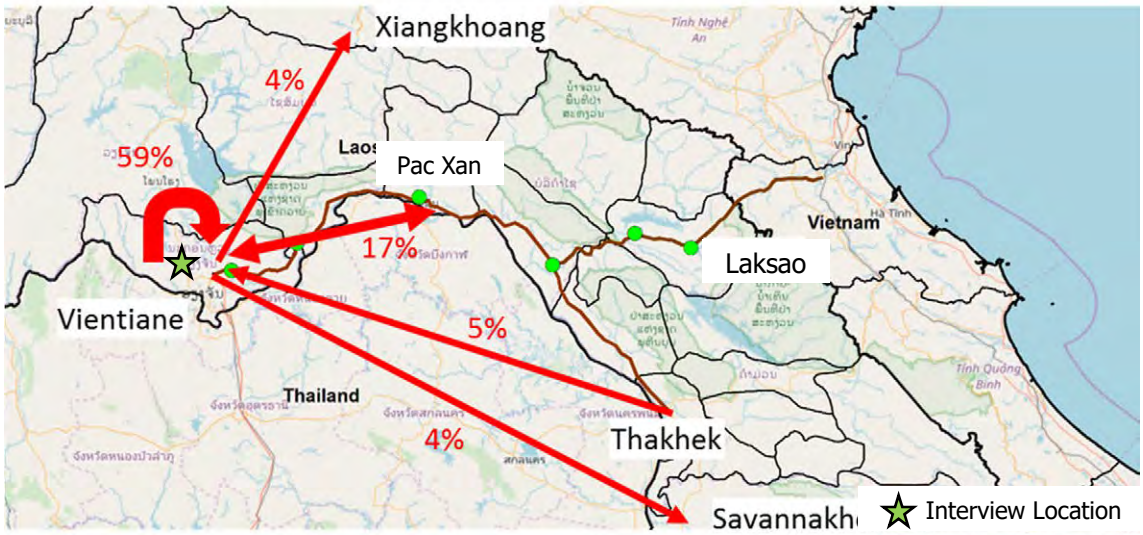
Source: JICA Study Team

Figure 7.1.3 Time Variation of Traffic Volume

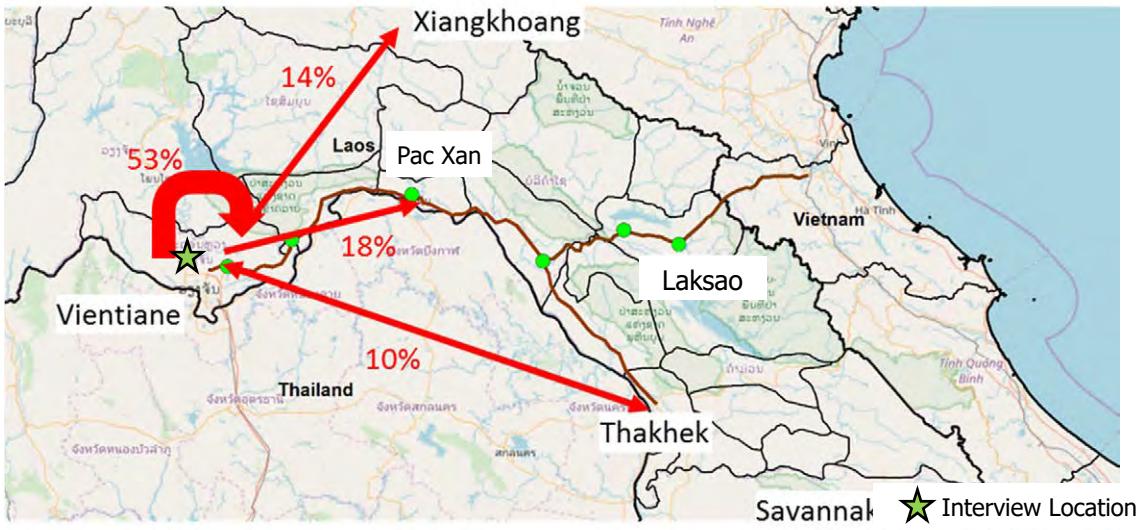
According to the roadside interview survey at the location in Vientiane, around 60% of the trip is intra-trip inside Vientiane. Also, traffic flow between Vientiane and Pac Xan, and between Vientiane and Savannakhet account for a large proportion. Similar trend is observed in passenger trips and in freight trips (Figure 7.1.4).

The survey at the intersection of NR13 and NR8 shows a high proportion of trips between Vientiane and Savannakhet, a trend similar to that of the survey location in Vientiane. Furthermore, freight traffic has its main OD between Vientiane and Champasack, accounting for 21% of total freight traffic flow (Figure 7.1.5).

According to the survey on NR8 Laksao, both passenger traffic and freight traffic have their OD inside Laksao mainly. And international traffic flow is also observed between Vientiane and Nghe An in Vietnam (Figure 7.1.6).



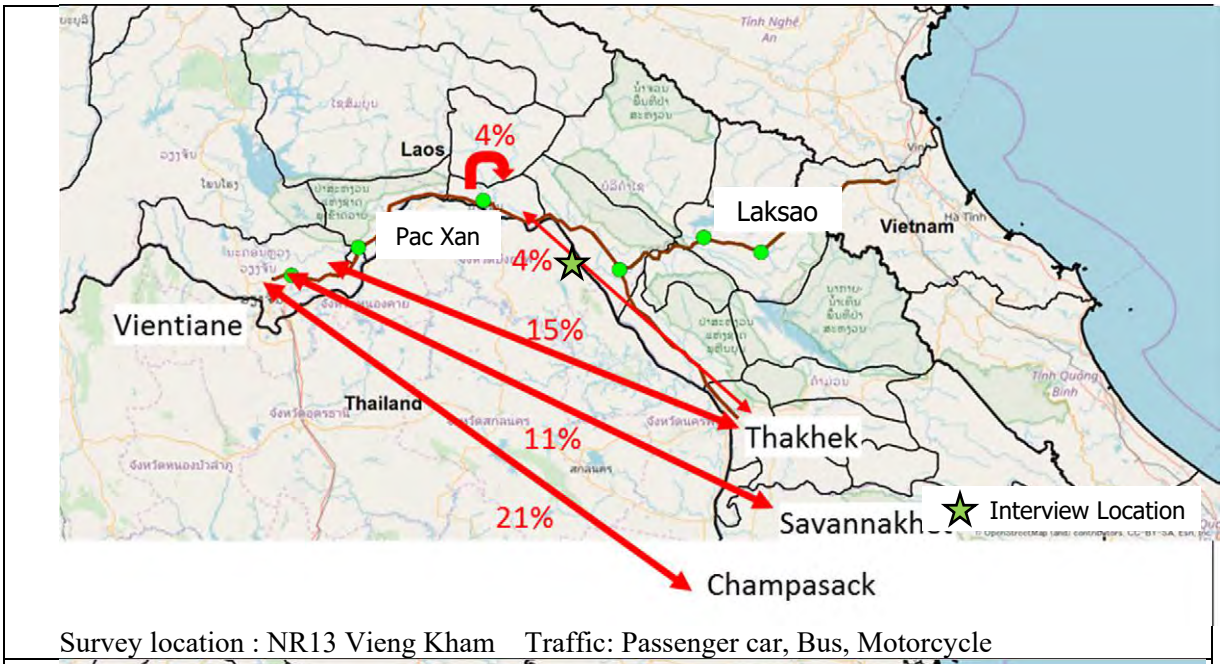
Interview location : NR13 Vientiane Traffic: Passenger car, Bus, Motorcycle



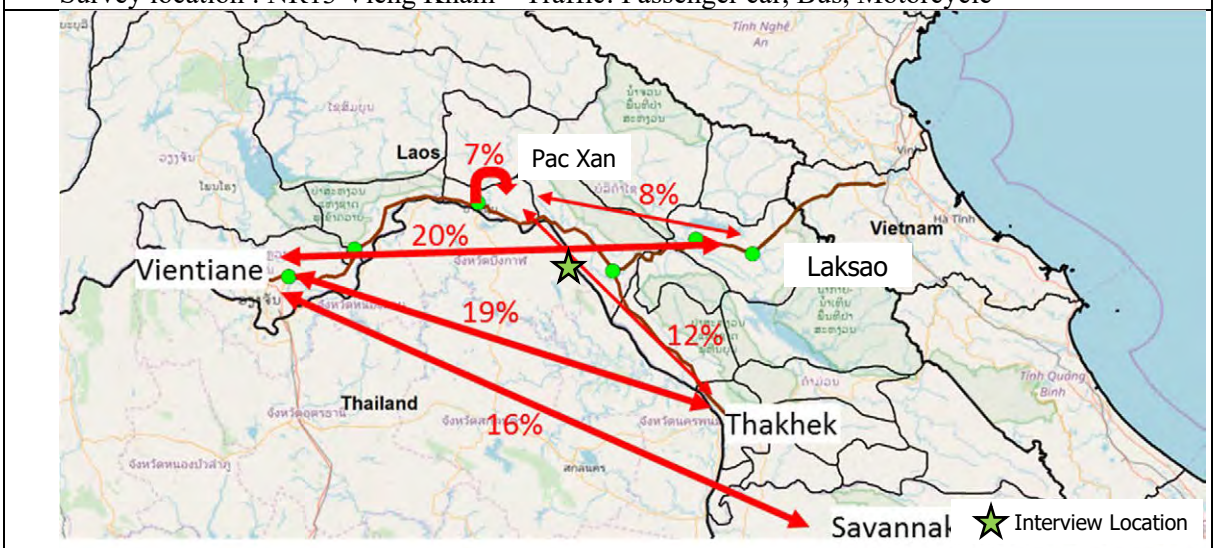
Interview location : NR13 Vientiane Traffic: Truck

Source: JICA Study Team

Figure 7.1.4 Main OD of the Roadside Interview Survey (Interview Location: NR13 Vientiane)



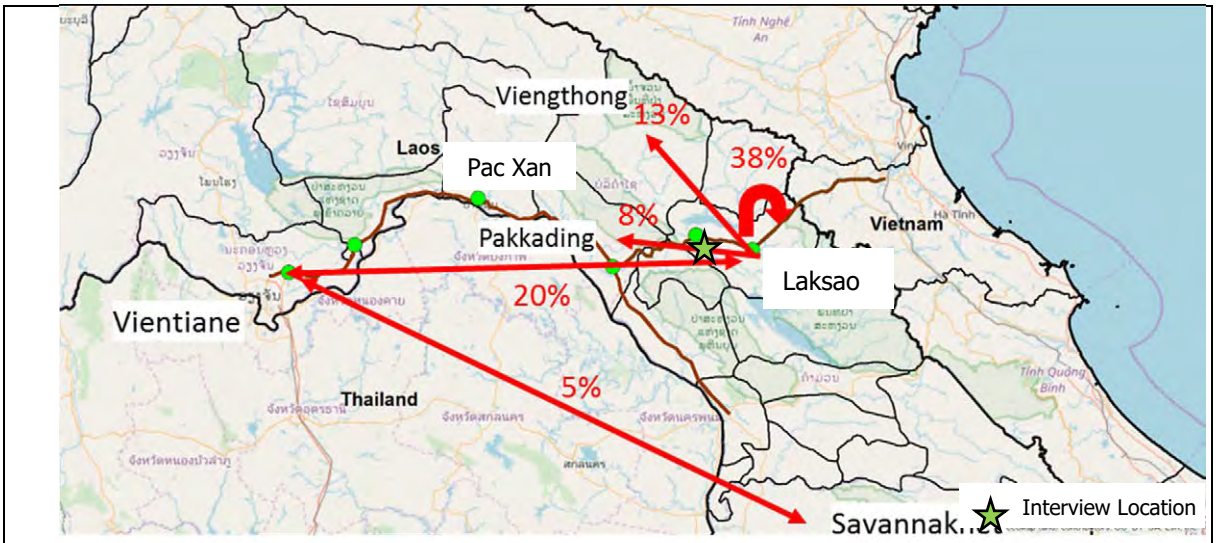
Survey location : NR13 Vieng Kham Traffic: Passenger car, Bus, Motorcycle



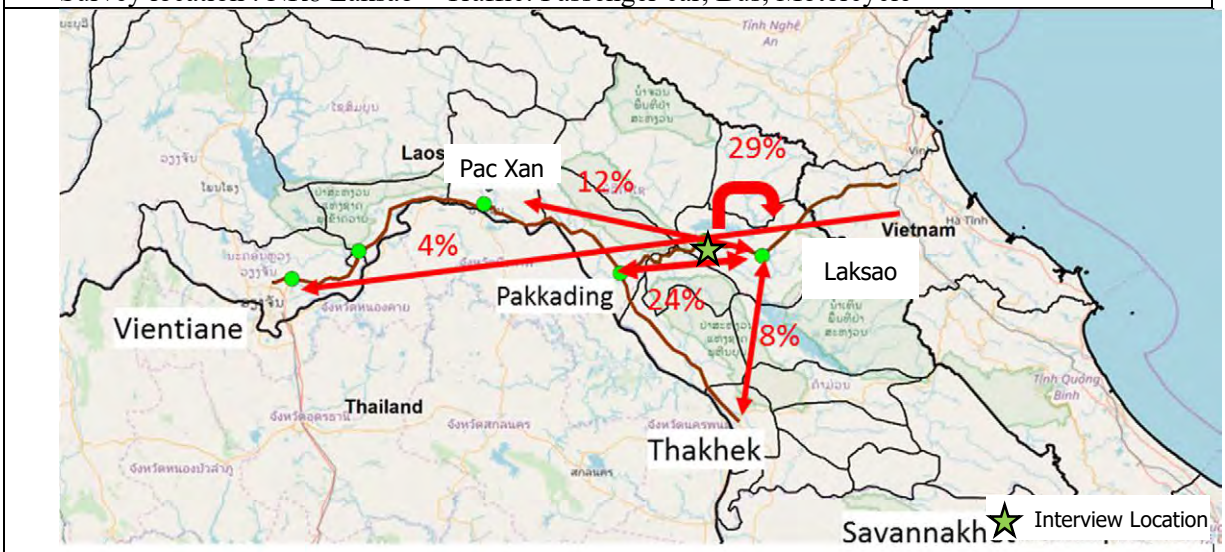
Survey location : NR13 Vieng Kham Traffic: Truck

Source: JICA Study Team

Figure 7.1.5 Main OD of the Roadside Interview Survey (Interview Location: NR 13 Vieng Kham)



Survey location : NR8 Laksao Traffic: Passenger car, Bus, Motorcycle

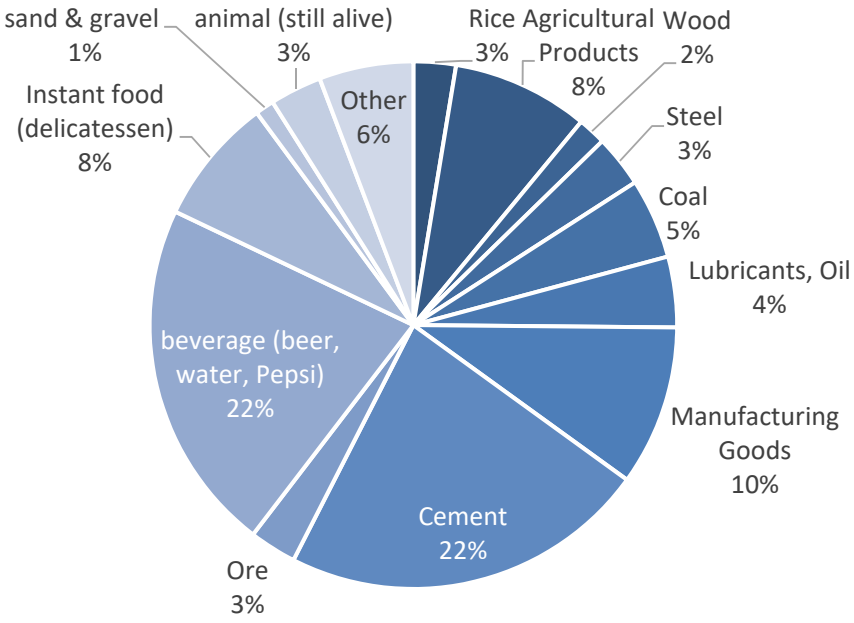


Survey location : NR13 Laksao Traffic: Truck

Source: JICA Study Team

Figure 7.1.6 Main OD of the Roadside Interview Survey (Interview Location: NR 8 : Laksao)

As for the types of freight, beverage, cement and cement materials are among the main products transported (Figure 7.1.7).



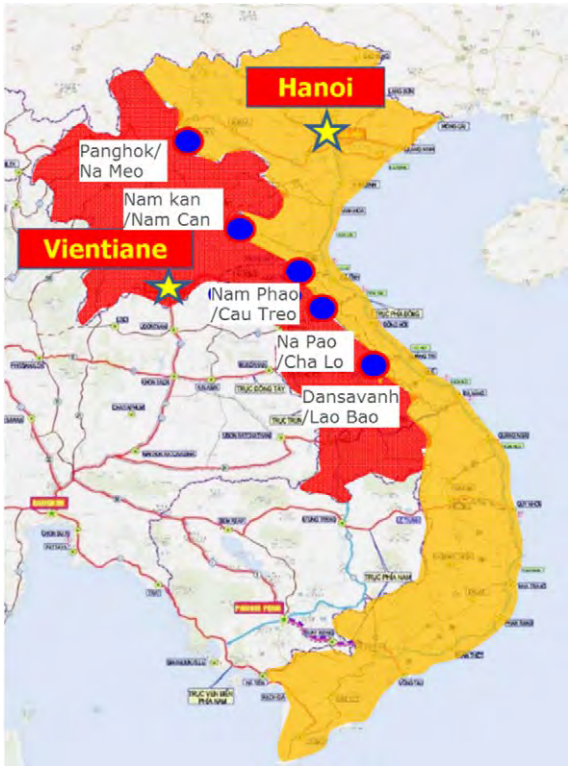
Source: JICA Study Team

Figure 7.1.7 Type of Freight based on the Roadside Interview Survey

7.1.2 International Traffic Flow between Laos and Vietnam

(1) Traffic volume at the border and OD

There are five border crossings between Laos and Vietnam altogether. According to the Pre-F/S report, the total traffic volume passing Laos-Vietnam border gates increased by 10.6% annually from 2005 to 2014.



Source: Hanoi - Vientiane Expressway Project Pre-feasibility study report

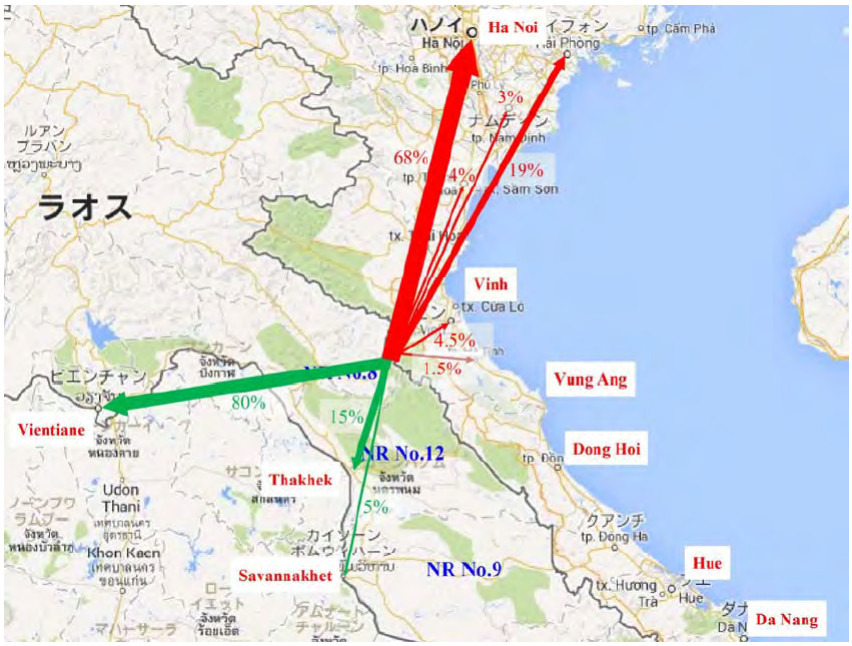
Figure 7.1.8 Location Map of Laos-Vietnam Border

Table 7.1.3 Traffic Volume passing Laos – Vietnam Border Gate in 2014

Year	Border gate					Total
	Na Meo	Nam Can	Cau Treo	Cha Lo	Lao Bao (Densavan)	
Traffic Volume (Unit: PCU/Year)	3,489	39,750	56,721	53,396	49,148	202,504
2005~2014 Growth rate (%/Year)	8.8	9.1	10.2	33.7	4.0	10.6

Source: Ha Noi - Vientiane Expressway Project Pre-feasibility study report

In the "*Project Formation Survey on Road Project in Southeast Asia in 2013*"(JICA, 2013), a roadside interview survey was conducted at the border between Laos and Vietnam on NR8. According to the survey, the OD between Vientiane and Hanoi accounted for 54%, the highest proportion. The second largest traffic was observed between Vientiane and Haiphong, accounting for 15%. It can be seen from the survey that the NR8 has been used as a main road to travel between Vientiane area and Hanoi as well as north of Hanoi



Source: Project formation survey on road project in Southeast Asia in 2013

Figure 7.1.9 Main OD surveyed at NR8

On NR12, the traffic to Vung Ang Port accounted for 65% of the total traffic, and this clearly shows that the NR12 is used as an industrial road to Vung Ang Port.

Source: Project formation survey on road project in Southeast Asia in 2013

Figure 7.1.10 Main OD surveyed at NR12

On NR9, traffic to Da Nang Port accounted for 60% of the total traffic, indicating that the road is used as an industrial road to the Da Nang Port. Traffic to Vung Ang could also be seen, accounted for 6% of the total traffic. On the Laos side, the vehicle heading for Savannakhet occupied about a half.

Source: Project formation survey on road project in Southeast Asia in 2013

Figure 7.1.11 Main OD surveyed at NR9

(2) Trade items at Nam Phao Border

The trade data from the Nam Phao Border show that mineral products are the largest trade items in terms of weight, followed by prepared foodstuffs, beverages and tobacco. In terms of trade value, on the other hand, machinery and mechanical appliances are the largest trade items.

Table 7.1.4 Trade Volume and Value by Items passing through Nam Phao Border (2014)

Items	Trade Weight (kg)	Trade Value (USD)
live animals; animal products	680,321	847,054
vegetable products	45,027,742	10,982,837
animal or vegetable fats and oils and their cleavage products	1,309	1,257
prepared foodstuffs; beverages, spirits and vinegar; tobacco and manufactured tobacco substitutes	160,496,623	97,937,109
mineral products	210,410,680	65,759,298
products of the chemical or allied industries	2,579,395	2,584,563
plastics and articles thereof; rubber and articles	5,512,254	2,228,830
raw hides and skins, leather, fur skins and articles	576,950	1,291,924
wood and articles of wood	12,619,087	7,132,856
pulp of wood or of other fibrous cellulosic material	871,296	394,317
textiles and textile articles	5,918,919	14,447,507
footwear, headgear, umbrellas, sun umbrellas, walking-sticks, seat-sticks, whips, riding-crops and parts	620,403	1,535,000
articles of stone, plaster, cement, asbestos, mica or similar materials	9,224,160	1,568,789
base metals and articles of base metal	35,441,781	23,773,116
machinery and mechanical appliances	41,061,034	117,358,381
vehicles, aircraft, vessels and associated transport equipment	129,491	43,754,092
optical, photographic, cinematographic, measuring, checking, precision, medical or surgical instruments and apparatus	256,166	2,414,160
miscellaneous manufactured articles	2,076,688	9,137,541
works of art, collectors' pieces and antiques	63	36,873

Source: summarized by JICA Study Team based on the data obtained from Laos Customs Department

The Nam Phao Border trade data confirms the existence of trade not only between Vietnam and Laos but also between China and Laos, and between China and Vietnam (Table 7.1.5). The main trade items transported from Vietnam to Laos include roots and tubers including edible vegetables and cassava, salt, sulfur, stones, plaster, lime and cement, wood, wooden products and charcoal.

Table 7.1.5 Trade Value passing Nam Phao Border (2014)

(Value USD)	China	Cambodia	Laos	Thailand	Vietnam
China	0	0	86,031,247	0	59,442
Cambodia	0	0	0	0	0
Laos	0	0	0	0	21,492,314
Thailand	0	0	69,313	17,455	99,845,785
Vietnam	0	0	120,892,437	0	0

Source: summarized by JICA Study Team based on the data from Laos Customs Department

7.2 Methodology of Traffic Demand Forecast

7.2.1 Basic Policy

Traffic demand forecast in this study is done by using JICA STRADA, and applying the four-step method. The Hanoi-Vientiane expressway is expected to be used as an industrial road that serves for the transport of international freight because it is a cross-border expressway linking two countries. The forecasting of international freight movement requires to reflect trade data, and thus its indicators are different from that of the passenger traffic. Therefore, passenger traffic and freight traffic are separately forecast. The year 2025 and 2035 are set as the prediction year for the annual traffic demand forecast in this study so that the result of this study and that of the existing Pre-F/S can be compared on the same ground.

A comparison of the method of traffic demand forecast and other surveys is shown below (Table 7.2.1).

Table 7.2.1 Comparison of Traffic Demand Forecast Method

	Creating an OD table	Estimating method		Consideration of other road development plan	Consideration of generated trips from the regional development	Considering the railway connecting Vientiane and Vung Ang	Expressway conversion rate
		Estimate by trend	Four-step models				
Pre-F/S	×[1]	✓[2]	×	×	×	×	×
JICA Study Team	✓	×	✓	✓	✓	✓	✓
NR 8(KOICA)	✓	×	✓	✓	?	×	×

Source: JICA Study Team

7.2.2 Traffic Demand Forecast Procedure

(1) Passenger traffic

Based on the results of traffic survey and traffic data from PTRI, the OD of the passenger traffic using the target route is estimated for the year 2018. The target area for the forecast is limited to the vicinities along the Hanoi-Vientiane expressway.

Next, distribution traffic was calculated from the created OD table by using gravity model. The existing OD was then calibrated according to the result of roadside interview survey and the traffic volume data. With reference to these data, correlation coefficients are checked by the Study Team.

Future generated and attracted traffic are estimated from the growth rate of the number of registered vehicles in each province. The number of registered vehicles has been recorded by Lao Statistics Bureau in an interval of few years. Based on this, the future number of registered vehicles is estimated using population data and GDP data as explanatory variables.

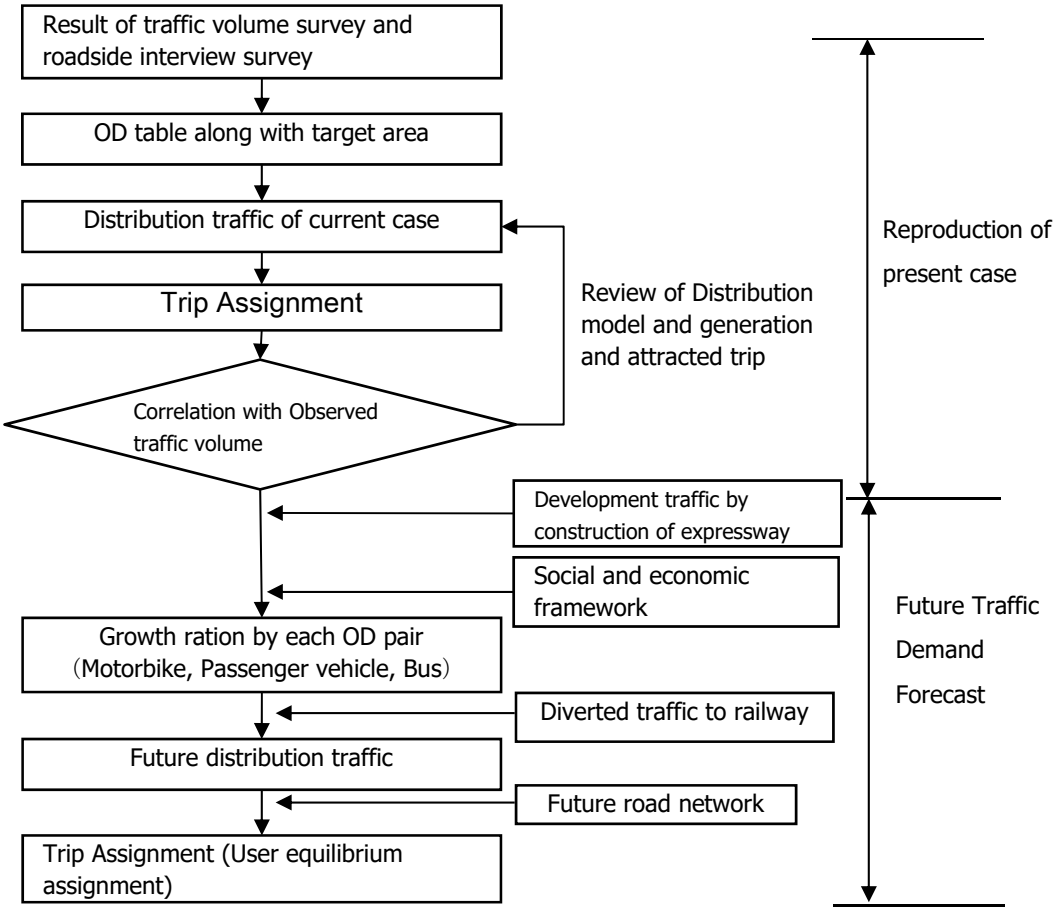
Future distribution of traffic was estimated by the method of average growth factor. Average growth factor was calculated based on the growth rate of traffic volume in each traffic zone. Current trip model was estimated by the gravity model, but gravity model cannot incorporate the time required for customs clearance at the border gate. Therefore, the average growth rate method, in which the current distribution tendency is followed, was adopted.

[1] Utilize traffic volume of the target route

[2] Estimate the future traffic volume from socioeconomic indicators

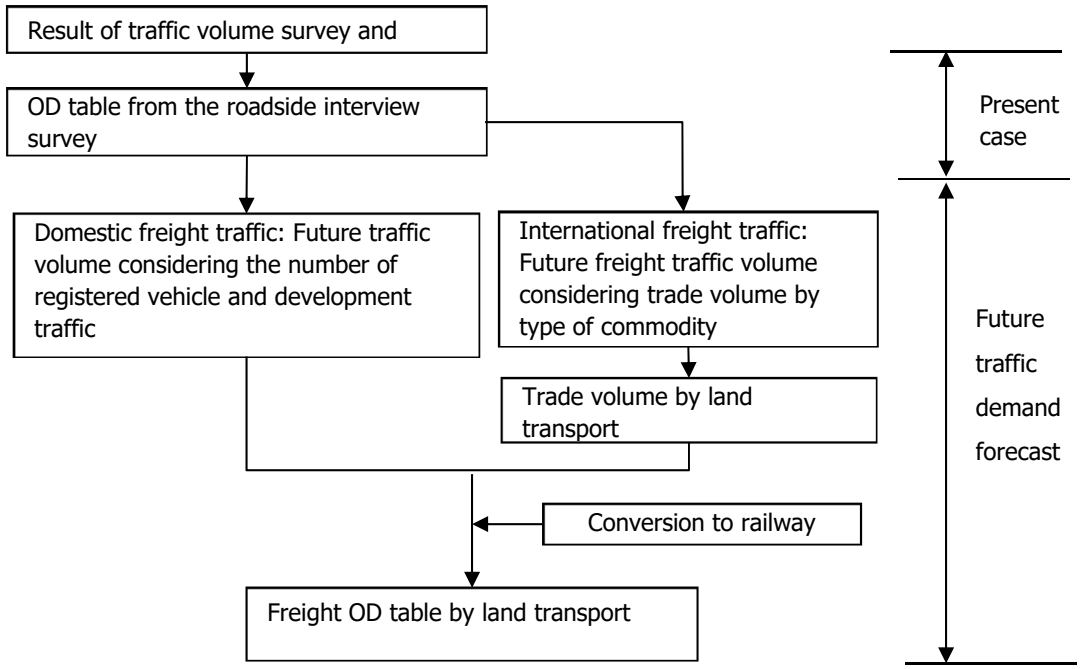
(2) Freight traffic

As for freight traffic, domestic traffic and international traffic are separately predicted. The growth rate of domestic freight traffic was set taking into account the growth rate of registered truck volume and generated traffic by industrial development along the planned route. The future growth rate of truck is predicted by creating a model in which GDP is used as an explanatory variable. On the other hand, international freight traffic between countries was estimated based on future trade volume from the existing trade statistics. The target area of freight transport includes the entire Indochina peninsula in addition to the area along the Hanoi-Vientiane expressway, since the expressway is expected to be used as an industrial road.



Source: JICA Study Team

Figure 7.2.1 Flow of Passenger Traffic Demand Forecast



Source: JICA Study Team

Figure 7.2.2 Flow of Freight Traffic Demand Forecast

7.2.3 Target Area of Traffic Demand Forecast

Target areas for passenger traffic and freight traffic are differently set. For passenger traffic, the target area covers the area along the Hanoi-Vientiane expressway; the Laos side includes Borikhamxay Province, Khammouan Province and Vientiane Prefecture, while in the Vietnam side includes Ha Tinh and Nghe An provinces. Meanwhile, for freight traffic, since the Hanoi-Vientiane expressway is expected to be a part of distribution network across neighboring countries, the target area is expanded to the whole Indochinese peninsula including Laos, Vietnam, Thailand, Myanmar, Cambodia and China. The traffic zones are shown in the table below.

Table 7.2.2 Traffic Zones using for Traffic Demand Forecast

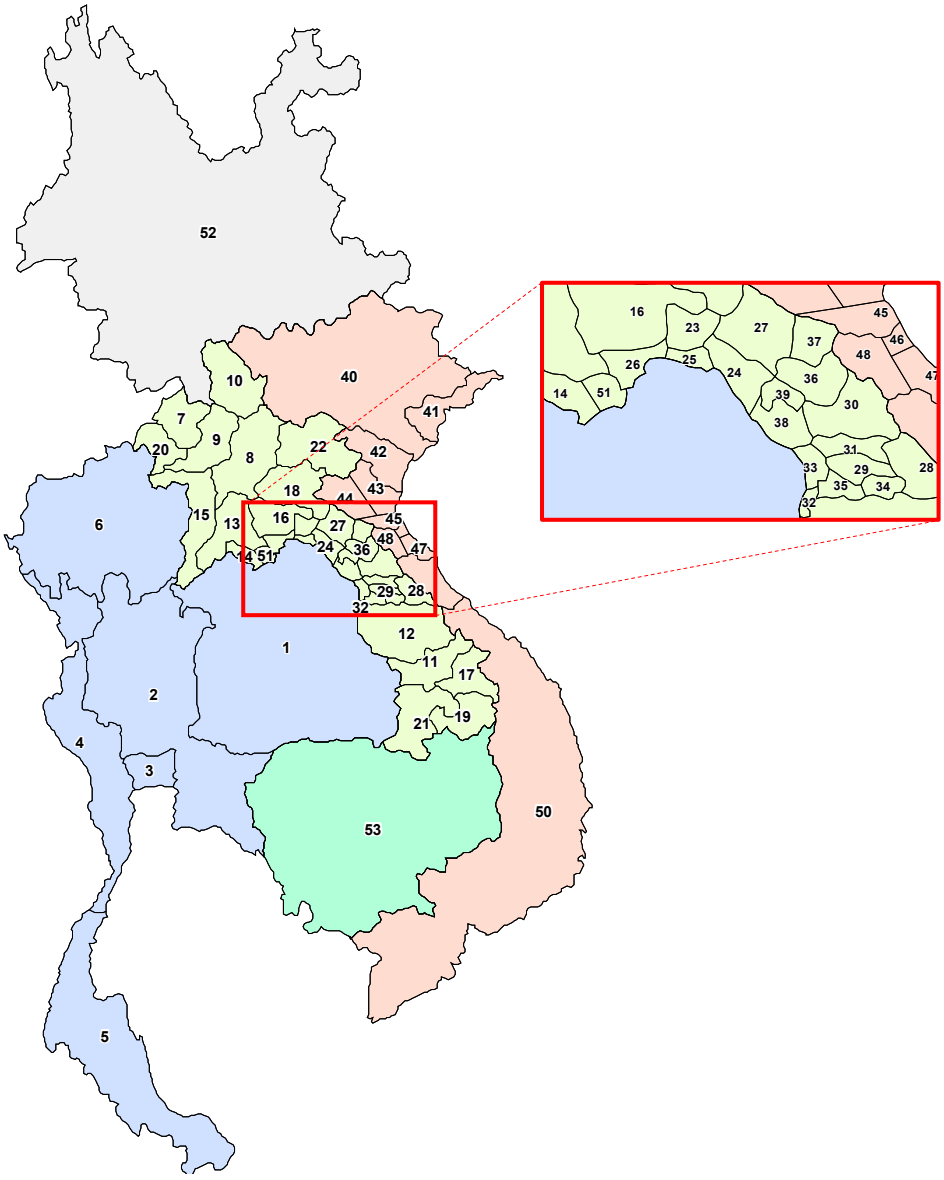
Zone	Zone Name	Country
1	North East Area of Thailand	Thailand
2	Middle Area of Thailand	Thailand
3	Bangkok	Thailand
4	West Area of Thailand	Thailand
5	South Area of Thailand	Thailand
6	North Area of Thailand	Thailand
7	Louang Namtha	Laos
8	Louangphrabang	Laos
9	Oudomxai	Laos
10	Phongsali	Laos
11	Saravan	Laos
12	Savannakhet	Laos
13	Vientiane	Laos
14	Vientiane [prefecture]	Laos
15	Xaignabouri	Laos
16	Xaisomboun	Laos
17	Xekong	Laos
18	Xiangkhoang	Laos
19	Attapu	Laos
20	Bokeo	Laos

Zone	Zone Name	Country
28	Khammuane	Laos
29	Khammuane	Laos
30	Khammuane	Laos
31	Khammuane	Laos
32	Khammuane	Laos
33	Khammuane	Laos
34	Khammuane	Laos
35	Khammuane	Laos
36	Borikhamsai-6	Laos
37	Borikhamsai-7	Laos
38	Khammuane-8	Laos
39	Khammuane-9	Laos
40	Hà Nội	Laos
41	Hải Phòng	Vietnam
42	Thanh Hóa	Vietnam
43	Nghe An 1	Vietnam
44	Nghe An 2	Vietnam
45	Vinh	Vietnam
46	Ha Tinh tp	Vietnam
47	Ha Tinh 1	Vietnam

Zone	Zone Name	Country
21	Champasak	Laos
22	Houaphan	Laos
23	Borikhamsai-1	Laos
24	Borikhamsai-2	Laos
25	Borikhamsai-3	Laos
26	Borikhamsai-4	Laos
27	Borikhamsai-5	Laos

Zone	Zone Name	Country
48	Ha Tinh 2	Vietnam
49	Quang Binh	Vietnam
50	South of Vietnam	Vietnam
51	Vientiane 2	Laos
52	Kunming	China
53	Phnom Penh	Cambodia

Source: JICA Study Team



Source: JICA Study Team

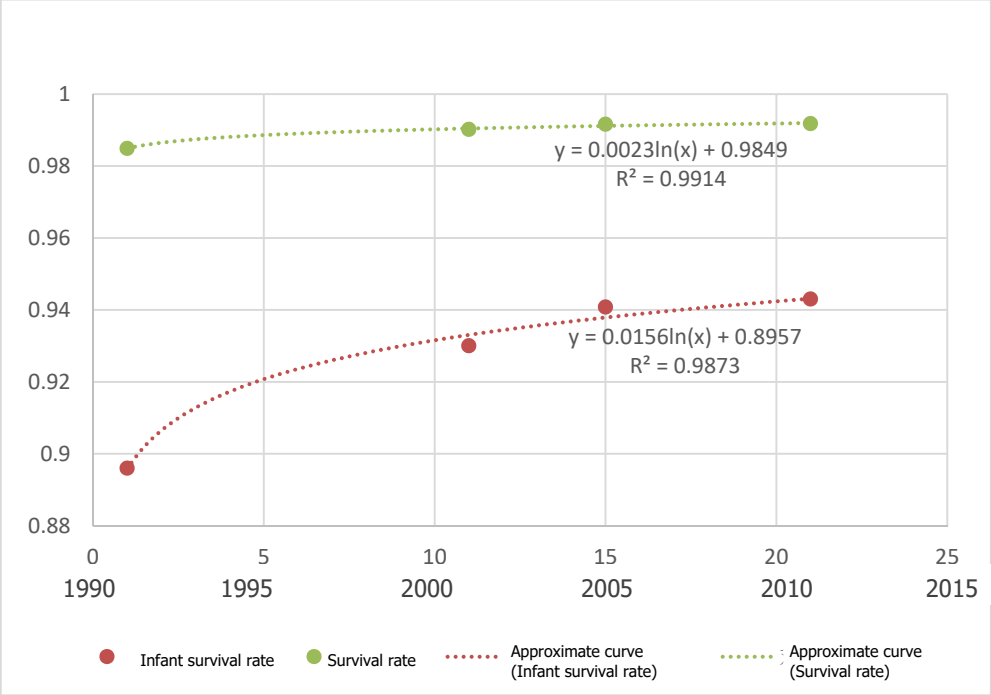
Figure 7.2.3 Traffic Zone of Passenger Traffic and Freight Traffic

7.2.4 Socio Economic Framework (Population, GDP, Development along Expressway)

(1) Population

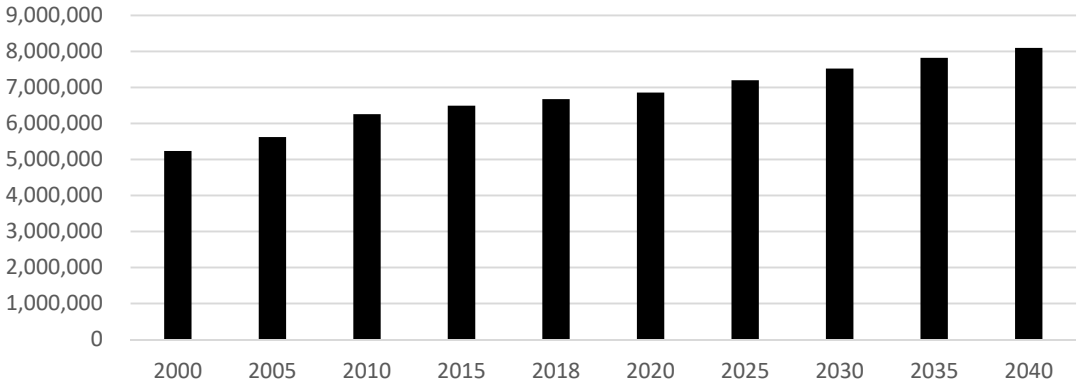
Due to the lack of future population data in Laos, JICA Study Team projected the future population by method of Cohort Factor using the official population statistics from 2005 to 2015 compiled by the Lao Statistics Bureau. The cohort factor method is for forecasting future population by assuming future natural variation (birth and death) and net migration (migration and departure) for each age group. Based on historical statistics, the birthrate, mortality rate and survival rate in each age group are calculated by a logit model and the future values are predicted. Regarding the net migration, it is necessary to take into consideration the effect of roadside development. Therefore, the net migration value is calculated by reflecting the expected population increase due to development.

The predicted population is shown in Figure 7.2.5. The forecasted population is organized by province and used for traffic demand forecast.



Source: JICA Study Team

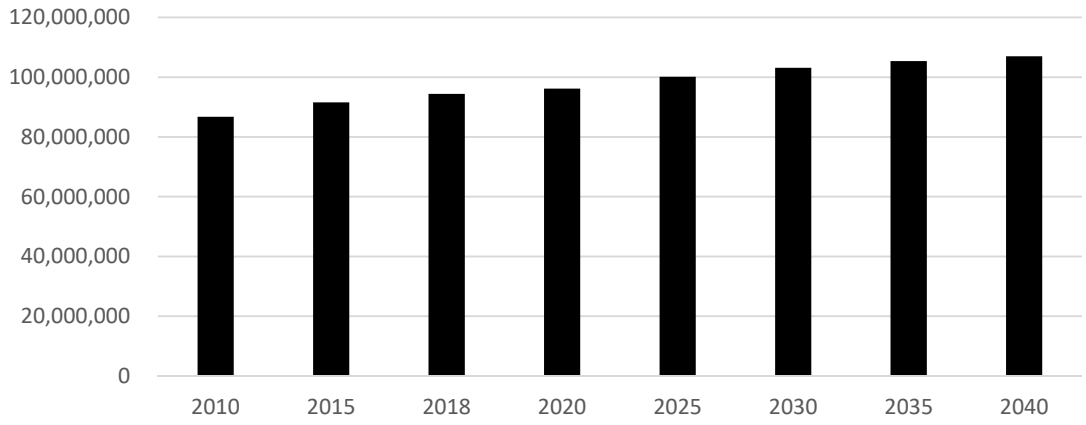
Figure 7.2.4 Trend of Crude Survival Rate and Infant Mortality Rate



Source: JICA Study Team

Figure 7.2.5 Population Projection in Laos

Regarding the future population in Vietnam, national population is projected until the year 2049 and provincial population is projected until the year 2034 by the General Statistics Office of Vietnam. Provincial population after 2035 was estimated with reference to the projection of national population (Figure 7.2.6).



Source: Vietnam Statistic Bureau

Figure 7.2.6 Population Projection in Vietnam

(2) GDP

The future values of GDP for both Laos and Vietnam are calculated by the Study Team. In both countries the real GDP figures are estimated based on 2010 USD constant prices.

Table 7.2.3 shows the GDP estimation from existing materials of Laos. In *"The Final Report of Comprehensive Study on Logistics System in Lao People's Democratic Republic"* (JICA, 2011), the real GDP growth rate in the social economic framework is set as follows: 7.5% between 2011 and 2015, and 7.0% between 2015 and 2025. In *"Final report of Preparatory study for improvement of roads and bridges in the southern region in Laos"* (JICA, 2010), economic growth rate is set as 6% until 2010, 7.5% between 2011 and 2020, and 6.5% between 2015 and 2030 for the economic growth scenario.

Table 7.2.3 Average GDP Growth Rate in Existing Reports (Laos)

（Unit：%）

	2010	2011-20	2021-25	2025-30
Final report of Preparatory study for improvement of roads and bridges in the southern region in Laos	6.0%	7.5%	7.0%	6.5%
Pre-F/S Report	7.8%	7.5%	-	-

	2010	2011-15	2015-25	-
The comprehensive study on logistics system in Lao People's Democratic Republic	-	7.5%	7.0%	-

Source: Final report of Preparatory study for improvement of roads and bridges in the southern region in Laos, Pre-F/S Report, Final Report of the comprehensive study on logistics system in Lao People's Democratic Republic

Based on the information in each report mentioned above, the following numerical values are set as the GDP growth rate for demand forecast in this study.

Table 7.2.4 Average Annual GDP Growth Rate of Laos

	2018-2025	2026-2035	2036-2040
Annual Average GDP Growth	7.0%	6.5%	6.0%

Source: JICA Study Team

Regarding the real GDP in Vietnam, there is no past forecast data after the year 2022 according to the Vietnam government, the IMF or the Pre-F/S report. On the other hand, *"Study for the Formulation of High Speed Railway Project on Hanoi - Vinh and Ho Chi Minh - Nha Trang"* (JICA, 2010) sets the growth rate by the year 2030 as follows.

Table 7.2.5 Average Annual GDP Growth Rate in Existing Reports (Vietnam)

(Unit：%)

	2010	2011-20	2021-25	2025-30
IMF	6.4%	6.1%	-	-
North-South Expressway Master Plan	6.0%	7.5%	7.0%	6.5%
Pre-F/S Report	7.8%	7.5%	-	-
National	6.4%	6.2%	-	-

Source: IMF, North-South Expressway Master Plan, Hanoi – Vientiane Expressway Project Stage: Pre-Feasibility Study Report General Report, General Statistics Office of Vietnam

In consideration of the above forecast values, the GDP growth rate is set as follows for this study.

Table 7.2.6 Average Annual GDP Growth Rate of Vietnam

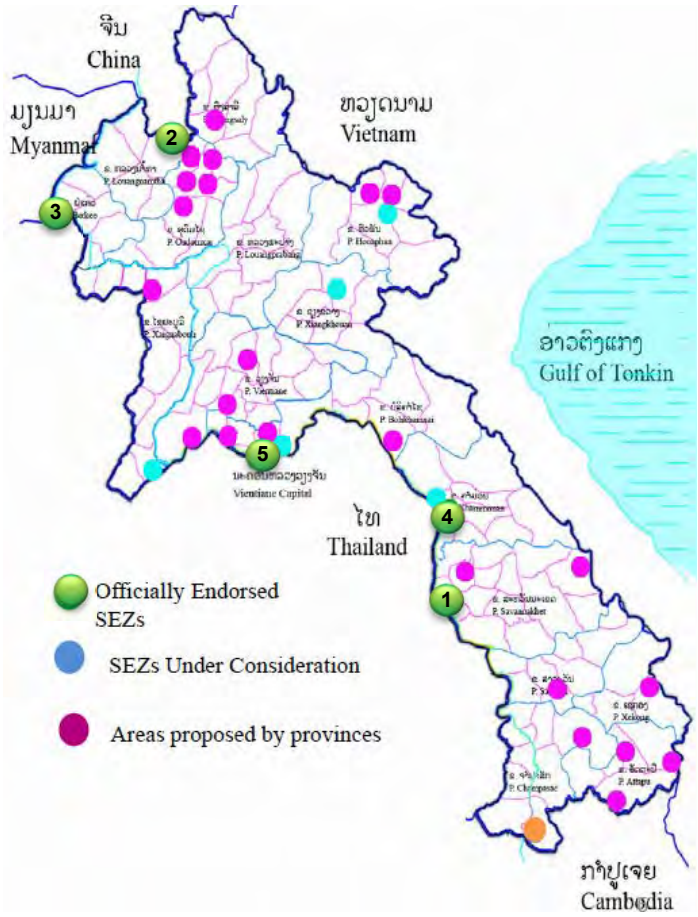
	2018-2025	2026-2035	2036-2040
Annual Average GDP Growth	6.2%	5.7%	5.2%

Source: JICA Study Team

(3) Development strategy along the expressway

To forecast traffic demand in the future, it is necessary to set road network and population based on future development plans. Therefore, SEZ plan and railway development plan are taken into account in this study. On the other hand, while the Hanoi-Vientiane expressway is expected to contribute to roadside development, there is no specific plan regarding roadside development.

Given the situation, the Study Team made original assumptions on this matter. The traffic generation and attraction of the SEZ were estimated based on the development area size and location according to existing documents. As of now, there are five SEZs officially being developed in Laos, and in addition, several other SEZs are planned and proposed. Figure 7.2.7 shows the distribution of SEZs including those approved by the Government of Laos. With reference to *"Preparatory Survey on Industrial Zone Development in the Lao People's Domestic Republic"* (JICA, 2010), the population increase per ha of development area is calculated.



Source: Japan ASEAN Center HP

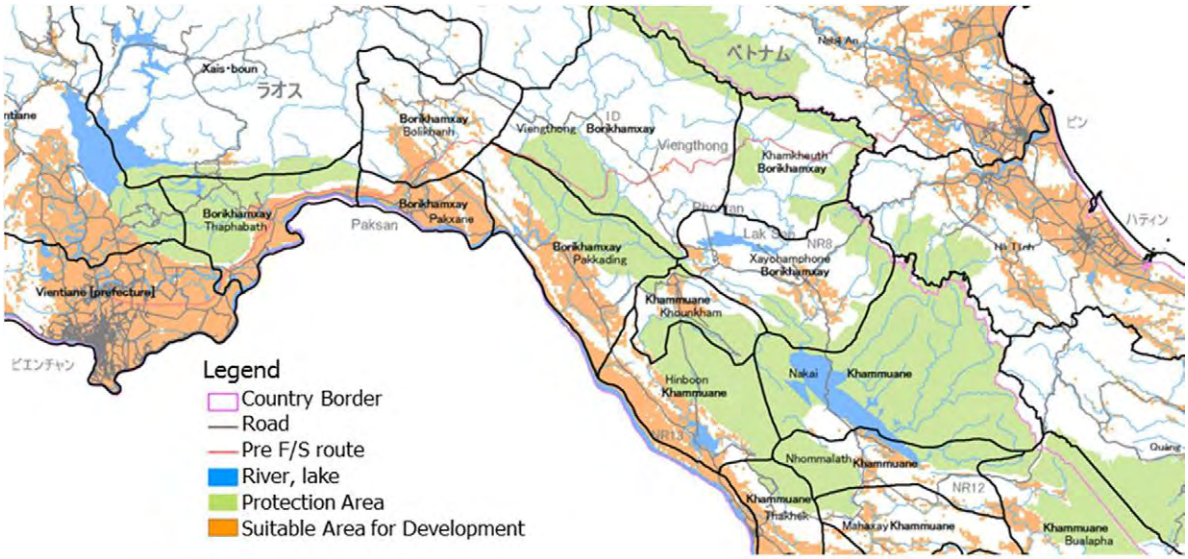
Figure 7.2.7 Planned SEZ Location Map

Table 7.2.7 Planned SEZ

SEZ	Province	Area Size (ha)
Savan-Seno Special Economic Zone (Lao government - Malaysian investor)	Savanakhet province	954
BotenSpecial Economic Zone (China)	Luangnamtha province	1,640
SarmliemDen KhamSpecial Economic Zone (China)	Bokeo province	3,000
PhouKieuNakhonSpecific Economic Zone (Lao)	Khammouan province	4,850
Vientiane Nonthong Industry and Trading SEZ	Vientiane province	110

Source: Japan ASEAN Center HP

In order to reflect the traffic from the new development along the Hanoi-Vientiane expressway, developable land is identified. The main conditions for identifying the developable land are the future development potentials of the areas and the suitability of the terrain conditions for development. Figure 7.2.8 shows the distribution of developable land.



Source: JICA Study Team

Figure 7.2.8 Distribution of Developable Land

Table 7.2.8 Developable Land by Province

	Province	Area size（km2）
Laos	Vientiane	2,525
	Borikhamxay	2,310
	Khammouane	4,523
Vietnam	Nghe An	1,245
	Ha Tinh	1,542

Source: JICA Study Team

The identified developable land is the flat or rolling terrain areas along the Pre-F/S route and along NR8 where industrial parks can be constructed.

The developable land was classified into three groups according to land use: industrial land, commercial land and residential land based on the result of *"Preparatory Survey on Industrial Zone Development in the Lao People's Domestic Republic"* (JICA, 2010), where the area size necessary for each land use has been estimated.

Table 7.2.9 Land Use and Area in Vientiane Industrial Zone

Industrial Zone	Area (ha)		Residence Zone	Area (ha)	
Sales site (for tenant companies)	96.50	74.2%	Residence	5.04	50.4%
Industrial park center	7.11	5.5%	Park, Amenity	0.9	9.0%
Adjustment reservoir	1.93	1.5%	Technical training school	0.95	9.5%
Substation facility	1.30	1.0%	Sewage treatment plant	0.94	9.4%
Road (including drainage)	20.79	16.0%	Road (including drainage)	1.82	18.2%
Slope, buffer green	2.51	1.9%	Slope, buffer green	0.35	3.5%
Total	130.14	100.0%	Total	10	100.0%

Source: Preparatory Survey on Industrial Zone Development in the Lao People's Domestic Republic

It is necessary to consider the generated traffic volume based on the calculated land use area. Regarding the trips generated and attracted by industrial land uses, JICA Study Team referred the core industrial park plan design standard (Japan Regional Development Corp), in which the number of workers per ha is estimated around 82 people. Based on this number of workers, JICA Study Team

estimated the generated traffic volume taking into consideration the commuting and business trips by workers and the freight traffic.

Regarding the traffic generated by the residential land uses, the generated traffic volume was estimated based on the above-mentioned workers and their families who reside in the development area. The number of workers and their families were estimated based on the average number of households obtained from the Lao Statistical Bureau. As for traffic of commercial land use, JICA Study Team considered trips by visitors to commercial facilities and trips by employees.

In addition, the modal share provided in the "*Feasibility Study for the Railway Link from Vientiane in the Laos to Vung Ang in Vietnam*" (KOICA, 2017) was adopted.

7.2.5 Reproduction of the Present Traffic Condition

From the results of the roadside interview survey and the traffic volume survey, the OD table of passenger and domestic freight traffic were created for the present condition.

Firstly, passenger OD table was summarized based on the result of roadside interview survey. However, the result of the roadside interview survey showed only sampled OD pairs. The Study Team applied a gravity model from the prepared OD table to create a complete OD table in the target area. The OD table on the Vietnam side was also estimated by applying the assumed gravity model. The OD table is divided into four types of motorcycles, ordinary passenger cars, buses and trucks. Vehicles were converted into PCU (Passenger Car Unit) by using conversion factors provided in the ASEAN Highway Standard (Table 7.2.10). In addition, since gravity model cannot takes into consideration the customs clearance time and fee, border crossing traffic volume was referred from "*Feasibility Study for the Railway Link from Vientiane in the Laos to Vung Ang in Vietnam*" (KOICA, 2017) and the Pre-F/S report to calculate the distribution pattern.

As for international freight OD table, trade volumes from 2013 to 2014 were summarized from customs clearance information at Cau Treo, then the elasticity of trade volume with respect to the GDP growth was estimated. To convert the estimated trade volume to traffic volume, the load amount by item obtained from roadside interview were referred. The Study Team assumed that the present OD pattern of international freight flows is the same as 2014 OD pattern. The target countries are China, Vietnam, Cambodia, Laos and Thailand, which are major countries of the international cargo transport passing through Laos. Since these inter-country trade volumes accounted for 83% of the total trade amount that passed through Laos in 2014, the selection of the target countries is judged to be appropriate.

Regarding domestic freight traffic, OD table was prepared based on the roadside interview survey with a methodology similar to that of the passenger traffic, and distribution traffic was estimated by gravity model.

Table 7.2.10 PCU Factor

Type of Vehicle	PCU factor
Motorcycle	0.5
Passenger Car, Van	1
Bus	2
Truck	2

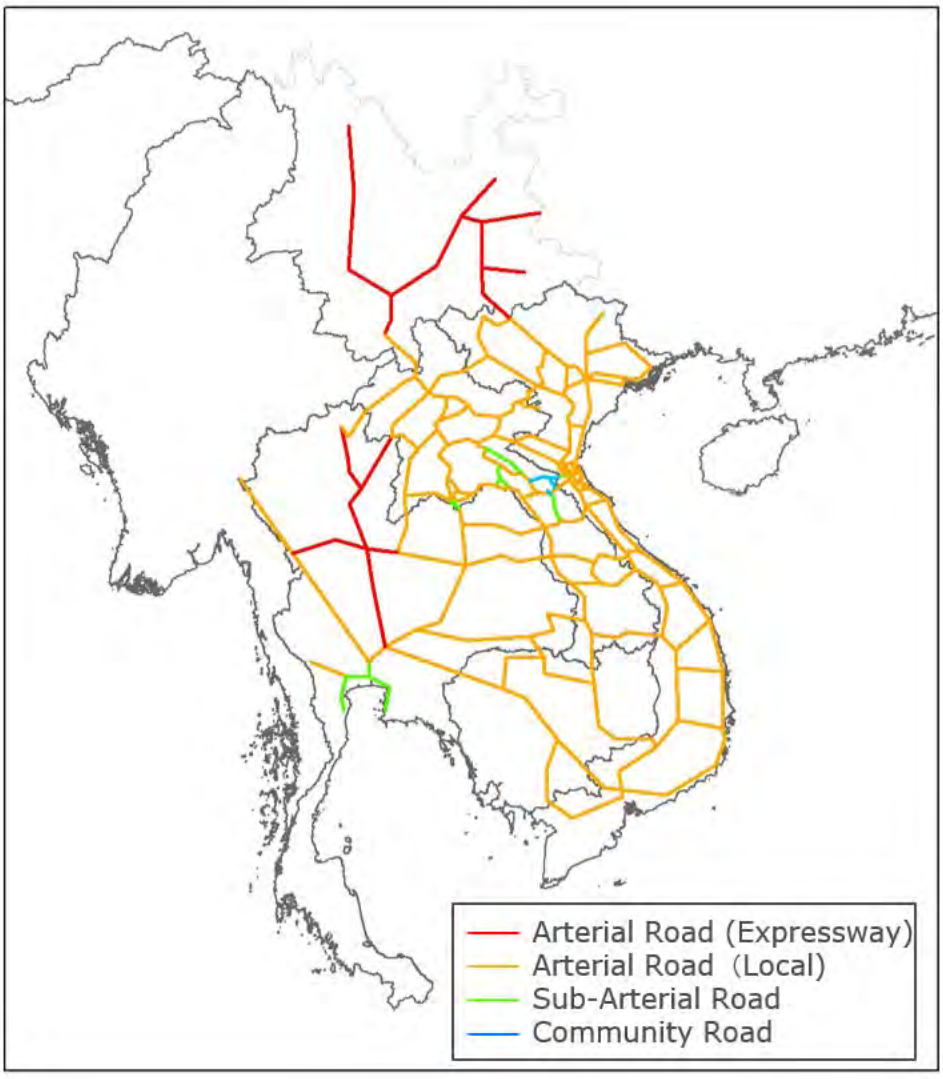
Source: JICA Study Team

The number of lanes and the speed limit in the target area were set based on the information gathered by the field survey, and the road capacity was decided for each road. The road capacity was converted to daily traffic volume with a peak ratio of 8.6% obtained from the traffic survey.

Table 7.2.11 Design Speed and Traffic Capacity for Road Classification

Road Classification	Design Speed (km/h)	Pcphpl (peak capacity per hour per lane)	Number of lanes	Daily Traffic Capacity (PCU)
Arterial Road (Expressway)	100	1,500	4	46,000
Arterial Road（Local)	80	850	2	14,000
Sub Arterial Road	60	680	2	10,000
Community Road	40	500	2	8,000

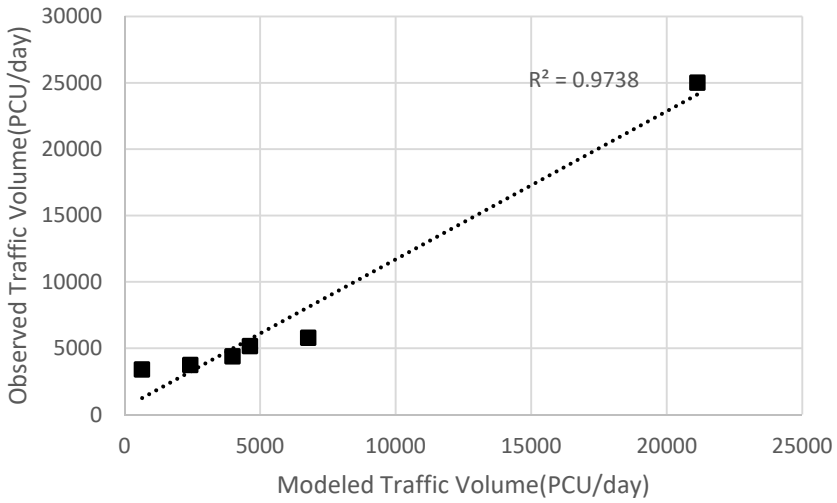
Source: JICA Study Team set based on Highway Capacity Manual



Source: JICA Study Team

Figure 7.2.9 Road Network in Present Case (2018)

The JICA Study Team applied a traffic assignment model using the present OD table and the present road network. To match assignment result and actual traffic volume, the OD table was calibrated. Actual traffic volume was also obtained from Road Maintenance System (RMS) maintained by PTRI and OD table of KOICA Railway Report and traffic volume survey. Finally, a high correlation was observed as shown in Figure 7.2.10.



Source: JICA Study Team

Figure 7.2.10 Reproduction Result of Present Case (2018)

7.3 Result of Traffic Demand Forecast

7.3.1 Forecast Case

Traffic demand was forecasted for a high growth case, in which roadside development of Hanoi-Vientiane expressway is progressing, and a low growth case in which roadside development is sluggish.

In the low growth case, it is assumed that the economy of the area along the Hanoi-Vientiane expressway will grow at the same rate as the national average real GDP growth rate. On the other hand, in the high growth case, the economic growth rate of the area along the Hanoi-Vientiane expressway is assumed to be higher than that of the national average GDP.

Specific growth rates were set with reference to the GRDP growth rate of Vientiane City, as described in the "*Final Report on The Project for Urban Development Master Plan Study in Vientiane Capital*" (JICA, 2011). The GRDP growth rate of Vientiane capital city, which is higher than that of the entire Laos, is considered for the future development of the industrial parks. For the middle growth scenario, the "*Final Report on The Project for Urban Development Master Plan Study in Vientiane Capital*" (JICA, 2011) adopted an annual average GDP growth rate of 8.0% between 2010 and 2030 considering the development of logistic parks and industrial parks. In addition, regarding the social increase in population aroused by the roadside development, different values were used for both high growth case and low growth case. The middle growth scenario described in the Urban Development Master Plan is a scenario that assumed Vientiane City would implement the existing economic policies and population will also increase in line with the future vision determined by Vientiane City.

Furthermore, difference of road network development was also considered in the traffic demand forecast. The adopted forecast case is corresponded to the expressway development plan proposed in the previous chapter, and totally five cases were prepared, four with the expressway alternatives and one without the Hanoi-Vientiane expressway construction.

Table 7.3.1 Forecast Cases

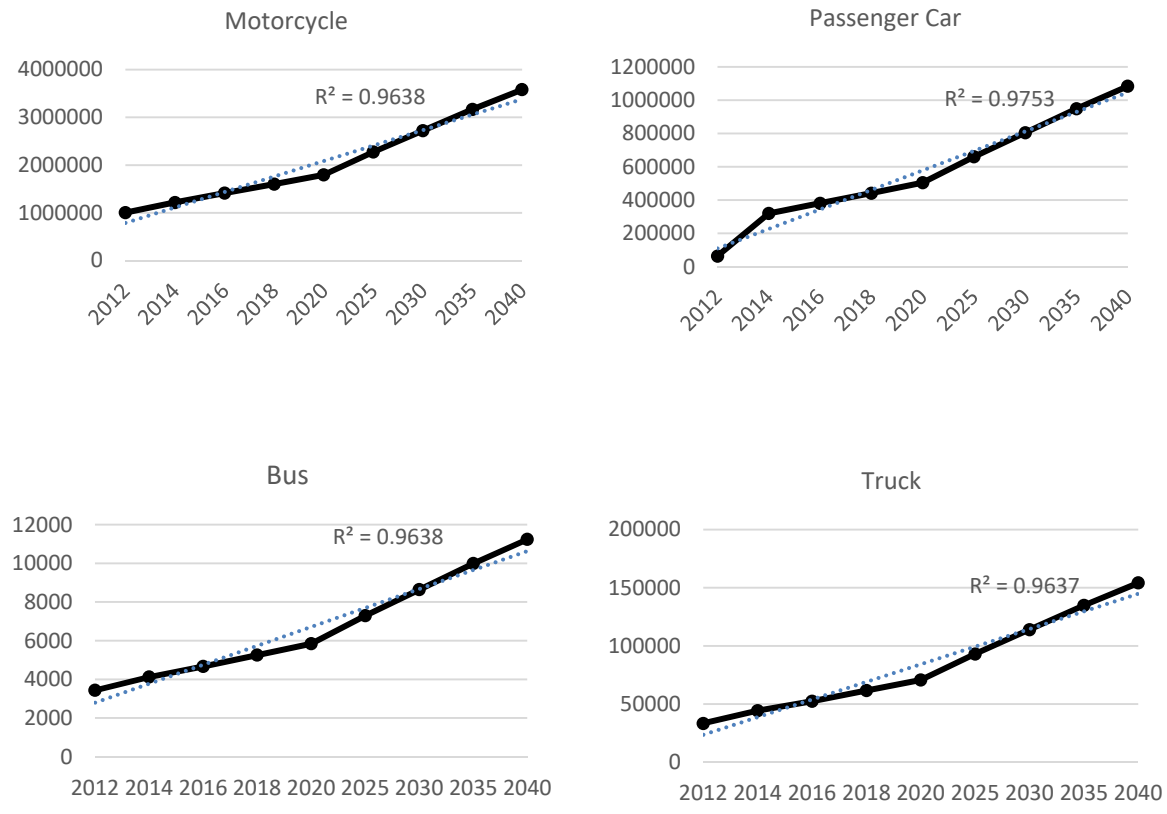
Alternative	Expressway Route	Economic Growth	
		High Growth Case	Low Growth Case
1	Pre-F/S Route	✔	—
2	Parallel route of NR8	✔	✔
3A	Parallel route of NR8 and Pre-F/S route (1)	✔	—
3B	Parallel route of NR8 and Pre-F/S route (2)	✔	—
4	Without development	—	✔

Note: Low growth case was calculated in only Alt.2 to analyse the impact of regional development.
Source: JICA Study Team

7.3.2 Future Traffic Generation and Attraction

(1) Passenger traffic and domestic freight traffic

In estimating the future traffic generation and attraction, JICA Study Team calculated the logit model based on the growth rate of the population and the number of registered cars. Furthermore, to calculate the number of registered vehicles (motorcycles and passenger cars and buses), the province population and the GDP growth rate are used as explanatory variables, and for trucks the growth rate of GDP is used as an explanatory variable. Estimated model is shown in the following figure.



Source: JICA Study Team

Figure 7.3.1 Forecast Result of Number of Registered Vehicle in Laos

Assuming that the traffic will show a distribution pattern similar to that of the current OD, JICA Study Team used the average growth factor method, which uses the average trip growth rate between traffic zones.

$$T_{ij} = t_{ij} * \frac{1}{2}(\frac{Gi}{g_i} + \frac{A_j}{a_j})$$

T_{ij}: $Future\ Distribution\ Traffic$ t_{ij}: $Distribution\ Traffic\ in$ 2018

G_i: $Future\ Generation\ Traffic$ g_i: $Generation\ Traffic\ in$ 2018

A_j: $Future\ Attraction\ Traffic$ a_j: $Attraction\ Traffic\ in$ 2018

Table 7.3.2 shows the forecasted results of growth rate for passenger traffic separately for Laos and Vietnam. Laos has a higher growth rate of traffic volume than Vietnam since its growth rate of GDP and population is higher than that of Vietnam and development traffic is bigger than that of Vietnam.

Table 7.3.2 Growth Rate of Passenger Traffic (%)

	Low Growth Case		High Growth Case	
	2018 - 2025	2025 - 2035	2018 - 2025	2025 - 2035
Laos Borikhamxay, Khammounane, Vientiane Province	7.23	4.89	9.21	5.94
Vietnam Nghe An, Ha Tinh Province	3.41	2.34	5.49	3.88

Source: JICA Study Team

Table 7.3.3 Growth Rate of Domestic Freight Traffic (%)

	Low Growth Case		High Growth Case	
	2018 - 2025	2025 - 2035	2018 - 2025	2025 - 2035
Laos Borikhamxay, Khammounane, Vientiane Province	10.02	5.47	13.48	7.14
Vietnam Nghe An, Ha Tinh Province	6.11	4.56	6.38	6.04

Source: JICA Study Team

(2) International freight traffic

Based on trade statistics within the Mekong region, future freight demand was estimated among major countries, which are expected to use Hanoi-Vientiane expressway. The target countries are Laos, Vietnam, Thailand, Myanmar, Cambodia, and China.

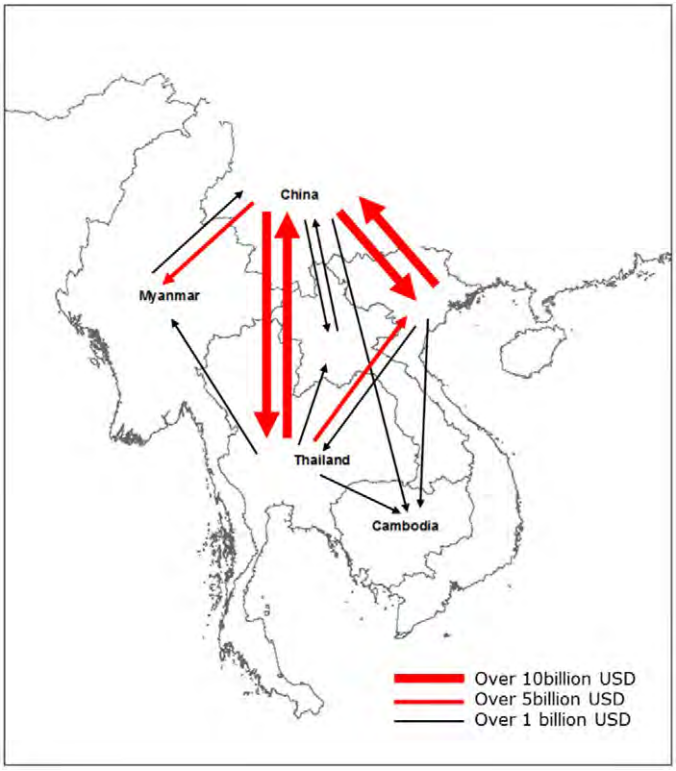
The future freight traffic was estimated using the elasticity of cargo items with respect to the GDP growth rate. The calculation formula is shown below.

Future Freight Demand＝ GDP elasticity by items×growth rate of GDP× Existing trade volume by items

GDP elasticity by items ＝ Growth rate of trade by items/GDP growth rate

1) Trade in Mekong region

Based on the UN Comtrade data showing import and export statistics by country, trade value by country of the Mekong region in the year of 2014 is summarized in Figure 7.3.2. There is a large amount of trade between Thailand and China and between Vietnam and China, followed by that of between Thailand and Vietnam and between Myanmar and China. Also, there are many trade activities between Laos and China, and between Laos and Thailand. The trade value between Laos and Vietnam is small.



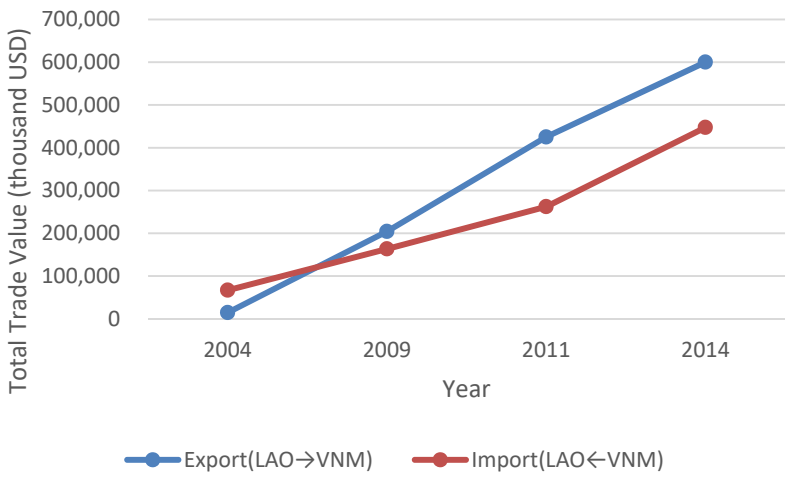
Source: JICA Study Team summarized based on UN Comtrade data

Figure 7.3.2 Trade Value in Mekong Region (2014)

2) Trade between Laos and Vietnam

GDP elasticity by item was calculated for the trade between Laos and Vietnam. In the process of calculating the elasticity, Vietnam GDP was used. As a result, the elasticity by item was calculated as shown later. Although the amount of trade is small compared to Laos-Thailand and Laos-China trades, the growth rate in recent years has increased. The import and export amounts are almost same in terms of value compared with amounts between Thailand - Vietnam and Laos – Thailand described later. The reason is that Laos imports mineral products, industrial products and petroleum products from Vietnam, but exports wood and mineral resources, vegetable products.

According to the statistical data of the Ministry of Finance Customs Bureau of Laos, the country imports more than it exports to Vietnam in terms of value. The difference is considered to be the result of other means of transportation such as inland water transport.

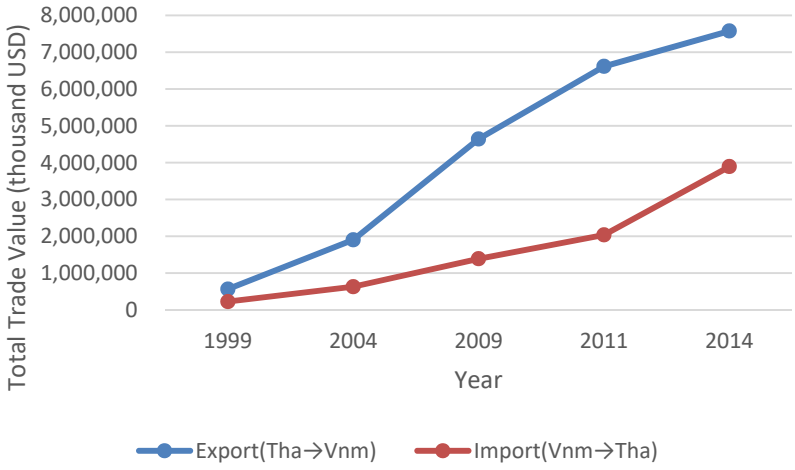


Source: JICA Study Team summarized based on UN Comtrade data

Figure 7.3.3 Trend of Trade Value between Laos and Vietnam

3) Trade between Thailand and Vietnam

Trade value between Thailand and Vietnam has been increasing since 1999, and Thailand exports more than it imports from Vietnam. The increasing trend of both export and import value is expected to continue in the future. Comparing the elasticity values of Thailand's GDP and Vietnam's GDP, strong correlation was observed in Thailand's GDP. Therefore, elasticity was calculated based on Thailand's GDP.



Source: JICA Study Team summarized based on the data from UN Comtrade

Figure 7.3.4 Trend of Trade Value between Thailand and Vietnam

Regarding the trade between Thailand and Vietnam, sea transport share is basically larger than that of the land transport. According to the "*Report on Discovery and Formation of Road Projects Relating to the ASEAN International Corridor*" (Infrastructure Development Institute, 2016), the interviews with Japanese logistics companies revealed that the land transport is more expensive, and it has customs clearance procedure issues at the border. Accordingly, Japanese logistic companies stated that they use sea transport as their main mode.

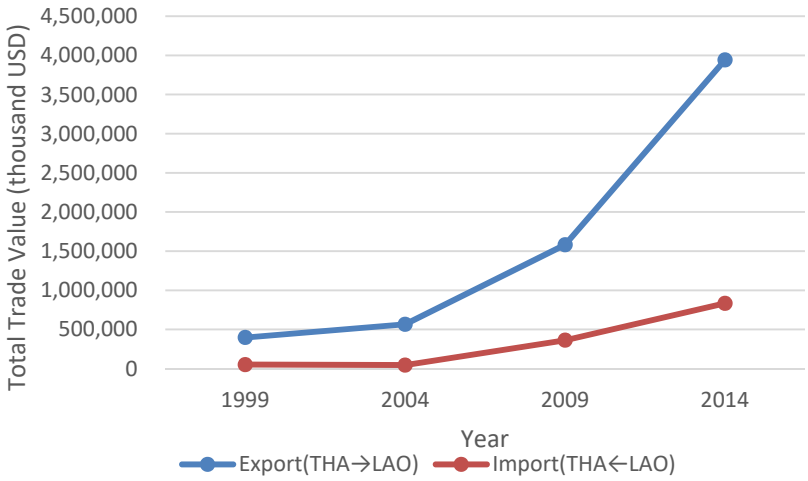
On the other hand, according to "*Information gathering and confirmation survey on promotion of utilization of east and west economic corridors mainly on logistics and road improvement*" (JICA, 2016), land transport service without transshipment is carried out between Bangkok and Hanoi. Lead time is 10 days to 15 days by sea transportation and 3 days by truck transportation. In terms of cost,

land transportation is 2.5 to 3 times higher than the sea transportation, but short lead time is considered as a merit of truck transport.

Although the lead time of the land transport may be further shortened by improving the infrastructure such as Hanoi-Vientiane expressway and the 5th Friendship Bridge between Thailand and Laos, transportation cost remains rather more important factor than lead time for the transportation between Thailand and Vietnam. Shortening the transportation time is also considered to decrease the transportation cost; however, transportation cost may become two times higher than sea transportation cost after shortening the land transportation time.

4) Trade between Laos and Thailand

The trade value between Laos and Thailand has been increasing since 1999, and this trend is expected to continue in the future. Comparing the elasticity values between Thailand's GDP and the GDP of Laos country, stronger correlation was found in Thailand's GDP; thus elasticity was calculated based on Thailand's GDP.



Source: JICA Study Team summarized based on the data from UN Comtrade

Figure 7.3.5 Trend of Trade Value between Laos and Thailand

5) Forecast of land transportation passing through Laos

Based on the calculated GDP elasticity and the GDP value estimated in Figure 7.2.4, future growth rate of international freight traffic volume is calculated by country (see Figure 7.3.4 and Figure 7.3.5). The GDP elasticity by product item is shown in Figure 7.3.6 through Figure 7.3.8. In addition, based on the assumption that the current modal share[3] does not change in the future, land transport volume is calculated.

[3] According to the final report of "Data Collection Survey for Logistics and Road Sector Development in East-West Economic Corridor" (JICA, 2016), three-fourths of all the transport volume in Laos is made by land transport means, while the remaining one-fourth is made either by inland water transport or by freight transport.

Table 7.3.4 Growth Rate of International Freight Traffic (2018–2025)

	China	Cambodia	Laos	Myanmar	Thailand	Vietnam
China	343%	-	274%	-	132%	0%
Cambodia	-	-	-	-	-	-
Laos	342%	195%	-	-	348%	418%
Myanmar	-	-	-	-	-	-
Thailand	190%	-	181%	-	282%	165%
Vietnam	-	-	237%	-	445%	440%

Source: JICA Study Team

Table 7.3.5 Growth Rate of International Freight Traffic (2025–2035)

	China	Cambodia	Laos	Myanmar	Thailand	Vietnam
China	240%	-	219%	-	143%	-
Cambodia	-	-	-	-	-	-
Laos	235%	167%	-	-	239%	250%
Myanmar	-	-	-	-	-	-
Thailand	233%	-	155%	-	223%	132%
Vietnam	0%	-	196%	-	200%	253%

Source: JICA Study Team

Table 7.3.6 GDP Elasticity between Laos and Vietnam by Items

Items	Export (Vnm→ Lao)	Import (Lao→Vnm)
live animals; animal products	0.88	-1.00
vegetable products	1.00	1.00
animal or vegetable fats and oils and their cleavage products	0.93	-
prepared foodstuffs; beverages, spirits and vinegar; tobacco and manufactured tobacco substitutes	0.97	0.89
mineral products	0.98	0.99
products of the chemical or allied industries	0.98	0.93
plastics and articles	0.96	0.96
raw hides and skins, leather, fur skins and articles	0.76	-
wood and articles of wood	0.93	0.96
pulp of wood or of other fibrous cellulosic material	0.99	-0.87
textiles and textile articles	0.98	1.00
footwear, headgear, umbrellas, sun umbrellas, walking-sticks, seat-sticks, whips, riding-crops and parts	0.96	-
articles of stone, plaster, cement, asbestos, mica or similar materials	0.92	-
base metals and articles of base metal	1.00	-0.99
machinery and mechanical appliances	1.00	0.99
vehicles, aircraft, vessels and associated transport equipment	0.95	-
optical, photographic, cinematographic, measuring, checking, precision, medical or surgical instruments and apparatus	0.97	-
miscellaneous manufactured articles	0.91	1.00

Source: JICA Study Team summarized based on the data from UN Comtrade

Table 7.3.7 GDP Elasticity between Thailand and Vietnam by Items

Items	Export (Tha→Vnm)	Import (Vnm→Tha)
live animals; animal products	0.96	0.98
vegetable products	0.94	0.94
animal or vegetable fats and oils and their cleavage products	-0.30	0.24
prepared foodstuffs; beverages, spirits and vinegar; tobacco and manufactured tobacco substitutes	0.98	0.99
mineral products	0.87	0.49
products of the chemical or allied industries	0.99	0.96
plastics and articles	0.97	0.97
raw hides and skins, leather, fur skins and articles	0.88	0.98
wood and articles of wood	0.72	0.81
pulp of wood or of other fibrous cellulosic material	0.99	0.91
textiles and textile articles	0.95	0.98
footwear, headgear, umbrellas, sun umbrellas, walking-sticks, seat-sticks, whips, riding-crops and parts	0.99	0.96
articles of stone, plaster, cement, asbestos, mica or similar materials	0.98	0.95
base metals and articles of base metal	0.94	0.95
machinery and mechanical appliances	0.99	0.84
vehicles, aircraft, vessels and associated transport equipment	0.97	0.92
optical, photographic, cinematographic, measuring, checking, precision, medical or surgical instruments and apparatus	0.83	0.94
miscellaneous manufactured articles	0.97	0.96

Source: JICA Study Team summarized based on the data from UN Comtrade

Table 7.3.8 GDP Elasticity by Items between Laos and Thailand

Items	Export (Tha→Lao)	Import (Lao→Tha)
live animals; animal products	0.95	-0.78
vegetable products	0.85	0.99
animal or vegetable fats and oils and their cleavage products	0.99	-0.82
prepared foodstuffs; beverages, spirits and vinegar; tobacco and manufactured tobacco substitutes	1.00	0.97
mineral products	0.98	-0.38
products of the chemical or allied industries	0.99	0.92
plastics and articles	0.99	0.91
raw hides and skins, leather, fur skins and articles	1.00	-0.95
wood and articles of wood	0.99	0.62
pulp of wood or of other fibrous cellulosic material	0.99	0.99
textiles and textile articles	0.64	-0.06
footwear, headgear, umbrellas, sun umbrellas, walking-sticks, seat-sticks, whips, riding-crops and parts	0.94	0.92
articles of stone, plaster, cement, asbestos, mica or similar materials	1.00	0.91
natural or cultured pearls, precious or semi-precious stones, precious metals, metals clad with precious metal and articles	0.93	0.90
base metals and articles of base metal	0.98	1.00
machinery and mechanical appliances	0.99	0.93
vehicles, aircraft, vessels and associated transport equipment	1.00	0.08
optical, photographic, cinematographic, measuring, checking, precision, medical or surgical instruments and apparatus	0.99	0.99
arms, ammunition	-	-
miscellaneous manufactured articles	0.98	0.92

Source: JICA Study Team summarized based on the data from UN Comtrade

7.3.3 Analysis of the Pricing Sensitivity

In the roadside interview survey, several questions about the possibility of shifting to expressway were included.

The probability of shift to the expressway is estimated based on the following expressway conversion formula and the result of the roadside interview survey was utilized to estimate the parameters:

$$P = \frac{1}{1 + \alpha(X/S)^{\beta}/T^{\gamma}}$$

P : Rate of shift to the expressway
X : Cost/Time difference comparing expressway and local road
T : Time difference among expressway and local road
S : Shift rate
α , β , γ : Parameter

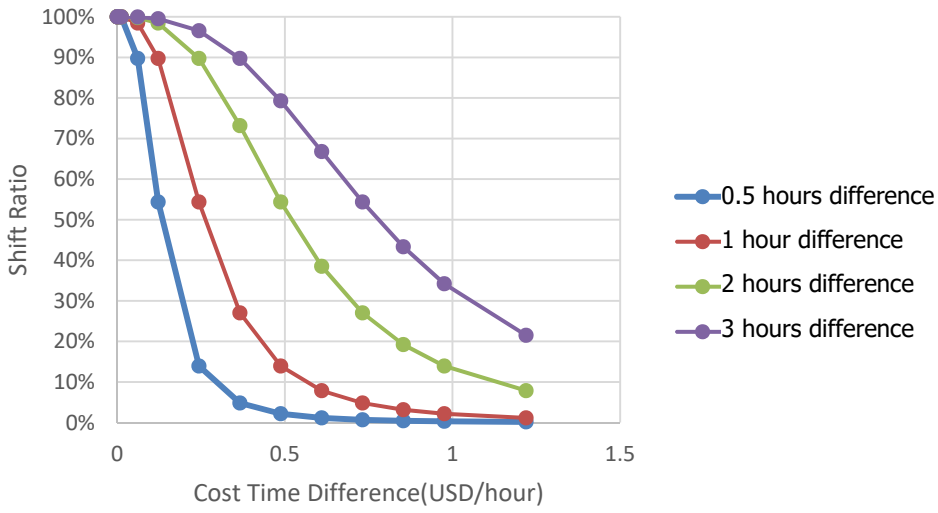
Table 7.3.9 Estimated Parameter by Type of Modes

	Motorcycle	Passenger Car	Bus	Truck
Time Value (USD/hour)	0.02219	0.03749	0.03288	0.04877
α	50.50189353	13217.49193687	21.81398886	2286.757749
β	0.82061942	2.87865098	1.201332194	2.982215087
γ	0.140647112	0	0	0
S	Annual Average GDP Growth			

Source: JICA Study Team

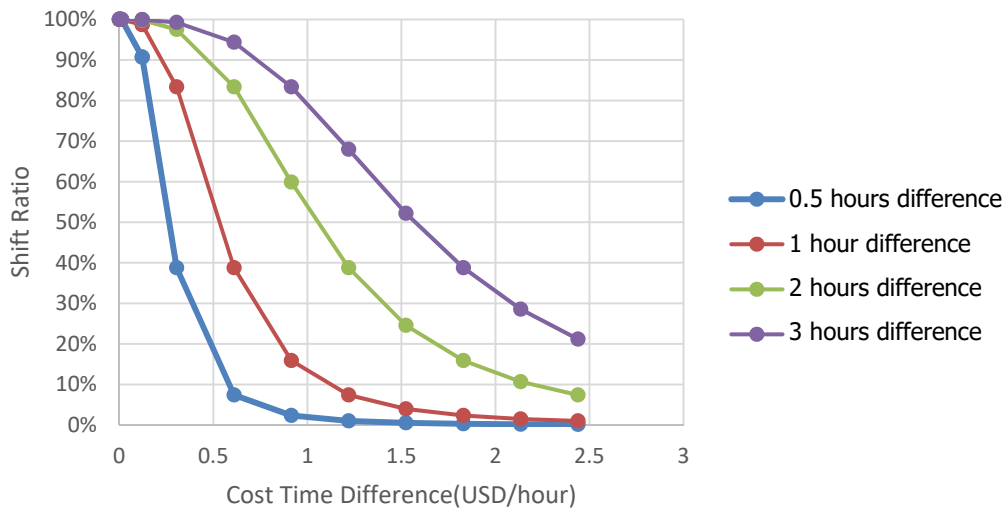
The figure below shows the usage rate of expressway for various time differences between expressway and local road. From this figure, sensitivity between road fare and travel time can be understood.

As for passenger car users, if the travel time difference between expressway and local road is 2 hours (yellow-green line in the graph), and the fare/travel time difference is 1.2 USD per hour, shift ratio will become 50%. On the other hand, from the results of the freight vehicle, if the travel time difference is 2 hours and fare/time difference become 1.2 USD per hour, the expressway users will account for 70%.



Source: JICA Study Team

Figure 7.3.6 Shift Ratio to Expressway by Cost Time Difference (Passenger Traffic)



Source: JICA Study Team

Figure 7.3.7 Shift Ratio to Expressway by Cost Time Difference (Passenger Traffic)

As for setting of expressway tolls, prices are set with reference to the publicly announced toll of Vientiane–Boten expressway. For normal vehicles, terminal charge is set at 1.14 USD, and the charge per km at 0.0128 USD. The prices for large-size vehicles and for two-wheel vehicles are, respectively, twice and 0.8 times of those of normal vehicles.

7.3.4 Assumption of Modal Share with Railway

In the vicinity of the Hanoi-Vientiane expressway, a railway connecting Vientiane-Vung Ang Port is planned. In the case the railway is opened, the current modal share between Vientiane and Vung-Ang may change. Regarding the modal share with the railway, the modal share was set based on the figure described in "*Feasibility Study for the Railway Link from Vientiane in the Laos to Vung Ang in Vietnam*" (KOICA, 2017).

The direct influence area by construction of railway is shown in Figure 7.3.8.

Table 7.3.10 Modal Share of Passenger Traffic

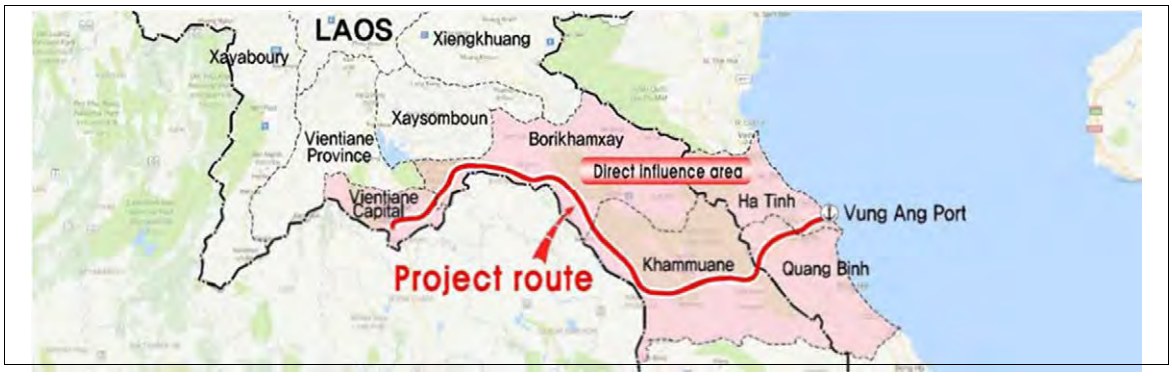
		Motorbike	Sedan	Bus	Railway	Total
2025	Without project	25.2%	43.8%	24.5%	6.5%	100.0%
	With Project	24.0%	41.0%	22.6%	12.4%	100.0%
2045	Without Project	25.2%	43.7%	24.4%	6.7%	100.0%
	With Project	23.9%	40.9%	22.5%	12.6%	100.0%

Source: Feasibility Study for the Railway Link from Vientiane in the Laos to Vung Ang in Vietnam (KOICA)

Table 7.3.11 Modal Share of Freight Traffic

		Truck	Inland Water	Railway	Total
2025	Without project	91.2%	4.6%	4.3%	100.0%
	With project	82.0%	4.3%	13.7%	100.0%
2045	Without project	90.1%	4.6%	5.3%	100.0%
	With project	79.5%	4.3%	16.2%	100.0%

Source: Feasibility Study for the Railway Link from Vientiane in the Laos to Vung Ang in Vietnam (KOICA)



Source: JICA Study Team

Figure 7.3.8 Route Alignment of Vientiane–Vung Ang Railway and Estimated Direct Influence Area

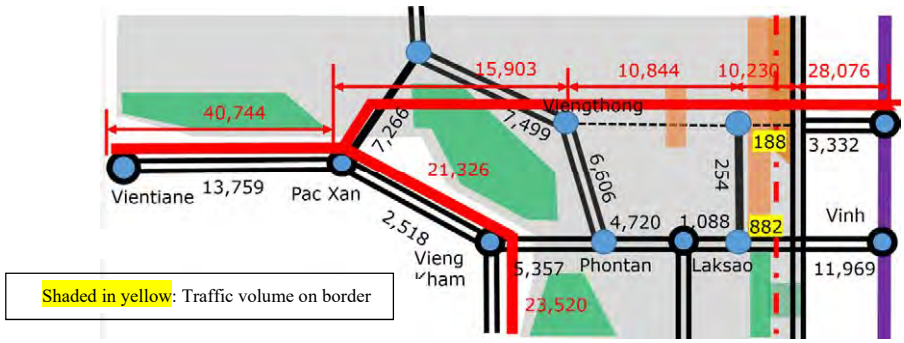
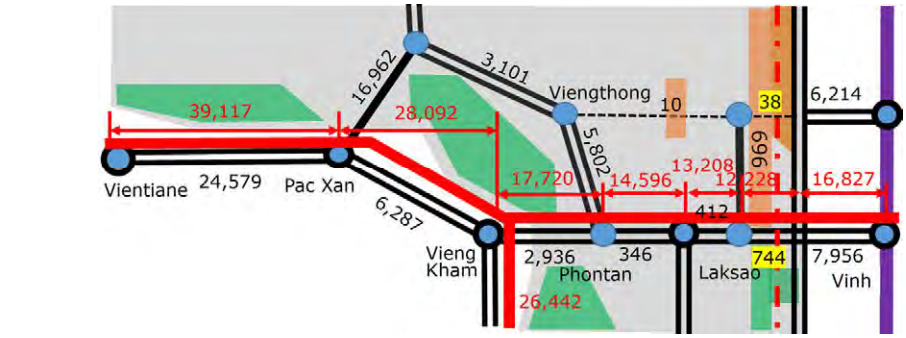
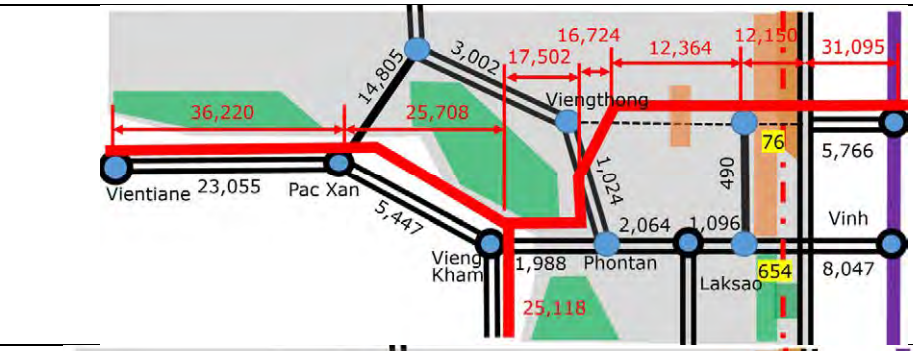
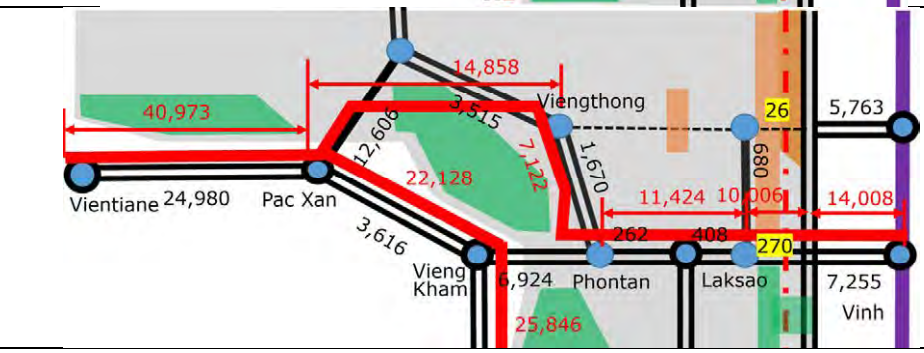
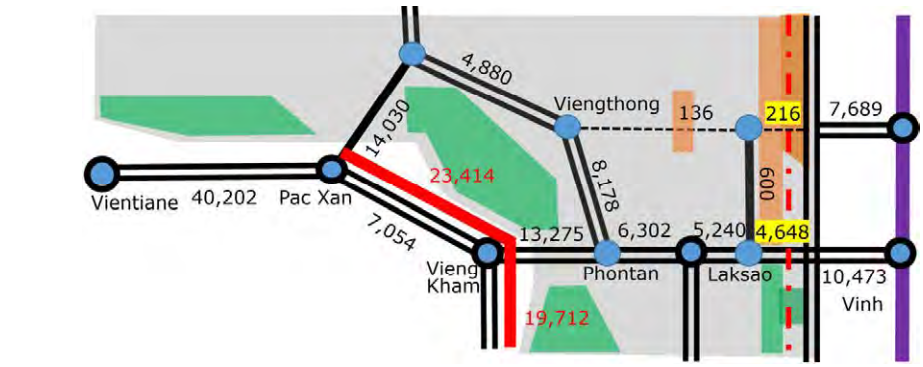
The comparison of the cases with and without the railway shows that 6.0% of the trips in the direct influence area will shift to the railway in 2035. As for freight traffic, 11.7% of trips will shift to the railway in 2035, and the shift of the freight traffic will be especially high.

7.3.5 Result of Traffic Demand Forecast by Forecast Case

Figure 7.3.9 shows the result of traffic assignment for each case of forecast.

- The section Vientiane-Pac Xan shows the heaviest traffic in all cases, around 40,000 PCU/day, and is obviously most suited to be developed as a toll road, followed by the section Pac Xan-Vieng Kham.
- On Vietnam side, the traffic of the Pre-F/S route is around 30,000 PCU/ day and that of NR 8 route is around 15,000 PCU/ day, showing that the former is nearly double of the latter. Since both routes have similar traffic around the border area (10,000–12,000 PCU/day), this divergence is due to the difference in traffic volume on Vietnam side.

- Among all cases compared, Case 2 shows the largest traffic volume, suggesting that the route along NR 8 is most suited from the viewpoint of meeting existing demand.

Case	Result of Traffic Assignment (Unit: PCU/day)
Alt.1	
Alt.2	
Alt.3A	
Alt.3B	
Alt.4	

Source: JICA Study Team

Figure 7.3.9 Future Traffic Demand Forecast in 2035

7.3.6 Comparison with the Pre-F/S Result

The results of comparison with the Pre-F/S are shown below. The forecasted traffic volume by JICA Study Team is lower than the Pre-F/S result. In particular, traffic volume is different in the road sections from Pac Xan to HCM. The average daily traffic volume predicted by JICA Study Team is 22,652 PCU/day, 61% of that of the Pre-F/S which is 37,236 PCU/day.

The growth rate of traffic volume predicted by the JICA Study Team is at 4.3% per annum from 2025 to 2035, which is almost the same as the annual growth rate of 4.5% used in the Pre-F/S. However, the traffic volume in 2020 of the Pre-F/S is more than double of that of the JICA Study Team in 2018, and consequently in 2035 the Pre-F/S survey result shows higher traffic volume.

Table 7.3.12 The Pre-F/S and JICA Study Forecasts

Unit：PCU/day

	Initial condition		2025	2035	
	2018	2020			
Section	JICA Study Team	Pre-F/S	JICA Study Team	JICA Study Team	Pre-F/S
Vientiane - Pac Xan	9,250	22,602	30,986	40,744	40,593
Pac Xan - Viengthong	4,569	18,018	8,685	15,903	37,090
Viengthong - Thanh Thuy	65	15,140	4,985	10,585	29,088
Thanh Thuy – Ro	15	15,898	4,802	10,230	30,543
Ro - Vinh	8,927	20,645	17,497	28,076	42,310
Average Traffic Volume	4,733	19,269	14,875	22,652	37,236
Traffic Growth Rate	-	-		4.3%/year	4.5%/year

Source: Hanoi – Vientiane Expressway Project Stage: Pre-Feasibility Study Report General Report

Note: Forecast case 1 is written in the table as forecast by JICA Study Team

Unit: pcu/day

Figure 7.3.10 Reproduction of the Present Traffic Condition (2018)

The discrepancy in the demand forecast result comes from difference of estimating method and preconditions described in Table 7.2.1. Particularly, since the impact of expressway development reaches to wider areas not limited to the roadside areas, it is necessary to grasp the wide-area transport movement as well as to consider the related road plans in forecasting demand. In this study, therefore, the method which is able to take into consideration those factors is employed.

7.3.7 Impact by Other Expressways

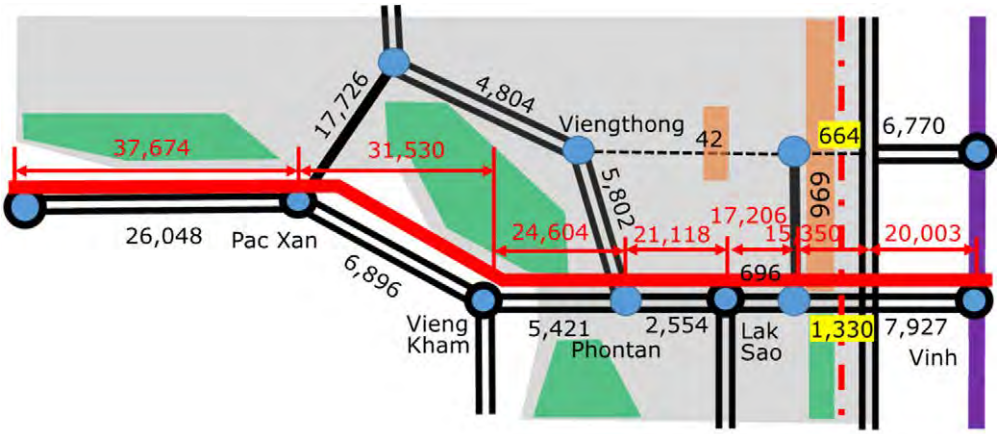
Figure 7.3.11 shows the demand forecast result in case that the other expressways linked to Hanoi–Vientiane expressway such as Vientiane-Boten expressway and southern section of Vieng Kham in Vientiane–Pakse expressway are not improved. The traffic volumes are larger compared to the base case (Alt. 2) in all sections except the Vientiane-Pac Xan section. Especially, increase of traffic volume from Vieng Kham to Laksao is remarkable. The following two factors are supposed:

① In case Vientiane–Boten Expressway is not improved, the traffic between southern part of China and central area of Laos will shift to North–South Expressway and Hanoi–Vientiane expressway.
② In case Vientiane–Pakse Expressway is not improved, the traffic between southern area of Laos and central area of Laos such as Vieng Kham and Phontan will shift to Hanoi–Vientiane expressway through NR-1E and Laksao.

Even if the other expressways are not improved and the traffic volume increases, the traffic volume will not exceed the capacity of a 4-lane road and it will not be a problem in travelling of the expressway. However, it is necessary to examine the impact on the roads used to access the expressway as the traffic volume of these roads changes.

Base Case
【Alt. 2】

Case without other expressways

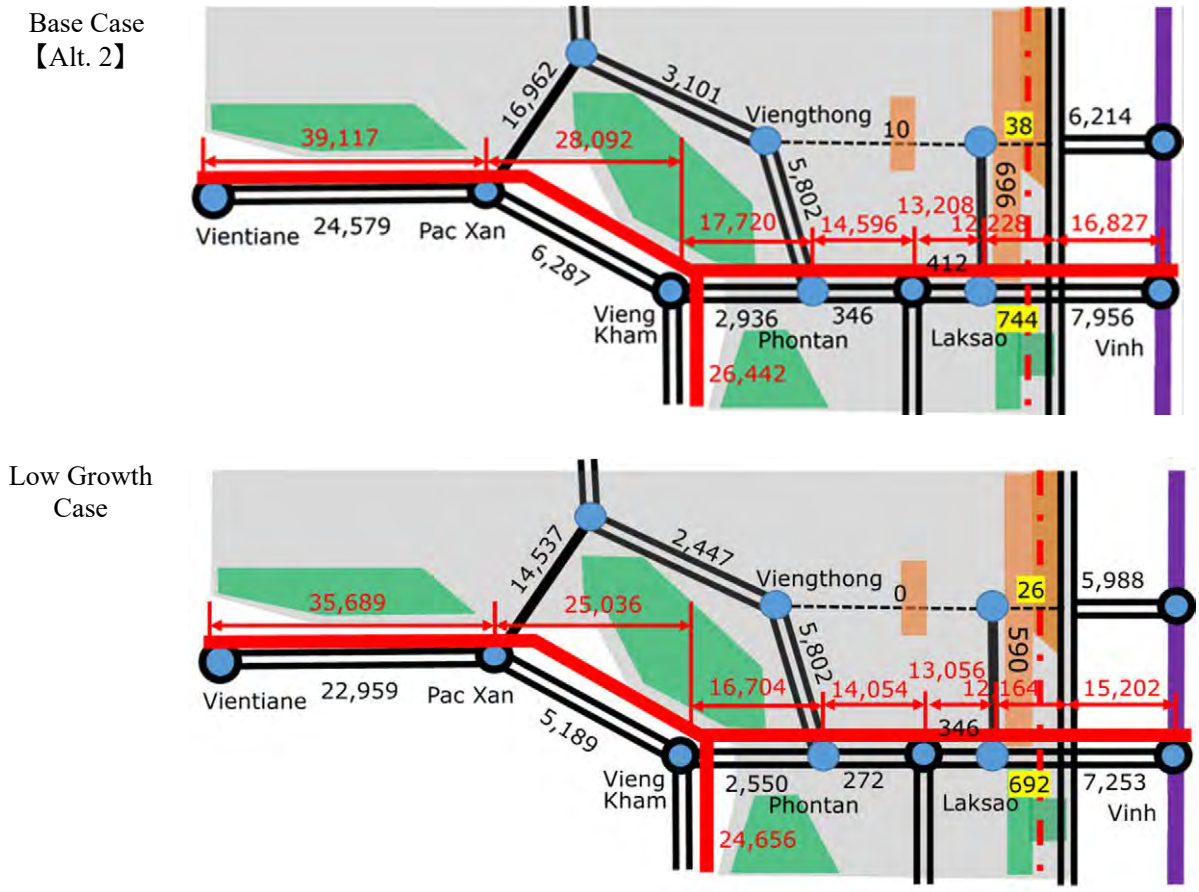


Unit: PCU/day

Figure 7.3.11 Impact of Other Expressways (Year 2035・Alt. 2)

7.3.8 Impact by Regional Development

Figure 7.3.12 shows the forecast result of traffic demand in case that the area around Hanoi–Vientiane expressway is not developed and traffic volume increases in lower level shown in table 7.3.1. The traffic volumes are lower in all sections, and that discrepancy is the result of regional development. Especially, there is a large difference of traffic volumes in the Vientiane–Phontan and HCM–NSE sections, and it shows regional development in these areas.



Unit: PCU/day

Figure 7.3.12 Impact of Regional Development (Year 2035・Alt. 2)

Chapter 8
Design and Cost Estimation of Road and Structure

Chapter 8 Design and Cost Estimation of Road and Structure

8.1 Review of Previous Studies

8.1.1 Road Design

(1) Previous studies

There are two principal previous study reports related to the target road of this study. The first one is the "Hanoi–Vientiane Expressway Project Pre-F/S Report (report/drawings)" prepared by PMU85 and TEDI in 2017, and the second one is the "Detailed Feasibility Study for Upgrading National Road No. 8 on the Asian Highway (AH15) Network in the Lao PDR" prepared by KOICA in May 2018.

In addition to the above two reports, the study team has reviewed "F/S, D/D report on the 5th Mekong River Crossing Bridge" and several reports provided by MPWT and DPWT/Bolikhamsai.

Table 8.1.1 Previous Studies/Data on the target Road Reviewed

	Route Name	Route	Report/Data
1	Pre-F/S Route	Vientiane – Pac Xan – Viengthong – Nam On-Thanh Thuy border – NSE (VN)	Hanoi – Vientiane Expressway Project Pre-F/S Report (report/drawings) (PMU85, TEDI, 2017)
2	NR8 Route, Laos	Vientiane – Vieng Kham – Phontan – Na Salom – Namphao/Cau Treo border – NSE (VN)	Detailed Feasibility Study for Upgrading National Road No.8 on the Asian Highway (AH15) Network in the Lao PDR, Final Report / 2nd Workshop (KOICA, May, 2018)
3	NR1D Route, Laos	Thasi – Viengthong – Phontan	Interview with DOT/Bolikhamsai
4	Provincial Road 1B (5110), Laos	Na Salom – Nam On	Interview with DOT/Bolikhamsai
5	Provincial Road 5117, Laos	Viengthong – Nam On – Thanh Thuy Border (VN)	Provided by DOT/Bolikhamsai
6	the 5th Mekong River Crossing Bridge	Pac Xan – Bueng Kan (TH)	Feasibility Study of Economic Engineering and Environmental Impact Assessment and Detailed Design for the 5th Mekong River Crossing Bridge Project (Bueng Kan – Pac Xan) (DOH/MOT, AEC/PSK/MACRO, Sep. 2014)

Source: JICA Study Team

(2) Hanoi–Vientiane Expressway Project Pre-F/S report

"Hanoi–Vientiane Expressway Project Pre-F/S Report" (referred to as "Pre-F/S Report") consists of a main report and drawings. Road design is discussed in "Chapter 3 Scope, Technical Specifications" and "Chapter 4 Main Design Solutions" of the Pre-F/S report.

1) Design policy

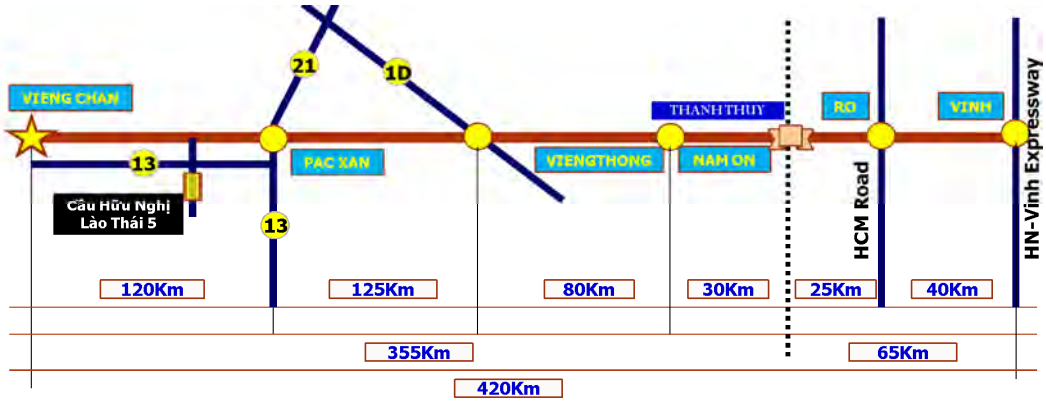
In the Pre-F/S report, the objective of expressway project between Hanoi and Vientiane is to connect the two countries' capitals, enhance connectivity of airports, ports, and high-speed railways, and meet the traffic demand. The beginning point and the ending point of the route are Vientiane and new interchange of the North-South Expressway (NSE) between Hanoi and Ha Tinh, respectively. The construction of NSE in the said section is planned to be completed in 2020.

In the report, the entire section is planned to be developed as a new expressway whereas existing roads are low-standard roads. The route through Nam On/Thanh Thuy border is proposed as the optimum route because it connects Vientiane and NSE with the shortest distance among all alternatives in the Pre-F/S.

The target route between Vientiane and NSE (Vinh) is divided into six sections for design as shown in the table below based on terrain conditions and functions as major linking points. The sections from 1 to 3 are decided based on the comparison study among alternative routes.

	Route	Distance
1	Vientiane–Pac Xan	120km
2	Pac Xan–Vienthong	125km
3	Vienthong–Nam On	80km
4	Nam On / Thanh Thuy Border	30km
5	Border–Ro (HCM Road)	25km
6	Ro–NSE (Vinh)	40km
	Total	420km

Source: JICA Study Team based on Pre-F/S, TEDI

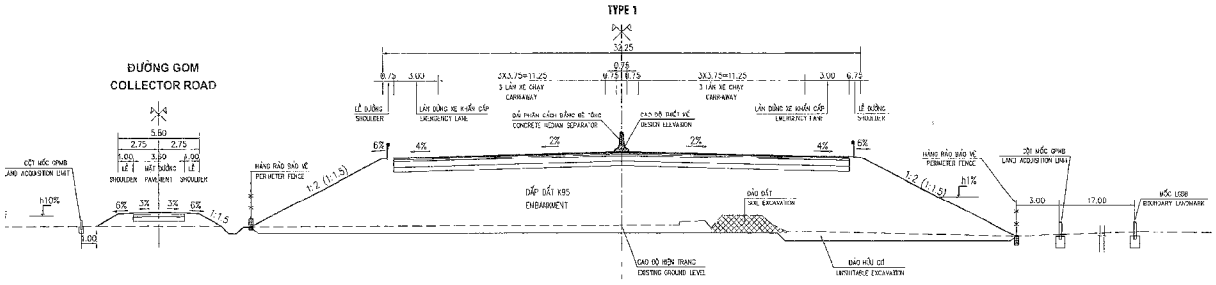


Source: Pre-F/S, TEDI

Figure 8.1.1 Schematic Drawing of Pre-F/S Route[1]

2) Road design

For typical cross section and road design criteria, ASEAN Highway Standard and Vietnamese Expressway Standard (TCVN 5729-12) are referred to. The sections between Vientiane and Pac Xan and between HCM road and NSE are on a flat terrain and design speed is from 100 to 120 km/h. The design speed of the sections located in mountainous terrain is from 60 to 80 km/h.



Source: Pre-F/S Report by TEDI

Figure 8.1.2 Typical Cross Section in Pre-F/S Report (6 lanes, fill)

[1] It includes 5% of design contingency. Total length in the drawing of Pre-F/S is 400km.

Table 8.1.2 Road Geometric Design Criteria in Pre-F/S

		Pre-F/S Report			
Applying Section		Vientiane -Paksan, HCM - NSE		Paksan- Border-HCM	
Design speed (km/h)		120	100	80	60
Width of Element (m)					
	Lane	3.75			3.50
	Inner Shoulder	Incl. in Median		-	-
	Outer Shoulder	3.00		2.50	
	Unpaved Shoulder	0.75		0.75	
	Median	0.75-4.00		-	-
Road Width (Bn) (m)					
	2-lane (w/o median)	15.0		14.0	13.5
	4-lane	23.3 ~ 26.5		21.5	20.5
	6-lane	30.8 ~ 34.0		29.0	27.5
Min. Horizontal curve radius (m)		650	450	250	150
Max. superelevation (%)		8.0			
Max. vertical grade(%)					
	Upslope	5.5		6.0	-
	Downslope				
Min. vertical curve (m)					
	Crest	12,000	6,000	5,000	-
	Sag	5,000	3,000	2,000	-

Source: JICA Study Team

For geometry of road alignment, the Pre-F/S report refers mostly to TCVN 5729-12, which is equivalent to Primary or Class-I standard road in the ASEAN Highway Standard. In the mountainous areas in Laos, there are more than 20 sections where 6% gradient continues for 500 m, and the longest section with 6% gradient is 1500 m. In these sections, traffic is likely to be affected by large-sized vehicles running at a low speed. In order to avoid this, installation of climbing lane is desirable if these sections are developed as a 2-lane road at the initial phase of the development.

In addition, there are some sections with over 100 m-high piers or tunnels with 6% vertical gradients. These sections shall be reviewed carefully at the design stage, since they lead to a high construction cost and pose high risks during construction and operation period.

3) Interchange plan

There are 14 interchanges (I/C) planned in the Pre-F/S. Among the planned I/Cs, trumpet type is applied at three major locations: at NR 13 (LA) as the beginning point of the route, at HCM road, and at NSE as ending point. On the other hand, other I/Cs are planned as diamond type, which is incomplete-I/C. In this report, the explanation in the Pre-F/S report is reviewed, as there are discrepancies between the drawings and explanation in the same Pre-F/S report.

Table 8.1.3 Interchange Plan in Pre-F/S

No.	Name of intersection	Station	Odd distance (km)	Type of intersection	Horizontal line		
					Name	B (m)	Vtk (km/h)
1	Vientiane	Km0+000	0	Trumpet	NR13	30	80
2	B. Don	Km10+000	10	Diamond	Local road	12	80
3	Na xay	Km48+000	38	Diamond	Local road	12	80
4	Tha box	Km73+000	35	Diamond	Local road	12	80
5	Pac Xan	Km118+000	45	Diamond	Local road	12	80
6	Borikhan	Km138+000	20	Diamond	NR.21	12	80
7	Nam Phoi	Km165+000	27	Diamond	Local road	12	80
8	Viengthong	Km237+000	72	Diamond	NR.1D	12	80
9	Cuc Tia	Km273+000	36	Diamond	Local road	12	80
10	Phon Si	Km295+000	22	Diamond	Local road	12	80
11	Nam On	Km311+000	16	Diamond	Local road	12	80
12	Ro	Km365+000	54	Trumpet	HCM road	12	80
13	NR.46	Km380+000	15	Diamond	NR.46	9	80
14	N-S expressway	Km430	25	Trumpet	N-S expressway	24,75	120

Source: Pre-F/S Report by TEDI

4) Road facilities and others

Parking areas at five locations along the route and installation of ITS are briefly mentioned in the Pre-F/S report.

(3) F/S report for NR8 in Laos (KOICA, 2018)

The result of review for the previous study report, "Detailed Feasibility Study Report for Upgrading National Road No.8 on the Asian Highway (AH15) Network in the Lao PDR" (KOICA, May, 2018), is summarized as follows.

1) Design contents

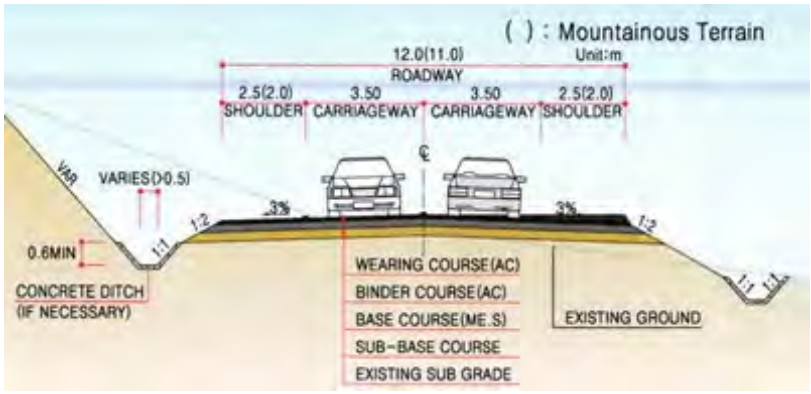
In the KOICA's F/S report, the optimum plan is proposed and implementation program is formulated with the purpose of strengthening connectivity with neighboring countries through NR8, increasing cross border transportation, reducing transportation cost and ensuring safety.

The design contents of the report are basically the improvement of the existing NR8 and a new bypass development. Re-alignment of the road is not considered in the report and the existing road alignment is used except for the new bypass road. Figure 8.1.3 shows route map and Table 8.1.4 shows major design criteria.

Source: NR8 F/S Report by KOICA

Figure 8.1.3 NR8 Development Project

Table 8.1.4 NR8 Improvement Project F/S by KOICA

	Item	Contents
1	Improvement Section	Section A: Vieng Kham - Nong Coc (49.2km) Section B: Nong Coc – Namphao Border (74.7km) Total length: 123.9km
2	Road Class	- ASEAN Highway Class II - Design speed: 40km/h - 60km/h - Lane width/No. of lanes: 3.5m / 2 lanes  Typical Cross Section of NR8 Improvement Project
3	Completion Schedule	Year 2024
4	Improvement Item	Widening of AC pavement Road alignment incl. new tunnel, new/widening bridges
5	Est. Cost	USD 196.2 million

Source: JICA Study Team based on F/S on NR8, 2017, KOICA

2) Bypass road plan

The KOICA's F/S examines alternative alignments of the road divided into ten sections. The alternative proposal is to improve the target road through construction of new bypass road and tunnel.

(4) Other previous studies

There are some previous studies related to the target road in Laos, Thailand and Vietnam.

1) The 5th Mekong River Crossing Bridge Project (Bueng Kan–Pac Xan) F/S, D/D (2014)

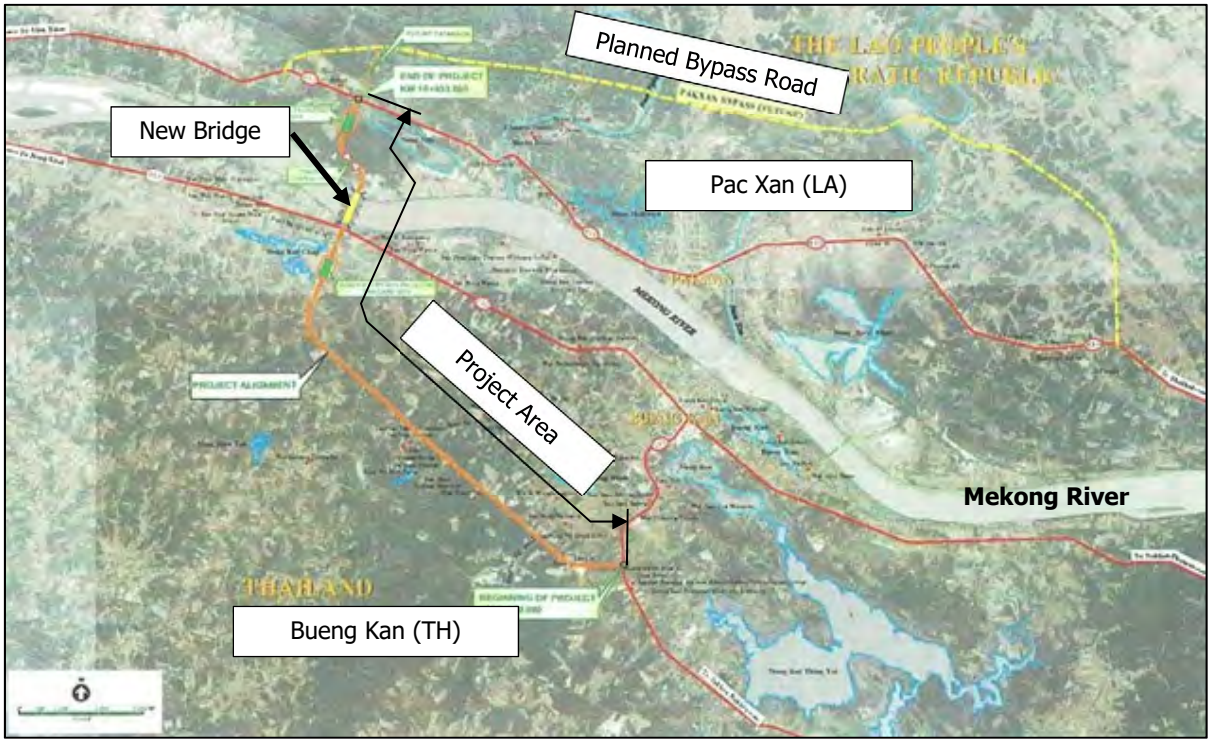
The 5th Mekong River Crossing Bridge Project consists of a new bridge between Bueng Kan (TH) and Pac Xan (LA), international border facilities and access roads in both countries. The F/S, D/D report was prepared with the assistance of Thailand in 2014. This project is planned based on the framework of economic cooperation through GSM and ACMECS (Ayarwaddy-Chao Phraya-Mekong Economic Cooperation Strategy), with the aim to improve the road network linking the regional countries.

According to the report, the project was supposed to start land acquisition in 2015, construction in 2017 and operation in 2020. However, it is already behind the schedule. The estimated project cost is THB 2,613 million and it is to be borne by the two countries. The GoL requested a loan through NEDA (Neighboring Countries Economic Development Cooperation Agency, Thailand) in August 2017 but it has not received official answer yet. The GoT has allocated budget for the land acquisition for the access road on the Thailand side in FY 2018.

Road design was prepared based on the road design standards in both countries and international road design standards. Consequently, it is equivalent to the Class I of the ASEAN Highway Standard.

There is no significant difference in distance among the three main routes between Bangkok and Hanoi: the 5th Mekong River Bridge route (approx. 1,385 km), Vientiane route (approx. 1,396 km), and NR12 route (approx. 1,371 km).

Through the construction of the 5th Mekong River Crossing Bridge, connectivity of Thailand, Laos and Vietnam is expected to be strengthened. In addition, this bridge is going to be linked with the target road for this study, the Hanoi-Vientiane expressway. Therefore, it is expected that transport between Bangkok and Thailand, which have conventionally been passing through the East-West Economic Corridor (crossing the 2nd Thai-Lao Friendship Bridge and NR 9), will instead use this bridge passing through Pac Xan.



Source: JICA Study Team based on the 5th Mekong River Crossing Bridge F/S, D/D Report

Figure 8.1.4 Project Plan for the 5th Mekong River Crossing Bridge Project

2) Road development plan in Laos

During this study, documents on development plan for Provincial Road No. 5117, from Viengthong to Thanh Thuy border, are obtained from the DPWT of Bolikhamsai Province. According to the documents, the project was planned to start in 2009 and completed in 2014, but it has been suspended due to shortage of budget.

Table 8.1.5 Development Plan of Provincial Road 5117

Route	Distance	Project Cost	Schedule	Road Geometry
Viengthong – Ban On				- DBST, 2 lanes
	70.32 km	LAK 340,602 mil.	2009.10 - 2013.10 (DBST 41% completed)	- Width: 9m (Residential area), 7m (others) - Min. Curve Radius: 60m
Ban On – Thanh Thuy Border				- Max. Vertical Grade: 12%
	60.00 km	LAK 445,261 mil.	2011.1 - 2014.12 (Earthwork 48% competed)	- Min. Vertical Curve (Crown): R=600m - Min. Vertical Curve (Sag): R=1000m

Source: DPWT/ Bolikhamsai

The DPWT in Bolikhamsai Province is delegated by MPWT to supervise constructions, improvement and maintenance of NR8. According to the DPWT, general maintenance of NR8 is done by a private company selected by competitive bidding.

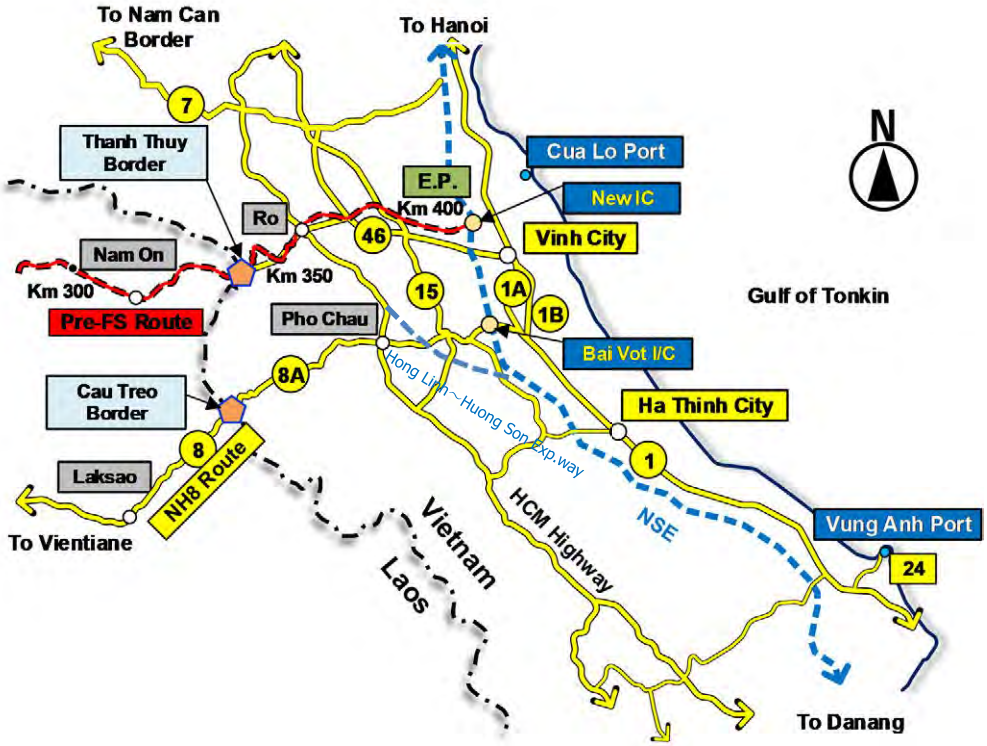
Source: JICA Study Team based on data from DPWT/Bolikhamsai

Figure 8.1.5 Plan of Viengthong – Thanh Thuy Road (PR5117)

3) Road development plan in Vietnam

Road development of Hong Linh – Huong Son expressway and NSE are planned. According to a MOT document issued in August 2017, the NSE section between Hanoi and Bai Vot interchange which connects to NR8A is planned to open in 2020.

There is no road development plan for NR46 which runs parallel to the Pre-F/S route. Also, there is no major or complete improvement plan for NR8A except minor or daily repairs and maintenances.



Source: JICA Study Team

Figure 8.1.6 Route Map around Thanh Thuy Border and NR8

4) Road development plan on Thailand side

There is no specific road development plan on the Thailand side except the 5th Mekong River Crossing Bridge Project. Therefore existing national roads, i.e. NR212 (along Mekong River) and NR222 (southward from Bueng Kan), shall be used. The route from Bueng Kan to Bangkok through the 5th Meking River Crossing Bridge shall be as follows: Buen Kan – Nong Khai – Udon Thani – Bangkok, or Bueng kan – Sakhon Nakhon – Udon Thani – Bangkok.

Source: JICA Study Team based on the 5th Mekong River Crossing Bridge F/S, D/D Report

Figure 8.1.7 Road Plan around the 5th Mekong River Crossing Bridge Project

8.1.2 Structural Design

(1) Structure design in Pre-F/S route expressway development

The structure design in the Pre-F/S on expressway development project prepared by TEDI is reviewed and main points are summarized as follows.

Although structural standards are not specified as it is not a detailed design, it has been planned based on the past examples in Vietnam. There are two major structures, namely, bridges and mountain tunnels. For other structures such as retaining walls or those related to slopes and soft grounds, only general theories are included.

Table 8.1.6 shows the outline of the main structure designs.

Regarding bridges, the applicable areas, type classifications, and the sections crossing the Lam River are all general. However, the height of the pier in the mountain section is extremely high; therefore, there is a concern that this may increase the construction cost.

Regarding tunnels, the applicable areas and the type classifications are also general. However, auxiliary construction method in a strong weathered ground is not studied; therefore, there is a concern of an increase in construction cost.

Regarding other structures, slope measures for long earth cut in strongly weathered ground is not studied and there is a concern of an increase in construction cost.

Table 8.1.6 Outline of the Structural Design (Pre-F/S Route Expressway Development)

Main Structure	Application Site	Type Classification	Technical Review
Bridge	Applied in sections of crossing rivers and high embankment in the mountainous areas	Type classification by span L<33: I digit L>33:BOX digit	As for Lam River part, planning the long bridge of 1600 m over the high-water channel as well with estimation of dike lines
Tunnel	Applied in sections requiring moderation of vertical gradient in mountainous areas	Adopted NATM, a typical construction method of mountain tunnels	Tunnel lengths are planned to be less than 3 km, and long tunnels are avoided
Other Structure	Applied in sections of large scale earth cut or embankment	Classified types for retaining wall, slope and measurement for soft ground	--------

Source: JICA Study Team

(2) Structural design in F/S for National Road No.8 development

The structure design in the report of "Detailed Feasibility Study for Upgrading National Road No.8 on the Asian Highway (AH15) Network in the Lao PDR (KOICA, May, 2017)" is reviewed and the main points are summarized as follows.

Structural standards are not specified, as it is not a detailed design. There are two main types of structures, i.e. bridges and mountain tunnels; and only general guidelines are provided on the type (classification) of the structures and site conditions that they should be adopted

Table 8.1.7 shows the outline of various structural designs.

Table 8.1.7 Outline of Structural Design（F/S for National Road No.8 Development）

Main Structure	Application Site	Type Classification	Technical Review
Bridge	Applied in sections of crossing rivers and high embankment in the mountainous areas	N/A	N/A
Tunnel	Applied in sections requiring moderation of vertical gradient in mountainous areas	Adopted NATM, a typical construction method of mountain tunnels	Tunnel lengths are planned less than 3 km, and avoided long tunnels Longitudinal slopes are less than 2% with consideration of tunnel ventilation

Source: JICA Study Team

8.1.3 Cost Estimation

(1) Cost estimation in Pre-F/S route expressway development

The cost estimation in the Pre-F/S on expressway development project prepared by TEDI is reviewed and the main points are summarized as follows.

◆ Cost Estimation Policy

- The total construction length of the project is 420 km, 355 km for the Laos side and 65 km for the Vietnam side.
- There are four construction sections in Laos (section I - 1 to I – 4) and two construction sections in Vietnam (section II - 1 to II – 2), totaling to six sections.
- Three development cases are assumed (6-lane, 4-lane, and 2-lane road cases).
- Project cost breakdown includes machinery depreciation, land acquisition and resettlement cost, construction supervision fee, contingency fund etc. in addition to construction cost (excluding interest rate)

◆Outline of the Project Cost

- The cost is estimated to be USD 4.3 billion (USD 10.2 million/km) in the 6-lane case (55% of the project cost for the earthworks, 26% for bridges, and 19% for tunnels).
- The cost is estimated to be USD 3.4 (USD 8.0 million/km) in the 6-lane case (50% of the project cost for the earthworks, 25% for bridges, and 25% for tunnels).

◆Outline of the Project Unit Cost

- Construction work is categorized into three types: earthwork, bridges and tunnel.
- The unit prices are shown in; per km of earthwork, per m^2 of bridges and per m of tunnels.
- It is necessary to add cost of interchanges in the project cost.
- Unit cost for earthwork is further categorized and set according to the terrain features: flat, rolling, mountainous and soft ground.
- Unit prices for bridges and tunnels are no further categorized according to the type of bridge/tunnel.
- Unit prices are set based on the previous project experience of North-South expressway development project in Vietnam.

Table 8.1.8 and Table 8.1.9 show the outline of estimated project cost.

Table 8.1.8 Outline of the Project Cost Estimation (Pre-F/S Route Expressway Development)

No.	Section	Length (km)	Unit	6 lane (W32m)	4 lane (W24,75m)	6 lane (W32m)		4 lane (W24,75m)	
				Ratio of total cost	Ratio of total cost	Total Cost (Billion VND)	Total Cost (Million USD)	Total Cost (Billion VND)	Total Cost (Million USD)
I	Laos Country								
1	Viêng Chăn - Pặc xan	120	Billion VND			15,144.0	662	11,836.8	518
	Length of Route (Km)	*117.44*	*km*	*115*	*90*	*13,505.6*		*10,569.6*	
	Length of Bridge (Km)	*2.56*	*m2*	*20*	*20*	*1,638.4*		*1,267.2*	
	Length of Tunnel (Km)		*km*	*1,700*	*1,700*	*0.0*		*0.0*	
2	Pặc xan - Viêng Thông	125	Billion VND			21,146.0	925	16,292.0	712
	Length of Route (Km)	*115.4*	*km*	*130*	*100*	*15,002.0*		*11,540.0*	
	Length of Bridge (Km)	*9.6*	*m2*	*20*	*20*	*6,144.0*		*4,752.0*	
	Length of Tunnel (Km)		*km*	*1,700*	*1,700*	*0.0*		*0.0*	
3	Viêng Thông - Nậm On	80	Billion VND			35,780.0	1564	29,479.0	1289
	Length of Route (Km)	*54.8*	*km*	*200*	*130*	*10,960.0*		*7,124.0*	
	Length of Bridge (Km)	*17*	*m2*	*20*	*20*	*10,880.0*		*8,415.0*	
	Length of Tunnel (Km)	*8.2*	*km*	*1,700*	*1,700*	*13,940.0*		*13,940.0*	
4	Nậm On - Thanh Thủy	30	Billion VND			7,418.2	324	9,675.6	423
	Length of Route (Km)	*22.43*	*km*	*180*	*130*	*4,037.4*		*2,915.9*	
	Length of Bridge (Km)	*5.07*	*m2*	*20*	*20*	*3,244.8*		*2,509.7*	
	Length of Tunnel (Km)	2.5	*km*	*1,700*	*1,700*	*4,250.0*		*4,250.0*	
Total in Lào		355	Billion VND			79,488	3,476	67,283	2,942
II	VietNam								
1	Thanh Thủy - Rộ	25	Billion VND			7,008.0	306	5,318.5	233
	Length of Route (Km)	*20.7*	*km*	*180*	*125*	*3,726.0*		*2,587.5*	
	Length of Bridge (Km)	3.8	*m2*	*20*	*20*	*2,432.0*		*1,881.0*	
	Length of Tunnel (Km)	0.5	*km*	*1,700*	*1,700*	*850.0*		*850.0*	
2	Rộ - Vinh	40	Billion VND			6,976.0	305	4,679.3	205
	Length of Route (Km)	*38.2*	*km*	*160*	*105*	*6,112.0*		*4,011.0*	
	Length of Bridge (Km)	1.8	*m2*	*15*	*15*	*864.0*		*668.3*	
	Length of Tunnel (Km)	0	*km*	*1,700*	*1,700*	*0.0*		*0.0*	
3	Vinh - Hà Nội	Out of Scope							
Total in Vietnam		65	Billion VND			13,984	611	9,998	437
Total		420.0	Billion VND			93,472	4,087	77,281	3,379
Pre-F/S Exchange rate : 1USD= 22,870 VND					Earth Work	53,343	57%	38,748	50%
					Bridge	25,203	27%	19,493	25%
					Tunnel	19,040	20%	19,040	25%

Source: Prepared by JICA Study Team based on the documents provided by TEDI

Table 8.1.9 Outline of the Project Cost Estimation (NR-8 Route Expressway Development)

No.	Section	Length (km)	Unit	6 lane (W32m)	4 lane (W24,75m)	6 lane (W32m)		4 lane (W24,75m)	
				Ratio of total cost	Ratio of total cost	Total Cost (Billion VND)	Total Cost (Million USD)	Total Cost (Billion VND)	Total Cost (Million USD)
I	Laos Country								
1	Viêng Chăn - Pặc xan	120	Billion VND			15,144.0	662	11,836.8	518
	Length of Route (Km)	*117.44*	*km*	*115*	*90*	*13,505.6*		*10,569.6*	
	Length of Bridge (Km)	*2.56*	*m2*	*20*	*20*	*1,638.4*		*1,267.2*	
	Length of Tunnel (Km)		*km*	*1,700*	*1,700*	*0.0*		*0.0*	
2	Pac Xan - Vieng Kham	100	Billion VND			17,199.0	752	13,905.0	608
	Length of Route (Km)	*95.3*	*km*	*130*	*100*	*12,389.0*		*9,530.0*	
	Length of Bridge (Km)	*3*	*m2*	*20*	*20*	*1,920.0*		*1,485.0*	
	Length of Tunnel (Km)	*1.7*	*km*	*1,700*	*1,700*	*2,890.0*		*2,890.0*	
3	Vieng Kham - Laksao	95	Billion VND			27,450.0	1200	20,239.0	885
	Length of Route (Km)	*82.3*	*km*	*200*	*130*	*16,460.0*		*10,699.0*	
	Length of Bridge (Km)	*10*	*m2*	*20*	*20*	*6,400.0*		*4,950.0*	
	Length of Tunnel (Km)	*2.7*	*km*	*1,700*	*1,700*	*4,590.0*		*4,590.0*	
4	Laksao - Border	35	Billion VND			11,400.0	498	8,200.0	359
	Length of Route (Km)	*25*	*km*	*200*	*130*	*5,000.0*		*3,250.0*	
	Length of Bridge (Km)	*10*	*m2*	*20*	*20*	*6,400.0*		*4,950.0*	
	Length of Tunnel (Km)	0	*km*	*1,700*	*1,700*	*0.0*		*0.0*	
Total in Lào		350	Billion VND			71,193	3,113	54,181	2,369
II	VietNam								
1	Border - HCM Road	50	Billion VND			39,310.0	1719	30,115.0	1317
	Length of Route (Km)	*19.5*	*km*	*200*	*130*	*3,900.0*		*2,535.0*	
	Length of Bridge (Km)	30	*m2*	*36*	*36*	*34,560.0*		*26,730.0*	
	Length of Tunnel (Km)	0.5	*km*	*1,700*	*1,700*	*850.0*		*850.0*	
2	HCM Road - Vinh	34	Billion VND			6,208.0	271	4,209.0	184
	Length of Route (Km)	*31.6*	*km*	*160*	*105*	*5,056.0*		*3,318.0*	
	Length of Bridge (Km)	2.4	*m2*	*15*	*15*	*1,152.0*		*891.0*	
	Length of Tunnel (Km)	0	*km*	*1,700*	*1,700*	*0.0*		*0.0*	
3	Vinh - Hà Nội	Out of Scope							
Total in Vietnam		84	Billion VND			45,518	1,990	34,324	1,501
Total		434.0	Billion VND			116,711	5,103	88,505	3,870
Pre-F/S Exchange rate : 1USD= 22,870 VND					Earth Work	56,311	48%	39,902	45%
					Bridge	52,070	45%	40,273	46%
					Tunnel	8,330	7%	8,330	9%

Source: Prepared by JICA Study Team based on the documents provided by TEDI

(2) Cost estimation of bypass development of National Road No.8

A review for bypass development of National Road No.8 by KOICA is summarized as follows:

◆Cost Estimation Policy

- The construction length of the project is 124 km in total (only on the Laos side).
- The construction site is divided into two.
- The assumed two project development cases are the 1) expansion to two-lanes and 2) improvement of the existing road together with a bypass development.

◆ Outline of the Project Cost Estimation

- The total project cost is estimated to be 200 million USD (0.17 million USD/km).
- The earthworks account for 55% of the project cost, bridges for 16%, and tunnels for 29%.

◆Outline of the Unit Cost

- Construction is categorized into three types, i.e. earthwork, bridge, and tunnel. For earthwork, cost for drainage, pavement and ancillary constructions are separately added.
- Earthwork is not divided according to topography.
- Bridges and tunnels are not subdivided.

Table 8.1.10 presents the outline of estimated project cost.

Table 8.1.10 Outline of Rough Cost Estimation (Pre-F/S Route Highway Development)

Cost Estimation

(Unit : USD)

Category	Section-A	Section-B		Total Amount
	Section-1	Section-2	Section-3	
1. Direct Construction Cost	**60,672,137**	**35,421,900**	**45,600,073**	**141,694,110**
1-1. Earthworks and Slope Protection	14,715,796	8,187,610	13,138,413	36,041,819
1-2. Drainage	6,127,847	2,958,964	2,219,656	11,306,467
1-3. Pavement	17,674,263	16,214,068	14,855,254	48,743,585
1-4. Road Safety & Ancillary	940,887	592,281	912,730	2,445,898
1-5. Bridge and Retaining Wall	4,262,332	7,468,977	14,474,020	26,205,329
1-6. Tunnel	16,951,012	-	-	16,951,012
2. Consulting fee and Indirect Cost	17,236,144	10,790,475	12,777,598	40,804,217
3. Compensation and Resettlement	4,896,176	4,772,550	4,008,475	13,677,201
4. Total Project Cost [1+2+3]	**82,804,457**	**50,984,925**	**62,386,146**	**196,175,528**

Source: "Detailed Feasibility Study for Upgrading National Road No.8 on the Asian Highway (AH15) Network in the Lao PDR" (KOICA, May, 2018).

8.2 Preliminary Design of Road and Structures

8.2.1 Target Route of Designing

The following design alternatives are considered to strengthening the connectivity between Hanoi and Vientiane:

- Alternative 1 : Pre-F/S Corridor
- Alternative 2 : NR8 Corridor
- Alternative 3A : Detour around protected areas (proposal)
- Alternative 3B : Elimination of bottlenecks (proposal)

Source: JICA Study Team

Figure 8.2.1 Target Route of Designing

In this study, road conditions of each route are examined, and related information, such as topography, the number of lanes of existing roads, pavement situation, and vertical gradient, is collected. The results are shown in Appendix 4. Table 8.2.1 shows the current status of the target routes. In addition, Table 8.2.2 shows the length of each section along the target routes described in Chapter 6.

Table 8.2.1 Current Status of the Target Route for Designing

	Route	Development Plan	Current Status
1	Pre-F/S Corridor	Pre F/S Development plan of Bolikhamsai	- NR 13 has a lot of traffic - Section between Pac Xan and Ving Thong is inaccessible by car due to undeveloped area - Section between Viengthong and Thanh Thuy border is under the development with simple pavement by province. A steep slope exceeds 10%. - Slope and road surface erosion are occurred by rain.
2	NR 8 Corridor	KOICA F/S	- Pavement damage is frequent in the mountainous section. - In the mountains section, there are places where the average gradient is about 7 %. - Especially from the boarder to the Vietnamese side is a step slope section over 12 km.
3	Detour (NR 1D)	- (Developed by Defence Department)	- The mountain section continues where the average vertical gradient is about 8 %.

Source: JICA Study Team

Table 8.2.2 Length of Each Section of Target Route of Designing

	Section	Terrain	Length (km)		Note
Alt. Route 1	Vientiane	flat	118	339	Laos
	Pac Xan	rolling	119		
	Viengthong	mountainous (steep)	102		
	Nam On	rolling	26	61	Vietnam
	HCM road	flat (urban area)	35		
	NSE				
	Total		400	400	

	Section	Terrain	Length (km)		Note
Alt. Route 3A	Vientiane	flat	118	416	Laos
	Pac Xan	rolling	96		
	Vieng Kham	rolling	50		
	Phontan	mountainous	50		
	Viengthong	mountainous (steep)	102		
	Nam On	Rolling	26	61	Vietnam
	HCM road	flat (urban area)	35		
	NSE				
	Total		477	477	

Section	Terrain	Length (km)		Note	Section
Alt. Route 2	Vientiane	flat	118	340	Laos
	Pac Xan	rolling	96		
	Vieng Kham	rolling	50		
	Phontan	rolling	76		
	Namphao	mountainous (steep)	12	63	Vietnam
	NR 8	rolling	27		
	HCM road	flat (urban area)	24		
	NSE				
	Total		403	403	

Section	Terrain	Length (km)		Note	Section
Alt. Route 3B	Vientiane	flat	118	363	Laos
	Pac Xan	rolling	119		
	Vieng Thong	rolling	50		
	Phontan	rolling	76		
	Namphao	mountainous (steep)	12	63	Vietnam
	NR 8	rolling	27		
	HCM road	flat (urban area)	24		
	NSE				
	Total		426	426	

Source: JICA Study Team

8.2.2 Design Condition of Road Design

(1) Cross-section elements and alignment

The design criteria for preliminary road design in this study are shown in Table 8.2.3, based on Pre-F/S report, ASEAN Highway Standard, and Vietnam Design Standard (TCVN-2012).

Basically, the alignments and cross-sections are designed to satisfy the ASEAN Highway Standard Class I and ensure the economic efficiency and safety as an expressway.

In this study, road alignment mostly runs through flat, rolling, or mountainous areas and it hardly passes through residential areas. As for the number of lanes, based on the result of traffic demand forecast, all sections will have 4 lanes except the Vientiane - Pac Xan section, which needs 6 lanes.

Table 8.2.3 Cross Section and Geometric Design Criteria

Geometric Design Criteria for JICA Data Collection Survey					
Highway classification	Equivalent to Class I of ASEAN Highway				
Terrain classification	Level		Rolling + Mountainous		
Applying Section	Vientiane-Along NH13, HCM - NSE		Eastward from NH13 - HCM Road		
Design speed (km/h)	120	100	80	60	
Width of Element (m)					
Traffic Lane	3.50				
Inner Shoulder	0.75		0.50		
Outer Shoulder	2.50 (BR:1.50,TN:1.00)		1.75 (BR:1.25,TN:0.75)		
Unpaved Shoulder	0.75				
Median	1.50		0.75		
Min. Horizontal curve radius (m)	650	450	250	150	
Max. superelevation (%)	8.0				
Max. vertical grade (%)	4.0	5.0	6.0		
Min. vertical curve (m)					
Crest	12,000	6,000	3,000	1,500	
Sag	5,000	3,000	2,000	1,000	
Min. ver. clearance (m)	5.0				

Source: JICA Study Team

(2) Road drainage facilities

In principle, the lateral drainage in fill sections shall be achieved naturally without any specific structure, but earth ditches have to be provided in the cut sections to drain the water to downstream. Installation of cross drainage pipes may be considered in the further design stage, with the confirmation of existing facilities in downstream and road vertical alignment.

(3) Interchange

Construction of an interchange is planned at the intersection between new road and existing road since both Pre-F/S corridor and NR8 corridor are fully access-controlled expressways. For the design of Alternative 1 (Pre-F/S corridor) in this study, the design of Pre-F/S shown in Table 8.1.3 is used as a reference. The interval of interchange is assumed to be 25 km and located close to the existing town area, avoiding mountainous area. Table 8.2.4 shows the interchange plan for each alternative route.

Table 8.2.4 Interchange Location

No.	Interchange Planned Location			
	Alternative 1	Alternative 2	Alternative 3A	Alternative 3B
1	**Vientiane (BP)**	**Vientiane (BP)**	**Vientiane (BP)**	**Vientiane (BP)**
2	B. Don	B. Don	B. Don	B. Don
3	Na xay	Na xay	Na xay	Na xay
4	Tha box	Tha box	Tha box	Tha box
5	Pac Xan	Pac Xan	Pac Xan	Pac Xan
6	Borikhan	Pak Kading	Pak Kading	Borikhan
7	Nam Phoi	Nam Dua	Nam Dua	Nam Phoi
8	Viengthong (NR1D)	Vien Kham	Vien Kham	Viengthong (NR1D)
9	Cuc Tia	Na Hin	Na Hin	Nam Cang (NR1D)
10	Phon Si	Pontan (NR1D)	Pontan (NR1D)	Pontan (NR1D)
11	Nam On	Lak Sao	Nam Cang (NR1D)	Lak Sao
12	**Ro (HCM road)**	**Po Chau (HCM road)**	Viengthong (NR1D)	**Po Chau (HCM road)**
13	NR.46	NR.15	Cuc Tia	NR.15
14	**N-S expressway (EP)**	**N-S expressway (EP)**	Phon Si	**N-S expressway (EP)**
15			Nam On	
16			**Ro (HCM road)**	
17			NR.46	
18			**N-S expressway (EP)**	

Note: Bolds are Trumpet Type I/C, others are diamond type I/C

Source: JICA Study Team

(4) Other road facilities

Installation of road ITS to the new expressway shall be considered and studied in further design stages. In this study, provision ITS cost are included the project cost. In addition, provisional cost for international border facilities are estimated, although it is not even mentioned in Pre-F/S. Frontage road and cross bridges shall be considered by other future projects.

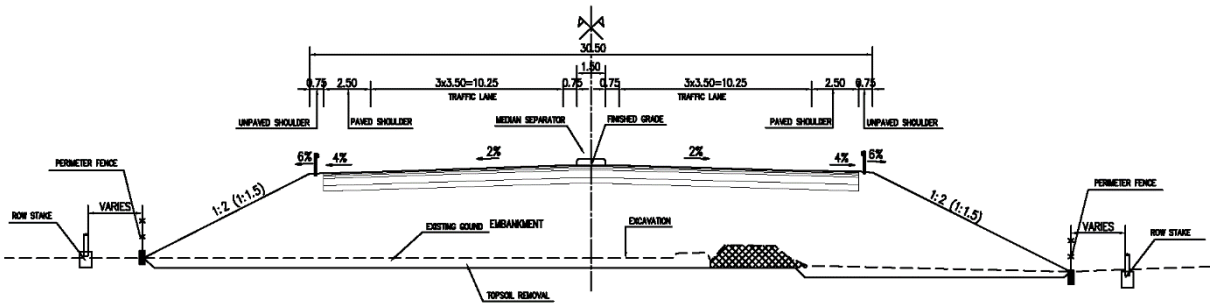
8.2.3 Typical Cross Sections

Figure 8.2.2 to Figure 8.2.8 show major typical cross sections of the road. All sections are included in the Appendix.

Table 8.2.5 Major Typical Cross Section

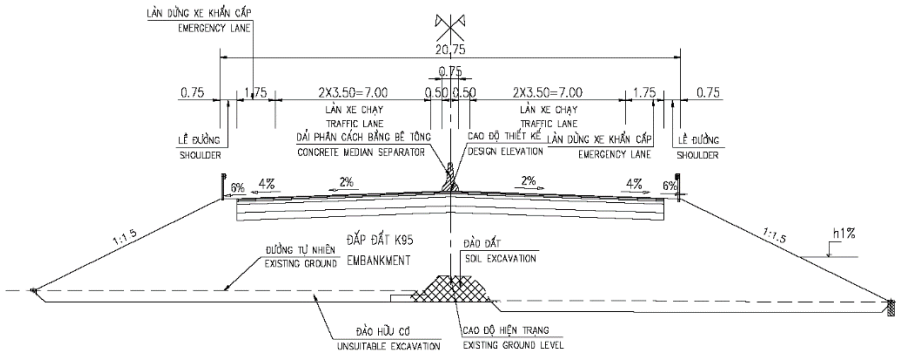
No.	Type	Lane	Design Speed (km/h)	Terrain Type	Cut/Fill
TCS-1	Cut/Fill	6	120-100	Flat	Fill
TCS-2		4	80-60	Rolling/ Mountainous (R/M)	Fill
TCS-3					Fill-one side
TCS-4					Cut
TCS-5	Bridge	6	120-100	Flat	—
TCS-6		4	80-60	R/M	—
TCS-7	Tunnel	4	80-60	R/M	—

Source: JICA Study Team



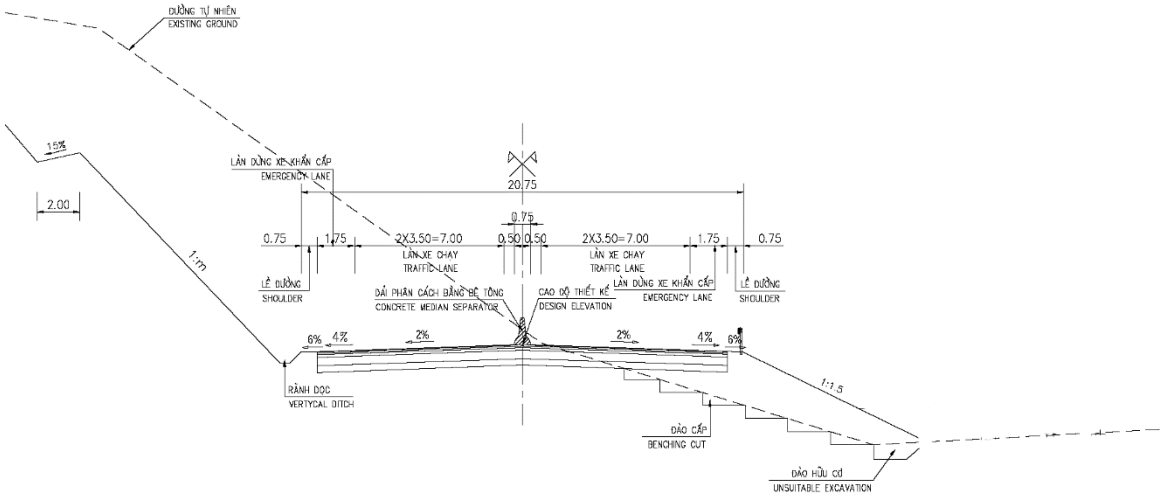
Source: JICA Study Team

Figure 8.2.2 Typical Cross Section (6-lane section, Flat)



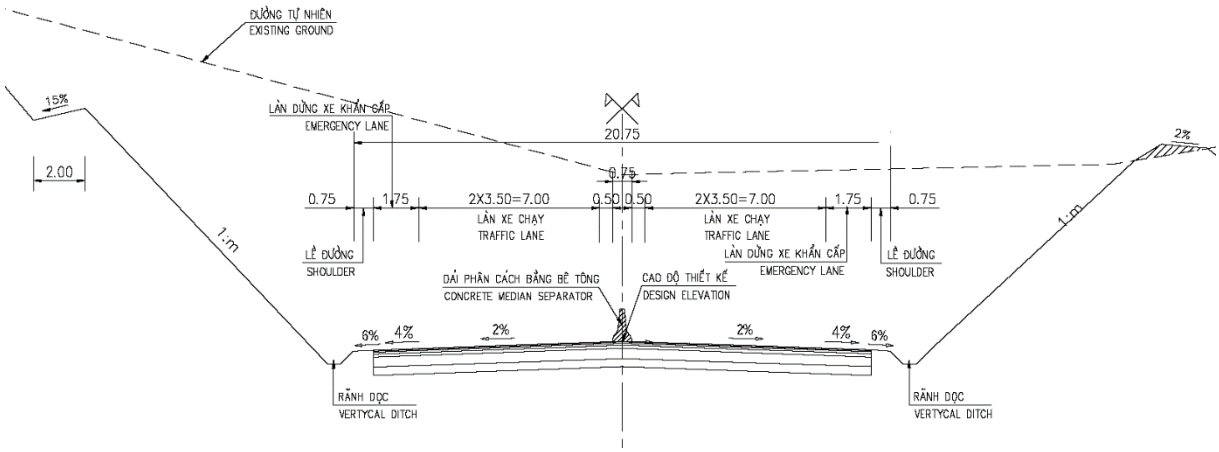
Source: JICA Study Team

Figure 8.2.3 Typical Cross Section (4-lane section, Rolling/Mountainous, Fill)



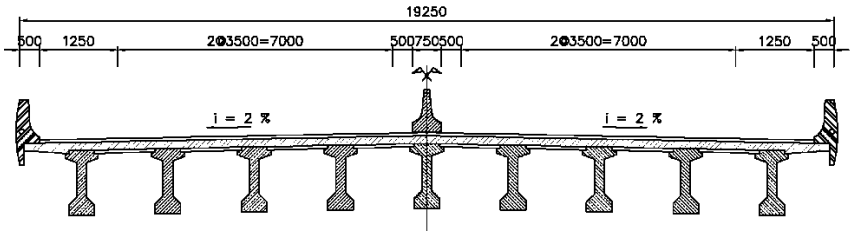
Source: JICA Study Team

Figure 8.2.4 Typical Cross Section (4-lane section, Rolling/Mountainous, Fill-oneside)



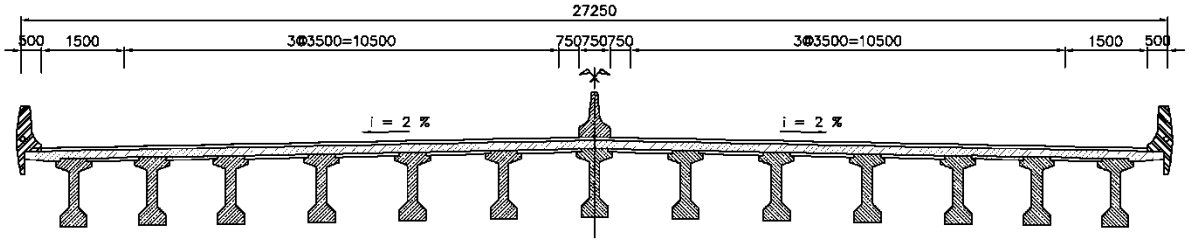
Source: JICA Study Team

Figure 8.2.5 Typical Cross Section (4-lane section, Rolling/Mountainous, Cut)



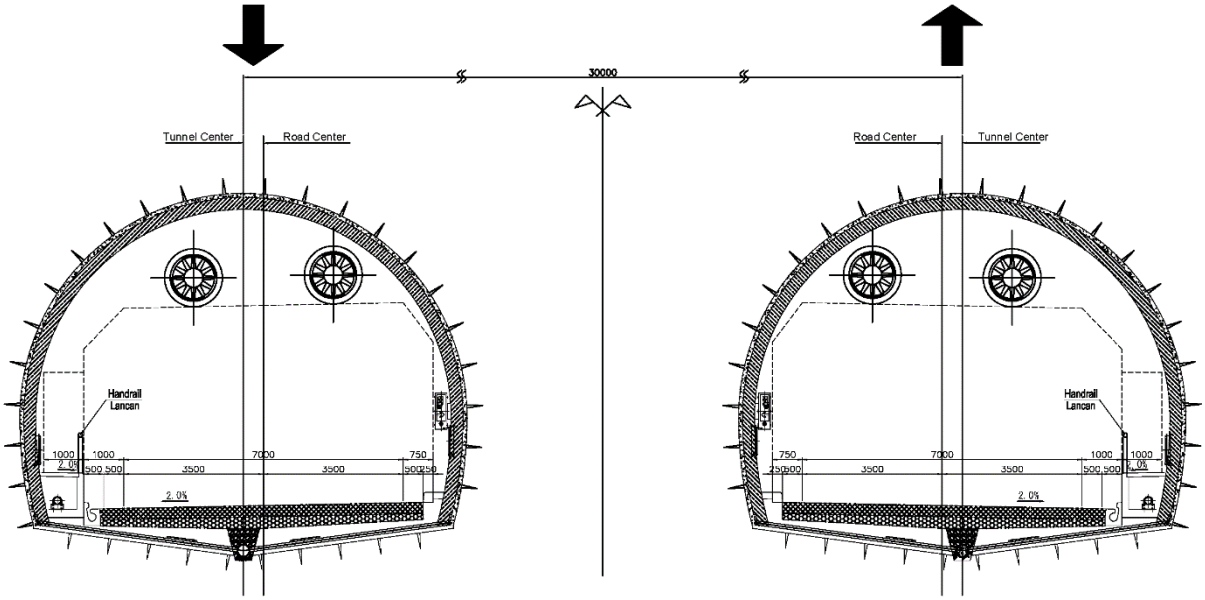
Source: JICA Study Team

Figure 8.2.6 Typical Cross Section (4-lane section, Bridge)



Source: JICA Study Team

Figure 8.2.7 Typical Cross Section (6-lane section, Bridge)



Source: JICA Study Team

Figure 8.2.8 Typical Cross Section (4-lane section, Tunnel)

8.2.4 Review of Main Structures

(1) Basic policy

In principle, road construction is basically based on earthworks (cuts, embankments) that are excellent in terms of workability and economic efficiency. In case of restrictions due to the site conditions, ambient conditions, and alignments, however, structures such as bridges, tunnels, retaining walls, and slopes may be considered. Furthermore, in this project, as in the Pre-F/S report, bridges and tunnels, which have a significant impact on the project cost, are identified as the main structures. In addition, considering the results of the geological survey, a study on the slope cutting methods will be carried out as well.

(2) Summary of geological survey

As a result of the geological survey in this project, many slope failure points like the one shown in Figure 8.2.9 below have been observed several times on the existing road in the mountain areas. The geological conditions of theses sections are fragile and extremely weak against water such as precipitation, and has characteristics that easily generates slope failures and cut slip.

Source: Picture by JICA Study Team

Figure 8.2.9 Slope Failures Generated around Border on National Road No.8

In the areas where such natural grounds are spreading, there are concerns that a top end collapse may occur at the time of tunnel construction, besides large slope failures of the cut slopes. Therefore, it is necessary to consider countermeasures.

(3) Bridge type selection

1) Bridge type selection

In selecting the bridge type, it is common to take into consideration of the past construction practices, construction method, etc., especially the points listed below:

- Economic efficiency: construction and maintenance costs based on local material procurement circumstances;
- Structural characteristics: runnability, earthquake resistance, influence of wind and so on;
- Workability: construction difficulty, actual performance, construction schedule etc. (based on local construction conditions and equipment procurement circumstances);
- Maintenance manageability: frequency of inspection, maintenance, and the degree of efforts needed (based on local maintenance conditions of the existing bridges);
- Landscape: harmony and balance with the surrounding environment.

Table 8.2.6 shows the general bridge types.

Table 8.2.6 Classification of Types of Bridges

Type-1 :Girder Bridge		Type-2 : Rigid Frame Bridge		Type-3 : Arch Bridge	
					
Main material	:Concrete / Steel	Main material	Concrete / Steel	Main material	Concrete / Steel
Type-4 : Suspention Bridge		Type-5 : Cable Stayed Bridge		Type-6 : Truss Bridge	
					
Main material	Wood / Composite	Main material	Composite	Main material	Steel

Source: JICA Study Team

The Pre-F/S report selected bridge Type 1, concrete girder, among the above types of bridges. The same bridge type [Type 1] (concrete girder) is selected by this project for the following reasons:

- Superior in operation and maintenance compared with steel bridge;
- Experiences of construction in both Laos and Vietnam;
- Reasonability of I digit (composite type) for span length below 33 m, and box I digit for span length above 33 m compared with the Japanese standard in Table 8.2.7.

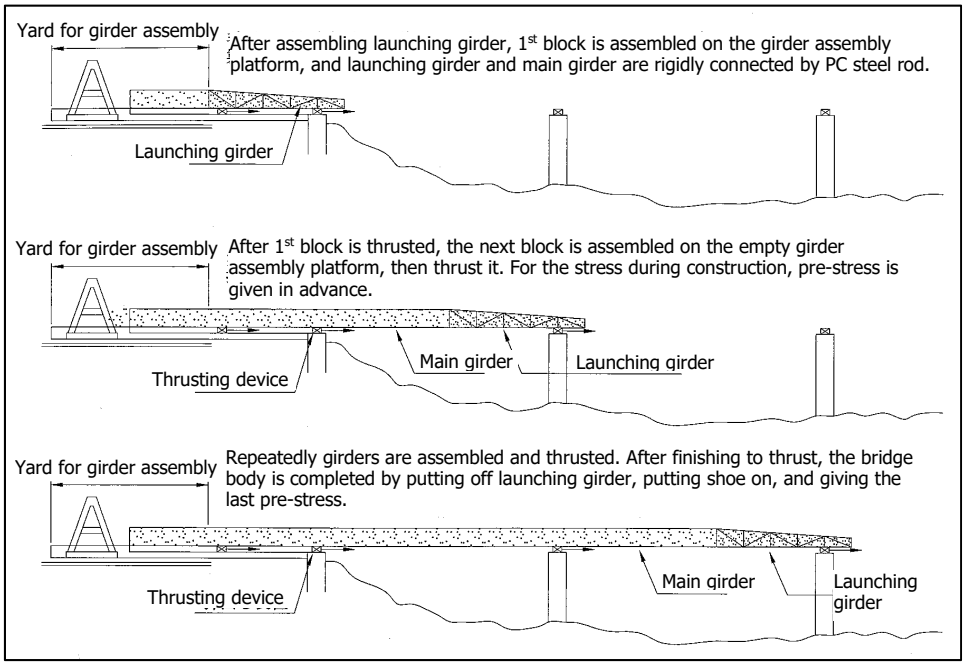
Table 8.2.7 Classification of Bridge Type (2)

Classification			Structure type	Shape of cross section	Applied span (m)
Continious bridge	Precast girder erection method	Pre-tension		Deck slab bridge	15~24
				T-girder bridge	18~24
		Post-tension		T-girder bridge	20~35
				Composite bridge	20~40
	Cast-in-place			Hollow slab bridge	20~30
				Box girder bridge	30~110
				Slab girder bridge	20~35

Source: Prepared by JICA Study Team based on PC Road Bridge planning manual

2) Bridge planning in mountainous area

According to the road alignment plan in the Pre-F/S, the pier heights of all the bridges in the valley are extremely high; hence the scale of substructure construction becomes bigger than that of the general bridges crossing river side, and the construction cost tends to be higher. For reference, Figure 8.2.10 shows an outline of the thrust construction method, which is one of the typical construction methods used in the valleys. In the project cost estimation, it is necessary to take into account the increase in the project cost by such bridges.



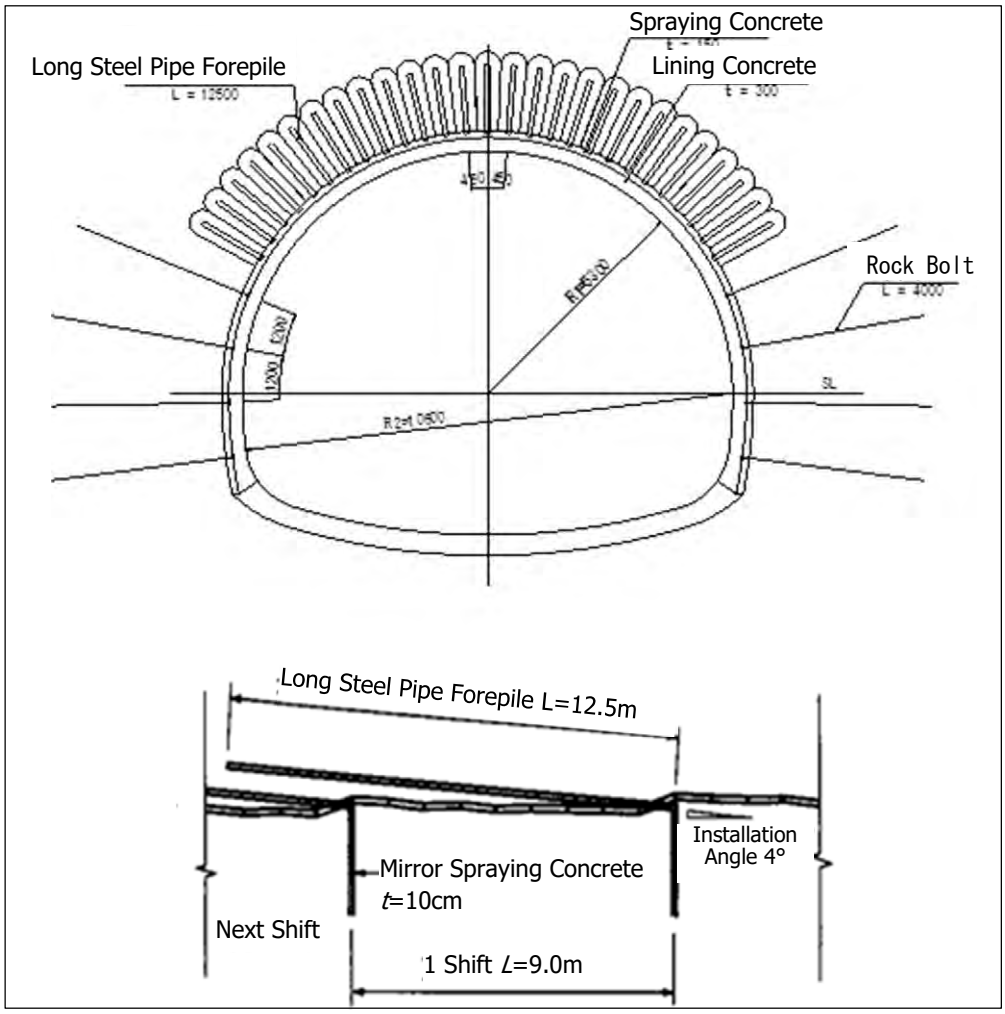
Source: Manual for PC road and bridge planning

Figure 8.2.10 Outline of Special Construction Method of High Piers in the Valley (Thrust Method)

(4) Selection of tunnel type

The mountain tunnel construction method is based on stabilizing the space by ground arches formed by the strength of the tunnel surrounding the ground itself. Furthermore, in order to construct a tunnel, self-standing of the tunnel face at the time of excavation is a prerequisite. In mountain tunnels, it is common to excavate while securing the stability of the ground by spraying concrete, rock bolts, etc. In the Pre-F/S report, the standard construction methods are organized and reflected in the project cost. However, as a result of this geological survey, there have been vulnerable weak grounds confirmed around this route; therefore, it is necessary to consider an auxiliary construction method.

The auxiliary construction method is subdivided into several types including the ground reinforcement, the forepiling, the mirror surface reinforcement, the foot reinforcement. Among these methods, the long steel pipe forepiling method shown in the following figure is superior in many aspects including construction experiences and economic efficiency, and it can be said that it is one of the most reliable auxiliary methods. Therefore, in the estimation of the project cost estimation, it is necessary to consider the increase in the project cost by the auxiliary construction method.



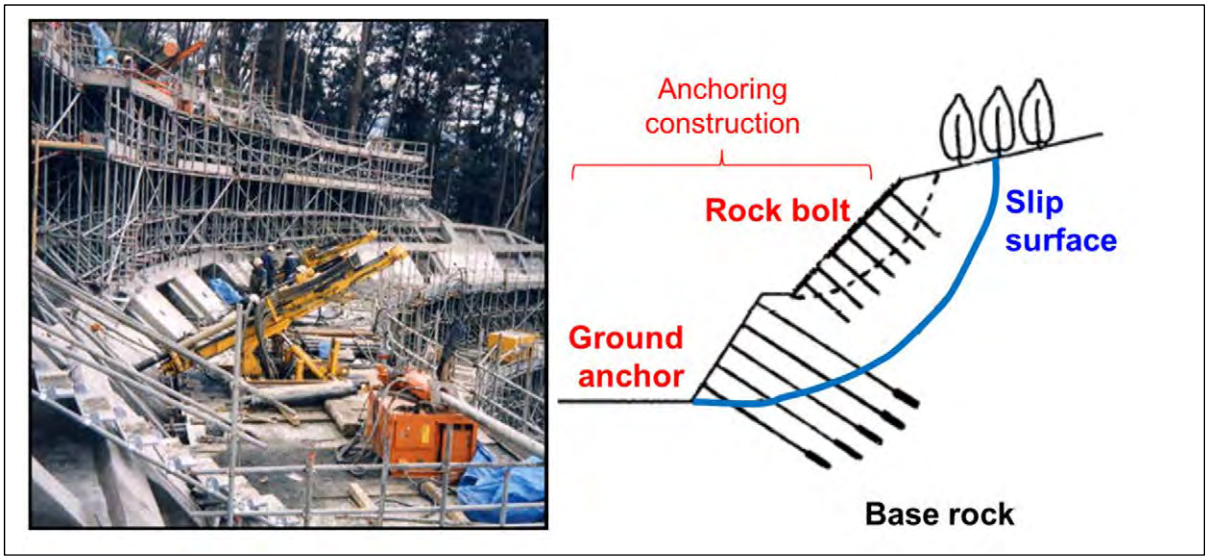
Source: Prepared by JICA Study Team based on Tunnel Standard Specification

Figure 8.2.11 Tunnel Auxiliary Construction Method (the long steel pipe tip forepiling method)

(5) Slope surface measurement selection

In the Pre-F/S report, slope stability countermeasures such as sodding, precast concrete plastering, mortar spraying and rock bolt work were studied under the assumption of large scale earth cuts in the mountainous sections. The project cost was estimated by the general method based on the past experiences. However, as a result of this geological survey, vulnerable weak grounds have been confirmed around this route, and there is a concern of a large-scale slope failure that cannot be dealt

with only by these construction methods. Therefore, in order to prevent such large-scale slope failures, several construction methods such as piling and collecting wells exist; however, the ground anchor method shown in the figure below has the most proven track record as a large-scale road slope countermeasure, and is highly reliable construction method. Therefore, in estimation of the project cost, it is necessary to consider the increase in the project cost by this auxiliary construction method.



Source: JICA Study Team

Figure 8.2.12 Image of Grand Anchor Work

(6) Component technology

Main structures are classified into bridges, mountain bridges, mountain tunnels, and slope protection works. The component technologies proposed for mountain bridges, mountain tunnels, and slope protection work (enthrusting construction, long steel pipe tip forepiling, ground anchor work) are suitable for Japan's steep topography and fragile grounds; these are major construction technologies that Japanese companies have strength in. These technologies that Japanese companies have advantages in are indispensable for implementing safe and high quality projects.

8.3 Rough Cost Estimation of Roads and Structures

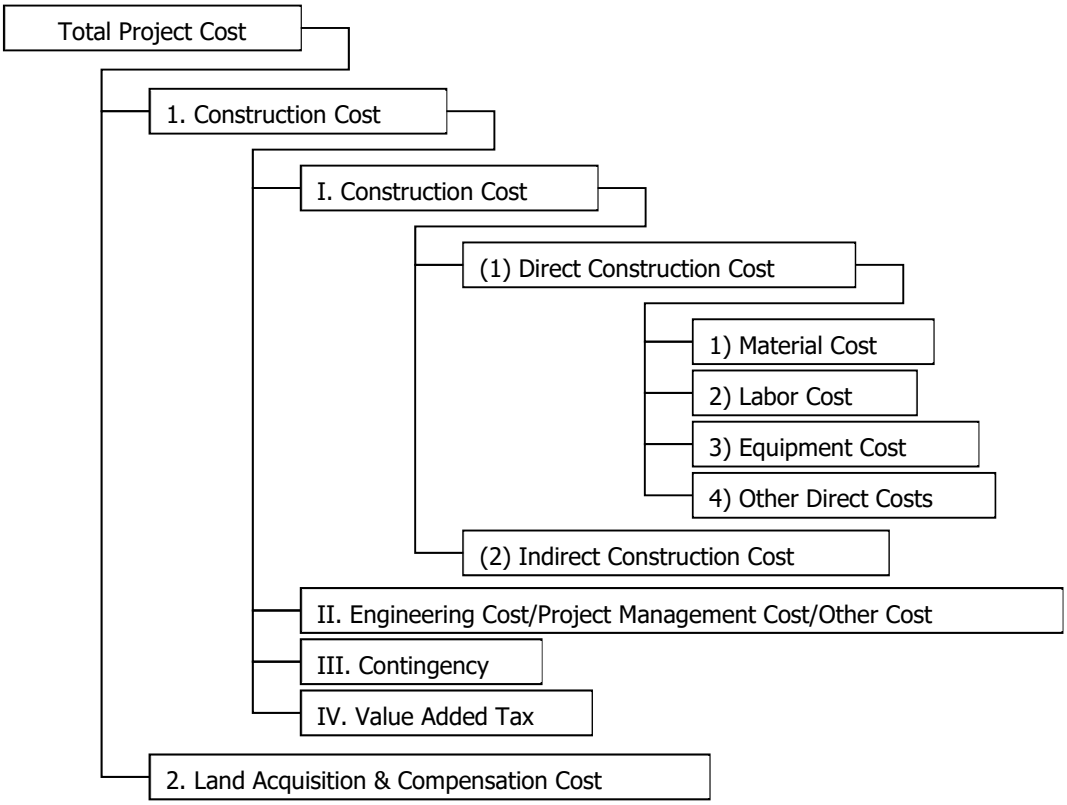
8.3.1 Cost Estimation Conditions

(1) Cost estimation policy

In the detailed design stage, the project cost consists of construction costs, design and construction supervision fees, contingency, compensation expenses for residents, as shown in Figure 8.3.1, and construction costs are required to be accumulated by material cost, labor cost, etc.

However, this study aims to review the project cost estimated in the Pre-F/S report therefore, accumulation method will not be used in this project, and the estimation will be based on the compound unit costs. This composite unit costs are set according to revision rates in the Pre-F/S report which are assumed reasonable from the past experiences.

In this study, the total project cost consists of direct construction cost, indirect construction cost (30% of the direct construction cost), value added tax (10% of the total construction cost) and land acquisition and compensation cost.



Source: JICA Study Team

Figure 8.3.1 Composition of Project Cost

(2) Project cost estimation cases

Table 8.3.1 presents the rough project cost estimation cases.

Table 8.3.1 Rough Project Cost Estimation Cases

Alternative 1（Pre-F/S corridor）
Alternative 2（National Road No.8 corridor）
Alternative 3A
Alternative 3B

Source: JICA Study Team

(3) Exchange rate

Exchange rate is settled as follows based on JICA monthly official rate in JFY 2018.

- USD = 108.812 JPY
- VND = 0.004782 JPY

June, 2018（monthly exchange rate in JFY 2018）

8.3.2 Classification of Terrains

In the estimation of the project cost, the unit cost depends largely on the terrain features. The terrain is classified into five types as shown in the following table.

Table 8.3.2 Classification of Terrains

Terrain type	Criteria for the classification of terrain type
Flat	flat area without densely clustered houses
Flat (Urban Area)	flat area with densely clustered houses, areas possibly with soft ground conditions, or areas possibly with soft ground conditions
Rolling	areas with continuous gentle undulations or hills (height difference: 2–300m)
Mountainous	areas with continuous mountains with a large height difference (300–500m)
Steep Mountainous	areas with continuous mountains with a significantly large height differences (over 500m)

Source: JICA Study Team

8.3.3 Setting of Unit Project Prices

Project unit prices are set based on the following policies.

- Unit of the unit prices are as follows.

Table 8.3.3 Unit of the Unit Cost by Construction Work

Work Item	Unit
Earthwork	(million Japanese Yen/km)
Bridge	(million Japanese Yen/m^2)
Tunnel	(million Japanese Yen/km)
IC, Border Facility	(million Japanese Yen/site)

Source: JICA Study Team

- Unit prices of earthworks, bridges, and tunnels were updated by multiplying the Pre-F/S unit price (2017 year) and by the revision rates. The revision rates were evaluated as shown in Table 8.3.4 below. However, since the Pre-F/S unit prices are set in 2017, annual corrections are not necessary.

Table 8.3.4 Revision rates

Work type	Revision rate	Concept of the Revision Rate
Earthwork	0.7–1.5	✓ It was confirmed that the Pre-F/S set the unit prices based on the planned values of the Vietnamese North-South Expressway Design, etc. ✓ Set at 0.7 for flat area assuming works done by local companies. ✓ Set according to urbanization considering the cost increase due to crossing box culvert for local roads in flat/urban areas. ✓ Set according to terrain features considering the increase of size of earth work in hilly/mountainous areas and measures against slope surface in unstable landforms.
Bridges	1.2–1.5	✓ It was confirmed that the Pre-F/S showed unit prices slightly lower than the planned values of the Vietnamese North-South Expressway Design, etc. ✓ Set according to terrain features considering the cost increase due to construction of a high pier, access road and overhanging installation in steep/mountainous areas.
Tunnels	1.3	✓ It was confirmed that the Pre-F/S set the unit prices based on the planned values of the Vietnamese North-South Expressway Design, etc. ✓ Set based on supporting works in unstable landform.
Interchange and border facilities	-----	✓ The Pre-F/S report implemented interchange plans, but did not reflect the cost in the project cost, so it is included in this survey. ✓ IC: set based on Japanese experience as 500 mil. JPY for diamond shape and 1,500 mil. JPY for trumpet shape ✓ BCF border control facility: set based on F/S report the 5th friendship bridge as 1,000 mil. JPY.

Source: JICA Study Team

Table 8.3.5 shows the list of the unit prices for the rough estimation of the project cost.

Table 8.3.5 Project Unit Price

Terrain		Item	Unit	6 Lane (W= 30.5m)				4 Lane (W= 20.75m)			
				Unit Cost (Pre-F/S)	Revision Rate	Unit Cost (Revised)	Unit Cost (Revised)	Unit Cost (Pre-F/S)	Revision Rate	Unit Cost (Revised)	Unit Cost (Revised)
			Billion VND	Billion VND		Billion VND	Million JPY	Billion VND		Billion VND	Million JPY
1	Flat	EARTH	km	100	0.7	70	330	75			
		BRIDGE	m2	0.014	1.2	0.02	0.080	0.014			
2	Flat (Urban Area)	EARTH	km	140	Pre F/S route→			90	1.5	135	650
		EARTH	km	140	NH-8 route→			90	1.2	108	520
		BRIDGE	m2	0.014				0.014	1.2	0.02	0.080
3	Rolling	EARTH	km	110				85	1.2	102	490
		BRIDGE	m2	0.014				0.014	1.2	0.02	0.080
		TUNNEL	km	1,300				1,000	1.3	1,300	6,200
4	Mountainous	EARTH	km	160				110	1.3	143	680
		BRIDGE	m2	0.014				0.014	1.3	0.02	0.087
		TUNNEL	km	1,300				1,000	1.3	1,300	6,200
5	Steep Mountainous	EARTH	km	180				110	1.5	165	790
		BRIDGE	m2	0.014				0.014	1.5	0.02	0.100
		TUNNEL	km	1,300				1,000	1.3	1,300	6,200

Source: JICA Study Team

8.3.4 Rough Estimation of Project Cost

(1) Outline of the rough project cost

Estimated project cost for each alternative plan is shown in Figure 8.3.2. Regarding the number of road lanes, the estimation is based on assuming that all sections will be developed as 4-lane roads except the Vientiane-Pac Xan section which will have 6 lanes.

Of the four cases, Alternative 2 (NR8 route), which has the shortest total length of steep mountainous sections, was found to need the lowest project cost. On the other hand, Alternative 3A, which has the longest total length of steep mountainous sections, was found to require the highest project cost.

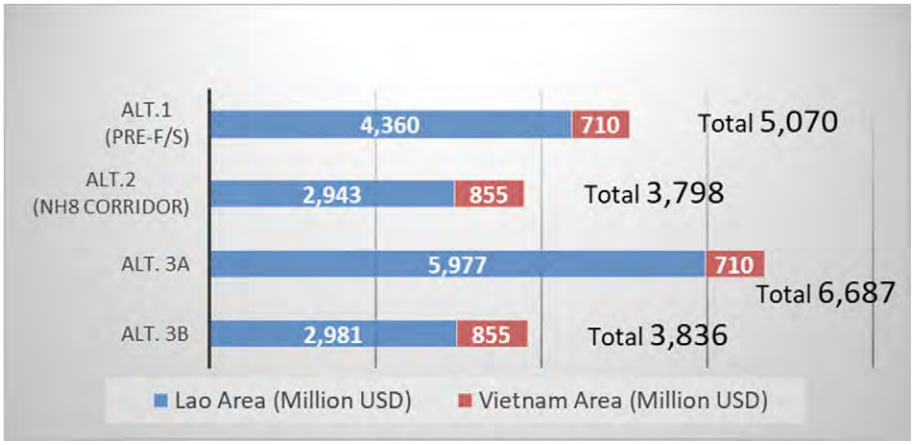


Figure 8.3.2 Summary of Project Cost Estimation

The rough breakdown of project cost is shown in Table 8.3.6. The project cost consists of direct construction cost, indirect construction cost, value added tax and land acquisition and compensation cost.

Table 8.3.6 Rough Breakdown of Project Cost

1. Alternative 1 (Pre-F/S Corridor 400km) Unit: Million USD

		Vientiane ~ Pac Xan	Pac Xan ~ Vieng Thong	Vieng Thong ~ Border			Lao Area	Border ~ HCM Road		HCM Road ~ Vinh	VietNam Area	Total
	Length (km)	118	119	102			339	26		35	61	400
	Terrain	Flat	Rolling	Steep Mountainous				Mountainous		Flat (Ubarn Area)		
Main Structure (km)	Bridge	2.56	9.60	28.97				6.65		1.80		
	Tunnel			18.01								
Construction Cost	Lane	6 Lane	4 Lane	4 Lane				4 Lane		4 Lane		
1Direct Work Cost		434	642	1,962			3,038	246		243	489	3,527
2Indirection Cost	30% of 1	130	193	589			912	74		73	147	1,059
3Value Added Tax	10% of 1,2	56	84	255			395	32		32	64	459
Total	1+2+3	620	919	2,806			4,345	352		348	700	5,045
Compensation												
4 Land Acquisition		5	5	3			14	1		5	6	20
5 Resettlement		1	1	0			1	0		3	4	5
Total	4+5	6	5	4			15	1		8	10	25
Total Project Cost	1+2+3+4+5	626	924	2,810			4,360	353		356	710	5,070

2. Alternative 2 (NH8 Corridor 403km) Unit: Million USD

		Vientiane ~ Pac Xan	Pac Xan ~ Vieng Kham	Vieng Kham ~ Phontan	Phontan ~ Border		Lao Area	Border ~ NH-8	NH-8 ~ HCM Road	HCM Road ~ Vinh	VietNam Area	Total
	Length (km)	118	96	50	76		340	12	27	24	63	403
	Terrain	Flat	Rolling	Rolling	Rolling			Steep Mountainous	Rolling	Flat (Ubarn Area)		
Main Structure (km)	Bridge	2.56	7.78	2.80	6.16			4.55	10.00	1.22		
	Tunnel		3.00	4.50				1.40				
Construction Cost	Lane	6 Lane	4 Lane	4 Lane	4 Lane			4 Lane		4 Lane		
1Direct Work Cost		434	675	517	420		2,046	219	232	144	595	2,641
2Indirection Cost	30% of 1	130	203	155	126	0	614	66	70	43	179	793
3Value Added Tax	10% of 1,2	56	88	67	55	0	266	29	30	19	78	344
Total	1+2+3	620	966	739	601	0	2,926	314	332	206	852	3,778
Compensation												
4 Land Acquisition		5	4	4	2		15	1	1	1	3	18
5 Resettlement		1	1	1	0		2	0	0	0	0	2
Total	4+5	6	5	4	2	0	17	1	1	1	3	20
Total Project Cost	1+2+3+4+5	626	971	743	603	0	2,943	315	333	207	855	3,798

3. Alternative 3 (Detour of Nature Reserve 477km) Unit: Million USD

		Vientiane ~ Pac Xan	Pac Xan ~ Vieng Kham	Vieng Kham ~ Phontan	Phontan ~ Vieng Thong	Vieng Thong ~ Border	Lao Area	Border ~ HCM Road		HCM Road ~ Vinh	VietNam Area	Total
	Length (km)	118	96	50	50	102	416	26		35	61	477
Terrain		Flat	Rolling	Rolling	Mountainous	Steep Mountainous		Mountainous		Flat (Ubarn Area)		
Main Structure (km)	Bridge	2.56	7.78	2.80	4.05	28.97		6.65		1.80		
	Tunnel	0.00	3.00	4.50	4.50	18.01						
Construction Cost	Lane	6 Lane	4 Lane	4 Lane	4 Lane	4 Lane		4 Lane		4 Lane		
1Direct Work Cost		434	675	517	578	1,962	4,166	246		243	489	4,655
2Indirection Cost	30% of 1	130	203	155	173	589	1,250	74		73	147	1,397
3Value Added Tax	10% of 1,2	56	88	67	75	255	541	32		32	64	605
Total	1+2+3	620	966	739	826	2,806	5,957	352		348	700	6,657
Compensation												
4 Land Acquisition		5	4	4	1	3	18	1		5	6	24
5 Resettlement		1	1	1	0	0	2	0		3	4	6
Total	4+5	6	5	4	1	4	20	1		8	10	30
Total Project Cost	1+2+3+4+5	626	971	743	827	2,810	5,977	353		356	710	6,687

4. Alternative 3B (Bottle Neck Reduction 426km) Unit: Million USD

		Vientiane ~ Pac Xan	Pac Xan ~ Vieng Kham	Vieng Kham ~ Phontan	Phontan ~ Border		Lao Area	Border ~ NH-8	NH-8 ~ HCM Road	HCM Road ~ Vinh	VietNam Area	Total
	Length (km)	118	119	50	76		363	12	27	24	63	426
	Terrain	Flat	Rolling	Mountainous	Rolling			Steep Mountainous	Rolling	Flat (Ubarn Area)		
Main Structure (km)	Bridge	2.56	9.60	4.05	6.16			4.55	10.00	1.22		
	Tunnel			4.50				1.40				
Construction Cost	Lane	6 Lane	4 Lane	4 Lane	4 Lane			4 Lane		4 Lane		
1Direct Work Cost		434	642	578	420		2,074	219	232	144	595	2,669
2Indirection Cost	30% of 1	130	193	173	126	0	622	66	70	43	179	801
3Value Added Tax	10% of 1,2	56	84	75	55	0	270	29	30	19	78	348
Total	1+2+3	620	919	826	601	0	2,966	314	332	206	852	3,818
Compensation												
4 Land Acquisition		5	5	1	2		14	1	1	1	3	17
5 Resettlement		1	1	0	0		1	0	0	0	0	2
Total	4+5	6	5	1	2	0	15	1	1	1	3	18
Total Project Cost	1+2+3+4+5	626	924	827	603	0	2,981	315	333	207	855	3,836

Source: JICA Study Team

(2) Detailed breakdowns of direct construction cost

Table 8.3.7 to Table 8.3.10 show the detailed breakdowns of the project costs by alternative.

Table 8.3.7 Breakdown of Direct Construction Cost for Alternative 1 (Pre-F/S corridor)

1. Alternative 1 (Pre-F/S Corridor 400km)		Length (km)	Unit	Unit Cost (Revised)	Total Cost (Billion JPY)	Total Cost (Million USD)
I	Laos Country					
Vientiane ～ Pac Xan	6Lane ・Flat NO.0--NO.118	118	Million JPY		47	434
	Length of Route (Km)	*115.44*	*km*	*330*	*38.1*	*350.1*
	Length of Bridge (Km)	*2.56*	*m2*	*0.080*	*5.6*	*51.5*
	IC trumpet shape	*1*	*n*	*1,500*	*1.5*	*13.8*
	IC dimond shape	*4*	*n*	*500*	*2.0*	*18.4*
Pac Xan ～ Vieng Thong	4Lane・Rolling NO.118--NO.237	119	Million JPY		70	642
	Length of Route (Km)	*109.4*	*km*	*490*	*53.6*	*492.6*
	Length of Bridge (Km)	*9.6*	*m2*	*0.080*	*14.8*	*136.0*
	IC dimond shape	*3*	*n*	*500*	*1.5*	*13.8*
Vieng Thong ～ Border	4Lane・Steep Mountainous NO.237--NO.339	102	Million JPY		214	1,962
	Length of Route (Km)	*55.02*	*km*	*790*	*43.5*	*399.8*
	Length of Bridge (Km)	*28.97*	*m2*	*0.100*	*55.8*	*512.8*
	Length of Tunnel (Km)	*18.01*	*km*	*6,200*	*111.7*	*1026.5*
	IC dimond shape	*3*	*n*	*500*	*1.5*	*13.8*
	BCF	*1*	*n*	*1,000*	*1.0*	*9.2*
Total in Lào		339	km		331	3,038
II	VietNam					
Border ～ HCM Road	4Lane・Mountainous NO.339--NO.365	26	Million JPY		27	246
	Length of Route (Km)	*19.35*	*km*	*680*	*13.2*	*121.3*
	Length of Bridge (Km)	6.65	*m2*	*0.087*	*11.1*	*102.0*
	Length of Tunnel (Km)	0	*km*	*6,200*	*0.0*	*0.0*
	BCF	*1*	*n*	*1,000*	*1.0*	*9.2*
	IC trumpet shape	*1*	*n*	*1,500*	*1.5*	*13.8*
HCM Road ～ Vinh	4Lane・Flat (Ubarn Area) NO.365--NO.400	35	Million JPY		26	243
	Length of Route (Km)	*33.2*	*km*	*650*	*21.6*	*198.5*
	Length of Bridge (Km)	1.8	*m2*	*0.080*	*2.8*	*25.7*
	IC trumpet shape	*1*	*n*	*1,500*	*1.5*	*13.8*
	IC dimond shape	*1*	*n*	*500*	*0.5*	*4.6*
	Vinh - Hà Nội	Out of Scope				
Total in Vietnam		61	km		53	489
Total		400	km		384	3,527

USD = 108.812 JPY

Source: JICA Study Team

Table 8.3.8 Breakdown of Direct Construction Cost for Alternative 2 (NR8 Corridor)

2. Alternative 2 (NH8 Corridor 403km)		Length (km)	Unit	Unit Cost (Revised)	Total Cost (Billion JPY)	Total Cost (Million USD)
I	Laos Country					
Vientiane ～ Pac Xan	6Lane ・Flat NO.0--NO.118	118	Million JPY		47	434
	Length of Route (Km)	*115.44*	*km*	*330*	*38.1*	*350.1*
	Length of Bridge (Km)	*2.56*	*m2*	*0.080*	*5.6*	*51.5*
	IC trumpet shape	*1*	*n*	*1,500*	*1.5*	*13.8*
	IC dimond shape	*4*	*n*	*500*	*2.0*	*18.4*
Pac Xan ～ Vieng Kham	4Lane・Rolling NO.118--NO.214	96	Million JPY		73	675
	Length of Route (Km)	*85.22*	*km*	*490*	*41.8*	*384.1*
	Length of Bridge (Km)	*7.78*	*m2*	*0.080*	*12.0*	*110.3*
	Length of Tunnel (Km)	*3.00*	*km*	*6,200*	*18.6*	*170.9*
	IC dimond shape	*2*	*n*	*500*	*1.0*	*9.2*
Vieng Kham ～ Phontan	4Lane・Rolling NO.214--NO.264	50	Million JPY		56	517
	Length of Route (Km)	*47.2*	*km*	*490*	*23.1*	*212.3*
	Length of Bridge (Km)	*2.80*	*m2*	*0.080*	*4.3*	*39.5*
	Length of Tunnel (Km)	*4.50*	*km*	*6,200*	*27.9*	*256.4*
	IC dimond shape	*2*	*n*	*500*	*1.0*	*9.2*
Phontan ～ Border	4Lane・Rolling NO.264--NO.340	76	Million JPY		46	420
	Length of Route (Km)	*69.84*	*km*	*490*	*34.2*	*314.3*
	Length of Bridge (Km)	*6.16*	*m2*	*0.080*	*9.5*	*87.3*
	Length of Tunnel (Km)	*0*	*km*	*6,200*	*0.0*	*0.0*
	IC dimond shape	*2*	*n*	*500*	*1.0*	*9.2*
	BCF	*1*	*n*	*1,000*	*1.0*	*9.2*
Total in Lào		340	km		222	2,046
II	VietNam					
Border ～ NH-8	4Lane・Steep Mountainous NO.340--NO.352	12	Million JPY		24	219
	Length of Route (Km)	*6.05*	*km*	*790*	*4.8*	*44.1*
	Length of Bridge (Km)	*4.55*	*m2*	*0.100*	*8.8*	*80.9*
	Length of Tunnel (Km)	*1.4*	*km*	*6,200*	*8.7*	*80.0*
	BCF	*1*	*n*	*1,000*	*1.0*	*9.2*
	IC dimond shape	*1*	*n*	*500*	*0.5*	*4.6*
NH-8 ～ HCM Road	4Lane・Rolling NO.352--NO.379	27	Million JPY		25	232
	Length of Route (Km)	*17*	*km*	*490*	*8.3*	*76.3*
	Length of Bridge (Km)	*10.00*	*m2*	*0.080*	*15.4*	*141.5*
	IC trumpet shape	*1*	*n*	*1,500*	*1.5*	*13.8*
HCM Road ～ Vinh	4Lane・Flat (Ubarn Area) NO.379--NO.403	24	Million JPY		16	144
	Length of Route (Km)	*22.78*	*km*	*520*	*11.8*	*108.4*
	Length of Bridge (Km)	*1.2*	*m2*	*0.080*	*1.9*	*17.5*
	IC trumpet shape	*1*	*n*	*1,500*	*1.5*	*13.8*
	IC dimond shape	*1*	*n*	*500*	*0.5*	*4.6*
	Vinh - Hà Nội	Out of Scope				
Total in Vietnam		63	km		65	595
Total		403	km		287	2,641

USD = 108.812 JPY

Source: JICA Study Team

Table 8.3.9 Breakdown of Direct Construction Cost for Alternative 3A

3. Alternative 3 (Detour of Nature Reserve 477km)		Length (km)	Unit	Unit Cost (Revised)	Total Cost (Billion JPY)	Total Cost (Million USD)
I	Laos Country					
Vientiane ～ Pac Xan	6Lane ・Flat NO.0--NO.118	118	Million JPY		47	434
	Length of Route (Km)	*115.44*	*km*	*330*	*38.1*	*350.1*
	Length of Bridge (Km)	*2.56*	*m2*	*0.080*	*5.6*	*51.5*
	IC trumpet shape	*1*	*n*	*1,500*	*1.5*	*13.8*
	IC dimond shape	*4*	*n*	*500*	*2.0*	*18.4*
Pac Xan ～ Vieng Kham	4Lane・Rolling NO.118--NO.214	96	Million JPY		73	675
	Length of Route (Km)	*85.22*	*km*	*490*	*41.8*	*384.1*
	Length of Bridge (Km)	*7.78*	*m2*	*0.080*	*12.0*	*110.3*
	Length of Tunnel (Km)	*3.00*	*km*	*6,200*	*18.6*	*170.9*
	IC dimond shape	*2*	*n*	*500*	*1.0*	*9.2*
Vieng Kham ～ Phontan	4Lane・Rolling NO.214--NO.264	50	Million JPY		56	517
	Length of Route (Km)	*47.2*	*km*	*490*	*23.1*	*212.3*
	Length of Bridge (Km)	*2.80*	*m2*	*0.080*	*4.3*	*39.5*
	Length of Tunnel (Km)	*4.50*	*km*	*6,200*	*27.9*	*256.4*
	IC dimond shape	*2*	*n*	*500*	*1.0*	*9.2*
Phontan ～ Vieng Thong	4Lane・Mountainous NO.264--NO.314	50	Million JPY		63	578
	Length of Route (Km)	*41.45*	*km*	*680*	*28.2*	*259.2*
	Length of Bridge (Km)	*4.05*	*m2*	*0.087*	*6.8*	*62.5*
	Length of Tunnel (Km)	*4.5*	*km*	*6,200*	*27.9*	*256.4*
	IC dimond shape	*0*	*n*	*500*	*0.0*	*0.0*
Vieng Thong ～ Border	4Lane・Steep Mountainous NO.314--NO.416	102	Million JPY		214	1,962
	Length of Route (Km)	*55.02*	*km*	*790*	*43.5*	*399.8*
	Length of Bridge (Km)	*28.97*	*m2*	*0.100*	*55.8*	*512.8*
	Length of Tunnel (Km)	*18.01*	*km*	*6,200*	*111.7*	*1026.5*
	IC dimond shape	*3*	*n*	*500*	*1.5*	*13.8*
	BCF	*1*	*n*	*1,000*	*1.0*	*9.2*
Total in Lào		416	km		453	4,166
II	VietNam					
Border ～ HCM Road	4Lane・Mountainous NO.416--NO.442	26	Million JPY		27	246
	Length of Route (Km)	*19.35*	*km*	680	*13.2*	*121.3*
	Length of Bridge (Km)	6.65	*m2*	0.087	*11.1*	*102.0*
	Length of Tunnel (Km)	0	*km*	6200	*0.0*	*0.0*
	BCF	*1*	*n*	*1,000*	*1.0*	*9.2*
	IC trumpet shape	*1*	*n*	*1,500*	*1.5*	*13.8*
HCM Road ～ Vinh	4Lane・Flat (Ubarn Area) NO.442--NO.477	35	Million JPY		26	243
	Length of Route (Km)	*33.2*	*km*	650	*21.6*	*198.5*
	Length of Bridge (Km)	1.8	*m2*	0.08	*2.8*	*25.7*
	IC trumpet shape	*1*	*n*	*1,500*	*1.5*	*13.8*
	IC dimond shape	*1*	*n*	*500*	*0.5*	*4.6*
	Vinh - Hà Nội	Out of Scope				
Total in Vietnam		61	km		53	489
Total		477	km		506	4,655

USD = 108.812 JPY

Source: JICA Study Team

Table 8.3.10 Breakdown of Direct Construction Cost for Alternative 3B

4. Alternative 4 (Bottle Neck Reduction 426km)		Length (km)	Unit	Unit Cost (Revised)	Total Cost (Billion JPY)	Total Cost (Million USD)
I	Laos Country					
Vientiane ～ Pac Xan	6Lane ・Flat NO.0--NO.118	118	Million JPY		47	434
	Length of Route (Km)	*115.44*	*km*	*330*	*38.1*	*350.1*
	Length of Bridge (Km)	*2.56*	*m2*	*0.080*	*5.6*	*51.5*
	IC trumpet shape	*1*	*n*	*1,500*	*1.5*	*13.8*
	IC dimond shape	*4*	*n*	*500*	*2.0*	*18.4*
Pac Xan ～ Vieng Kham	4Lane・Rolling NO.118--NO.237	119	Million JPY		70	642
	Length of Route (Km)	*109.4*	*km*	*490*	*53.6*	*492.6*
	Length of Bridge (Km)	*9.60*	*m2*	*0.080*	*14.8*	*136.0*
	IC dimond shape	*3*	*n*	*500*	*1.5*	*13.8*
Vieng Kham ～ Phontan	4Lane・Mountainous NO.237--NO.287	50	Million JPY		63	578
	Length of Route (Km)	*41.45*	*km*	*680*	*28.2*	*259.2*
	Length of Bridge (Km)	*4.05*	*m2*	*0.087*	*6.8*	*62.5*
	Length of Tunnel (Km)	*4.5*	*km*	*6,200*	*27.9*	*256.4*
	IC dimond shape	*0*	*n*	*500*	*0.0*	*0.0*
Phontan ～ Border	4Lane・Rolling NO.287--NO.363	76	Million JPY		46	420
	Length of Route (Km)	*69.84*	*km*	*490*	*34.2*	*314.3*
	Length of Bridge (Km)	*6.16*	*m2*	*0.080*	*9.5*	*87.3*
	Length of Tunnel (Km)	*0.00*	*km*	*6,200*	*0.0*	*0.0*
	IC dimond shape	*2*	*n*	*500*	*1.0*	*9.2*
	BCF	*1*	*n*	*1,000*	*1.0*	*9.2*
Total in Lào		363	km		226	2,074
II	VietNam					
Border ～ NH-8	4Lane・Steep Mountainous NO.363--NO.375	12	Million JPY		24	219
	Length of Route (Km)	*6.05*	*km*	790	*4.8*	*44.1*
	Length of Bridge (Km)	4.55	*m2*	0.10	*8.8*	*80.9*
	Length of Tunnel (Km)	1.4	*km*	6200	*8.7*	*80.0*
	BCF	*1*	*n*	*1,000*	*1.0*	*9.2*
	IC dimond shape	*1*	*n*	*500*	*0.5*	*4.6*
NH-8 ～ HCM Road	4Lane・Rolling NO.375--NO.402	*27*	Million JPY		25	232
	Length of Route (Km)	*17*	*km*	*490*	*8.3*	*76.3*
	Length of Bridge (Km)	*10.00*	*m2*	*0.08*	*15.4*	*141.5*
	IC trumpet shape	*1*	*n*	*1,500*	*1.5*	*13.8*
			n		*0.0*	*0.0*
HCM Road ～ Vinh	4Lane・Flat (Ubarn Area) NO.402--NO.426	24	Million JPY		16	144
	Length of Route (Km)	*22.78*	*km*	520	*11.8*	*108.4*
	Length of Bridge (Km)	1.22	*m2*	0.08	*1.9*	*17.5*
	IC trumpet shape	*1*	*n*	*1,500*	*1.5*	*13.8*
	IC dimond shape	*1*	*n*	*500*	*0.5*	*4.6*
	Vinh - Hà Nội	Out of Scope				
Total in Vietnam		36	km		65	595
Total		399	km		291	2,901

USD = 108.812 JPY

Source: JICA Study Team

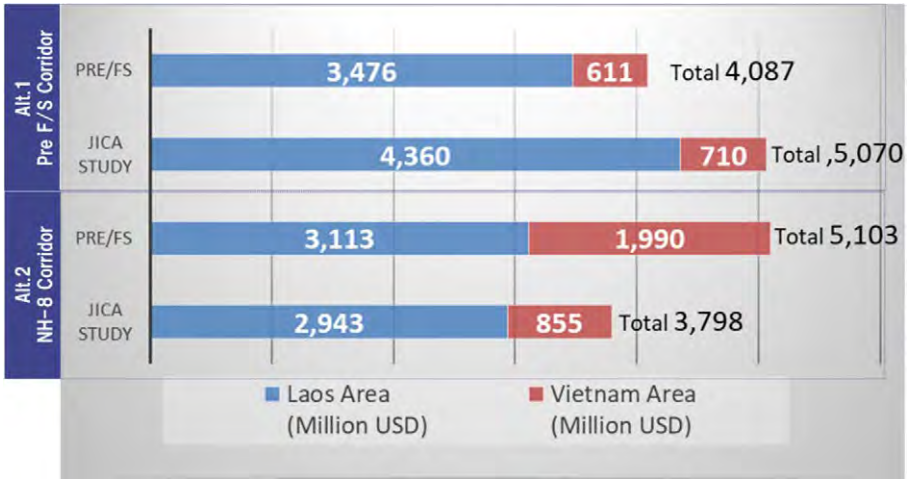
(3) Comparison of the Pre-F/S and this study cost estimation results

As for Alternative 1 and Alternative 2, the comparison of the Pre-F/S and this study cost estimation results are summarized in Figure 8.3.3.

In this study, topographic maps were created with a scale of 1/5000 for sections with mountainous terrain and steep mountainous terrain. The approximate number of bridge and tunnel sections was estimated based on these topographic maps. As a result, this study provides more accurate construction cost estimations for bridge and tunnel sections, leading to differences between this study and the Pre-F/S total cost estimates.

Regarding the construction cost of Alternative 1 in the Laos area, the main reason behind the large increase in the cost estimation results of this study compared with the Pre-F/S is the increased length of bridge and tunnel sections. On the other hand, the estimated construction cost of Alternative 1 in the Vietnam area has increased in this study compared with that of the Pre-F/S due to the increased unit cost of earth works in flat/urban section after taking into consideration the impact of the additional costs attributed to box culvert crossings for local roads.

Regarding the construction cost of Alternative 2 in the Laos area, the main reason behind the large decrease in the cost estimation results of this study compared with that of the Pre-F/S is the decrease in the total length of steep mountainous sections achieved based on the topographic survey maps. On the other hand, the estimated construction cost of Alternative 2 in the Vietnam area has decreased in this study compared with that of the Pre-F/S due to the decreased length of bridge sections as a result of adopting a route 10 km to the south of the existing NR8.



Source: JICA Study Team

Figure 8.3.3 Comparison of Cost Estimation Results in Pre-F/S and in this Study

Chapter 9
Evaluation of Proposed Expressway Development Plan

Chapter 9 Evaluation of Proposed Expressway Development Plan

9.1 Evaluation Method

In this chapter, the four alternative plans for expressway development proposed in Chapter 6 are evaluated and suggestions are made as to the most desirable development pattern for the Hanoi-Vientiane expressway. The indicators used in the evaluation include construction cost, traffic demand, travel time between major cities, contribution to regional development and impact on the environment, etc. The items and indices used for the evaluation are shown in Table 9.1.1.

Table 9.1.1 Evaluation Items and Evaluation Indices of Alternative Plans

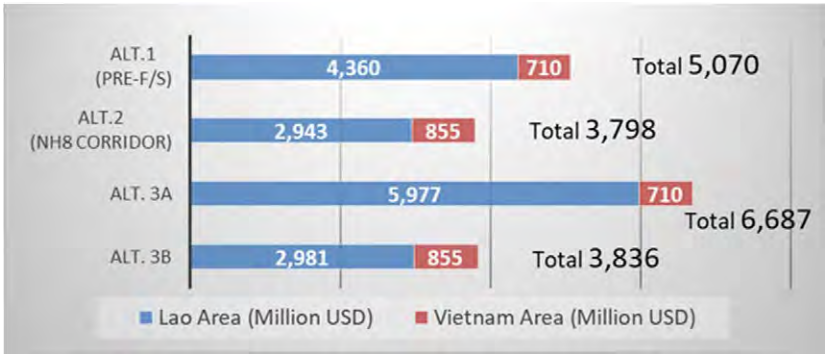
Evaluation Item	Evaluation Indices
Project Cost	Total project cost (sum of direct cost, indirect cost, land acquisition cost, compensation for resettlement and taxes, etc.)
Traffic Demand	Estimated traffic volume by each section (PCU/day)
Travel Time between Major Cities	Required travel time between ①Hanoi – Vientiane, ②Bangkok – Hanoi and ③Vientiane – Vung Aung port
Vertical Gradient	Length of steep gradient section (± 6%)
Contribution to Regional Development	Size of flat and unused areas along the roadside
Impact on Environment	Inhabitancy of endangered species along the roadside
Resettled Structure	The number of resettled structure within ROW(60m)
Effectiveness of Phased Approach	Feasibility of mini bypass development

9.2 Evaluation by Each Evaluation Item

Each alternative plan is evaluated as quantitatively as possible by the indices set in the previous section, and three-scale evaluation criteria are prepared for each evaluation item (++: Good, +: Fair, －: Bad).

9.2.1 Project Cost

Approximate project cost for each alternative is shown in Figure 9.2.1 and Table 9.2.1. The cost of Alt. 2 is the smallest followed by Alt 3B, Alt. 1 and Alt. 3A, respectively.



Alternative	1	2	3A	3B
Evaluation	+	++	－	++

Note: ++: Good +: Fair －: Bad

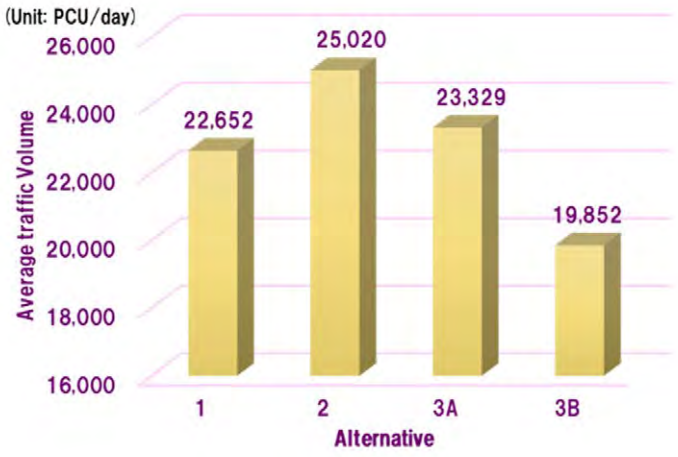
Figure 9.2.1 Summary of Project Cost (Cost breakdown by country)

Table 9.2.1 Project Costs by Alternative

		Alt.1	Alt.2	Alt.3A	Alt.3B
Laos	Direct Work Cost	3,038	2,046	4,166	2,074
	Land Acquisition	14	15	18	14
	Resettlement	1	2	2	1
	Indirect Cost	912	614	1,250	622
	VAT	395	266	541	270
	Total	4,360	2,943	5,977	2,981
Vietnam	Direct Work Cost	489	595	489	595
	Land Acquisition	60	3	6	3
	Resettlement	4	0	4	0
	Indirect Cost	147	179	147	179
	VAT	64	78	64	78
	Total	710	855	710	855
Total	Direct Work Cost	3,527	2,641	4,655	2,669
	Land Acquisition	20	18	24	17
	Resettlement	5	2	6	2
	Indirect Cost	1,059	793	1,397	801
	VAT	459	344	605	347
	Total	5,070	3,798	6,687	3,836

9.2.2 Traffic Demand

Figure 9.2.2 shows average daily traffic volume in 2035 by alternative. The traffic volume of Alt. 2 is the largest and it is found that the Alt. 2 would function well as an expressway, followed by Alt. 3A, Alt. 1 and Alt. 3B, respectively, in terms of traffic volume.



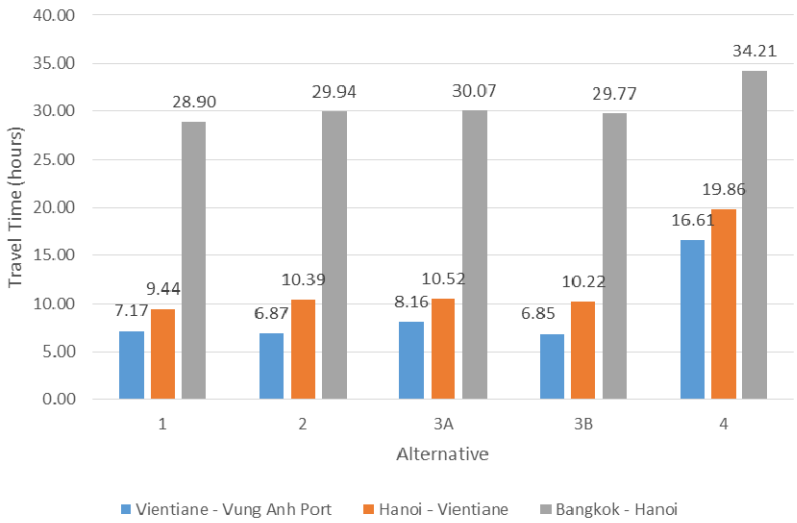
Alternative	1	2	3A	3B
Evaluation	+	++	+	−

Note: ++: Good +: Fair −: Bad

Figure 9.2.2 Average Daily Traffic Volume by Alternative (PCU/day) (2035)

9.2.3 Travel Time between Major Cities

Figure 9.2.3 shows the required travel time between major cities by alternative. All alternative plans show remarkable time reduction compared to the Case 4, a case without the project implementation. This result demonstrates the expected positive effect of the expressway. Although differences among the cases are not great, time reduction of Alt.1 for Hanoi–Vientiane section and Bangkok–Hanoi section, and of Alt.2 and Alt.3B for Vientiane–Vung Anh Port section are relatively large.



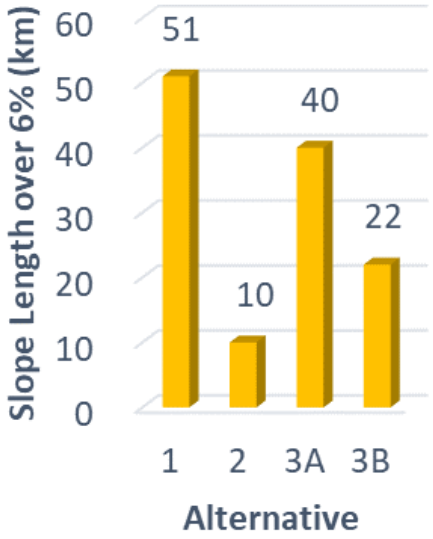
Alternative	1	2	3A	3B
Evaluation	++	+	−	+

Note: ++: Good +: Fair −: Bad

Figure 9.2.3 Travel Time between Major Cities

9.2.4 Vertical Gradient

Figure 9.2.4 shows slope length with ±6% of vertical gradient by alternative. Alt. 1 has the length with ±6% gradient section, in the Pre-F/S route. The large vertical gradient causes reduction of travel speed of large trailer trucks and this becomes an impediment to serving as a major logistics corridor.



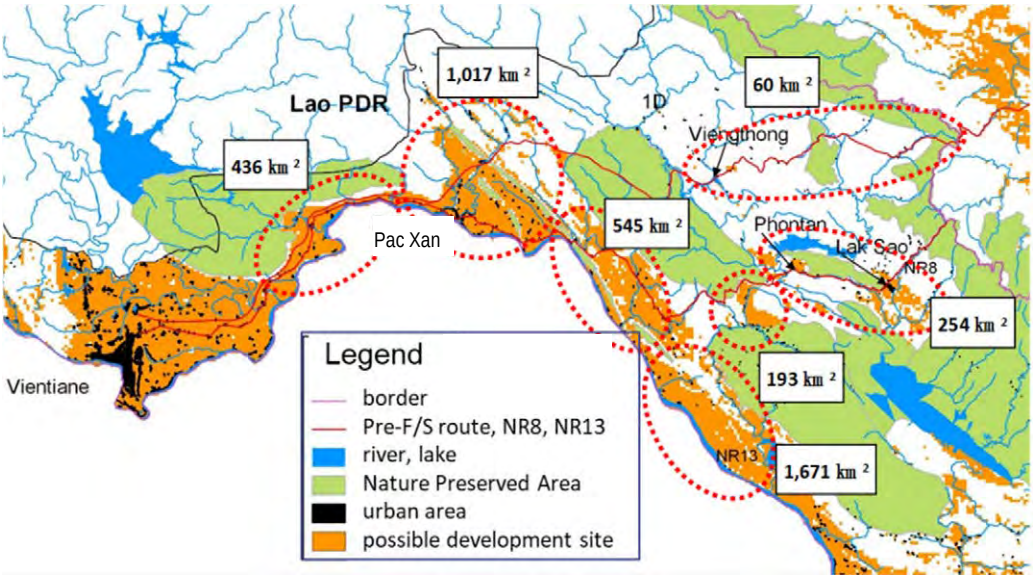
Alternative	1	2	3A	3B
Evaluation	−	++	−	+

Note: ++: Good +: Fair −: Bad

Figure 9.2.4 Length of Road Section with over 6% of Vertical Gradient

9.2.5 Contribution to Regional Development

Figure 9.2.5 shows developable land, i.e. plane or gently rolling hills spreading over 100 ha or more. Alt. 2 has the largest developable land followed by, respectively, Alt. 3A, Alt. 3B and Alt. 1.



Alternative	1	2	3A	3B
Area size of developable land within 1km from each route	264km^2	438km^2	378km^2	309km^2

Alternative	1	2	3A	3B
Evaluation	—	++	+	—

++: Good +: Fair —: Bad

Figure 9.2.5 Contribution to Regional Development (Area of Possible Development Site)

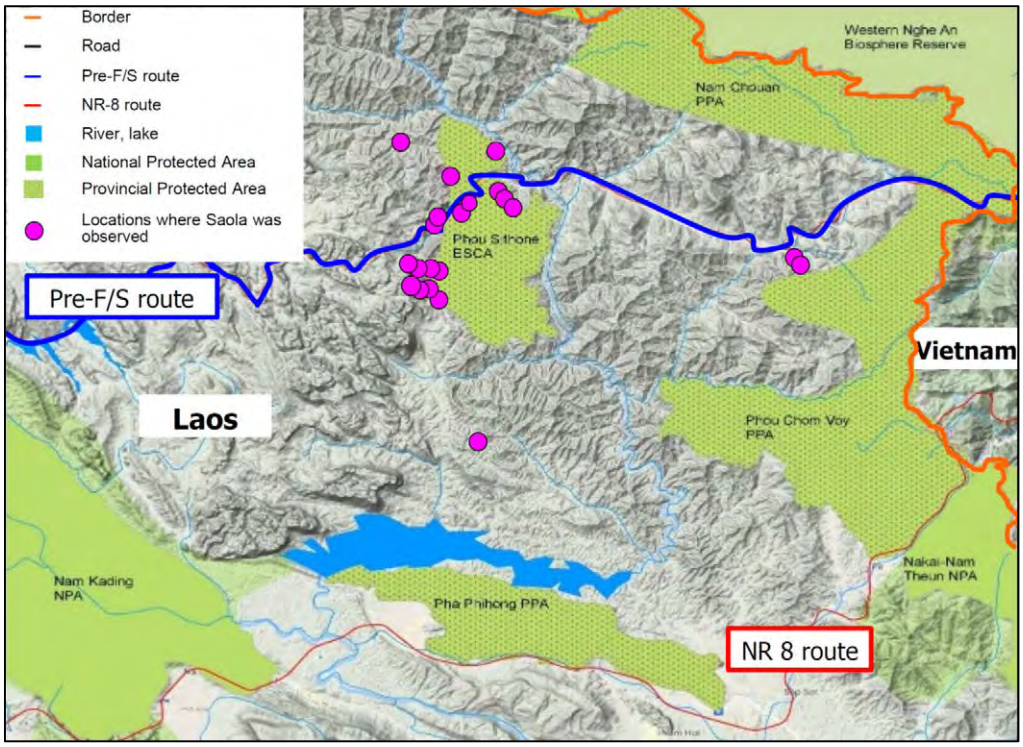
9.2.6 Impact on Environment

All alternative routes pass protected areas in Laos and/or Vietnam. However, reviews of related laws and regulations in both countries and interviews with the concerned agencies have confirmed that construction of a new road will not have adverse impacts as long as designated procedures are appropriately followed (Table 9.2.2).

Table 9.2.2 Regulations on Passing Protected Areas / Natural Reserves

Laos	Vietnam
– All routes pass NPA/PPAs. – Submission of EIA and approval from MPWT, MOAF, MONRE as well as Prime Minister and National Congress are necessary to change forest designation. – No governmental agencies raised concern over this issue.	– Alt 1 and 3A pass Biosphere Reserve. – Road construction is not prohibited in Transition Zone in Biosphere Reserve (Biodiversity Law, article.7). – Procedure to change designation is unnecessary. – EIA and approval from Prime Minister are necessary.

However, both governments are in accord on the point that road construction in the habitats of critically endangered species are not allowed. According to the interview, impacts on Saola's habitat in the target areas of Laos is a concern. As Alt. 1 and 3A run through locations where Saola were spotted in the past (Figure 9.2.6), these routes are more likely to cause negative impact on their habitat, i.e. division of the habitat.



Source: Created by JICA Study Team based on Phommachanh et al. (2017) Tropical Conservation Science. vol. 10:1-15

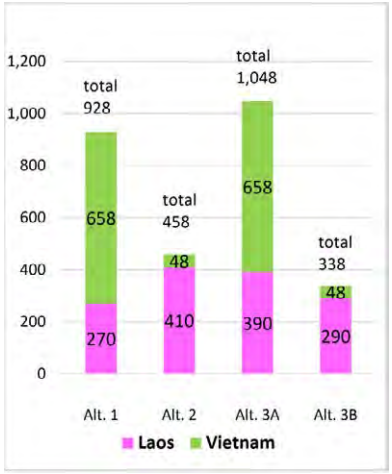
Alternative	1	2	3A	3B
Evaluation	−	+	−	+

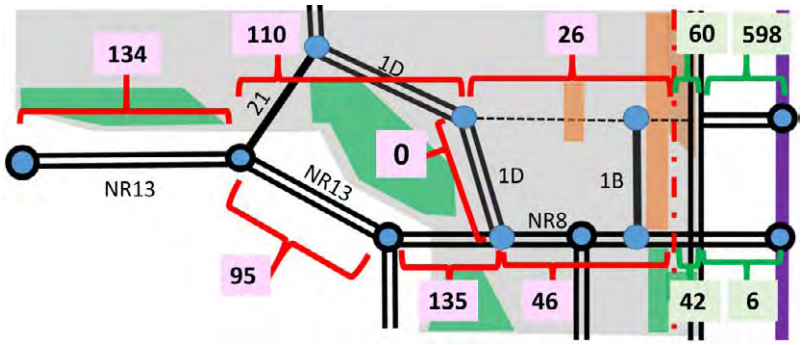
Note: ++: Good +: Fair −: Bad

Figure 9.2.6 Habitat of Critically Endangered Species (Saola)

9.2.7 Resettled Structures

The number of resettled structures by alternative/section are estimated based on the precondition that the ROW of the expressway is 60 m. The result is shown in Figure 9.2.7. The numbers of resettled structures along the Alt. 1 and Alt. 3A are more than double of those of Alt. 2 and Alt.3B. The reason for this big difference is that Alt. 1 and Alt. 3A pass through residential areas in the section between HCM road (north side) and Vinh on Vietnam side.





Alternative	1	2	3A	3B
Evaluation	−	+	−	+

++: Good +: Fair −: Bad

Figure 9.2.7 Number of Resettled Structures by Alternative/Section

9.2.8 Effectiveness of Phased Approach

It is not easy to construct an expressway of over 400 km at once. Therefore it is recommendable to introduce a step-wised construction policy according to which mini bypasses are developed in stages first and then the bypasses are connected to complete one expressway. This step-wised development is preferable when the existing general roads run in parallel with the proposed expressway. In this light, Alt. 2 is the most desirable because there are NR 8 and NR 13, followed by Alt. 3A and Alt.3 B. Alt. 1 has no existing roads nearby, and thus it is evaluated as the least desirable.

STEP	Image	Content of development
1		Development of mini BP avoiding a bottleneck section in the existing road
2		Another development of mini BP
3		Making one road by connecting these mini BPs

Alternative	1	2	3A	3B
Evaluation	−	++	+	+

++: Good +: Fair −: Bad

Figure 9.2.8 Strategy of Phased Approach

9.3 Evaluation Result

The evaluation result is shown in Table 9.3.1. Based on the analysis in Section 9.2 the scores are as follows: 2 points for "Good", 1 point for "Fair", and 0 point for "Bad. Alt. 2 is found to be the most desirable, followed by Alt.3 B. The other two, Alt.1 and Alt. 3A, showed the lowest result. According to the result, Alt. 2, despite showing a lower evaluation in terms of travel time between major cities (especially Hanoi-Vientiane and Bangkok-Hanoi), has high evaluation marks in all the other evaluation criteria. On the other hand, Alt.1 which is selected in the Pre-F/S passes through long sections along mountainous areas and has lower evaluation in terms of vertical gradient, contribution to regional development, etc. The overall low evaluation of Alt. 1 also results from the facts that it passes through the potential habitat of Saola, critically endangered species, and that the number of resettled structures on Vietnam side is large along the route.

Table 9.3.1 Evaluation Results of Alternative Routes

Alternative	Project cost	Traffic demand	Travel time between major cities	Vertical gradient	Contribution to regional development	Impact on environment	Number of resettled structure	Effectiveness of phased approach	Overall Evaluation	
1	+:1	+:1	++:2	-:0	-:0	-:0	- : 0	-:0	4 points	-
2	++:2	++:2	+:1	++:2	++:2	+:1	+:1	++:2	13 points	++
3A	-:0	+:1	-:0	-:0	+:1	-:0	-:0	+:1	3 points	-
3B	++:2	-:0	+:1	+:1	-:0	+:1	+:1	+:1	7points	+

Note: ++ (Good)(2 points), + (Fair)(1 point), - (Bad)(0 point)

9.4 Study of Routes on Vietnam Side

9.4.1 Route Comparison on Vietnam Side

Comparison of alternative routes is summarized in Table 9.4.1. Pre-F/S route (Alt.1 and Alt. 3A) shows higher evaluation than NR 8 route (Alt. 2 and Alt.3B) in terms of length, construction cost and low-speed sections. However, the Pre-F/S route has significant challenges in environmental and social considerations as it passes through protected areas (Biosphere Reserve) and requires a large number of resettled structure. In Vietnam, road construction in Biosphere Reserve is not legally prohibited and the Vietnamese government sees no problem with it as long as appropriate procedures are followed. However, it is difficult to solve the issue of the large number of resettled structures even if a minor change in the route alignment is made. Specifically, the number of resettled structures in Vietnam alone is 658, and that of Alt.1 as a whole is 928. This means that 70.9% of all the resettled structures along Alt.1 are located in Vietnam side.

Table 9.4.1 Comparison of Alternative Routes on Vietnam Side

Route	Length	Construction Cost	Low-speed sections due to steep slope (below 30km/h)	Environmental Impact Road length passing through protected area	The Number of Resettled Structures
Alt.1 Alt.3A (Pre-F/S route)	61km	Border - HCM road (mountainous, 4-lane) 354 Million USD HCM road - NSE (flat, 4-lane) 356 Million USD Total 710 Million USD	8.6km	• It passes through Biosphere Reserve. • Road construction is not prohibited in BR (Biodiversity law, article No.7) but EIA and approval of Prime Minister is necessary.	658 (including temple, school, and cemetery)
	1.00	1.00	1.00	-	1.00
Alt. 2 Alt. 3B (NR 8 route)	63km	Border - NR 8 (steep mountain, 4-lane) 315 Million USD NR 8 - HCM road (rolling, 4-lane) 333 Million USD HCM road - NSE (flat, 4-lane) 207 Million USD Total 855 Million USD	10.8km	• It does not pass through any protected areas.	48
	1.05	1.20	1.26	-	0.07

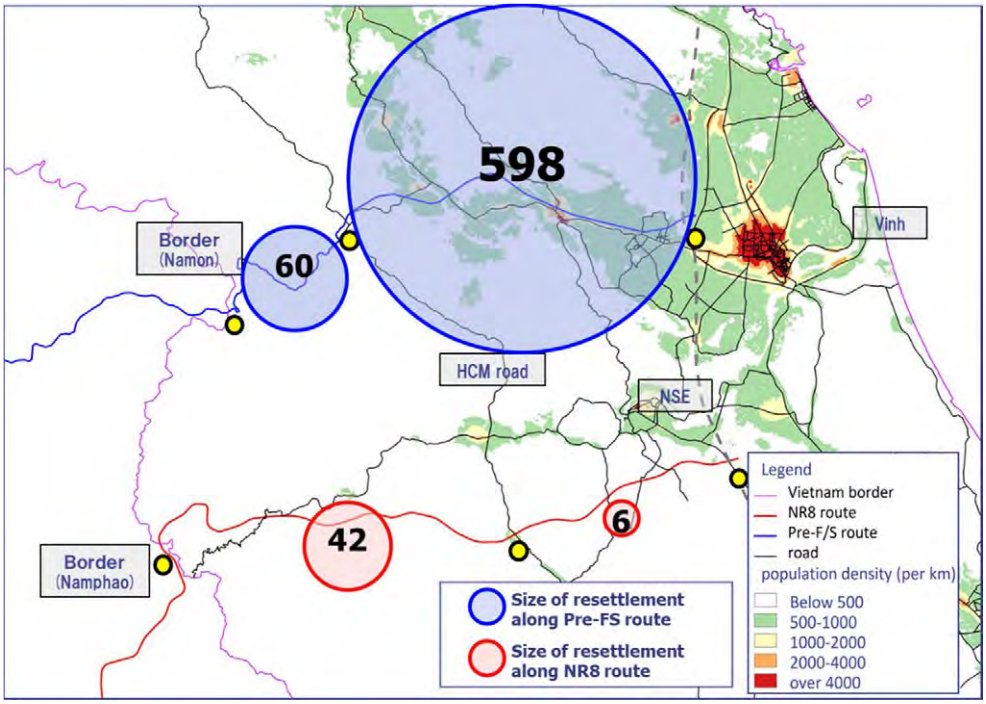


Figure 9.4.1 Comparison of the Number of Resettled Structures

9.4.2 Route Evaluation through Whole Length (Laos and Vietnam)

As mentioned above, except the number of resettled structure, the Pre-F/S route shows higher evaluation in Vietnam side alone. In this study, however, NR 8 route is selected as the most desirable route plan from a holistic point of view, because the Pre-F/S route has the following problems on the Laos side, which accounts for more than 80% of the total road length.

1) Since the Pre-F/S route passes many mountainous areas in Laos, the project cost becomes expensive (Table 9.4.2). A detailed re-examination on the project cost of Pre-F/S route might be able to make a minor reduction, but there is little possibility that the cost of Pre-F/S route becomes smaller than that of NR route.

Table 9.4.2 Comparison of Project Cost

	Project Cost (million USD)			(A)/(B)
	(A) Pre-F/Sroute	(B) NR-8 route	(A)-(B)	
Laos	4,360	2,943	1,417	1.48
Vietnam	710	855	-145	0.83
Total	5,070	3,798	1,272	1.33

2) It is considered internationally unacceptable as it passes through habitats of Saola, one of the critically endangered species (see Figure 9.2.6)

3) The route alignment runs on mountainous terrain with little potential for roadside development and it will serve no other use

9.4.3 Measures for Structural Issues along NR 8 Route

As for Alternative 2 and Alternative 3B on Vietnam side, the route alignment passing around 10km south of the existing NR 8 is adopted because there are dense residential areas and frequent floods in the nearby areas along NR 8 (Figure 9.4.2).

The area proposed for a new border crossing facilities for expressway users is planned to be located 5 km to the north of the current facilities (Laos: Nam Phao; Vietnam: Cau Treo). A field survey

conducted for this study has confirmed the existence of flat terrain on which the new border facilities could be constructed.

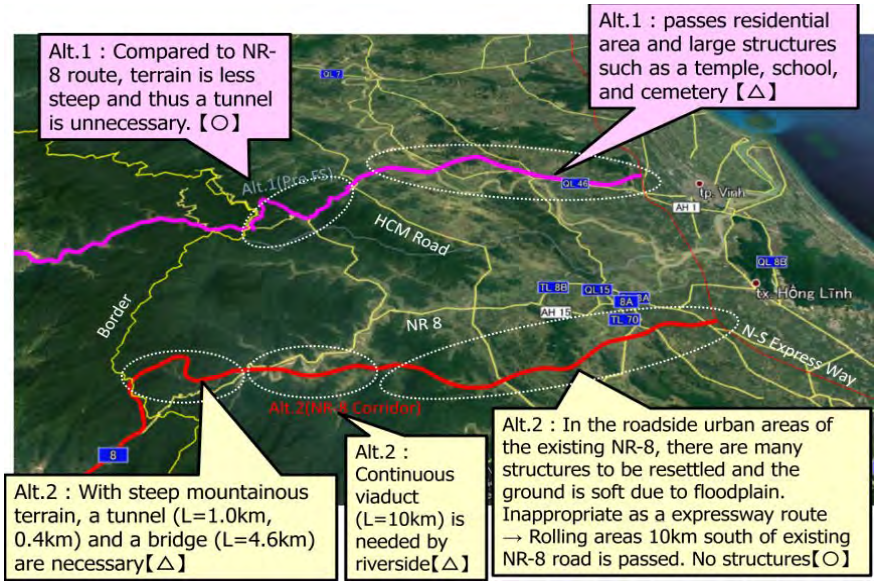


Figure 9.4.2 Comparison of Routes on Vietnam Side

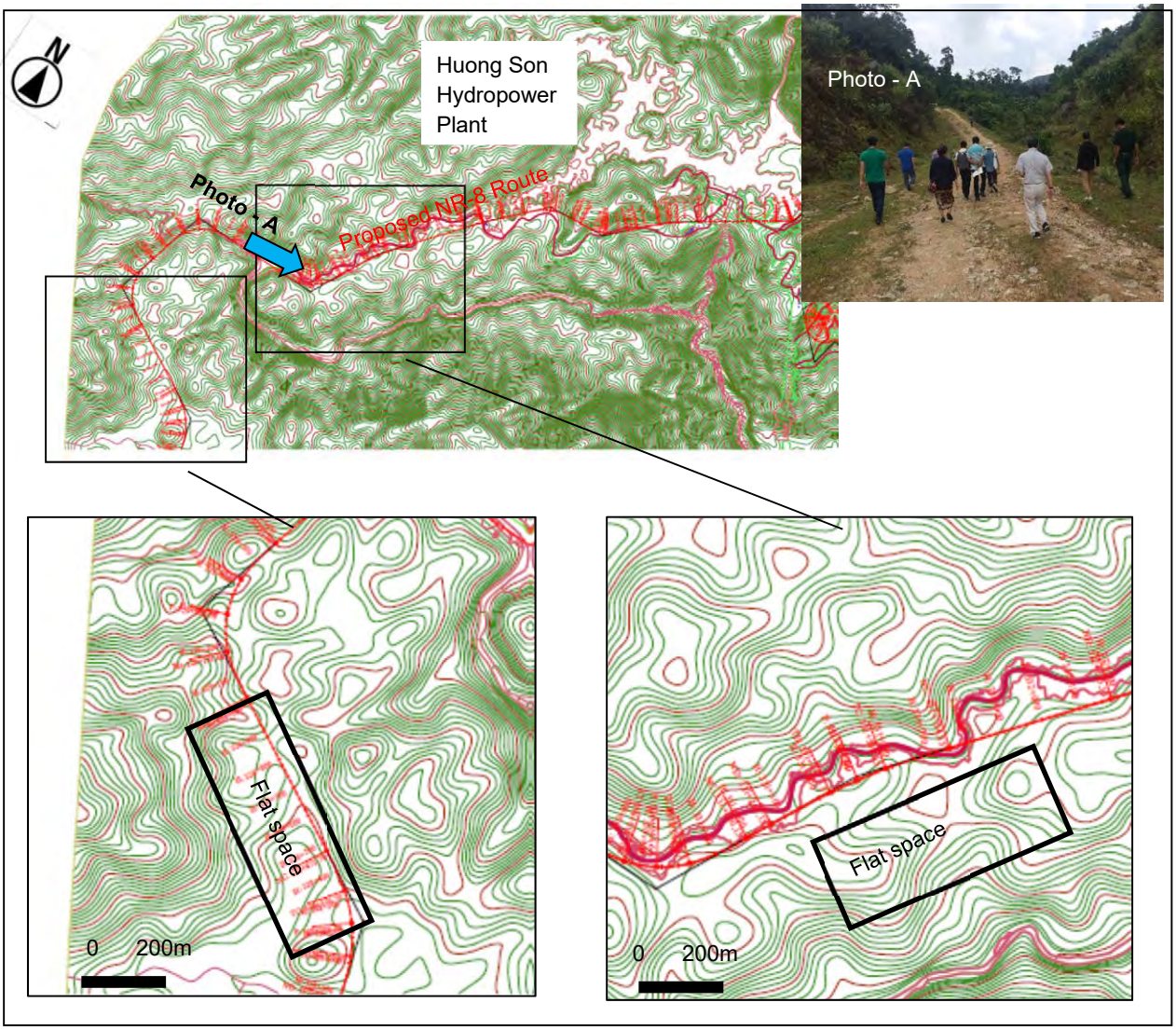


Figure 9.4.3 Potential Location for New Border Facility

9.5 Detailed Plan of Selected Route

9.5.1 Points to Consider along the Whole Alignment

A rough alignment for Alt. 2, the route parallel to NR 8, is examined using paper location with a 1/50,000 scale map, noting the control points. The section studied for Alt. 2 is between Vientiane and the connection point with NSE, with a total estimated length of 403 km[1] (Pre F/S route length 400 km).

In this study, selection of rough route alignment is done only at the pre F/S level. Regarding the improvement project of NR 8 of which KOICA has carried out F/S study slightly ahead of this study, consideration has been made so as not to overlap the road lines. However, coordination with other plans such as railway development plan between Vientiane and Vung Ang port, Vientiane - Pakse expressway plan and Hong Linh - Huong Son expressway plan, as well as detailed route examination for reducing the project cost mainly by reducing the size of structures such as tunnels and bridges should be implemented during the future F/S as necessary.

The required considerations for the NR 8 route are shown in Table 9.5.1.

Table 9.5.1 Points to Consider on National Road 8 Route

	Section	Route Summary	Required Route Considerations
Laos	[A] 118 km Vientiane – Pac Xan	Same route as in Pre-F/S	- Minimizing resettlement - Avoiding impact on high voltage power lines
	[B] 96 km Pac Xan – Vieng Kham	Route parallel to NR 13	- Minimizing resettlement - Avoiding impact on high voltage power lines - Possible crossing for Nam Kading River - Need for tunnels in the mountainous areas
	[C] 50 km Vieng Kham – Phonthan	Route parallel to NR 8	- Minimizing resettlement - Avoiding impact on high voltage power lines - Steep terrain in Knoun Ngeun-Ban Khounkeo section (current road is steep with sharp corners) - Steep terrain in Na Hin-Nong Coc section (current road is steep with sharp corners) - Theun Hinboun Hydropower Plant in Na Hin - Distance from existing road in the flat terrain - Need for tunnels in the mountainous areas - Intersection plan with the existing road - Relationship with KOICA F/S plan.
	[D] 76 km Phonthan – Border	Same as above	- Minimizing resettlement - Avoiding impact on high voltage power lines - Bypass for central Laksao - Impact on protected area (Phouchomvoy PPA) - Minimizing the impact on small hydropower facilities - Securing land for new border facilities - Relationship with KOICA F/S plan
Vietnam	[E] 39 km Border – HCM road	Same as above	- Minimizing resettlement - Border (Cau Treo)-Vung Tron steep section consists of a sharp terrain (with an altitude difference of 710 m) (Current road is steep with sharp corners) - Huong Son Hydropower Plant in Son Kim - Need for tunnels in the mountainous areas
	[F] 24 km HCM road - NSE	Approximately 8 km south of NR 8	- Minimizing resettlement - Avoid frequent flood areas.

[1] As no route comparisons were completed for the studied range, this 403 km is a reference value.

[A] For Vientiane- Pac Xan, almost the same alignment as Pre-F/S route has been adopted. In the future F/S, it has been considered necessary to coordinate with the Vientiane- Vung Ang port railway development plan. [B] As for the section between Pac Xan and Vieng Kham, a linear tunnel is introduced that extends to a part of the existing mountainous areas and avoids the influence on existing facilities as much as possible. [F] For the section between HCM road and NSE, an alternative route has been adopted that goes through the area of about 10 km to the south of the existing NR8 so as to minimize resettlement and avoid floodplain (frequent flood areas). In future F/S, adjustment with planned Hong Linh ~ Huong Son expressway would be necessary.

Points ① to ④ of the sections [C] [D] [E] shown in Figure 9.5.1 below are considered as bottlenecks along NR 8 route and hence their structural countermeasures are examined, and summarized in the next section.

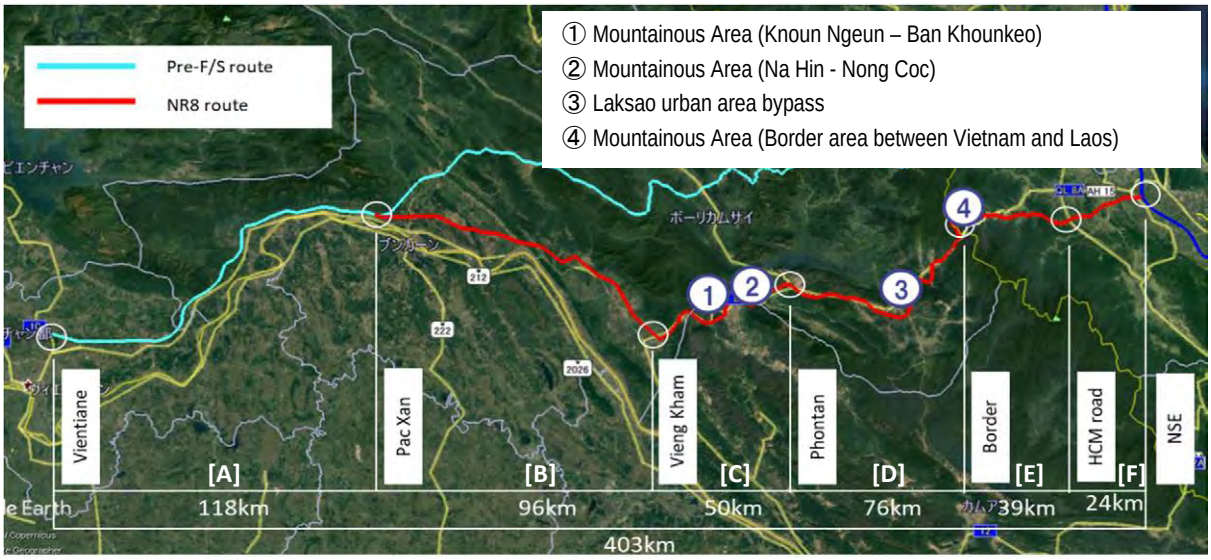


Figure 9.5.1 Target Sections along NR 8 Route

9.5.2 Study Results by Section

(1) Mountainous area (Knoun Ngeun – Ban Khounkeo)

In the following valley terrain section, basically, road alignment plan to ensure separation from existing NR8 is made. In addition, intersection plan has been made for sections where intersection with existing NR8 is necessary. As for the intersection points with the existing road and the locations where the separation from the NR8 is not possible, additional structures such as retaining walls, bridges and box culverts, etc. are considered necessary, and they have been reflected in the approximate construction cost.

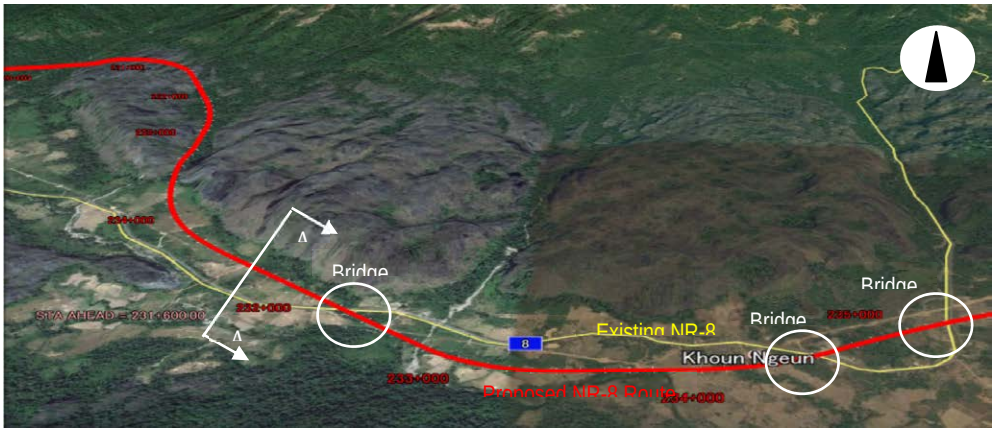


Figure 9.5.2 Improvement of NR 8 Route Alignment

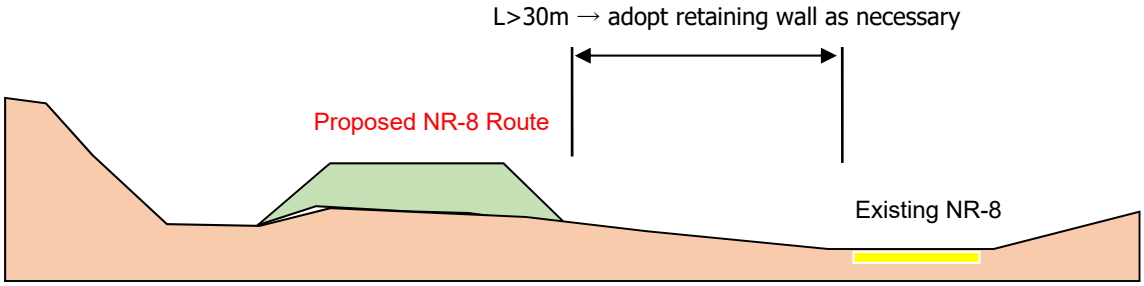


Figure 9.5.3. A-A Cross section (Parallel to NR8 Route)

Also, in the following locations, the vertical gradient of the existing road is about 8%, posing a problem for traveling of large-sized vehicles. The traveling performance of large-sized vehicles has been improved by constructing a 2.9 km-long tunnel through mountainous sections.

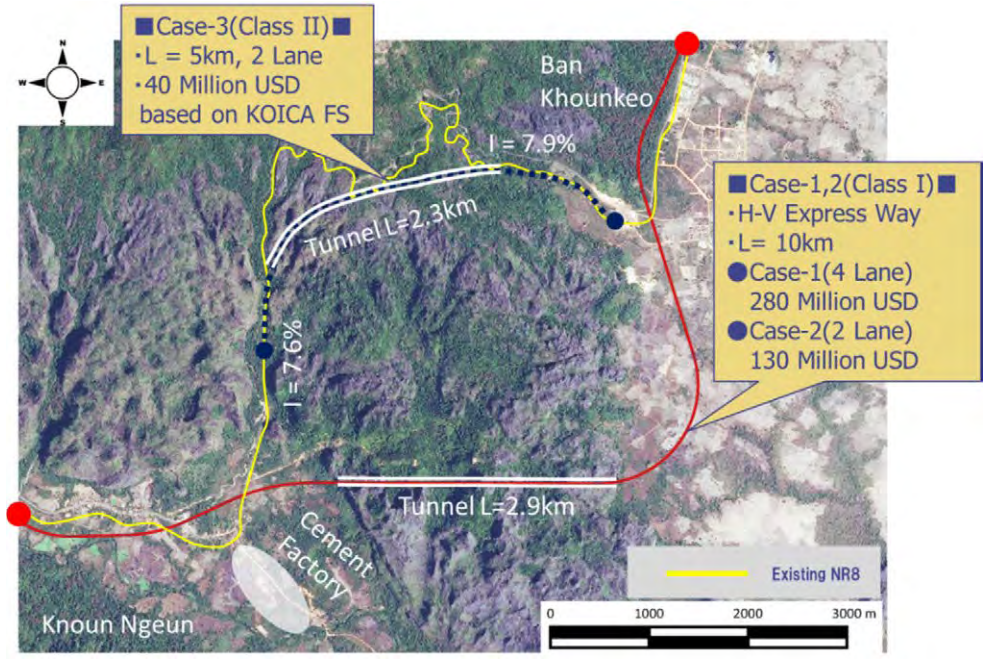


Figure 9.5.4. Improvement of NR 8 Route (Knoun Ngeun – Ban Khounkeo)

The large, steep bedrock landmass for the planned tunnel is extremely hard, but with many vertical and horizontal cracks. Although tunnel construction out of this landmass is considered to be possible, it would be better in the future to investigate the possibility of bedrock failure at tunnel entrance, roof collapse during main excavation and sidewall collapse from horizontal earth pressure.

	
Landmass near planned tunnel site	Ultra-mafic rock

Figure 9.5.5. Geology near Planned Tunnel site (Knoun Ngeun-Ban Khounkeo section)

(2) Mountainous area (Na Hin - Nong Coc)

The Theun Hinboun hydroelectric power station, located in Na Hin, is considered as a control point in the linear alignment and the planned road has shifted to the mountainous side. In addition, regarding the existing catchment area, structures such as a bridge would be necessary, and that has been reflected in the approximate construction cost.

Figure 9.5.6. Improvement of Route Alignment along NR 8

(Theun Hinboun Hydropower Station)

Also, in the following locations, the vertical gradient of the existing road is about 8%, posing a problem for traveling of large-sized vehicles. The traveling performance of large-sized vehicles has been improved by constructing a tunnel of 1.6 km in length through mountainous sections.

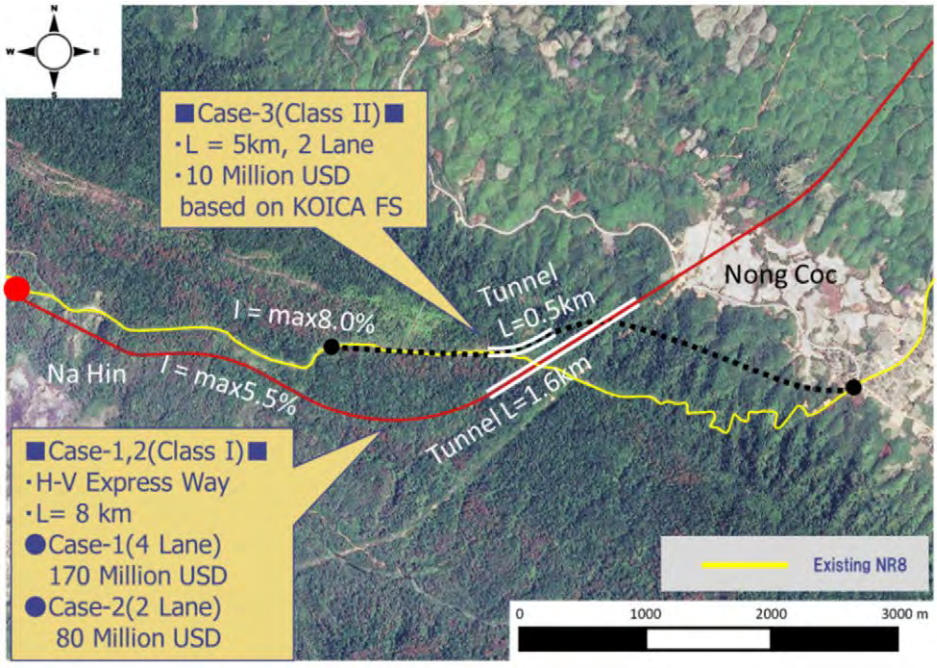


Figure 9.5.7. Improvement of NR 8 Route (Na Hin - Nong Coc)

The tunnel is planned for a steep, mountainous region made up of weathered siltstone and slate. Tunnel construction is not impacted by this rock composition. Nevertheless, the tunnel entrance requires a sufficient topographical study as road alignment at the tunnel entrance may be slanted relative to the mountain ridge.

Mountain for planned tunnel

Weathered silt

Figure 9.5.8. Geology near planned tunnel site (Na Hin-Nong Coc section)

(3) Laksao urban area bypass

In order to prevent large-sized vehicles from entering into Laksao urban areas, and thereby to improve urban roadside environment and reduce traffic accident, the construction of a bypass road around urban areas is proposed.

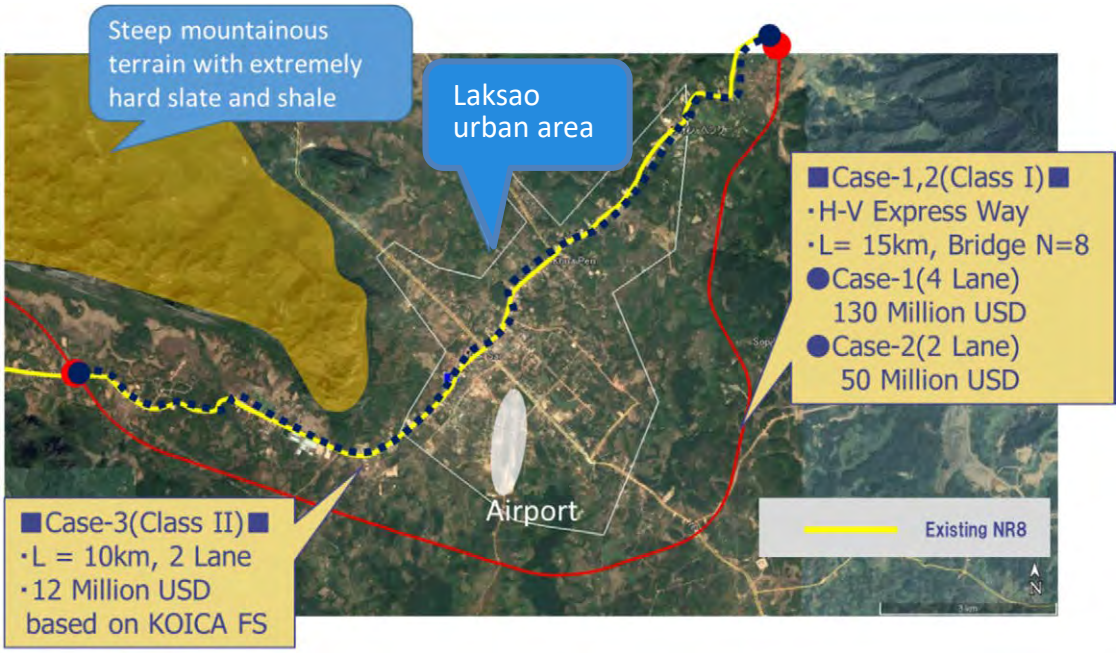


Figure 9.5.9. Improvement of NR 8 Route (Laksao BP)

(4) Mountainous area (Border area between Laos and Vietnam)

About 20 km of the NR 8 section on the Vietnam side from the border with Laos has a gradient of about 8% and continuous sharp curves, making the smooth flow of traffic difficult. Therefore, it is proposed that border control facilities be built 5 km north of the existing facilities, enabling a new alignment with less gradient.

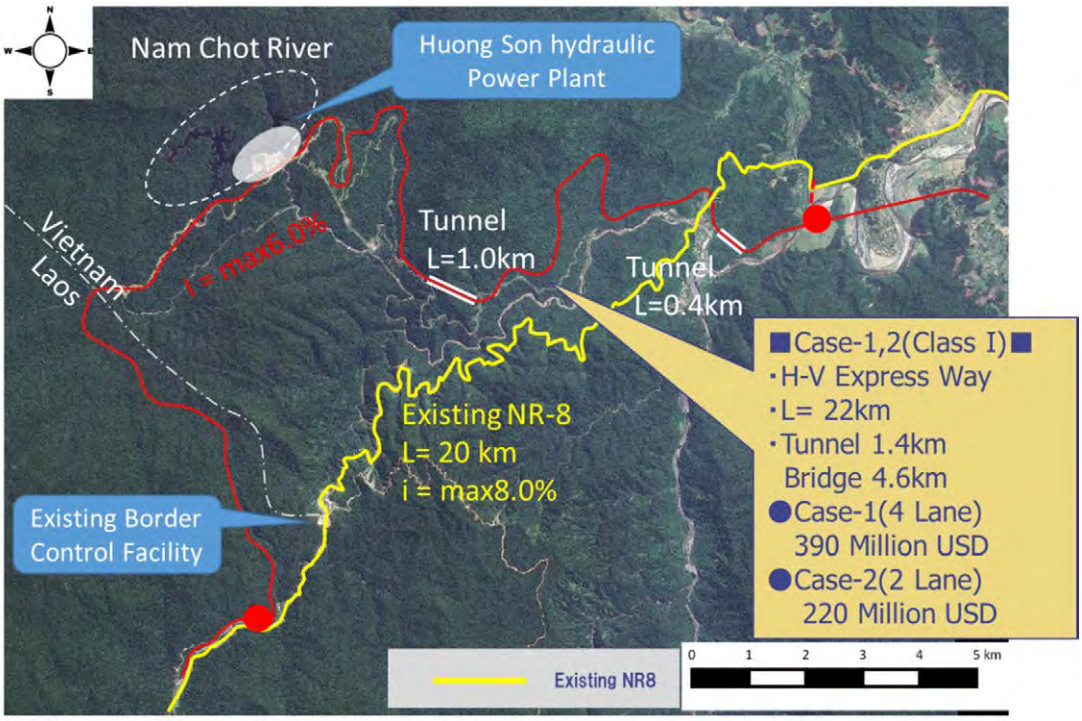


Figure 9.5.10. Improvement of NR 8 Route (alignment change around border areas)

As the proposed route passes near the Huong Son Hydropower Plant, structures such as bridges and slant surface countermeasures such as ground anchor work, etc. are slated and reflected in the approximate construction cost.

In terms of geology, the proposed route stands on solid bedrock with hard gneiss and weathered granite, and it should pose no issues for tunnel construction. Still, it is necessary to pay attention to the shallow slides and landslide failures in the weathered reddish-brown cohesive soil.

Weathered quartz, biolite schist, and mica schist found in reddish-brown area
(Note: white particles in the image on the left are quartz)

Figure 9.5.11. Geology near Proposed Route (border area)

As a counter proposal, a route which passes Thanh Thuy border and runs in parallel with NR 8 could be a possibility. However, it necessarily increases the project cost in Laos and cannot be considered as the most desirable choice. The road development between Pac Xan and Thanh Thuy was promised by the Laos and Vietnam governments. Although the construction is now temporarily halted due to the budget shortage, ordinary road construction (2-lane road) has already started in 2009 in Laos. Therefore, the border facilities in Thanh Thuy is necessary and will be used in the future regardless of the Hanoi-Vientiane expressway development.

9.6 Review of Stage-Wised Development Plan

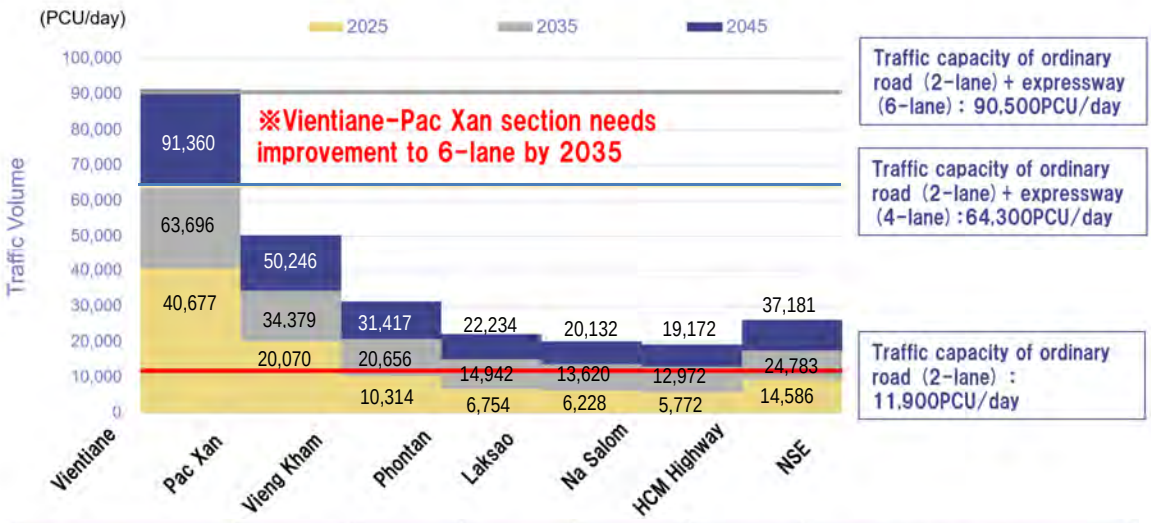
From the viewpoint of financing, it is not practical to construct an expressway of over 400 km in one go. Therefore it is necessary to select sections that can be regarded as feasible considering their priority and economic efficiency, and to carry out the project in phases. In this light, the following viewpoints need to be considered:

- Elimination of the current traffic problems (traffic congestion, elimination of sections preventing the passage of large-sized vehicles)
- Response to future traffic demand
- Filling missing links
- Feasibility of project (project scale, financing, etc.).

9.6.1 Study for Phased Development Plan by Section

Figure 9.6.1 shows the relationship between yearly traffic demand and traffic capacity (existing road plus expressway) by section of NR 8 route.

- In the first place, as for the section between Vientiane and Vieng Kham, the demand will exceed the capacity of the existing road by 2025 and the development of expressway (4-lane) is desirable as soon as possible.
- Next, as for sections between Vieng Kham and Laksao and between HCM Road and NSE, the demand will exceed the capacity of existing road at some point during the period from 2027 to 2031. The development of expressway (4-lane) by 2030 is thus desirable.
- Lastly, the development of the road section between Laksao-HCM road through the border between Vietnam and Laos by 2035 is desired. However, in case there is a disruption in the logistics function by traffic increase around border area and the consequent increase of time required for customs procedure, earlier development of this section together with the construction of customs facilities may as well be considered.
- It should be noted, however, that the practical feasibility needs to be studied from the debt sustainability point of view because the above-mentioned implementation period is the one considered desirable according to the demand forecast only.



Before 2025	2027	2031	2033	2033	2028	←year when expressway becomes necessary
2025	2030		2035		2030	←Proposed implementation period

Figure 9.6.1 Implementation Period by Section from the Viewpoint of Traffic Demand

9.6.2 Study for Phased Development Plan

The phased development plan is proposed in Figure 9.6.2. It is noted, however, that this proposal is made based solely on the result of the demand forecast.

（1st phase：2019–2024）

The section between Vientiane–Vieng Kham is to be developed as an expressway (Pac Xan–Vieng Kham section is planned to be developed under BOT scheme as a part of Vientiane-Pakse expressway project). In addition, a regional road (with a width of 7–9 m) will be constructed to fill missing the link between Viengthong–Nam On (Thanh Thuy). Also, the bottleneck section is expected to be eliminated according to the F/S of NR 8 improvement conducted by KOICA.

（2nd phase：2025–2029）

The Vieng Kham-Laksao and HCM Road- NSE sections, which have the largest traffic demand after Vientiane-Vieng Kham section of the Hanoi–Vientiane expressway, will be developed. The improvement of Provincial Road 1B, which is a missing link around the border, will be completed.

（3rd phase ：2031–2035）

The remaining section of the Hanoi-Vientiane expressway, Laksao-HCM section, will be developed. At the same time, the section between Vientiane and Pac Xan will be upgraded from 4-lane to 6-lane road.

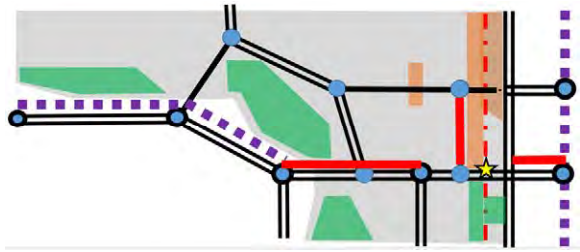
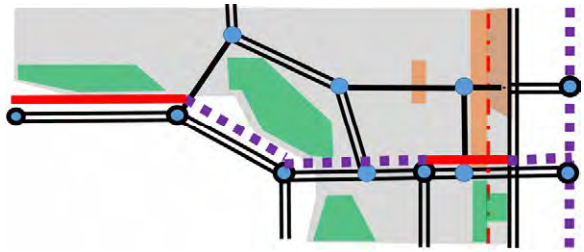
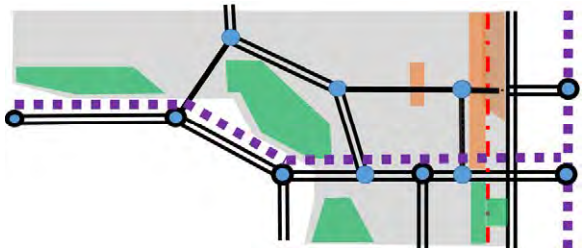
Phase	Hanoi – Vientiane Expressway Development	Other Main Roads
1st Phase （2019～2024） 	• Expressway development between Vientiane-Vieng Kham (Pac Xan – Vieng Kham section is planned to be developed under BOT scheme as a part of Vientiane - Pakse expressway project)	• Elimination of bottleneck of NR8 (proposed in KOICA F/S) • Resolution of missing links (7~9m in width) between Viengthong - Nam On
2nd Phase （2025～2029） 	• Expressway development between Vieng Kham - Laksao, HCM road - NSE	• Improvement of PR 1B • Elimination of bottleneck of NR8 (proposed in KOICA F/S)
3rd Phase （2031～2034） 	• Expressway development between Vieng Kham - Laksao, HCM road - NSE • Improvement of expressway between Vientiane - Pac Xan (to 6-lane)	
Ultimate road network （2035～） 	• Completion of expressway between Hanoi - Vientiane	• Development of missing links • Improvement of NR-8 （KOICA F/S）

Figure 9.6.2　Proposed Phased Development Plan

Chapter 10
Economic and Financial Analysis

Chapter 10 Economic and Financial Analysis

10.1 Economic Analysis

10.1.1 Analysis Method

Economic analysis is to evaluate a project through cost-benefit analysis, by comparing direct economic benefit produced by the project and economic cost. The evaluation flow is shown in Figure 10.1.1.

Both cost and benefit are calculated in economic price. The indicators for benefit analysis are limited to the ones most directly expected from the project, which include (1) vehicle operation cost saving, (2) travel time saving and (3) traffic accident saving. These benefits are calculated based on the result of traffic demand estimation. The conditions for economic evaluation are illustrated in Table 10.1.1.

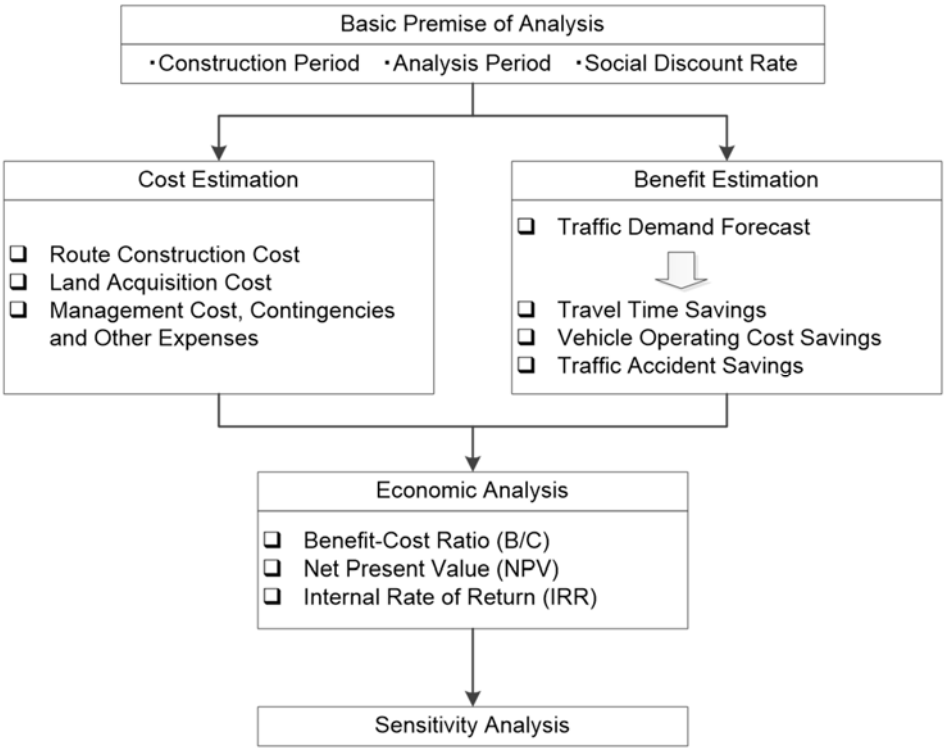


Figure 10.1.1 Method of Economic Analysis

Table 10.1.1 Conditions for Economic Analysis

Calculation Condition	☐ Construction Period：3 years before operation based on the Phased Development Plan ☐ Analysis Period ：30 years from the Commencement of Operation (Operation: 2025 onwards) ☐ Social Discount Rate：12%
Conversion to Economic Cost	☐ 85% of initial cost, O&M cost
Unit Price for Time Value	USD/vehicle･hour Classification | Motorcycle | Car | Bus | Truck Lao PDR | 1.64 | 4.01 | 18.55 | 2.10 Source：Feasibility Study for the Railway Link from Vientiane to Vung Ang
Vehicle Operating Cost	USD/km Vehicle Type / Speed | Motorcycle | Car | Bus | Truck 10 km/h | 0.13 | 1.01 | 1.88 | 1.05 20 km/h | 0.11 | 0.86 | 1.59 | 0.86 30 km/h | 0.10 | 0.73 | 1.34 | 0.70 40 km/h | 0.08 | 0.63 | 1.13 | 0.58 50 km/h | 0.07 | 0.55 | 0.97 | 0.48 60 km/h | 0.07 | 0.48 | 0.84 | 0.41 70 km/h | 0.06 | 0.44 | 0.76 | 0.37 80 km/h | 0.06 | 0.42 | 0.72 | 0.36 90 km/h | 0.06 | 0.42 | 0.73 | 0.38 Source：Feasibility Study for the Railway Link from Vientiane to Vung Ang

10.1.2 Economic Analysis of Pre-F/S route and NR 8 route

Table 10.1.2 shows the result of economic analysis. The EIRRs of the Pre-F/S route and NR 8 route are 11.59% and 12.40%, respectively. The EIRR of the NR 8 route exceeds the social discount rate, justifying the necessity of the project.

Table 10.1.2 Economic Analysis Results of Hanoi-Vientiane Expressway

Items	Pre-F/S route	NH-8 route
EIRR (Economic Internal Rate of Return)	11.59%	12.40%
NPV (Net Present Value)	-USD 31.92 million	USD 58.83 million
B/C (Benefit Cost Ratio)	0.98	1.03

10.1.3 Feasibility of Vientiane - Pac Xan Section

In this study, the target of economic analysis is the section between Vientiane and Pac Xan only, as this section has the highest traffic demand. The project cost is estimated based on the premise that the Vientiane-Pac Xan section is developed as a 4-lane road by 2025 and improved to 6-lane road by 2035. The result of project cost estimation is shown in Table 10.1.3. The total project cost here (USD 784 million) is USD 157 higher than the total cost in case of one-step construction (USD 626 million) shown in Chapter 8 (see Table 8.3.6). This is because the unit cost in the second-step construction, for widening from 4 lanes to 6 lanes, is more expensive.

Result of economic analysis is shown in Table 10.1.4. The cost and benefit calculated in economic prices for the period of 30 years are compared and then the cash flow is prepared. The IRR (internal rate of return) drawn from this cash flow shows as high as 23.4%, exceeding the social discount rate of 12% by far. This result suggests that the project is economically feasible.

Table 10.1.5 shows the result of sensitivity analysis, illustrating how the IRR changes when values of cost and benefit are changed. It is clearly found that, even when the cost increases by 20% and the benefic decreases by 20%, the economic feasibility of this project is not critically affected.

Table 10.1.3 Result of Project Cost Estimation

(Unit: Million USD)

Item			1st Step 4 Lane	2nd Step 4→6 Lane	Total
Construction Cost					
	1Direct Work Cost		334	211	545
	Earth Work Cost		266	191	457
	Bridge		36	20	56
	IC trumpet Shape		14	0.0	14
	IC Diamond Shape		18	0.0	18
	2Indirect Cost and Consulting Cost and Others	30% of1	100	63	163
	3Value Added Tax	10% of1,2	43	27	70
	Total	1+2+3	477	301	778
Compensation					
	4 Land Acquisition		5	0	5
	5 Resettlement		1	0	1
	Total	4+5	6	0	6
Total Project Cost		1+2+3+4+5	483	301	784

Table 10.1.4 Result of Economic Analysis

(Unit: Million USD)

Year		Cost						Benefit				Cash Flow
		Construction Cost (I)	Reparing & Upgrade Cost	Operating Cost	Launch Cost of SPC	Administrative Cost of SPC	Total Cost	TTC Savings	VOC Savings	VAC Savings	Total Benefit	
-3	2022	123.17			5.10	1.53	129.80				0.00	-129.80
-2	2023	164.22				1.53	165.75				0.00	-165.75
-1	2024	123.17				1.53	124.70				0.00	-124.70
1	2025			12.32		1.53	13.85	13.80	100.92	0.39	115.11	101.26
2	2026			12.32		1.53	13.85	14.76	107.98	0.42	123.17	109.32
3	2027			12.32		1.53	13.85	15.73	115.05	0.45	131.23	117.38
4	2028			12.32		1.53	13.85	16.70	122.11	0.48	139.28	125.44
5	2029			12.32		1.53	13.85	17.66	129.17	0.50	147.34	133.49
6	2030			12.32		1.53	13.85	18.63	136.24	0.53	155.40	141.55
7	2031			12.32		1.53	13.85	19.59	143.30	0.56	163.46	149.61
8	2032			12.32		1.53	13.85	20.56	150.37	0.59	171.51	157.67
9	2033		127.93	12.32		1.53	141.77	21.53	157.43	0.61	179.57	37.80
10	2034		127.93	16.15		1.53	145.61	22.49	164.50	0.64	187.63	42.02
11	2035			19.99		1.53	21.52	26.46	193.50	0.76	220.71	199.19
12	2036			19.99		1.53	21.52	27.37	200.17	0.78	228.32	206.80
13	2037			19.99		1.53	21.52	28.28	206.84	0.81	235.92	214.40
14	2038			19.99		1.53	21.52	29.19	213.51	0.83	243.53	222.01
15	2039	41.06		19.99		1.53	62.58	30.10	220.18	0.86	251.14	188.56
16	2040			19.99		1.53	21.52	31.02	226.84	0.89	258.75	237.22
17	2041			19.99		1.53	21.52	31.93	233.51	0.91	266.35	244.83
18	2042			19.99		1.53	21.52	32.84	240.18	0.94	273.96	252.44
19	2043			19.99		1.53	21.52	33.75	246.85	0.96	281.57	260.05
20	2044			19.99		1.53	21.52	34.66	253.52	0.99	289.18	267.65
21	2045			19.99		1.53	21.52	35.58	260.19	1.02	296.78	275.26
22	2046			19.99		1.53	21.52	36.35	265.85	1.04	303.23	281.71
23	2047			19.99		1.53	21.52	37.12	271.50	1.06	309.68	288.16
24	2048			19.99		1.53	21.52	37.90	277.16	1.08	316.13	294.61
25	2049		25.59	19.99		1.53	47.11	38.67	282.81	1.10	322.59	275.48
26	2050			19.99		1.53	21.52	39.44	288.47	1.13	329.04	307.51
27	2051			19.99		1.53	21.52	40.22	294.12	1.15	335.49	313.96
28	2052			19.99		1.53	21.52	40.99	299.78	1.17	341.94	320.42
29	2053			19.99		1.53	21.52	41.76	305.43	1.19	348.39	326.87
30	2054			19.99		1.53	21.52	42.54	311.09	1.21	354.84	333.32
Total		451.61	281.44	526.84	5.10	50.49	1315.47	877.61	6418.56	25.05	7321.23	
				EIRR:	24.04%			NPV:	US$534.83		B/C:	2.07

Table 10.1.5 Sensitivity Analysis

		IRR	NPV (Million USD)	B/C
Base Case		24.04%	534.83	2.07
Change of Cost	-20%	28.80%	634.58	2.59
	-10%	26.21%	584.71	2.30
	+10%	22.19%	484.96	1.88
	+20%	20.58%	435.08	1.73
Change of Benefit	-20%	19.85%	328.12	1.66
	-10%	22.00%	431.48	1.87
	+10%	26.00%	638.19	2.28
	+20%	27.88%	741.55	2.49

10.2 Financial Analysis

10.2.1 Introduction

(1) Objective

The construction cost for Hanoi-Vientiane expressway project (NR 8 route) is approximately 3,798 million USD. The costs to be borne by Lao PDR and Vietnam are 2,943 million USD and 855 million USD, respectively. The amounts cannot be easily shouldered by the both governments considering their original budget scales and current fiscal conditions. Therefore, both governments are expecting to utilize private funds such as PPP (public-private partnership) for the implementation of the Hanoi-Vientiane expressway project as much as possible.

With these backgrounds, financial viability of the entire section (between Hanoi and Vientiane) is evaluated. Then, financial viability with the highest traffic volume (Vientiane-Pac Xan) is evaluated to have the potential of being developed under PPP.

(2) Analytical method

Regarding the entire section (NR 8 Route), toll revenue, operation and maintenance (O&M) cost and repavement cost are estimated. Preliminary evaluation is made to check whether the total amount of toll revenue from the commencement of service to the end of the project exceeds the total amount of O&M cost, repavement cost and construction cost.

Then, regarding Vientiane-Pac Xan section, based on the precondition specified in Table 10.2.2, a cash flow analysis is made to assess the financial viability of the project assuming the application of PPP. Sensitivity analysis is also made to identify conditions which enable the project financially.

10.2.2 Preliminary Evaluation of Financial Viability of the Entire Section

The construction cost of the NR 8 route expressway project is approximately 3,798 million USD. Assuming the operation and maintenance phase is 30 years, the total amount of O&M cost is expected to be 2,949 million USD. Re-paving of the road will be conducted once every 15 years, and the total cost is expected to be 390 million USD. The total cost is approximately 7,137 million USD (initial construction cost of 3,798 million USD + O&M cost etc. of 3,339 million USD).

Meanwhile, based on the demand forecast results in this study, the toll revenue for 30 years obtained from this project is estimated to be 3,541 million USD. The total amount of the toll revenue (3,541 million USD) is below the total amount of the costs (7,137 million USD), and the difference is 3,596 million USD. (If initial construction cost is excluded, the toll revenue will remain larger than the O&M cost etc.) From this preliminary evaluation, it is interpreted that the profitability of NR 8 route is quite low and it is difficult to implement on a commercial basis.

10.2.3 Financial Evaluation of Vientiane - Pac Xan Section

(1) Project implementation schedule

In this section, a financial evaluation is made for Vientiane-Pac Xan section, which has the highest traffic demand and toll revenue. The schedule of implementation of the Vientiane-Pac Xan section is shown in Table 10.2.1. It is assumed that the feasibility study will be conducted from 2018 to 2019. After tendering, environmental impact assessment and detailed design of the section will be conducted. In 2021, this project will be given approval by the Government of Lao PDR, and land acquisition and construction work will be started. The operation of this section is expected to start in 2025.

Table 10.2.1 Project Implementation Schedule between Vientiane and Pac Xan

	2018	2019	2020	2021	2022	2023	2024	2025
F/S								
Tendering of Contractor								
Environmental Impact Assessment								
Detailed Design								
Approval from Laos gov.								
Land acquisition and Resettlement								
Construction work								
Commencement of service								

Source: JICA Study Team

(2) Precondition of financial analysis

The precondition of financial analysis the section between Vientiane and Pac Xan is shown in Table 10.2.2. Financial analysis is conducted for the Vientiane-Pac Xan section (118km), which is expected to have the most traffic demand in the entire NR 8 route. The PPP type is concession (BOT) where the project company directly collects toll from the road-users. The project period is assumed to be 33 years, consisting of 3 years of construction phase and 30 years of operation and maintenance phase. The initial investment by private company is 500 million USD, which consists of 483 million USD for facility construction cost (4-lane road) and 17 million USD[1] for others. The target section is upgraded from four-lane to six lane the highway in the two years from 2033 to 2034. The additional construction cost for the expansion is expected to be 301 million USD. Land acquisition cost and resettlement cost are included in the construction costs.

Table 10.2.2 Preconditions of Financial Analysis for Vientiane–Pac Xan Section

Item	Precondition	Remarks
Section	Vientiane-Pac Xan（118km）	—
Type of PPP	Concession（BOT）	—
Project period	Construction phase：3 year	—
	Operation & Maintenance phase：30 year	—
Revenue and Expense	Construction cost（4-lane）：483 Million USD	Including land acquisition cost etc.
	Upgrade cost（6-lane）：301 Million USD	Ditto
	Launch cost of SPC：3 Million USD	Assumed by JICA Study Team
	Traffic demand, revenue forecast: refer to Figure 10-2	Forecast by JICA Study Team
	Toll（Passenger car）：2.65 USD／Vehicle[2]	Assumed by JICA Study Team (Same level as Vientiane – Vang Vieng highway)
	Toll（Bus, Truck）：5.30 USD／Vehicle	Ditto
	Toll increase rate：63% (by 2035)	6 lanes after widening
	Administrative cost of SPC：1 Million USD／year	Assumed by JICA Study Team
	Ratio of operating cost：3% of construction cost	Ditto
	Ratio of repairing cost：10% of construction cost	Once every 15 years
Financing	Debt Equity Ratio 70:30	Assumed by JICA Study Team

[1] Other 17 million USD includes launch cost of SPC etc. Unused funds are reserved.
[2] As for toll (Passenger car, Bus and Truck), it is set by reference to Vientiane-Vang Vieng project which will be implemented as BOT by Chinese company.

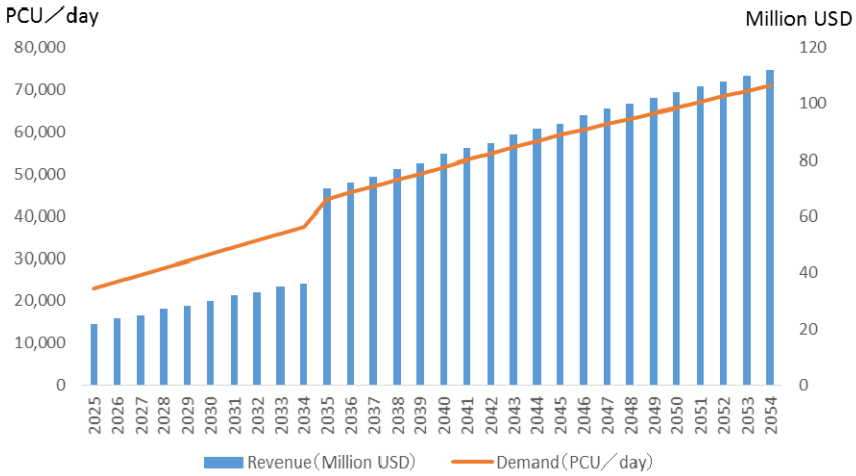
Item	Precondition	Remarks
	Number of execution of loan：5 times[3]	Ditto
	Interest rate：10%	No commercial banks available for loans in Laos
	Payment period：10 year period（level payment）	Assumed by the JICA Study Team
	Equity IRR hurdle rate：15%	Ditto
	WACC=FIRR hurdle rate：11.5%	—
Taxes and other public duties	Profit tax rate：24%	Tax Law in Laos
	Depreciation：20 year（Straight-line method）	Assumed by JICA Study Team
Other	Inflation rate：0%	Tentatively

Source: JICA Study Team

The demand and revenue forecast of the section is shown in Figure 10.2.1. As for revenue, it consists of toll from passenger cars, truck and bus[4]. The Demand and revenue sharply increases in 2035 because of the section upgraded from 4 lanes to 6 lanes.

Regarding financing of the entity, the debt equity ratio is 70:30. The interest rate was set at 10% with assumption of loans by ECA of other countries since there are no commercial banks that can loan this project in Lao PDR. The payment period is for 10 years from the first year of operation and maintenance phase. Payment method is level payment. The hurdle rate of equity IRR was set at 15% by reference to case of surrounding countries (assuming that companies with experience in toll road operation abroad will also participate). As a result, the hurdle rate of FIRR (Weighted Average Cost of Capital, WACC) was 11.5%. In other words, if FIRR above that rate is obtained from the project, the applicability of PPP is recognized in terms of finance.

In addition to the base case, sensitivity analysis is made by the combination of reduction of the construction cost (by 10% and 20%) and the increase of revenue from traffic growth (by 10% and 20%). In addition, because there is a possibility that sufficient profitability cannot be obtained from the project, it is also assumed that Viability Gap Funding (VGF) will be provided by the Government for supporting the construction cost. The rate of VGF was set at 50% of the construction cost.



Source: JICA Study Team

Figure 10.2.1 Demand and Revenue Forecast between Vientiane and Pac Xan

[3] The number of execution of loan for upgrade to 6-lane is supposed to be 2 times.

[4] Originally, in the expressway business, revenue from the service area and parking area is also anticipated as additional business. However, it is not included in this financial analysis.

(3) Result of financial analysis

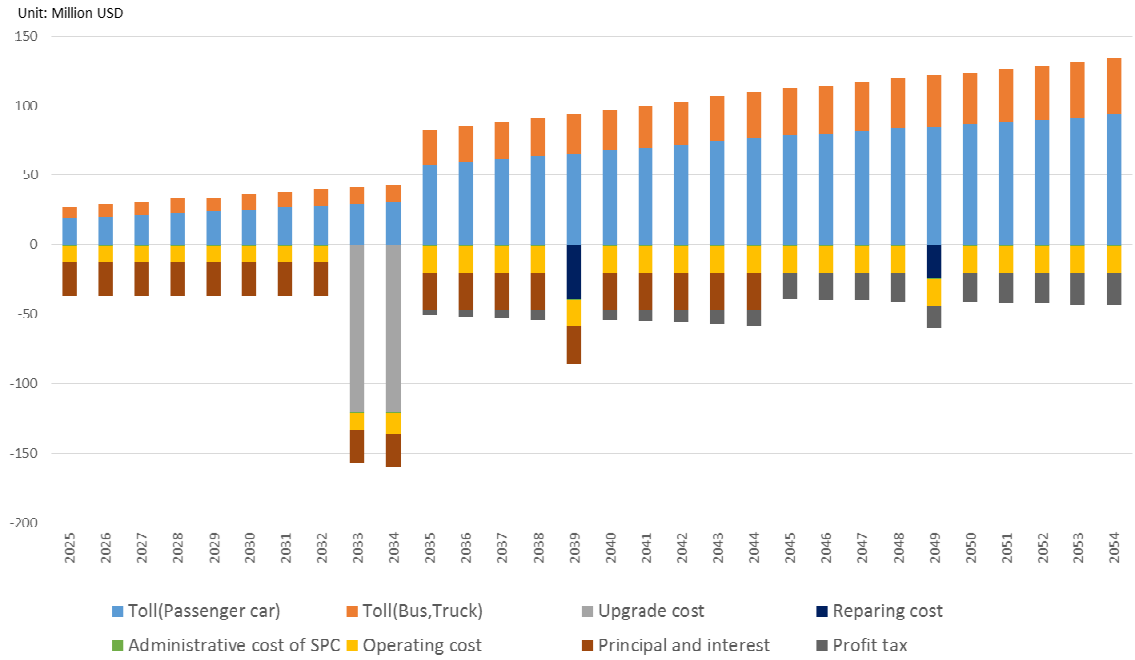
The result of financial analysis and sensitivity analysis are shown in Table 10.2.3.

Table 10.2.3 Result of Financial Analysis and Sensitivity Analysis

Change rate of construction cost \ Change rate of revenue	0%	+10%	+20%
0%	0.79% (4.64%)	1.84% (6.08%)	2.82% (7.46%)
-10%	1.91% (6.15%)	2.98% (7.67%)	4.00% (9.15%)
-20%	3.18% (7.91%)	4.30% (9.54%)	5.35% (11.00%)

Note：The upper shows the result of FIRR without VGF and the lower shows the result of FIRR with VGF50% .
Source：JICA Study Team

As shown in the table above, FIRR of this project is 0.79% in base case. In addition, in case the VGF which is 50% of construction cost is provided, the FIRR will become 4.69%. Additionally, as the sensitivity analysis shows, if the revenue increases by 20% and the construction cost including upgrading cost decreases by 20% from base case, the FIRR of the project will be 5.35%. Furthermore, in case the VGF which is 50% of construction cost (4 lanes) is provided, the FIRR will be 11.00%. The revenue and expenses forecast of the section during O&M phase in case of FIRR 11.00% is shown in Figure 10.2.2.



Source: JICA Study Team

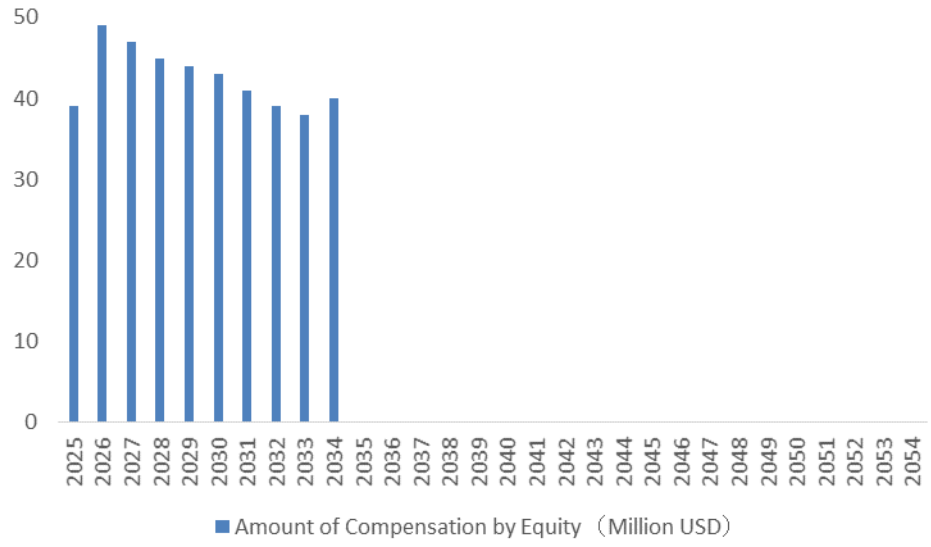
Figure 10.2.2 Revenue and Expenses Forecast between Vientiane and Pac Xan (FIRR 11.00% case)

According to the analysis, FIRR of each case was below FIRR hurdle rate of 11.5%, making the application of PPP for the project difficult from the financial perspective. The reasons for low profitability of the Vientiane – Pac Xan section are as follows:

- For private company, traffic demand is not sufficient,
- Toll level is low,
- The cost of financing is high.

Net cash will be negative between 2025 and 2034 due to low toll revenue. Therefore, the deficit is compensated by equity. The amount of compensation by equity in the O&M phase is shown in Figure

10.2.3. One of the reasons that net cash will be negative is the burden of high payment principal and interest. The payment principal and interest account for about 79% of the amount of cash out between 2025 and 2032.



Source: JICA Study Team

Figure 10.2.3 Amount of Compensation by Equity in O&M Phase

Even the FIRR of the Vientiane–Pac Xan section which has the highest traffic demand was below the FIRR hurdle rate, and according to the preliminary evaluation, the profitability of NR 8 route is quite low. Therefore, the FIRR in NR 8 route will be lower than that of Vientiane–Pac Xan. Therefore it is deemed difficult to apply PPP for the entire section. Nonetheless, as pointed out before, the toll revenue is larger than O&M cost etc., and it does not rule out the possibility of adopting a toll road option.

10.3 Study of the Project Scheme and Financing Policy

10.3.1 Governments' Fiscal Status and Financing Policy

(1) Fiscal status and external borrowing policy of the Government of Vietnam

In 2016, the Vietnamese National Assembly decided to limit the ratio of external borrowing to no more than 65% of their GDP between the fiscal year 2016 and 2017. As the fiscal situation of the government is tight and its external borrowing has already reached nearly 65% as shown in Table 10.3.1, the Ministry of Finance is strictly controlling external borrowing, including freeze of new external borrowings.

Table 10.3.1 Trends in Vietnam's External Borrowing (percentage of GDP)

	2013	2014	2015	2016	2017
External Borrowing Ratio to GDP	54.5%	58.0%	61.3%	63.7%	61.3%

Source：Ministry of Finance, Vietnam

As can be seen in the table above, in 2016, the ratio of external borrowing reached 63.7% of the GDP and the Government faced a critical financial situation. However, in 2017, Vietnam's economic growth rate marked 6.81% with a GDP of 220 billion USD. Owing to the economic growth, the external borrowing ratio decreased to 61.3%. It is true that GDP of Vietnam has been growing and it will enlarge the head room for external borrowing. However, such a head room will not improve dramatically in a short period and the financial condition of the Government will still remain in a critical situation.

With the above-mentioned background, the Ministry of Finance carefully examines borrowings for development of infrastructure from international development partners. The country has developed the mid-term public investment plan (2016–2020), and it prioritizes selected projects, and allocates external borrowings according to the priority. In other words, the Government is taking a policy to allocate budget for the project with high priorities, including option of external borrowing, while carefully monitoring and keeping the target rate of 65% through careful control of the entire borrowing amount.

Meanwhile, the country is actively promoting infrastructure development through private-sector investment to compensate for the shortage of infrastructure investment funds affected by the suppression of external borrowing. Specifically, the country has been discussing legalization of PPP in order to promote infrastructure investment through PPP. For example, the revised draft decree (Decree No.63/2018) became effective in June 2018. However, government officers and private companies still point out insufficiency of the current PPP legal framework and procedures, and optimistic position should not be taken for implementing the project in the form of PPP.

(2) Fiscal status and external borrowing policy of the Government of Laos

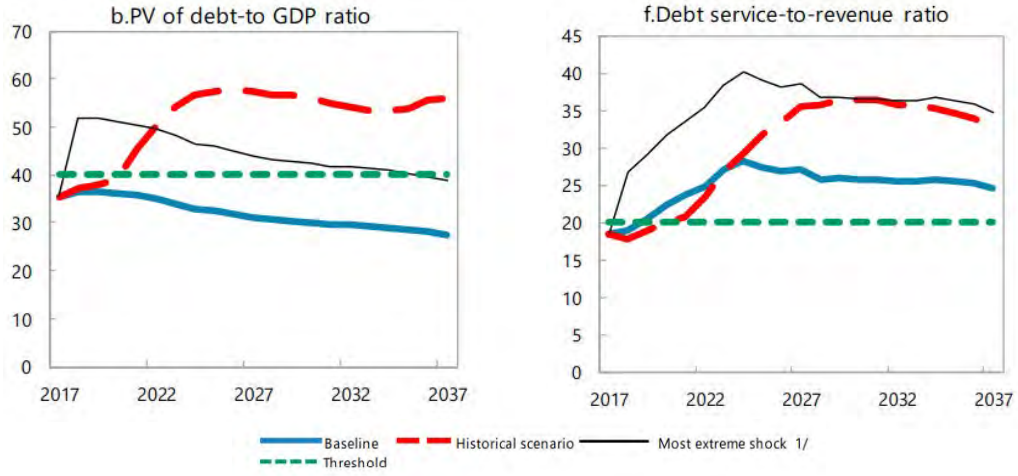
The GDP of Lao PDR was 15.9 billion USD in 2016. Although economic growth rate of Lao PDR was as high as 6.9% in 2016, its GDP was actually less than 10% of that of Vietnam. According to the updates of IMF Article 4 as of March 2018, the fiscal condition of Lao PDR is as follows:

Table 10.3.2 Public Sector Debt (ratio of GPD) of Lao PDR

	Benchmark	2015	2016	2017	2018	2019	2020	2021	2022	2027
Public Sector Debt	56%	57.7%	58.5%	61.1%	65.3%	65.9%	66.2%	67.9%	70.1%	73.6%
PPG External Debt, Nominal	—	45.4	46.6	49.1	49.9	48.8	47.4	46.9	46.5	40.7%
PPG External Debt, PV	40%	-	33.1%	35.5%	36.6%	36.5%	36.0%	35.6%	35.1%	31.0%
Debt Service to Revenue Ratio	20%	11.0%	15.5%	18.5%	18.8%	20.4%	22.3%	23.6%	24.8%	27.0%

Note: The figures after 2018 are projections.
Source：IMF

Regarding public sector borrowing, IMF sets the benchmark at 65%. The figure of 2016 has already reached the benchmark and it is understood that the government's borrowing is already in a critical situation. The figure will be even worse in 2022 (70%). Regarding the next indicator, i.e. is public and public-guaranteed external debt (PPG, PV), the benchmark is 40% and the figures are all under the threshold. However, regarding the debt service to revenue ratio, it is expected that the figure will go beyond the benchmark in 2019 and it will continue to increase. In addition, IMF observes that the economy of Lao PDR is quite vulnerable to external shocks such as foreign exchange fluctuations. Therefore, IMF maintains high concern on the fiscal sustainability of Lao PDR.



Source: IMF

Figure 10.3.1 Fiscal Projection of Lao PDR by IMF

Anyway, it is expected that the debt of Lao PDR will continue to increase, and the Government strongly recognizes the necessity of tight fiscal control. As a measure to deal with such a situation, for instance, the enactment of Public Debt Management Law is being discussed with the aim to set a limit to external borrowing. In addition, the Thongloun administration emphasizes the importance of economic stability and has set the target of fiscal deficit to less than 5% of GDP in the 8th National Social and Economic Development Plan (NSEDP). While the rise of income level per capita and the exit from the LDC in the early 2020s make it difficult to obtain grant aid, it also makes difficult to raise funds, as the IMF rates its debt sustainability as 'High risk' in consideration of vulnerability to external shocks.

The Lao PDR government announced a direction to promote PPP in infrastructure development based on the above-mentioned circumstances. For instance, it refers to the use of PPP in the *"8.2 Financing Plan"* of the 8th NSEDP. Although PPP has not yet been applied in the road sector, it is studied positively. For example, the use of BOT is being studied by the joint venture company of Lao PDR and China for the Vientiane-Vang Vieng Expressway project. In addition, the use of BOT is being studied for the Pac Xan-Pakse section, and there is a possibility of signing the memorandum of understanding (MOU) between the Government and Chinese company or Laotian company for the implementation of the F/S of the section.

10.3.2 Study of the Project Scheme

(1) Operating Structure of Expressway in Laos

In terms of the operating structure, independent operating bodies are to be established for Vietnamese section and Lao section.

As for the Vietnamese side, there are several potential candidates, i.e. MOT, VEC, and private companies in consideration of the current practice of expressway development and operation. However, as the financial analysis result shows, the demand and profitability of the section is low from the commercial point of view and it is unlikely that VEC and private companies will show high interest without any government support.

As for the Lao side, there is no state-owned nor private company with abundant experience in operating toll road. Therefore, regardless of whether the project is financed by the government or by PPP, an operating company in Laos inevitably needs support from foreign companies which have a great deal of related experience. Therefore, the following two patterns can be expected as a proponent of this project:

- SPC (Special Purpose Company) or JV consisting of Laotian company(s) and foreign company(s) experienced in toll road operation
- Laotian company with the foreign support from road operation company(s) or governmental agency(s).

These kinds of operating structures are also being studied in the on-going feasibility study for Pac Xan-Pakse expressway. In short, a joint venture of Lao and foreign companies is deemed probable. In either of the above cases, it is essential to make sure that technical transfer on toll road operation is duly implemented, and capacity development is undertaken for the government officials and companies in Laos. Especially, considering that several studies are being carried out to examine the adoption of PPP, technology transfer and capacity development of PPP are urgent matters for Lao PDR.

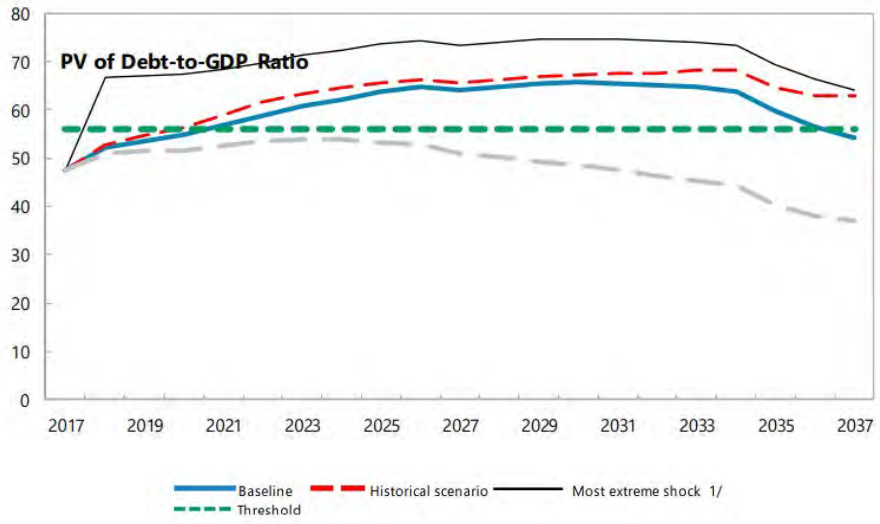
Lastly, regarding the operating structure, there is an idea that a single joint venture, which consists of Vietnamese and Lao companies and covers operation of the entire section between Vientiane and Hanoi, shall be established. It helps Lao side because it does not have sufficient experience in operating toll roads. However, for the Vietnamese side, the incentive for participation may not be high enough because the profitability of the entire section is quite low. Based on these considerations, establishing separate entities for Vietnamese and Lao sides are most realistic option as of now, although there is still a possibility of establishing a joint venture consisting of companies from the two countries are not completely denied.

(2) Profitability and funding method of this project

Neither Vietnam nor Laos has comfortable fiscal conditions. The Vietnamese government in particular, as stated in Section10.3.1, is strictly managing its external borrowing. Under the status quo, there is no concrete plan or secured budget for the implementation of this project in Vietnam or Lao PDR. Therefore, the effort to secure the budget for this project will have to start from the scratch. However, according to the estimation of the cost in this study, the construction costs to be borne by Vietnam and Laos are 854 million USD and 2,942 million USD (NR 8 route), respectively. The amounts cannot be easily shouldered by both governments.

According to the interviews with some Vietnamese and Lao government agencies, the countries expect to use private funds as much as possible for the implementation of this project in the form of PPP. However, the demand forecast in this study shows that the demand exceeds 40,000 PCU/day in some sections while the traffic is only around 15,000 PCU/day in other sections. The projected traffic demand differs by section; hence as a basic approach, the application of PPP should be considered only for the section with sufficient profitability.

However, the financial analysis shows that the FIRR of even in the section with the highest traffic demand, i.e. VVientiane-Pac Xan section, is 0.79% and it is not enough to attract private investment. Even if PPP is adopted, government's support such as VGF would be required. On the other hands, as observed above, the fiscal conditions of both Vietnamese and Lao government is quite serious. Especially, with regard to Lao PDR, it is expected that the public debt against its GDP will continue to grow until 2034/2035 (see the figure below). Under these circumstances, provision of government's support by using external borrowing seems quite difficult even considering grace period for the debt service.



Source: IMF

Figure 10.3.2 Public Sector Debt Projection for Lao PDR

Moreover, PPP-enabling environment of Lao PDR is yet to be developed and capacities of government officers as well as private companies regarding toll road operation are still immature. These evaluation results indicate that it is realistic to develop the road on a non-commercial basis, using state budgets.

(3) Challenges for project financing

Regardless of financing source (government budget or PPP), there are significant challenges in building a project scheme and financing this project.

Firstly, this project is not clearly positioned in the development plan of the Vietnamese and Lao governments. Therefore, in order to implement this project, it is necessary to clearly position it in the development plans of both countries. Furthermore, it is necessary to obtain approval from the Diet and

related ministries and agencies. In order to obtain the approval, it is necessary to prove that sufficient economic benefits will be generated for both countries by conducting economic analysis of this project.

Secondly, the funds required for completion of this project are enormous. According to the interviews with the officers of the Vietnamese and Lao governments, they believe the government budgets will not be enough to finance the project and they have great expectations of implementing under PPP where private funds are going to be mobilized. However, the financial analysis result shows that the commercial viability of the project is quite low, and government support such as VGF will be required even if PPP is adopted.

Firstly, there are issues of PPP legal system and the lack of experience in PPP. There is already a legal system pertaining to PPP and a track record in road PPP projects in Vietnam (Nonetheless, the current PPP/BOT road projects in Vietnam are all carried out based on unsolicited proposals which do not comply with PPP legal framework. Criticisms on the PPP legal framework are often heard both from public and private sectors). On the other hand, there is no PPP legal system and no experience in PPP of road projects in Lao PDR. Thus, one of the critical issues is how to develop an environment that can realize PPP projects and the capacity of related organizations.

(4) Development status of legal system with regard to PPP and investment standards

In Vietnam, the development of PPP legal systems is underway to promote PPP in infrastructure development. The current status is shown in Table 10.3.3.

. A PPP Unit was established in MPI's Public Procurement Agency, as an organization for promoting PPP. Decree No.15, which is the basic decree for the promotion of PPP, was being revised by MPI (Decree No.63/2018, which is a revised version thereof, became effective in June 2018). Also, enactment of the PPP Law has been considered with sublimation of Decree No. 63.

Article 4 of Decree No.63 stipulates the following sectors as PPP-applicable, and it is found that it includes the road sector targeted by this study:

- Transportation infrastructure and related services
- Street light system, water supply, drainage system, waste and sewage collection and treatment system, housing, resident resettlement, cemetery
- Power plants, transmission lines
- Facilities related to medical care and insurance, education, vocational training, culture, sports, and related services, government buildings
- Facilities related to commerce, science and technology, and weather forecast, special economic zone and centralized IT parks
- Development of services related to agriculture, regional development, agricultural production, processing and sales
- Others (based on Prime Minister's decision)

Public projects including PPP for which government budget is applied are classified into several categories as shown in Table 10.3.4, which is stipulated by Article 6 to10 of the Law on Public Investment. As shown in the table, the basic criteria for the classifications are investment amount, project significance and sectors.

On the other hand, the legal system and organizations with regard to PPP have not yet been developed in Lao PDR as mentioned above. The investment for the road project is stipulated in the State Investment Law. At the present, there is information that the Lao PDR’s MPI is preparing a draft of PPP decree with support of the ADB. However, it is uncertain when it will be completed and become effective.

Table 10.3.3 Development Status of Law and Decree with regard to PPP in Vietnam

Law/Decree	Issued date	Description
Decree No. 63/2018/ND-CP on investment in the form of Public-private partnerships	19, June, 2018	Basic Decree of PPP in Vietnam.
Decree No. 15/2015/NĐ-CP on investment in the form of Public-private partnership	14, February, 2015	Basic Decree of PPP in Vietnam.
Law on Public Investment No.49/2014/QH13	18, June, 2014	Law stipulated on procedures and budgets for public investment projects.
Law on Bidding No. 43/2013/QH13	1, July, 2014	Law stipulated on procedures and conditions for bidding for public projects.
Law on State Budget No. 83/2015/QH13	25, June, 2015	Law stipulated on the planning, implementation, audit etc. of the government budget.
Decree No. 30/2015/ND-CP on the Government guiding the implementation of a number of articles on investor selection of the law on bidding	17, March, 2015	Decree stipulated on procedures and standards used in selecting PPP operators based on the Law on Bidding above.
Decree No. 77/2015/NĐ-CP on annual and medium-term public investment	10, September, 2015	Decree stipulated on development and implementation of medium-term public investment plan and annual public investment plan.
Decree No. 131/2015/NĐ-CP on guidance on projects of national significance	15, December, 2015	Decree concerning the planning and implementation of national important projects stipulated in Article 7 of the Law on Public Investment.
Decree No. 136/2015/ND-CP on Guidance on implementation of certain articles of the law on public investment	31, December, 2015	Decree stipulated on the details of interpretation, standards, operation policy, etc. on some provisions of the Law on Public Investment.
Decree No. 6/2016/NĐ-CP on management and use of official development assistance and concessional loans granted by foreign sponsors	16, March, 2016	Decree stipulated on management and use of official development assistance and loans by other foreign institutions.

Source: JICA Study Team

Table 10.3.4 Project Classification in Public Investment Law

Important National Projects (Art. 7)		1		Projects that expense the government budget over VND 10 trillion
		2		Projects that may entail the following considerable impacts on the environment
				A) Nuclear power plant
				B) Projects that require changes in the following land use: national parks, nature reserves, landscape protected areas, forest areas over 50 ha reserved for scientific research, basin protection forests over 50 ha, protected forests over 500 ha that provide protection against wind, sand, wave, and coastal erosion, production forests over 1000 ha
		3		Projects that require changes in urban land use in wetlands where several species of rice are cultivated over 500 ha
		4		Project that require relocation of more than 20,000 habitants in mountainous areas and over 50,000 residents in other areas
		5		Projects that require adoption of special rules or policies by National Assembly
Group A (Art. 8) ※Except projects described in Art. 7	Projects meeting the conditions specified on the right, regardless of investment amount	1	a	Projects located in districts including special national heritages
			b	Projects located in highly critical districts for national defense and security defined in Defense and National Security Law
			c	Projects that contain confidential information on national defense and security
			d	Projects that produce hazardous substances and explosives
			e	Infrastructure projects in Industrial Parks or Export Processing Zones
	Total capital invested over VND 2.3 trillion	2	a	Projects of transportation infrastructure including bridge, seaport, river port, airport, railway, and national highway
			b	Projects of power generation
			c	Projects of exploration of oil and gas
			d	Projects of chemistry, fertilizer, and cement
			e	Mechanical engineering and metallurgy
			f	Mineral extraction and processing
			g	Housing construction
	Total capital invested over VND 1.5 trillion	3	a	Projects of transportation excluding above 2.a
			b	Projects of irrigation
			c	Projects of water supply, drainage and technical infrastructure equipment
			d	Projects of electric engineering
			e	Projects of information communication technology and audio equipment manufacturing
			f	Projects of medicinal chemistry
			g	Projects of raw material manufacturing excluding above 2.d
			h	Projects of machine construction facility excluding above 2.dd
			i	Projects of post and telecommunications
	Total capital invested over VND 1 trillion	4	a	Agriculture, forestry, fishery industry
			b	National parks and nature conservation
			c	Technology infrastructure in new urban areas
			d	Industrial projects excluding those described in above CL. 1, 2 and 3
	Total capital invested over VND 800 billion	5	a	Health care, culture, education
			b	Scientific research, information science, wireless communication, television broadcasting
			c	Warehouse
			d	Tourism, physical education, sports
			e	Projects of civil engineering excluding above 2.g housing construction
Group B (Art. 9)	1	Projects in the sector corresponding to Art. 8 CL. 2 with total invested capital over VND 120 billion and lessthan 2.3 trillion.		
	2	Projects in the sector corresponding to Art. 8 CL. 3 with total invested capital over VND 80 billion and lessthan 1.5 trillion		
	3	Projects in the sector corresponding to Art. 8 CL. 4 with total invested capital over VND 600 billion and lessthan 1 trillion		
	4	Projects in the sector corresponding to Art. 8 CL. 5 with total invested capital over VND 45 billion and lessthan 800 billion		
Group C (Art. 10)	1	Projects in the sector corresponding to Art. 8 CL. 2 with total invested capital less than VND 120 billion		
	2	Projects in the sector corresponding to Art. 8 CL. 3 with total invested capital less than VND 80 billion		
	3	Projects in the sector corresponding to Art. 8 CL. 4 with total invested capital less than VND 60 billion		
	4	Projects in the sector corresponding to Art. 8 CL. 5 with total invested capital less than VND 45 billion		

Source: JETRO (Vietnam Public Investment Law)

Chapter 11
Road Development by Providing Road Construction Equipment

Chapter 11 Road Development by Providing Road Construction Equipment

The construction of expressway which has over 400 km of the total length requires significantly large financial resources as well as a long period of time. Accordingly, it is probable that the manifestation of development effect is slow or often delayed. As one of the provisional measures until the expressway is constructed, "Road Development by Providing Road Construction Equipment" is considered for National Road No.8. The expected positive effects from this measures include smooth commencement and completion of construction work, reduction of construction cost incurred by the government of Laos, utilization and fostering of local private companies or government corporations and enhancement of the sustainability of road development.

11.1 Current Status of Road Development Project in Lao PDR

11.1.1 Method of Road Development

All road development projects in MPWT/DPWT (including maintenance and management) are entrusted to private construction companies and government corporations. Road development projects are not directly managed by MPWT/DPWT. All public work projects are outsourced by competitive bidding. Government corporations equally compete with the private construction companies in the bidding. In exceptional cases, negotiated contracts are signed with government corporations when the emergency construction is required due to disasters.

11.1.2 Current Status of Road Development

The MPWT uses DBST (simple pavement) for road development.

Slope stabilization is hardly implemented except for simple gabions and concrete retaining walls. Priority is given to paving work rather than slope stabilization.

KOICA has recently implemented a feasibility study for developing National Road 8 (approx. 130 km) with high standard, and the final report of this study was submitted in May, 2018. In the report, upgrading of the bypass section including tunnel sections is proposed.

Road development between Viengthong and Tanh Thuy (approx. 130 km) was suspended due to lack of funds of the Government of Laos. The construction will resume after the National Assembly approved the resumption. The construction was divided into two phases and contracts were signed in 2009 and 2011. Although constructions were suspended, the contracts are still valid. The contractor of both phases is the Douangchalearn Developing Group.

11.1.3 Status of Construction Companies

Construction companies in Laos are roughly divided into government corporations called "state enterprise" and private enterprises.

There are currently only two major public corporations engaged in national-level road construction works, namely "Road No.8 Construction Enterprise (R8CE)" and "SECC". There are, however, small government corporations that work at provincial level. There is one government corporation (State Enterprise Road, Bridge and Irrigation Construction and Maintenance) in Bolikhamsai Province. The two major corporation engaged in national level are outlined below.

In 1989, a government corporation was established by the government for the construction of the National Road 9 with the road construction equipment granted from the former Soviet Union. Thereafter, it has been divided into several companies and has carried out other national road development. In the past, the corporation management was supported by the government, but now it is independent. The corporation is managed in accordance with the Government Corporation Law, also pays taxes and conducts audit, and transfers the profit to the government. The company and its asset portfolio belong to the Ministry of Finance. Currently, public works projects are basically participating in competitive bidding and are receiving orders in the same way as the private companies.

On the other hand, there are currently over 30 private construction companies in Laos. Five of them are larger than the major government corporations.

In the table below, outlines of the R8CE, the state enterprise in Bolikhamsai Province (State Enterprise Road, Bridge and Irrigation Construction and Maintenance) and private enterprises are summarized. Although all of them own general civil engineering machineries, it is apparent that many of them lack equipment such as paving equipment mobile workshops. According to an interview conducted during the survey trip, while the civil engineering machines owned by the R8CE are in a good condition, many of those owned by the State Enterprise in Bolikhamsai or private enterprises are not maintained well and thus in a poor condition.

Table 11.1.1 Outline of Construction Companies in Laos

Item			R8CE	State Enterprise in Bolikhamsai	Private Enterprise
No. of employee			about 50	about 30	over 100 in large companies
Technical level			relatively high	relatively low (only maintenance)	depends on each company
Construction Machinery or Equipment Owned	civil engineering machinery	general equipment (bulldozer, excavator, etc.)	Yes	Yes	Yes
		vibrating roller	Yes	No	No
	paving equipment	asphalt plant	Yes	No	No
		asphalt finisher	Yes	No	No
		line marker	No	No	No
	others	mobile workshop	No	No	No

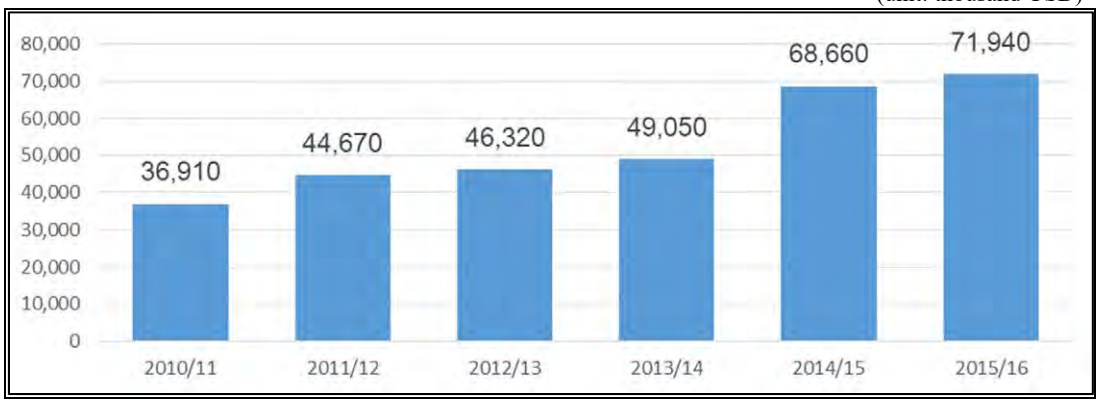
Source: JICA Study Team

11.2 Study for Target Road Development Plan

11.2.1 Financial Situation of Road Sector in Laos

MPWT's budget for the year 2014/15 was 2,852 Billion Kip (about 340 million dollars), of which about 70% was overseas loans and grants. The government budget consists of the Road Maintenance Fund (RMF) and the general budget, and the RMF accounts for about two-thirds of the budget. RMF was founded in 2001 by the prime ministerial order in order to maintain and manage roads by the revenue from the road users, and most of the sources of the fund are fuel taxes. The revenue of the RMF is continuously increasing as shown in the figure below, and the average growth rate from 2010/11 to 2015/16 was over 14% per year.

(unit: thousand USD)



Source: MPWT

Figure 11.2.1 Transition in Revenue of RMF

The result of the estimation of the amount investable in the target road development for three years is as follows:

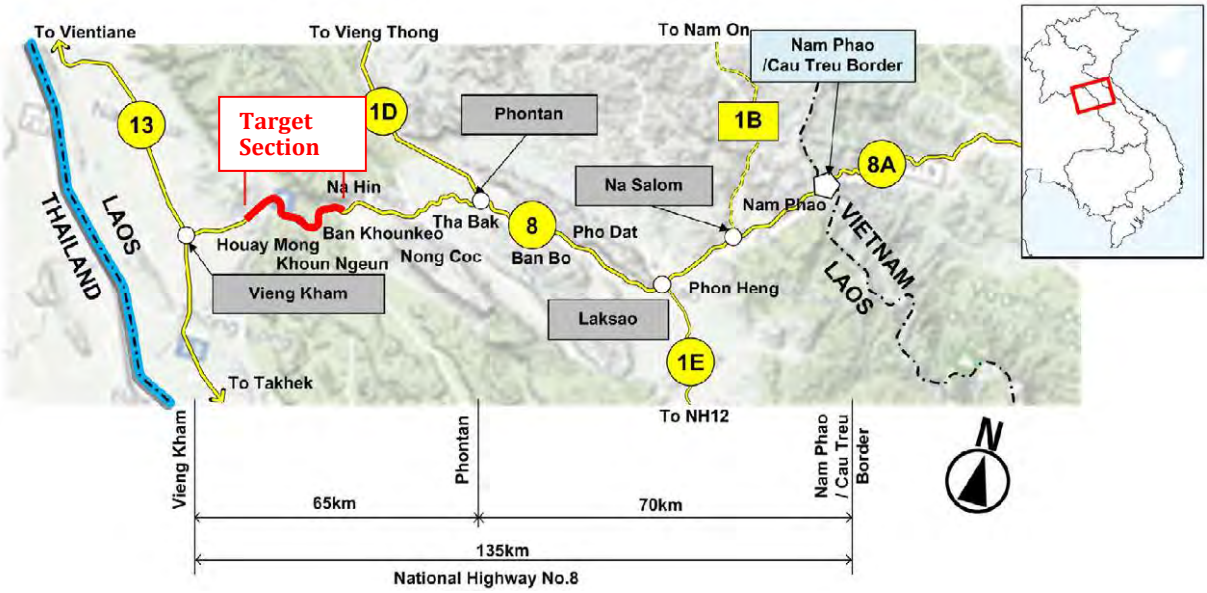
- MPWT budget : Assuming the annual growth rate of RMF as 10%, and the domestic budget as 1.5 times of the RMF, the investment of the MPWT is estimated to be 400 Million USD in 3 years starting from 2020/21.
- Proportion used for national highway renovation: 75% based on the February 15, 2016 budget document (73.5%).
- Proportion used by Bolikhamsai Province: 7% based on the February 14, 2015 data (6.4%).

Therefore, the amount to be used by Bolikhamsai Province in the three years starting from 2020/2021 during which the target road development will be implemented is estimated to be 21 million USD (i.e., 400 Million USD x 75% x 7%).

11.2.2 Study for Road Development Plan

(1) Selection of target road

The target road for development that would be implemented by Laos over the period of three years after the handover of the road construction equipment is National Route 8, which runs in parallel with Alternative 2. The top-priority section is assumed to be STA.13–33km (road length 20 km), which is a section with continuous steep slopes, small curves and frequent rock falls. This is followed by the secondary priority target include the following sections: 20 km to the east of the said top-priority section, 10 km to the border area and 10 km along Laksao urban area prone to traffic congestion.



Source: JICA Study Team

Figure 11.2.2 Target Road Section

(2) Specification of road development

Under this plan, the following specifications are followed:

- ✓ Slight improvement in longitudinal gradients and alignment
- ✓ Improvement of service level by widening the road
- ✓ Ensuring durability against future increase of heavy traffic by asphalt concrete pavement
- ✓ Prevention of rainwater erosion by development of concrete side ditches
- ✓ Large-scale construction works including bridge sections and slope protection are out of scope.

(3) Traffic volume after road development

Current and future traffic volumes are estimated for comparison as Figure 11.2.3 shows. The current traffic volume of the target section is less than 2,000 pcu/day, and the traffic volume of 2033 is estimated to be less than 10,000 pcu/day. Traffic capacity would increase by 25 to 35% to 12,000 pcu/day by widening the width of the lanes and lateral clearance, and it is expected to meet the future traffic demand.

Traffic demand	Vieng Kham	Phontan	Laksao	Na Salom
Current (2017)	1,586	1,563	8,098	741
Future (2033)	9,154	5,886	16,425	4,440

(unit: pcu/day)

Source: prepared by JICA Study Team based on the KOICA F/S report

Figure 11.2.3 Traffic Volume of NR 8

11.3 Necessity of Road Construction Equipment

In this study, the situations of construction machineries and equipment owned by state enterprises or private enterprises in Laos are researched. The research result indicates that the poor maintenance conditions of, or the total lack of machines and equipment, makes it difficult for them to implement road development effectively. In light of this situation, as one of the possible project schemes, providing construction equipment with the Government of Japan's Grant Aid scheme is considered important for the promotion of the road development.

11.3.1 Process of Providing Construction Equipment

In Laos, the government does not carry out construction under direct management and own construction road equipment. In addition, public works are basically procured through competitive bidding. Thus, the process of providing road construction equipment is expected to be as follows:

a) Delivering the road construction equipment to MPWT or DPWT, which temporarily stores it until the construction contractor of the target road development is determined,

b) Deciding construction contractor by competitive bidding,

c) Lending the road construction equipment to the contractor,

d) Returning the road construction equipment to MPWT/DPWT after completion of the construction,

e) Handing over the road construction equipment from MPWT/DPWT to the government corporation.

In this case, the construction contract should include the following conditions:

- ✓ Lending and using the road construction equipment (reduce construction cost for that equipment)
- ✓ Proper maintenance and management the road construction equipment by the contractor during the contract period
- ✓ Returning the road construction equipment to the contractor at the end of the contract.

In case it is possible for the government to make a negotiated contract with a state enterprise for the development of the target road, the construction equipment may be handed over to the state enterprise directly. However, the interview result with the concerned governmental agencies reveals that the negotiated contract with state enterprise is not allowed.

11.3.2 Overview of the Government of Japan's Grant Aid scheme

(1) Composition of construction equipment

List of road construction equipment for a general road development project is as shown in the table below. The total project cost is estimated around 1.0 billion yen. Furthermore, if the recipient is known at the time of project implementation, technical guidance on how to use the road construction equipment, construction method, and so on can be provided as a soft component.

Table 11.3.1 Proposed Composition of Construction Equipment and Estimated Project Cost

Classification	Equipment	Main Works	Quantity	Cost/unit (million yen)	Total cost (million yen)
Civil Engineering Machinery	Bulldozer	Excavating/dozing/spreading/hauling/compacting soil	2	28.2	56.4
	Excavator (Crawler)	Excavating/stockpiling/loading/hauling/removing soil/trimmimg slope face	3	12.8	38.4
	Hydraulic Breaker	Excavating earth and breaking rock	2	2.0	4.0
	Motor Grader	Spreading fill soil, leveling, finishing sub-base course/base course	2	17.2	34.4
	Wheel Loader	Stockpiling/loading/hauling/removing soil	2	16.0	32.0
	Sheep foot Compactor	Compacting embankment and base/sub-base course	2	13.9	27.8
	Vibratory Tandem Roller	Compacting/sub-base course/surface course	2	11.0	22.0
	Tire Roller	Compacting/sub-base course/surface course	2	10.4	20.8
	Plate Compactor	Compacting narrow part	10	0.1	1.0
Paving Machine	Asphalt Plant	Production of hot mix asphalt mixture	1	150.0	150.0
	Asphalt Finisher	Asphalt Paving	2	40.0	80.0
	Line Marker	Painting traffic line for pavement	1	1.0	1.0
Transport Machine	Dump Track	Hauling the road construction materials	20	7.7	154.0
	Cab Back Crane	Loading and unloading, and to transport the construction materials	1	10.0	10.0
	Rough Terrain Crane	Loading and unloading the construction materials	1	36.8	36.8
	Low Bed Semi-trailer	Transport heavy equipment	1	20.8	20.8
Other Machine	Water Bowser	Watering for embankment or to supply water for concrete work	2	7.0	14.0
	Mobile Workshop	Repairing/maintaining the construction machiines at the construction site	0	18.0	0.0
	Inspection Vehicle	Going round the road construction sites for inspection and supervision	2	3.0	6.0
	Generator	Emergency power	2	6.5	13.0
①	**Total Machinery Cost**				**722**
②	Transport・Insurance Fee		①	x 20%	144
③	Spare Parts Price		①	x 5%	36
④	General Administrative Cost		①②③	x 5%	45
⑤	Consultant Fee		①②③④	x 6%	57
Project Total Cost			①～⑤		**1,005**

Source: JICA Study Team

The cost on Laos's side is assumed to be as follows:

- Target Road development fee: Approx. 2 billion yen (assumptions: 20 km is upgraded to 2-lane road, and project unit cost is 100 million/km)
- Maintenance cost for construction equipment: 1 million yen /year for the first 3 years (to provide spare parts for 3 years), and 20 million yen /year after the fourth year

(2) Major construction equipment

Of all the construction equipment possibly to be provided to Laos, those not owned by local construction companies are explained in Table 11.3.2. This include vibratory tandem roller, asphalt plant, asphalt finisher, line marker and mobile workshop.

Table 11.3.2 Brief Explanation of Major Construction Equipment

<table>
<tr>
<td colspan="2">■ Vibratory tandem roller
 
Main use: compacting sub-base or surface course</td>
<td colspan="2">■ Asphalt plant
 
Main use: production of hot mix asphalt mixture</td>
</tr>
<tr>
<td colspan="2">■ Asphalt finisher
 
Main use: asphalt paving</td>
<td>■ Line marker
 
Main use: painting traffic line for pavement</td>
<td>■ Mobile workshop
 
Main use: repairing or maintaining construction machines at construction site</td>
</tr>
</table>

Source: JICA Study Team

11.4 Agenda for Future Implementation

In concretizing the Government of Japan's Grant Aid scheme, it is necessary to further study and confirm the following points:

- Coordinating with KOICA is necessary as it is currently carrying out the F/S on upgrading the standard of all along the NR 8 (approx. 130km)
- Since the cost of construction of the target road will be covered by Laos, it is necessary to consider the Road Development Policy of Laos in selecting the target road development.
- In lending out the provided road construction equipment to the contractor selected by bidding, the following consideration is also required:
  - ① How to decide the type the construction equipment to be provided since the construction equipment owned by a contractor is not identified in advance
  - ② Mechanism (contract form) in which the construction equipment is properly operated and managed by the contractor
  - ③ Maintenance method of construction equipment after target road development is completed (after 4th year).

Chapter 12
Soft Component for the Enhancement of Connectivity

Chapter 12 Soft Component for the Enhancement of Connectivity

12.1 Necessity of Measures to Enhance Connectivity through Institutional Improvement

To achieve economic development of Laos and Vietnam after the development of Hanoi-Vientiane expressway, it is essential to take measures to enhance connectivity in terms of "soft" infrastructures, in addition to the road development ("hard" infrastructure). These measures are comprised of (i) promotion of investment, industries and export to assure economic development of the roadside areas based on the development potential of the areas, leading to economic development of the two countries, and (ii) efforts to reduce the time and cost for freight transport by improving the system related to customs clearance, immigration control and quarantine (CIQ), and logistic services between Laos and Vietnam and among GMS/ASEAN members for utmost utilization of the benefits of expressway development, in other words, prevention of the incremental time for border crossing (in particular, customs clearance), due to increase in the trading volume, from exceeding the saved travel time as a result of the expressway construction. The measures to be taken to achieve these two objectives are proposed below. Since these measures are mutually interrelated, it is essential to implement them by close cooperation of related government agencies (relevant central ministries and the local governments along the expressway) and related private sectors from the early stage of planning and designing. In addition, coordination with neighboring countries, application and coordination of the programs and projects of GMS and ASEAN, are also necessary in the course of development and implementation of the plan.

12.2 Measures to Achieve the Freight Transport Volume Appropriate to Expressway

For Laos, as a land-locked country without any sea port, to achieve economic development, securing accessibility to Vung Ang Port, which is currently under development jointly with Vietnam, is extremely important. Construction of the Hanoi-Vientiane expressway can be an initiator for Laos's economic development, providing better access to markets in Vietnam, coastal areas of China and the global market through ports in Vietnam. As for Vietnam's economy, the construction of the expressway will enable better access to markets in Thailand and Myanmar, and strengthen supply chains of manufacturers of Vietnam.

Besides, cost recovery of the huge amount of investment incurred for the expressway construction requires securing the cargo transport volume appropriate to the expressway for collection of the toll or increase in tax revenue through economic development. In addition to development of "hard" infrastructure (such as construction of the expressway), "soft" measures (institutional improvement) related to regional development, investment promotion, and trade promotion should be developed, implemented, and promoted systematically and comprehensively in a synchronized manner by the Government of Lao PDR. These activities should be implemented through collaboration and cooperation among the central government ministries (such as Ministry of Planning and Investment, Ministry of Industry and Commerce, Ministry of Agriculture and Forestry, Ministry of Finance, and Ministry of Public Works and Transport), and the provincial governments along the expressway. It appears that Laos is less experienced in such comprehensive roadside developments when compared with the neighboring countries. Therefore, it is essential that the central government takes the leadership in studying and formulating development and promotion measures and to examine and design their implementation method and procedure, followed by planning and implementation of the measures appropriate to the characteristics of the areas along the expressway.

Meanwhile, Peoples' Committees of Nghe An and Ha Tinh Provinces of Vietnam are very active in developing numbers of Economic Zones/Industrial Parks, such as Vietnam Singapore Industrial Park (VSIP), Vung Ang Economic Zone and related infrastructure, and attracting enterprises to the provinces in cooperation with Ministry of Planning and Investment, Ministry of Industry and Commerce and foreign organizations such as JETRO and Korean Chamber of Commerce and Industry.

Roadside development in Vietnam side, taking advantages of the expressway construction, is highly expected to be realized by implementation of the policies and plans of the two provinces. Therefore, recommendations are described hereunder for roadside development, investment promotion, attraction of foreign enterprises and export promotion required in Lao side.

Vitalization of the roadside economic activities according to the procedure shown in Figure 12.2.1 is recommended to promote exports of the roadside products. The procedure described below is proposed as it is desirable that the Laos Government, which has little experiences in full-scale promotion of investment (attraction of foreign direct investment and enterprises) other than Savannakhet Economic Special Zone development, formulate specific measures for promotion of investment and export while attending to the requests in this regard presented by the enterprises considering investment in Laos.

Figure 12.2.1 Proposed Procedure for Development of Roadside Areas

12.2.1 Planning for Regional Development and Industrial Promotion along the Expressway and Enhancement of Relevant Institutions

(1) Selection of potential export products

Promotion of investment and export along the expressway requires, first of all, selection of export products considered highly promising in the future. At present, Laos is facing growing imports from or via Thailand and Vietnam substantially larger than exports to or via these countries. This has led to the so-called "one-way" shipment issue, which is one of factors responsible for higher cargo transport costs. Promotion of export is therefore necessary for reducing logistics and the transport costs.

Ministry of Industry and Commerce, Ministry of Agriculture and Forestry, and Bolikhamsai Province have proposed potential export products from the roadside areas, such as processed goods and products including processed agricultural products (starch extracted from cassava), beef (processed), organic vegetables (tomatoes, chili, lettuce, etc.), bamboo shoots, mushrooms, rubber, glutinous rice, tea, as well as light industry products, and electric and electronic products.

It is proposed to select specific agricultural products and processed goods, light industry products, electric and electronic products considering regional characteristics and potential (climate, geography, soil, existing infrastructures, natural resources, and human resources), demand analysis of Thailand, Vietnam, and the destination markets, and the production trends of competitive countries aiming at the same markets. It is also proposed to formulate subsequently specific measures to promote production and export of these products and goods. Note that agricultural products and processed goods are extremely sensitive to the world market price fluctuations, so that promotion of mono-cultural agricultural products and processed goods may prove vulnerable to price decline. Due consideration must therefore be made in balancing between mass production and branding on one hand and diversification on the other.

For light industry products and electric/electronic products, the domestic demand for their final products is small because of small population of Laos. In addition, the average monthly wages of

workers in Vientiane was USD 179 as of December 2015, which is higher than that of Yangon (USD 127), Phnom Penh (USD 162), and Da Nang (Vietnam) (USD 158). Therefore, development and promotion of labor-intensive processing industries (including production of intermediate materials) based on low labor costs offer little hope. In consequence, the export products will be selected by taking into account (i) abundant electric power, (ii) clear water resources, (iii) products and goods utilizing unique mineral resources and other Laos characteristics, (iv) demand trends in the promising export targets, (v) state and prospects of competition with the competitive countries, (vi) possibility of fostering domestic partners to work with the foreign companies producing the export products.

(2) Formulation of the regional development plan and industry promotion measures

After selection of potential export products, the development plan for regions along the expressway should be formulated examining spatial plans (land use plans), infrastructure development plans (pavement and construction of access roads), public service (power supply, water supply, wastewater/sewage treatment, solid wastes management) plans, and regional human resources (education, health) development plans. It is also essential to formulate simultaneously the promotion plan for each of the related industries. Promotion plan on processing of agricultural products has to include the promotion plan for agriculture, which provides raw materials, and the promotion plan for the processing industry. The agricultural promotion plans are to be formulated for elements shown in Table 12.2.1.

Table 12.2.1 Proposed Agricultural Promotion Measures

Elements	Outline
1) Selection and development of cultivated species and farmed breed	Selection of development (as required) of cultivated species and farmed breed by taking into account aptitude for climate and soil; yield; resistance against disease/insects; market price; eating quality, etc.
2) Farming guidance and dissemination activities	Demonstration and guidance on the cultivation method; implementation of consulting services
3) Irrigation・infrastructure development plan (as required)	Guidance on development, maintenance of irrigation facilities; guidance and support of water management by the irrigation association; development of access road, etc.
4) Support for mechanization	Guidance and support for cooperative holding and use; guidance and support on the loan system by the association; financing, etc.
5) Quality management, quality assurance systems	Guidance on quality management; establishment and operation of the certification system; establishment and operation of the rating system; establishment and operation of the certification of origin system,
6) Certification system for organic cultivation, farming without agricultural chemicals	Guidance on organic cultivation and farming without agricultural chemical; establishment and operation of inspection certification system
7) Collaborative procurement of materials and equipment	Establishment and operation of the system to develop, produce collaboratively, and purchase inexpensive and quality materials and equipment
8) Supporting the collaborative shipment	Establishment and operation of marketing, collaborative production, and procurement system, and support for branding
9) Cooperative credit	Guidance and support for establishment and operation of cooperative credit

Source: JICA Study Team

For the measures to promote the industries, the selection of the export items will be followed by development and implementation of, respectively, the industrial parks in the special economic zones, the export promotion measures, and the enterprise attraction plan and investment promotion measures.

(3) Establishment of planning and implementation systems

For formulation and implementation of plans and measures, cooperation among various relevant organizations is indispensable. If the organizations engaged in demand and competition analysis in the export market, production promotion, and attraction of processing enterprises do not collaborate, it will be difficult if not impossible to realize the roadside development and export promotion. Also it is

essential to establish an implementation and support system to ensure effective cooperation and collaboration in the implementation stage by allowing the participation of the local governments along the road, in the stage of planning, in addition to related ministries. The related ministries are the Ministry of Planning and Investment in charge of formulation of development plan, promotion of investment, and arrangement of the industrial parks in the special economic zones; the Ministry of Industry and Commerce in charge of industrial and trade promotion; the Ministry of Agriculture and Forestry in charge of agricultural development, guidance on farming, and animal and plant inspection; the Ministry of Public Works and Transport in charge of development of transport infrastructure and improvement of logistics; and the Ministry of Finance in charge of customs clearance and tariff collection. However, such measures should not be of a something-for-everyone type. Instead, it is proposed to formulate a strategic plan under the leadership of the Deputy Prime Minister (Chairman of the Committee for Promotion and Management of Investment) or the Minister of Planning and Investment so as to ensure the formulation of effective investment promotion and foreign direct investment (FDI) attraction measures and trade promotion measures with the input from related ministries.

12.2.2 Selection the Candidate Industries/Enterprises to Attract according to the Regional Development and Industry Promotion Plans

(1) Description of the roadside regional development, relevant industry promotion, and export promotion measures

Before selection of the potential target companies, it is proposed to hold a briefing session (road show) on the proposed strategy and plan on the potential export products, promotion of relevant industries, promotion and attraction of investment, promotion of exports. The session may be held in Vientiane, Bangkok, Hanoi, Vinh, Tokyo, Osaka, or Nagoya. It could be held also in principal cities in Europe and US where potential target companies may exist. It is recommended to provide sufficient time for individuals consulting in the course of the session. Preparation of high-quality video, booklets, and other contents may be necessary for the session. It is also recommended to prepare necessary data and information for immediate and proper provision to companies planning entry into Laos and distribute such data and information through relevant agencies, such as the Investment Department (Representative Office of the Investment One Stop Service Bureau) of Laos Embassy in each country.

(2) Supporting interested companies, consider their requests concerning roadside regional development and industrial/investment/export promotions, and reflect them in the planning and measures

The investment department of the Laos embassies in the countries where the session will be held should act as contact points to support the examination and survey for entering the region by providing continuous follow-up services to companies attending the session and individuals consulting. During the support for these companies considering to enter into Laos market, it is recommended to organize discussions on the concerns associated with entry in Laos and requests on the roadside development and industrial/investment/export promotions and consider the results in the formulation of the roadside regional development plan, and investment promotion and industrial/export promotion measures.

(3) Selecting potential companies

For the companies that have been interested in investment in Laos while receiving the follow-up services as described above, the Laos counterpart, specifically, the Minister of Planning and Investment, undertakes survey and examination on the technical capabilities, future possibilities, and financial status of the companies concerned and selects appropriate ones. Even after the selection is over, the invitation as well as review and preparation activities for entry will continue.

12.2.3 Planning and Implementation for Development of Special Economic Zones/ Industrial Parks to Attract Industries/Enterprises

(1) Selecting the location

Potential location for special economic zones and industrial parks will be selected, in principle from the following locations along the Hanoi–Vientiane Expressway in Laos: (i) key junction areas, (ii) agricultural areas where selected agricultural products are concentrated, (iii) locations where sufficient land area for future expansion may be secured, (iv) location offering satisfactory means of transport from the existing supply chain, and (v) location where the public services necessary for production of selected export goods (including the services necessary for the new workers moving into the region) are readily available. At present, SEZ along the expressway in Laos is planned only in Vientiane City. Considering the factors such as regional development, labor force cost and traffic convenience, it is proposed to plan developing SEZ in the neighborhood of Pac Xan or Laksao.

Vieng Kham, located in the junction of National Road No. 8 and No. 13, is in an important area of traffic and has a high potential for economic development. The town, however, is not recommended as a priority candidate for strategic point for the roadside development in this report because there is no border facility and no plan for its establishment. In addition, population concentration of Vieng Kham is much smaller compared to that of Pac Xan or Laksao.

(2) Preparation for required infrastructure and provision of public services

After the potential export goods and enterprises to be attracted are selected, development of the infrastructure necessary for provision of special economic zones/industrial parks appropriate to the industry type has to be planned. Specifically, roads for connection with other supply chains or agricultural products, infrastructures for public services (such as power supply, water supply, wastewater/sewage treatment and solid waste management), and, if necessary, the irrigation infrastructures and agricultural roads will have to be included. It is also necessary to formulate plans for establishing or reinforcing organizations for operation and maintenance of the SEZ, and take all the necessary measures to enable the provision of public services by the time the companies move into SEZ and industrial parks.

(3) Developing logistics infrastructure

In order to achieve the effective freight transport on the expressway, development of the following facilities around: bases and facilities for logistics (logistic parks, dry ports (the inland transshipment terminal (for multimodal transportation), which enables storage, reloading, and customs clearance)), the inland clearance depot (ICD, which can handle also special cargoes, such as hazardous materials, etc.[1], as compared to the dry port which handles ordinary cargoes only). Together with export promotion, development of above facilities is expected to contribute to elimination of “one-way” shipment issue, improvement and cost reduction of the freight transport.

In Laos, modern supermarkets, convenience stores, etc. are mainly available in and around Vientiane, which causes rapid increase in the needs for distribution of chilled and refrigerated foods. Besides, only extremely limited number of warehouse owners and distributors are equipped with refrigerated and chilled warehouses[2]. It is essential to develop cold chains to promote export of agricultural processed products in the future. For increased need of cold chains, it is proposed that Department of Transport of MPWT in charge of development of infrastructure undertake the pump-priming policy; namely, the Department should construct small-scale refrigerated and chilled warehouses in Dongphosy (Ta Na Laeng), Pac Xan and Laksao for use of logistics operators jointly.

[1] From interview with Department of Transport, Ministry of Public Works and Transport, Laos, February 2018

[2] From the 2016 Survey on Food Value Chain Structure (Asia), “Report of Survey on Production, Distribution, and Investment Environment of ASEAN countries” (March 2017) by Ministry of Agriculture and Forestry

12.2.4 Planning and Implementation of Export Promotion for Products of Regions along the Expressway

(1) Improving the export procedure

Measures to improve the export procedure for the selected export products are to be formulated and implemented. For agricultural processed products and electric products, Laos has conventionally been dependent mostly on imports. If Laos is to shift the course toward increase in export in the future, the export procedure should be substantially improved as described below. The analysis of existing survey results[3] and interviews has identified the export procedure issues as follows:

1) Laos has relied conventionally on imports for various consumer goods (such as processed foods) and almost all of industries have no system for promoting exports complying with the international standards.
2) Export from Laos to Vietnam decreased substantially (US$ 1.2 billion to US$8 billion) from 2015 to 2016. Prior to foundation of AEC, Vietnam used to import surplus agricultural products from Laos according to the bilateral agreement between Laos and Vietnam. After the foundation of AEC, however, any products not complying with the export criteria of AEC (WTO) could not be exported even to Vietnam.
3) EU is imposing import ban on a part of agricultural products from Laos due mainly to contamination by insects and partly to that quality certificate of Laos is regarded as not reliable by the EU. EU has found discrepancy between the submitted documents by Laos and the situations in reality, and it presents to Laos Government conditions necessary for lifting the import ban.
4) For farmers, the number of documents to be prepared and items to be controlled has increased. Most of the farmers have abandoned export because they cannot meet such conditions. According to the on-site interviews conducted in December 2016, only five producers were found to be meet the export criteria to EU.
5) At present, there is only one inspection agency in Laos, and many export-oriented farmers commission inspection to the inspection agency in Thailand. For many farmers with weak management foundation and financial capacity, costs required for inspection presents a significant hurdle for export. In addition to the number of inspection agencies, qualitative fulfilment of necessary equipment, etc. is essential. The inspection equipment is indispensable in order to issue the quarantine certificate, but inspection could not be sufficiently executed without sufficient quantity of equipment. Moreover, the human resources capable of handling the equipment are insufficient, resulting in failure of maximum utilization of existing inspection equipment.
6) For plant quarantine, all major customs, except few of them, do not have simple test kits, resulting in insufficiency of the available kits. In addition, only one laboratory exists in the suburb of Vientiane; as a result, the time required for inspection may become longer due to the capacity and accessibility issues.
7) Even the central inspection agency is reported suffer from lack of sufficient skilled staff. Though the inspection equipment has been introduced with the assistance of JICA, there were reports that the sophisticated equipment is not fully utilized by the staff, and the reagent is too expensive to be accommodated with the budget.
8) Some foreign supermarkets have their own vegetable certification system. Specifically, vegetables are classified into “green” (organic), “white” (hydroponic), “blue” (without residual agricultural chemicals, without residual chemical fertilizer; agricultural chemicals used only in the initial stage of cultivation), “yellow” (without agricultural chemicals; the use of agricultural chemicals refrained in ten days before harvesting), and “red” (others). Seals identifying each

[3] From the 2016 Survey on Food Value Chain Structure (Asia), “Report of Survey on Production, Distribution, and Investment Environment of ASEAN countries” (March 2017) by Ministry of Agriculture and Forestry

color classification are attached to the packages. Since certification is currently done in the headquarters not locally, vegetables are mostly import even when their production quantity in Laos is large. Actually, domestic vegetables account for 10% only.

In order to eliminate above problems and to export any conventionally imported goods and products, the radical measures listed must be taken:

a) **Confirmation of the International standard and certification system applicable to export and designation of the inspection agency：** Inspections and verification items to be conducted by the governmental agencies and producers (organizations) of Laos are confirmed by surveying the orientation of consumers of export target countries. Collection and analysis of applicable international standards and certification systems and the standards and systems of major export countries are also conducted concerning the selected export products.

b) **Estimation of the required inspection and verification quantity, inspection equipment, and the number of inspection staffs:** On the basis of the production and export amounts estimated for each export products, the required inspection and verification quantities are estimated. Also estimated is the number of required inspection equipment and staffs.

c) **Formulation and implementation of the inspection and certification agencies strengthening plans, equipment procurement and maintenance plans, and staff employment plans:** On the basis of planning and estimation on distribution of locations of production and processing, the inspection and certification agencies strengthening plan, equipment procurement and maintenance plan, and staff employment plan are formulated and implemented.

d) **Implementation of the capacity development of inspection and verification agencies:** The skills necessary for execution of inspection and issuance of the certificate are summarized to help implementation of the capacity assessment of the existing staffs and listing up of the required training courses. In addition, survey is made on the training courses provided by the international agency on inspection and certification, and the applicable training courses are listed up. On the basis of these survey results, the training plan (comprising the implementing agencies, curriculum, period, number of trainees, and costs for each training course) is formulated. For training, both the training of trainers (TOT) and the normal and regular trainings in which the instructors trained by TOT attempt horizontal development are planned and implemented. For the TOT course, cooperation of international agencies is basically indispensable, so that the request for cooperation is prepared and submitted to the international development agencies after formulation of the plan.

For planning and implementation of the above measures, it is proposed to establish a task force comprising several dedicated staffs from the Ministry of Industry and Commerce and the Ministry of Agriculture and Forestry and cooperative staffs of the Ministry of Finance and the Ministry of Foreign Affairs, instead of causing the staffs having their daily jobs to serve concurrently as inspectors.

(2) Improvement in quality of export products

For promotion of export requires, Laos (which imports most of its consumer goods) requires, among other things, improvement of the procedures to comply with international standards, satisfying consumers' taste for export and strengthening of international competitiveness through improvement of the quality of export products, as described above. Though qualitative improvement of export products may basically for foreign companies, Laos Government should take the following measures strengthening of competitiveness of Laos's companies in the long term:

1) **Promotion of employment of Laotian by foreign companies:** Hoping the spin-off and foundation of a company by Laotians with experiences in foreign companies, employment of Laotians should be made obligatory or recommended. The investment preferential system requiring employment of Laotians as a prerequisite should be established.

2) **Improvement and strengthening of vocational education and training for Laos roadside areas**: By incorporating advices of foreign companies in vocational training, the vocational education and training for Laos roadside areas should be improved and strengthened.

3) **Promotion of the cooperation between foreign companies and Laos's academic institutions :** Participation of Laos's academic and research institutions in research and development of foreign companies should be promoted and assistance should be provided to foreign companies and academic and research institutions engaged in collaborative Research and Development.

According to the existing surveys, companies from Japan, Thailand, and Vietnam expressed concerns as follows when making entry into Laos: (i) difficulty of securing engineers, technicians, (ii) high wages of engineers and technicians. Considering these concerns, implementation of the measure (2) proposed above may contribute to attracting foreign investment. It is also important to appeal to potential companies by sharing the contents and state of implementation of the above three quality improvement measures.

12.2.5 Attraction of Industries/Enterprises, and Planning and Implementation for Investment Promotion

Once a candidate company decides to invest in Laos, it is essential that the Department of Investment Promotion of the Ministry of Planning and Investment collaborate with the provincial and district One-Stop Service offices to provide well-considered support toward establishment of the enterprise or initiation of the business.

Laos also may face competition from other competitive countries in attracting investments. Therefore it is proposed to conduct surveys on the investment preferential and promotion measures of other ASEAN countries or those countries that have succeeded in attraction of foreign companies. Any experiences applicable to Laos may be incorporated in the investment preferential and promotion measures. These measures may be implemented with the assistance of development partners, such as international agencies.

The latest version of the Laos's investment guide (the version as downloaded from internet) is the 2014 Investment Guide Book (20 pages in English) prepared by the Investment Promotion Department of the Ministry of Planning and Investment with the assistance of a JICA expert. On the other hand, the latest version of Vietnamese guide is the "Legal, Tax & Investment Guide, Vietnam, 2016" (208 pages in English), (its Japanese version is the "Investment Guide Book of 2016"and has 119 pages). Thailand has the "Thailand Board of Investment Guide 2016 (162 pages in Japanese)" which serves as an original guidebook for companies planning entry and investment, rather than providing introduction of the laws, regulations, and notifications. It is recommended that the Investment Promotion Department of the Ministry of Planning and Investment of Laos prepares and disseminate the investment guide while referring to those from neighboring countries, such as Thailand, Vietnams, or other countries that have succeeded in attracting foreign companies.

Nghe An Province, Ha Tinh Province and other Vietnamese provinces have prepared respective unique investment guides and the guides on industrial parks. Such guides are distributed to executives and employees of companies vising the site, and embassies of main investment countries in Vietnam. The Lao Investment Promotion Department of the Ministry of Planning and Investment should consider assisting the Bolikhamsai Provincial Government in preparation of the procedure describing information unique to each province as well as the person in charge and contact point of each province and district. If possible, it is advisable to prepare versions in Thai, Vietnamese, Japanese, Chinese, Malay, etc. in addition to English. Once prepared, these guides should be renewed at least every two to three years.

12.2.6 Implementation of Regional Development and Industry, Investment and Export Promotions Appropriate to Characteristics of Regions along the Expressway

How regional development appropriate to characteristics of roadside areas should be is proposed below. Note, however, that information specific to any roadside areas is limited and the proposals described below are based on the limited information made available to the study team up to now. Laos is not well experienced in planning and implementing overall development plans for a specific area by mutually interlocking regional development and industrial, investment, and export promotions. In order to utilize fully the effects of expressway development involving huge amount of investment, it is advisable that relevant central ministries and provincial governments collaborate to plan and implement measures for regional and industrial development, and investment and export promotions suitable to the characteristics of the roadside areas according to the procedure in Section 12.2.1 to 12.2.5.

Pac Xan and Laksao may be considered as two key promising points for roadside development outside the Vientiane Metropolitan Area. Pac Xan is expected to become a relay base for trade among Thailand, Laos, and Vietnam and between northern and southern parts of Laos after the completion of the 5th Thai-Laos friendship bridge. Similarly, Laksao will act as an entrance on the Laos side in the Laos-Vietnam trade when the expressway is completed. For Vientiane City, development is considered to continue on the basis of existing development momentum and plans. Accordingly, the development strategy for Pac Xan is as listed below:

(1) Development potential of Pac Xan roadside areas

Regional characteristics of Pac Xan and surrounding areas are considered as follows:

1) It has the potential to become the strategic point of traffic, that is, a logistics center connecting Thailand, Laos, and Vietnam, and northern and southern areas of Laos, when the expressway construction is completed.
2) It has a flat terrain, with the land appropriate for development of industrial parks including the logistic parks, physical logistics facilities, and SEZ.
3) The population is concentrated along National Road No. 13, which enables to secure certain labor force though not comparable with that of Vientiane or Savannakhet.
4) It has plain areas spreading along the Mekong River and tributaries, and agricultural activities, mainly growing rice and cultivation of beans, are common.
5) The north side of the road, including Vientiane Province, has wide spread of hilly areas and grassland, enabling promotion of stock raising and fruit growing.
6) There is substantial increase in hydraulic power generation due to huge amount of investment in hydraulic power generation during 2005 to 2015. There is no problem in terms of power supply in the area.
7) There are abundant water resources and water supply facilities are developed with assistance from ADB.
8) The surrounding provinces are abundant with mineral resources, such as potassium (Vientiane City, Vientiane Province), lead and zinc (Vientiane Province), and tin (Khammouan Province). National Road No. 13 and other trunk roads connect to these mines.

(2) Regional development and industrial promotion for Pac Xan

For regional development and industrial promotion exploiting the above regional characteristics, the following options may be considered. Major targets toward which regional development would be directed are as follows: (i) development of logistics and customs clearance facilities and promotion of relevant service industry in line with construction of the 5th Thai-Lao friendship bridge and expressway, (ii) promotion of food processing industry using agricultural and forestry products in the surrounding hinterland while making the of merits of being close to Vientiane and being on the export route to Thailand and Vietnam, and (iii) promotion of metal processing industry, such as manufacturing of

metal-plated products, utilizing locally available abundant resources (electric power, water resources, mineral resources, etc.).

i) Development of the logistics and customs clearance facilities and promotion of relevant service industry

a) Development of ICD (Inland Clearance Depot), logistics facilities, etc. in the neighborhood of extended check points, which unlike the dry port handles not only general cargoes but also special cargoes and hazardous materials, such chemicals, oil;

b) Development of warehouses and storage facilities including the facilities and equipment for establishment of the cold chain in collaboration with promotion of food processing described later, in the vicinity of check points, logistics facilities and ICD;

c) Study on utilization of PPP participated by foreign partners for the development and operation of ICD and logistics facilities;

d) Attraction of logistics companies from Japan, Thailand, Vietnam and Singapore;

e) Fostering and attraction of relevant businesses, such as packaging service companies, in the neighborhood of check points, logistics facilities, and ICD;

f) Development of feeder roads to collect agricultural products or to transport inputs for agriculture, forestry, and fisheries, such as materials and equipment, seeds, fertilizers, feedstuff;

ii) Promotion of collection, processing, and export of agricultural products (livestock and aquaculture products) in the surrounding area;

a) Development of SEZ near the logistics base;

b) Processing of rice, beans, cane, and tea produced in the surrounding area into foodstuff like snack, for shipment to Vientiane, then further to Thailand and Vietnam or to the world via these countries, and linking with food processing companies in these countries or their attraction to these areas;

c) Promotion of cattle feeding in the surrounding grassland, intensive cattle feeding (breeding of beef cattle and cow for milking, pig farming), feeding of domestic poultry in roadside areas as well as aquaculture of fisheries products, and production of meats and processed products. Development of cold chain facilities and equipment is expected to ensure promotion as above described;

d) Promotion of vegetables, fruits, and flowers and ornamental plants through greenhouse cultivation and promotion of their shipment to Vientiane and further to Thailand and Vietnam as well as their processing;

e) Collection of para rubber sap produced in the surrounding area and in the northern area and attraction and promotion of rubber products manufacturers;

f) Promotion of processing of agricultural products for domestic market first as the products need to be inspected and managed to ensure compliance with international standard and quality requirements; followed by entry into foreign markets when the processing industry proves qualified. Foreign food processing companies (including those of Europe and North America) superior in quality control will be invited positively for utilization of brand strength and for introduction of technologies.

g) Strengthening of the inspection and certification agencies and supporting the farming (improvement of breed, raising of seeding) systems in the roadside areas, advancement and support for agriculture-supporting industries (private corporations in charge of sales and repair of agricultural equipment, sales of required materials for farming, such as seeds, fertilizers, agricultural chemicals, etc.), and strengthening veterinary services for their wider use;

h) Promotion of processing of wide variety of agricultural, forestry, and fisheries products while utilizing the regional characteristics and diversification of the processing industry to diversify

risks; and development of unique products for niche markets of diet foods, etc. to ensure competitiveness with the surrounding countries;

i) Taking well-considered environmental measures (such as wastewater treatment) to prevent adverse effects of food processing and stock breeding on residents, natural reserves, and tourists;

iii) Attraction and promotion of metal processing industries, such as manufacturing of metal plated products

a) Promotion of investment by foreign and domestic companies on metal plated products and machine parts utilizing abundant electric power and metals (tin, zinc, copper, etc.) refined in the surrounding mines, and promotion of manufacturing industries;

b) Implementation of well-considered environmental measures, such as wastewater treatment, etc., even in case of attraction and promotion of above manufacturing industries to prevent adverse effects on residents, natural reserves, and tourists.

(3) Development potential of Laksao roadside areas

The Laksao area is be characterized as follows:

1) It has the potential of being a logistics base as an entrance to connect the two countries in the course of the trade with Vietnam.

2) The Laos side of the expressway section up to Laksao is of a relatively flat terrain except for certain portions, containing many appropriate locations for development of logistics and industrial estate, such as logistic parks and SEZ.

3) The population is concentrated along the National Road No. 8, which enables to secure certain labor force though not comparable with that of Vientiane or Savannakhet.

4) The north side of the expressway has wide spread of hilly areas and grassland, offering the possibility of cattle breeding, fruit growing, tea, para rubber, mushroom, bamboo and the possibility of developing the processing industries for these products.

5) During the period between 2005 and 2015, huge amount of investment was made in the hydraulic power generation mainly in the Central Laos. The hydraulic power generation has increased substantially and there is no problem in power supply to the area.

6) The provinces along the road have rich mineral resources: potassium (Kahmmouan Province), tin (Kahmmouan and Bolikhamsai Provinces), gold and copper (Xieng Khouang Province). There are trunk roads, such as National Roads No. 1D and No. 8, connecting these mines.

7) There are environmental protection areas and scenic sites dotted around in the neighborhood, and resort development is under way along National Roads No. 8 and No. 1E. Development of hot spring resort is also planned in Laksao.

(4) Regional development and industrial promotion in Laksao

For candidate regional development and industrial promotion utilizing regional characteristics, major targets toward which regional development would be directed are as follows: (i) development of logistics and customs clearance facilities and promotion of relevant service industry after construction of expressway, (ii) promotion of food processing industry using agricultural and forestry products of surrounding hinterland while exploiting the locational merits, that is, a location on the export route to Vietnam, (iii) promotion of tourism and resort developments and attraction of the rehabilitation-related industries while utilizing tourism and hot spring resources, (iv) promotion of metal processing industry for cement production and manufacturing of metal plated products by using locally abundant resources (electric power, water resources, mineral resources).

i) Development of logistics and customs clearance facilities and promotion of relevant service industries

a) Development of ICD and check points in the section between 18 and 25 km along National Road No. 8 from Laos toward Vietnam; and designing the expressway in such a manner that the forwarders can run on both the expressway and National Road No. 8 when they are parallel;

b) Development of logistics facilities around the interchange near Laksao, and development of warehouses and storage facilities, including facilities and equipment for establishment of the cold chain, in line with promotion of food processing described later;

c) Consideration of utilizing PPP for the development and operation of ICD and logistics facilities;

d) Attraction of logistics companies from Japan, Thailand, Vietnam, and provision of branch offices;

e) Fostering and attraction of relevant businesses, such as packaging companies, near the check point, logistics facilities, and ICD;

f) Development of feeder roads to collect agricultural products or to transport inputs for agriculture, forestry, and fisheries, such as materials and equipment, seeds, fertilizers, feedstuff;

ii) Promotion of collection and processing of agricultural products (cattle feeding, aquaculture products, etc.) in the surrounding area

a) Development of SEZ near the interchange;

b) Processing of cassava, tea, mushroom, bamboo, fruits produced in the neighborhood for shipment to the Laos domestic market and for export to Vietnam and Thailand;

c) Promotion of cattle feeding in the surrounding grassland (breeding of beef cattle and cow for milking, pig farming), feeding of domestic poultry as well as aquaculture of fisheries products, and production of meats and processed products. Development of cold chain facilities and equipment is expected to ensure promotion as above described.

d) Promotion of manufacturing of wooden furniture, rattan products, bamboo wares, and silk fabric, including handicraft, and supporting the development of their sales channels;

e) Collection of para rubber sap produced in the surrounding area and in the northern area and attraction and promotion of rubber products manufacturers;

f) Strengthening of the inspection and certification agencies and support the farming (improvement of breed, raising of seeding) systems in the roadside areas, advancement and support for agriculture supporting industries (private companies in charge of sales and repair of agricultural equipment, sales of required materials for farming, such as seeds, fertilizers, agricultural chemicals, etc.), and strengthening veterinary services for their wider use;

g) Promotion of processing of wide variety of agricultural, forestry, and fisheries products while utilizing the regional characteristics and diversification of the processing industry to diversify risks, and development of unique products for niche markets of diet foods, etc. to ensure competitiveness with the surrounding countries;

h) Taking well-considered environmental measures, such as environmental deodorization, wastewater treatment, etc., to prevent adverse effects of food processing and cattle feeding on residents, natural reserves, and tourists as well as damage to the image;

iii) Promotion of tourism and resort developments, and attraction of the rehabilitation-related industries while utilizing tourism and hot spring resources

a) Promotion of resort development by attracting tourism-related companies inside and outside Laos;

b) Support of fostering human resources related to spa and rehabilitation, and attraction and promotion of these industries;

iv) Attraction and metal plating industries

a) Promotion of cement production using abundant lime stones available in the surrounding area;

b) Promotion of investment by foreign and domestic companies on metal plated products and machine parts utilizing abundant electric power and metals (tin, zinc, copper, etc.) refined in the surrounding mines, and promotion of manufacturing industries;

c) Well-considered environmental measures, such as dust proofing, and wastewater and waste treatment, taken even in the case of enterprise attraction and production promotion, so as to prevent adverse effect on residents, natural reserve, tourists as well as damage to the image.

12.3 Measures for Institutional Improvement to Reduce Time and Costs of Freight Transport

Current status, issues and tasks to be tackled are described in Section 2.3.1 (2) and (3). Based on the recognition, the following "soft" measures for reduction of time and cost for freight transport are proposed to ensure generation of benefits of expressway construction and to exploit the geographical merits of being in the middle among GMS countries by reducing the Laos's freight transport costs, which are relatively expensive compared with that of neighboring countries, and by supporting Laos's industrial promotion:

1) Promotion and improvement of electronic processing of customs clearance and quarantine procedures

2) Realization of a single-window system for customs clearance and quarantine procedures and extension of the single stop inspection

3) Improvement of the agreement related to cross-border traffic

4) Reinforcement of cross-border facilities and increase in the customs officers

5) Training of the customs officers

6) Fostering of domestic logistics operators, attraction of foreign logistics operators, and establishment of the foreign and domestic logistics operators network.

12.3.1 Promotion and Improvement of Electronic Processing of Customs Clearance, Immigration and Quarantine Procedures

It is proposed to promote and improve electronic processing of customs clearance, immigration, and quarantine procedures as follows:

1) **Completion of introduction of ASYCUDA:** Electronic processing of customs clearance of Laos was started with introduction of the Automated System for Customs Data (ASYCUDA) developed by UNCTAD in 2011. ASYCUDA is currently available in 11 international cross-border facilities. It is proposed to extend the system to cross-border facilities throughout Laos in the future as planned by the Department of Customs, Ministry of Finance.

2) **Electronic processing of required documents and attached reference materials:** Electronic processing of required documents and attached reference materials is promoted in the early stage for operation of ASYCUDA with improved efficiency.

3) **Improvement of emergency power supply and communication environment:** There are reports of time loss caused by repeated operations due to power failure, shutdown of communication circuit, and low baud-rate. Measures such as installation of the emergency power supply (UPS, generator), change of internet service provider, or contracting with multiple providers are to be implemented.

4) **Extension of the Smart Card System :** At 11 principal customs clearance points, the Smart Card System has been introduced. This system allows withdrawal of the tariff from the registered bank account when a smart card (IC card) is held over the system. This system makes payment of tariff and taxes easier. In the future, the system will be made available at other customs clearance points.

12.3.2 Realization of a Single Window for Customs Clearance, Immigration, and Quarantine Procedures, and Extension of Single Stop Inspection

(1) Realization of the national single window

Though ASYCUDA is introduced already at principal customs offices, submission of original documents is demanded for documents other than the customs declaration form. When the required documents do not reach the border, customs clearance cannot be made, adversely affecting the export of foods. It is proposed to make efforts for linking of ASYCUDA with the original document issuing system of the Ministry of Industry and Commerce. It is further recommended to link with the Ministry of Agriculture and Forestry to realize the national single window through electronic processing of animal and plant health inspection service, and for promotion of interlocking between the ASYCUDA system and the quarantine system.

(2) Participation in the ASEAN Single Window (ASW)

Laos is proceeding with introduction and dissemination of ASYCUDA and Smart Card System and establishment of the National Single Window. In this context, Laos is ready to participate in the ASEAN Single Window (ASW) system that is intended to accelerate the trade procedure by integrating and networking such procedures within the ASEAN countries. Five countries (Indonesia, Malaysia, Thailand, Singapore, and Vietnam) have already participated in the ASW, and Laos's aims at joining the ASW in the 2018 according to the trade facilitation roadmap 2017–2020. Since ASW is based on a national single window of each country, it is proposed that the Ministry of Finance should be in charge of the national single window of Laos and collaborate with the Technology Committee, ASEAN Secretariat Office, to prepare for connection of the Laos system to the ASW system[4].

(3) Extension of the single stop inspection

Concerning the single stop, the actual cargo inspection (single stop inspection) was introduced only at Lao Bao (on by the export side of Vietnam) and at Dansavan (on the import side o Laos) in February 2015. According to the results of the study on the time required for customs clearance at the border between 2012 and 2016, however, the average time of import cargoes from arrival at and departure from the cross-border facilities at Dansavan was 1 hour 43 minutes in 2012. This was more than twice the average time needed in 2016, 3 hours and 33 minutes. Such increase may be considered large when considering that the average customs-clearance time (a total of import and export) decreased from 11 hours 24 minutes to 6 hours 30 minutes (40% or more down) for all cases at all points. The study attributed such increase in the customs-clearance time to a certain abnormal cases requiring 13 hours 16 minutes for customs clearance (the longest time in 2012 was 5 hours 20 minutes). However, such explanation is considered not enough for the above abnormal increase in time because the number of imports at Dansavan was 32 cases during the study period, in which the above abnormally long time caused an increase in the average clearance time per case of only 25 minutes (13 hours 16 minutes divided by 32 cases). The causes for such longer time are not yet clear.

Originally, the single stop inspection is done to reduce the customs clearance time. The Customs Bureau of the Ministry of Finance of both countries must firstly ascertain the causes of the increase in the clearance time at Dansavan/Lao Bao border and take necessary measures to ensure the realization of the effects of single stop inspection. Then, it is recommended for both agencies to introduce the single stop inspection at the new cross border points and strengthen it after completion of expressway.

Introduction of the single stop inspection is also planned at the Laos (Savannakhet) – Thailand (Mukdahan) border. Though a building for single stop inspection was completed, the single stop inspection system is not yet introduced because Thai civil servants are not allowed to execute any public service outside the country by law[5]. It is recommended that both governments hold negotiations

[4] As of August 2018, JICA Study Team has not obtained any information that Lao National Single Window system is connected with ASEAN Single Window system.

[5] Though the law allowing the national civil servants of Thailand to execute the duties outside the country has passed the Assembly, it is not confirmed whether single stop inspection becomes possible on the Thailand border.

to address this problem and to introduce the single stop inspection at Pac Xan (Laos) and Bung Kang (Thailand) that are connected via the 5th Thai-Lao Friendship Bridge.

12.3.3 Agreement Concerning Cross-Border Traffic and Improvement of the Customs Clearance System

(1) Access of Laos vehicles to the bonded area in Thailand

The agreement on cross-border traffic between Laos and Thailand permits mutual entry of vehicles, that is Lao vehicles and drivers can cross into Thailand. By the effective use of this agreement, Lao vehicles and drivers can directly access the port of Thailand without reloading cargoes at the border, which in turn can reduce the time necessary for transport and thus the personnel expenses. But, actually, the Laos-registered vehicles are not allowed to enter the bonded areas around the port and airports in Thailand. On the other hand, the Thai operators can run and deliver goods freely within Laos, which shows inequality. Since permission for Lao vehicles to enter the bonded areas of Thailand contributes to reduction of logistics costs, negotiation between both governments is desirable. In addition, thorough training should be provided for Laotian drivers as described in 4) of Section 12.3.6 to ensure the prevention of troubles frequently caused by them in Thailand.

(2) Introduction of advance ruling

Singapore, Malaysia, Thailand, and many other ASEAN countries have advance ruling that enables advices on the HS code, tariff rate (amount) prior to importing goods. Vietnam has also started full-scale preparation toward introduction. Laos has not yet institutionalized the system, but the workshop toward introduction of the system was held by World Customs Organization (WCO) in November 2017. The advance ruling, if introduced, would help the importers/exporters get official information from the customs authority on the customs clearance and taxation necessary for imports/exports in advance. This is considered to avoid trouble between importers/exporters and the customs offices, contributing smooth customs clearance and thus reduction of the clearance time. It is recommended, therefore, that Laos undertakes full-scale preparation for introduction.

(3) Introduction of Authorized Economic Operator (AEO) Program

AEO Program is a program in which the customs authority undertakes authorization and registration of the operators with the established cargo security control and compliance system, and the authorized operators can enjoy merits of simplification and speedup of the customs clearance procedure. As a rule, operators authorized as AEOs can execute a series of customs clearance and export without examination of the declaration documents and actual cargoes. Japan has made mutual recognition of AEO program with Singapore and Malaysia. Mutual recognition of AEOs with these countries will help enhancing the security level in logistics with these countries, thereby ensuring smooth, integrated, and rapid logistics.

Under support from the World Bank, Laos started preparation for introduction of the AEO Programs and authorized four companies as pilot entities. Besides, some point out concern that, considering the administrative climate of Laos, forwarders and custom agents closer to the government may be authorized as AEOs. AEO Programs have been introduced in many countries and have proved successful in many cases. Note that AEO Programs that provide many privileges to authorized operators may have harmful effects if not operated fairly. Introduction of a transparent program and adequate operation are essential.

12.3.4 Reinforcement of Border Facilities and Increase in the Customs Officers

According to the demand forecast of this study team, the total number of freight vehicles (in PCU) at the existing cross-border facilities between Namphao (Laos) and Cau Treo (Vietnam) and at the cross-border facilities to be newly constructed and expanded along with construction of an expressway was estimated to be 60 times (Alternative plan 3B) to 75 times (Alternative plan 2) of that of 2018. Assuming that the number of freight vehicles per import/export does not change, the number of import/export cases is also estimated to increase by 60 to 75 folds. The number of freight vehicles (in CPU) at cross-border facilities to be newly constructed and expanded along with completion of the

expressway was forecast to be 48 times (Alternative plan 3B) to 67 times (Alternative plan 2) that of 2018 at the existing cross-border facilities. Regarding the size of vehicles and in the cargo volume per import/export is considered, it is not evident whether the number of import/export cases increases in a manner similar to that of the number of freight vehicles (in PCU). Obviously, the number of import/export cases to be handled at the facilities to be newly constructed or expanded along with construction of expressway is expected to be incomparably larger than that of the current existing facilities of Laos.

According to the results of the Time Release Study described above, the average time for the import cargoes to Laos from arrival at Namphao cross-border facilities to departure was 3 hours 9 minutes in 2012, which, however, increased by four hours or more to 7 hour and 48 minutes, about 2.5 times, in 2016. The reason for such increase is said to be the substantial increase in the number of import cases from 26 to 73 (2.6 times) during the survey period (eight days from August 30 to September 6 for 2012 and seven days from March 22 to 28 for 2016). Contrary to the expectation that the transit time would be reduced by three to four hours after completion of the Hanoi-Vientiane expressway, the customs clearance time would become longer and the benefit of reduction of transit time due to expressway may be totally lost if the authorities concerned do not take any fundamental measures to cope with such increase in import/export cases. In other words, if the customs clearance time when the expressway is used becomes longer by four hours or more than that of the case with National Road No. 8, the forwarders will use not the expressway, but National Road No. 8.

Ministry of Finance of Lao PDR has acquired a land for expansion of Laksao Checkpoint to respond to short-term increase in import and export. It is essential that the authorities concerned to respond promptly to drastic increase in the number of import/export cases caused by the expressway construction. This could be done by establishing large-scale cross-border facilities and by preparing inspection equipment to a large number of customs officers.. It is indispensable that the Department of Customs of the Ministry of Finance collaborate with the Ministry of Planning and Investment, Ministry of Industry and Commerce, and Ministry of Public Works and Transport to monitor and forecast the company locations and import/export amount along the road and the traffic volume on the expressway/National Road No. 8 and to add the facilities/equipment and increase the staff adequately and rapidly for the cross-border facilities.

12.3.5 Training of Customs Officers

The following complaints have been presented from logistics operators to the customs officers:

a) The required procedure and documents differ among officers. The officers do not provide clear and sufficient answers to questions concerning the procedures and documents.

b) The procedure is often stacked up because there is no replacement when the person in charge is absent. In some cases, no officer could be found even during office hours.

c) Payment other than the regular fare is demanded in the form of charges for import declaration. The sum demanded by the officer increases when the request is made to accelerate the procedure.

d) Many customs officers of Laos has insufficient knowledge on customs and import/export permission.

In response to these comments, the Department of Customs of the Ministry of Finance is planning to provide training to (a) new employees, (b) officers with a few experience years and (c) senior officers. The area for planned training are; (i) customs clearance procedure (including training concerning e-customs), (ii) tax classification (HS code), (iii) tax evaluation, (iv) certificate of origin, (v) information technology (IT), and (vi) eradication of improprieties and corruption. The department is also developing a comprehensive training plan in which more than 50 courses of customs-officers trainings are systematized, and is also requesting the assistance of the WCO. Implementation of the training plan in consistent manner is important to address the severe criticism against customs officers.

12.3.6 Fostering of Logistics Operators of Laos, Attraction of Foreign Logistics Operators, and Establishment of a Network of Logistics Operators of Laos and Foreign Countries

Laos, a land locked country without any sea port, has a national strategy to turn into a land linked country by considering its location (being in the middle of GMS countries) as a geographical merit. However, logistics operators of Laos have to overcome various issues including the following[6]:

a) Many operators are micro or small companies such as family businesses, and most of have problems in terms of management skills (financial management including accounting and cost control), management capacity on assignment of vehicles and drivers, and marketing capacity.

b) The drivers' driving skills are low, and the number of drivers that can drive large trailers is limited. Many drivers cannot drive vehicles in a foreign country (in particular, Thailand with right-hand steering vehicles). In addition, most of logistics operators are not capable of providing training to the drivers.

c) In many cases, skilled mechanics and engineers are to be invited from Thailand and Vietnam because of lack of skilled auto mechanics, repair mechanics, and auto electric mechanics in Laos.

d) Many companies are using used vehicles imported from Japan. Old aging vehicles are used frequently. Therefore, there are many vehicle failures, which make offering of reliable services difficult.

e) Most of international logistics services excluding the ones related to mining are provided by Thai or Vietnamese operators (Though businesses of transport and logistics account for 8% of GDP in many countries, their contribution to GDP in Laos is as low as 4%.[7])

f) Laos is not positioned in the international value chain and is facing continuous increase of imports of consumable goods. This is particularly increasing the freight transport cost because of one-way shipment from Thailand and Vietnam to Laos.

g) Awareness and skill level concerning safety control are low, resulting in frequent accidents during operation and reloading.

h) When compared with logistics operators of Thailand, and other countries, those of Laos face a substantial delay in the use of ICT.

The following measures are proposed to solve above logistics problems:

1) **Establish licensing systems:** The Department of Transport, MPWT, should establish and operate licensing systems for driving of large trailers and for transporting of hazardous materials.

2) **Foster the services of auto mechanics, repair mechanics, and auto electric mechanics:** The Department of Transport, MPWT, should develop, expand, and reinforce training courses to foster skilled mechanics in cooperation with the development partners, industrial high schools, etc.

3) **Provide opportunity of training concerning company management to micro and medium/small logistics operators**: The Department of Transport, MPWT, should provide training opportunities on the fundamentals of company management to micro and medium/small logistics operators in cooperation with the Laos Government, division in charge of supporting medium/small businesses of ASEAN Connectivity Coordination Committee (ACCC), and development partners.

---

[6] The issues are compiled based on the results of interviews with official of Department of Transport of MPWT, staff of resident representatives of Japanese logistic companies, and the president/advisors of the Laos International Freight Forwarders Association (LIFFA) as well as on literature reviews on transport and logistics in Lao PDR; Impact of the ASEAN Economic Community (GIZ, Dec. 2014), "Report of Survey on Production, Distribution and Investment Environment of ASEAN countries" (March 2017), etc.

[7] Transport and Logistics in Lao PDR: Impact of the ASEAN Economic Community (GIZ, Dec. 2014)

4) **Implement driving skill/safety courses for drivers:** Department of Transport, MPWT, should organize periodically driving skill and safety trainings for drivers engaged in logistics. In cooperation with the Laos International Freight Forwarders Association (LIFFA), the attendance of all drivers engaged in logistics to the above trainings once every few years should be made mandatory.

5) **Implement preventive vehicle maintenance course:** The Department of Transport, MPWT, should organize a training on the preventive vehicle maintenance for drivers and mechanics engaged in logistics.

6) **Provide opportunities for business matching with foreign logistics operators:** The Department of Transport, MPWT, should allow the logistics operators of Laos to accompany when the meeting is to be held with divisions in charge of transport of Thailand, Vietnam, etc. This is to provide the opportunity of business matching (business collaboration and accommodation for solution of one-way shipment issue) with operators of these countries, which will be continued in the future. Due care and measures must be taken so that benefits obtained from such opportunities are not enjoyed by only limited number of leading logistics operators.

7) **Attract foreign logistics operators and improve management and technology levels of Laos's logistics operators:** In cooperation with the Department of Investment Promotion of the Ministry of Planning and Investment, the Department of Transport, MPWT, should attract foreign logistics operators to improve Laos's logistics operators. Attracted foreign operators should be encouraged to employ Laotians to improve the logistics industry of Laos in the long term.

8) **Establish a network between foreign and domestic logistics operators:** The Department of Transport, MPWT, should promote networking between foreign and domestic logistics operators in corporation with the division in charge of the seamless logistics of ASEAN and divisions in charge of transport of Thailand and Vietnam.

9) **Promote utilization of ICT and IoT in the logistics industry of Laos:** The Department of Transport, MPWT, should promote utilization of ICT and IoT in the logistics industry of Laos in cooperation of divisions in charge of seamless logistics and those in charge of promotion of utilization of ICT of ASEAN, and the Ministry of Science and Engineering and Ministry of Postal and Communication of Laos. These activities should be interlocked with those of (6) to (8) above.

Chapter 13
Conclusion and Future Challenges

Chapter 13 Conclusion and Future Challenges

13.1 Conclusion

1) As for the Hanoi-Vientiane expressway, considering the evaluation results of alternative routes including Pre-F/S route, Alternative 2 (route parallel to NR8) is proposed as the most desirable route. When looking at Vietnam side, although the Pre-F/S route has a lower cost and a higher expected demand, it requires a large number of people and structures to be resettled. In Laos's side, on the other hand, the NR 8 route has a lower project cost and a considerable amount of expected demand, and there is little negative impact on environment. Alternative 2 is regarded as the most appropriate from the perspective of Hanoi -Vientiane expressway as a whole

2) The section with highest priority is the one between Vientiane - Vieng Kham, which is desirable to be developed by the year 2025 given the demand forecast. Next comes Vieng Kham - Laksao section (Laos), HCM road- NSE section (Vietnam), and then Laksao - HCM road at last. In case a bottleneck is caused in the border control facility due to the traffic increase, the early development of these area together with the improvement of custom facilities should be studied.

3) As for the number of traffic lane, according to the result of demand forecast, 4-lane development for all sections can deal with the demand in the initial phase. However, the section between Vientiane - Pac Xan should be improved to 6-lane by 2035 from the viewpoint of demand forecast.

4) The project cost and EIRR of the NR 8 route are approximately 3,798 million USD and 12.4 %, respectively. This result indicates the necessity of the project to be implemented by public investment. However, since both Laos and Vietnam are in difficult financial situation, public expenditure is restricted for such a large-scale public project. Meanwhile in Vietnam, foreign loan is strictly managed to make sure it accounts for less than 65 % of the country's GDP. In Laos, the result of IMF's evaluation of debt sustainability in February, 2018 shows that the Laos's debt is expected to continue as "High Risk" until the middle of 2030s. Laos is also currently in the situation where it is unable to make foreign loans easily.

5) On the other hand, in case private fund (or PPP) is used for the project, the project will not stand on a commercial basis because the profitability of all NR 8 route is critically low. Even in the section with the highest traffic demand, i.e. Vientiane -Pac Xan section, the FIRR is estimated to be 0.79% and the expressway project alone is not enough to attract private investment. Moreover, PPP-enabling environment of Lao PDR has not been developed yet and capacities of government officials as well as private companies regarding toll road operation are still immature. These evaluation results indicate that it is realistic to implement the project on a non-commercial basis, using state budgets.

13.2 Future Challenges

1) The Pre-F/S route has been agreed upon for Hanoi-Vientiane expressway by both the Laotian and the Vietnamese governments in November 2016. According to the MOT's revision of expressway masterplan of Vietnam, the route is listed as a road section expecting an investment by the year 2030.

However, this study evaluated route plans throughout whole length including both Laos and Vietnam and proposes the route parallel to NR 8 as the optimum plan. Meanwhile, the ultimate decision shall be made by discussion between the two governments, and in doing so, it is desirable to consider the project cost and the economic ripple effect on the region, etc., along with strengthening of logistics functions required for the Hanoi-Vientiane expressway.

2) As this is a Pre-F/S level survey, it is necessary to examine the feasibility of the project in detail by conducting a more precise survey as a next step. Specifically, the following areas need to be studied closely.
   - Traffic demand forecast
   - Geodesic alignment plan and re-examination of project cost
   - Formulation of regional development plan integrating expressway development
   - Project scheme and method of financial procurement

3) The possible impacts on regional development from expressway development and from railway plans are already examined in this study report. In the next step, it is necessary to look into factors such as induced traffic of wider areas, modal shift from shipping traffic or conversion rate from ordinary road to expressway.

4) In this study, design of road alignment and estimation of project cost are conducted roughly for the purpose of route evaluation. To estimate project cost more accurately, it is necessary to elaborate the size and quantity of structures and in doing to, there is a need to examine geodesic alignment and estimate project cost based on geographic survey. In addition, there are some transport plans such as expressway plans, railway plans and bridge plans related to this project. The coordination with these projects will be necessary in terms of competition, connection and project schedule. In particular, the route alignment of the Vientiane-Pakse expressway and this project are overlapping in the section between Pac Xan and Vieng Kham. According to the Laos government, the F/S of that section will be implemented by the awarded Chinese company, but in order to ensure connectivity and continuity with this expressway, it is important to unify the design standards and the fee system. Thus, it is desirable that a clear policy on how to connect them and on cost sharing would be presented.

5) Expressway development is expected to promote regional development. To make this Hanoi-Vientiane expressway a strong driver for regional development, it is essential to consider formulation of regional development plan integrating the expressway development together with the strategies to promote it.

6) As the result of this financial analysis, it is difficult to implement the project in the entire section and Vientiane-Pac Xan section on a commercial basis. However, there is a possibility of application of PPP to some parts of the section (e.g. Vientiane-Pac Xan section) in the future once the road is developed on a non-commercial basis. Nevertheless, PPP legal system has not yet been developed in Lao PDR, nor has the capacity of both government officers and private companies. Therefore, it is necessary to develop PPP legal system in Lao PDR, and improve the knowledge and skills of government officers and private companies regarding toll road business and PPP projects through

capacity building.

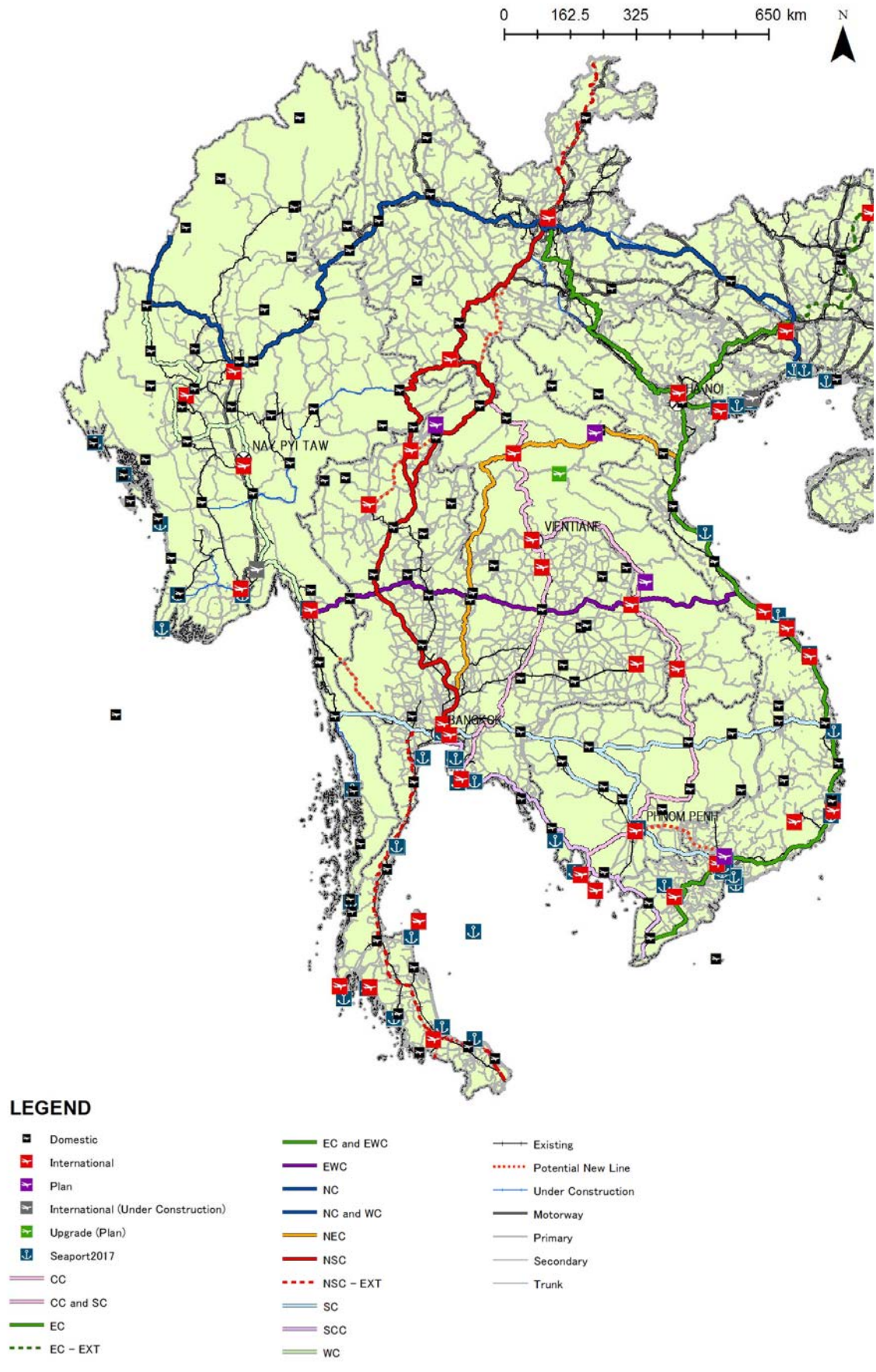
7) Regarding Thanh Thuy, the Vietnamese side already has development plans for border facilities and access roads, and the development has started to advance gradually. Regarding to Laos side (Vienthong to Thanh Thuy), although development of an ordinary road started in 2009, the construction has been stopped due to budget shortage. Since this section passes through areas with low road maintenance levels in Laos, it is desirable that an ordinary road, not expressway, to be developed to secure access to roadside areas. When this is done, the planned border facilities in Thanh Thuy and access roads will be effectively used. The possibility of connecting Thanh Thuy and Laksao by expressway has also been discussed, but it has to pass through more than 50 km of mountainous areas in Laos. Thus, the increase in the project cost would be significant, and the validity of the development would be low.

Appendix

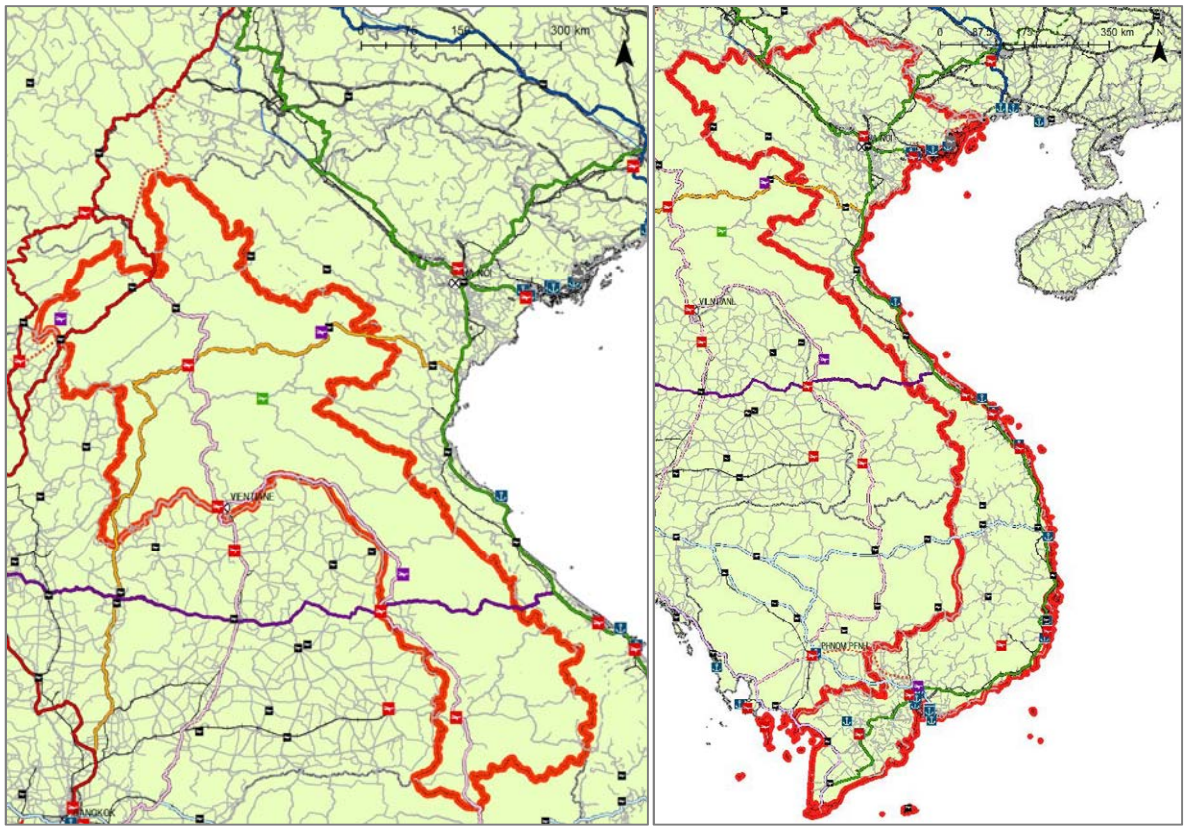
Appendix

1. : The overview map of infrastructure development of Mekong region
2. : The overview map of infrastructure development of Laos and Vietnam
3. : Demand forecast data
4. : Outline of road condition survey results
5. : Drawings of road alignment
6. : Drawings of road design

1. ：The overview map of infrastructure development of Mekong region


0
162.5
325
650 km
N
NAY PYI TAW
HANOI
VIENTIANE
BANGKOK
PHNOM PENH
LEGEND
Domestic
International
Plan
International (Under Construction)
Upgrade (Plan)
Seaport2017
CC
CC and SC
EC
EC - EXT
EC and EWC
EWC
NC
NC and WC
NEC
NSC
NSC - EXT
SC
SCC
WC
Existing
Potential New Line
Under Construction
Motorway
Primary
Secondary
Trunk

2. ：The overview map of infrastructure development of Laos and Vietnam



LEGEND

- Domestic
- International
- Plan
- International (Under Construction)
- Upgrade (Plan)
- Seaport2017
- CC
- CC and SC
- EC
- EC – EXT
- EC and EWC
- EWC
- NC
- NC and WC
- NEC
- NSC
- NSC – EXT
- SC
- SCC
- WC
- Existing
- Potential New Line
- Under Construction
- Motorway
- Primary
- Secondary
- Trunk

3. : Demand forecast data

Demand forecast data

Future Population by Prefecture in Laos

	2018	2025	2035
Vientiane Capital	848,435	914,264	993,402
Phongsaly	183,967	194,371	211,196
Luangnamtha	181,594	194,371	211,196
Oudomxay	317,915	338,350	367,637
Borkeo	185,313	201,570	219,018
Luangprabang	446,380	475,129	516,256
Huaphanh	299,101	316,753	344,171
Xayaboury	394,081	417,538	453,680
Xiengkhuang	252,903	266,360	289,416
Vientiane	433,153	460,731	500,612
Borikhamxay	282,876	302,355	328,527
Khammuane	405,253	439,135	477,146
Savannakhet	1,002,229	1,087,038	1,181,131
Saravane	410,320	446,334	484,968
Sekong	116,996	122,382	132,975
Champasack	717,279	777,484	844,783
Attapeu	144,282	158,376	172,085
Xaysomboon	88,054	86,387	93,865

Source: JICA Study Team

Future population of Vietnam

	2018	2025	2035
Vientnam	94,394,000	100,129,000	105,388,000
Nghe An Province	3,178,955	3,306,000	3,449,000
Ha Tinh Province	1,278,045	1,297,000	1,336,000

Source: Vietnam National Bureau of Statistics

Vietnam and Laos future GDP

Country	Units	Scale	2000	2005	2010	2015	2020
Laos	Gross domestic product, constant prices	Billions	35,026.27	47,705.20	70,102.55	101,767.55	142,745.84
	Growth ratio (%/Year)			6.37%	8.00%	7.74%	7.00%
Vietnam	Gross domestic product, constant prices	Billions	1,115,369.05	1,588,645.95	2,157,828.50	2,875,856.19	3,892,704.68
	Growth ratio (%/Year)			7.33%	6.32%	5.91%	6.24%

Source: JICA Study Team

Survey spots of traffic survey

The results of the traffic survey

			Motor cycle	PC, Pickup ,Jeep	Van & Small Bus	Medium Bus	Large Bus	2 or 3 axle Truck	4-axle Truck	5 or 6 axle truck	More axle truck
Location 1 NH13 Vientiane	To Vientiane	Daytime 7:00-19:00	4,105	3,712	797	17	42	1,858	54	26	32
		Nighttime 19:00-7:00	640	652	109	3	12	331	28	23	17
		Sub Total	4,745	4,364	906	20	54	2,189	82	49	49
	From Vientiane	Daytime 7:00-19:00	3,839	3,450	837	20	40	1,954	61	40	90
		Nighttime 19:00-7:00	633	602	88	0	37	349	39	36	19
		Sub Total	4,472	4,052	925	20	77	2,303	100	76	109
	Grand Total		**9,217**	**8,416**	**1831**	**40**	**131**	**4,492**	**182**	**125**	**158**
Location 2 NH13 Naxay	From Pak San	Daytime 7:00-19:00	516	888	185	26	17	322	36	33	42
		Nighttime 19:00-7:00	114	301	43	9	45	147	47	26	18
		Sub Total	630	1,189	228	35	62	469	83	59	60
	To Pak San	Daytime 7:00-19:00	607	1,066	230	39	30	375	60	59	76
		Nighttime 19:00-7:00	115	380	31	7	36	128	33	18	20
		Sub Total	722	1,446	261	46	66	503	93	77	96
	Grand Total		**1,352**	**2,635**	**489**	**81**	**128**	**972**	**176**	**136**	**156**
Location 3 5101 Pak San	From Pak San	Daytime 7:00-19:00	1,292	811	103	13	10	324	31	15	0
		Nighttime 19:00-7:00	145	126	14	2	3	47	21	2	3
		Sub Total	1,437	937	117	15	13	371	52	17	3
	To Pak San	Daytime 7:00-19:00	1,282	771	92	16	3	277	14	26	0
		Nighttime 19:00-7:00	140	125	24	1	0	67	21	17	0
		Sub Total	1,422	896	116	17	3	344	35	43	0
	Grand Total		**2,859**	**1,833**	**233**	**32**	**16**	**715**	**87**	**60**	**3**
Location 4 NH13 Vieng Kham	From Pak San	Daytime 7:00-19:00	511	662	60	6	35	199	53	75	12
		Nighttime 19:00-7:00	95	193	22	1	49	45	15	85	4
		Sub Total	606	855	82	7	84	244	68	160	16
	To Pak San	Daytime 7:00-19:00	497	669	77	6	20	212	53	71	24
		Nighttime 19:00-7:00	77	153	7	0	49	62	24	91	6
		Sub Total	574	822	84	6	69	274	77	162	30
	Grand Total		**1,180**	**1,677**	**166**	**13**	**153**	**518**	**145**	**322**	**46**
Location 5 1D Phontan	From Xiengkhuang	Daytime 7:00-19:00	272	87	8	1	2	65	4	4	1
		Nighttime 19:00-7:00	12	40	0	0	0	8	0	0	0
		Sub Total	284	127	8	1	2	73	4	4	1
	To Xiengkhuang	Daytime 7:00-19:00	253	103	19	0	2	55	9	9	0
		Nighttime 19:00-7:00	14	18	2	0	0	10	2	1	1
		Sub Total	267	121	21	0	2	65	11	10	1
	Grand Total		**551**	**248**	**29**	**1**	**4**	**138**	**15**	**14**	**2**
Location 6 NH8 Lak Sao	From Lak Sao	Daytime 7:00-19:00	805	384	34	6	2	143	42	39	3
		Nighttime 19:00-7:00	79	95	7	0	6	38	16	39	2
		Sub Total	884	479	41	6	8	181	58	78	5
	To Lak Sao	Daytime 7:00-19:00	868	419	36	6	16	165	5	40	3
		Nighttime 19:00-7:00	99	79	4	0	2	22	1	12	3
		Sub Total	967	498	40	6	18	187	6	52	6
	Grand Total		**1,851**	**977**	**81**	**12**	**26**	**368**	**64**	**130**	**11**

Source: JICA Study Team

Forecast of the number of vehicle ownership by vehicle type

Unit: vehicle

	MC	PC	BUS	TRUCK
2012	1,005,047	63,653	3,430	33,346
2014	1,218,379	319,753	4,120	44,293
2016	1,413,990	88,454	4,665	52,443
2018	1,602,711	441,727	5,252	61,625
2020	1,796,932	504,685	5,839	70,708
2025	2,276,260	660,064	7,288	93,126
2030	2,722,405	804,686	8,637	113,991
2035	3,168,550	949,308	9,986	134,857
2040	3,581,356	1,083,123	11,234	154,163

	Threewheeler	Sedan	Pickup	Jeep	Van	Truck	Bus
2012	8,588	35,514	147,497	17,153	37,729	33,346	3,430
2014	8,737	51,284	185,081	22,515	52,136	44,293	4,120
2016	8,879	65,699	225,060	30,223	49,061	52,443	4,665
2018	9,013	79,723	259,887	35,735	57,368	61,625	5,252
2020	9,151	94,060	296,685	41,923	62,867	70,708	5,839
2025	9,492	129,442	387,500	57,193	76,437	93,126	7,288
2030	9,809	162,375	472,028	71,406	89,068	113,991	8,637
2035	10,127	195,307	556,556	85,619	101,699	134,857	9,986
2040	10,420	225,779	634,767	98,770	113,386	154,163	11,234

Source: JICA Study Team

Number of vehicle ownership by province (2018)

Unit : vehicle

	MC	PC	BUS	TRUCK
Vientiane Capital	618,467	247,252	2148	34,070
Phongsaly	11,730	2,062	108	250
Luangnamtha	28,740	4,932	121	693
Oudomxay	37,593	5,791	389	1,643
Bokeo	41,479	6,793	153	910
Luangprabang	98,557	16,245	392	1,344
Houaphanh	66,134	9,306	39	1,773
Xayabury	40,741	3,407	160	874
Xiengkhuang	42,875	9,664	124	1,667
Vientiane	64,154	16,048	86	3,290
Borikhamxay	3,317	7,698	233	1,145
Khammouane	42,482	18,472	155	3,917
Savannakhet	287,273	52,804	359	5,500
Saravane	26,670	6,159	63	608
Sekong	8,004	1,686	30.	333
Champasack	141,887	30,259	567	3,142
Attapeu	12,027	3,028	117	450
Xaisomboun	715	111	1	8

Number of vehicle ownership by province (2025)

Unit : vehicle

	MC	PC	BUS	TRUCK
Vientiane Capital	878,382	369,465	2,982	51,486
Phongsaly	16,660	3,082	150	378
Luangnamtha	40,818	7,370	169	1,048
Oudomxay	53,393	8,654	540	2,484
Bokeo	58,911	10,152	212	1,376
Luangprabang	139,977	24,276	545	2,031
Houaphanh	93,928	13,906	55	2,680
Xayabury	57,863	5,092	223	1,321
Xiengkhuang	60,894	14,441	173	2,520
Vientiane	91,115	23,981	120	4,972
Borikhamxay	47,119	11,504	323	1,731
Khammouane	60,336	27,603	216	5,920
Savannakhet	408,002	78,905	498	8,312
Saravane	37,879	9,204	87	920
Sekong	11,369	2,521	42	504
Champasack	201,516	45,216	787	4,748
Attapeu	17,082	4,526	162	680
Xaisomboun	1,016	167	2	12

Number of vehicle ownership by province (2035)

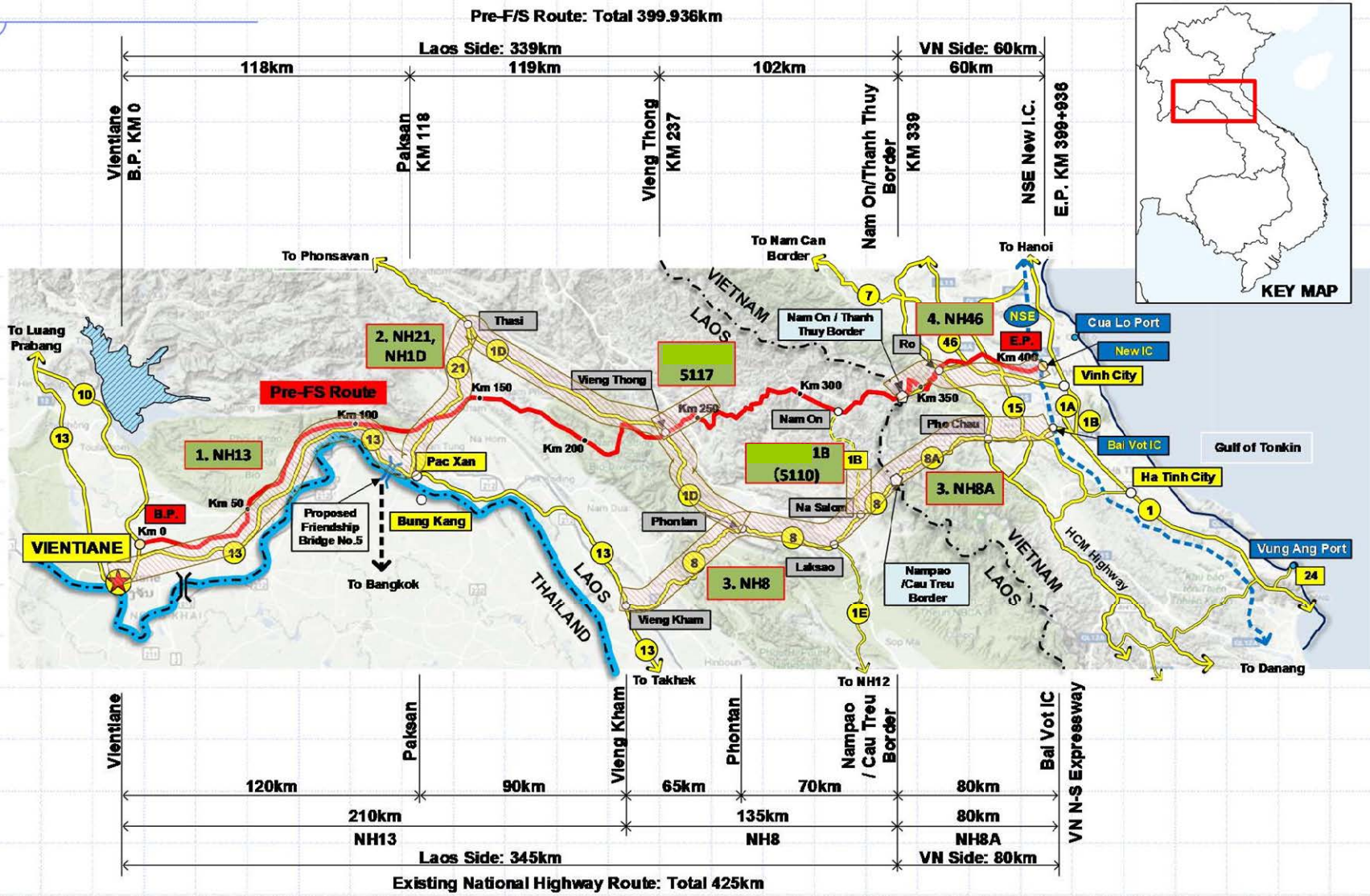
Unit: vehicle

	MC	PC	BUS	TRUCK
Vientiane Capital	1,222,706	531,366	4,086	74,558
Phongsaly	23,191	4,432	205	548
Luangnamtha	56,819	10,600	231	1,517
Oudomxay	74,323	12,446	740	3,598
Bokeo	82,004	14,601	291	1,993
Luangprabang	194,847	34,914	747	2,942
Houaphanh	130,747	20,000	75	3,880
Xayabury	80,545	7,323	306	1,913
Xiengkhuang	84,765	20,769	238	3,649
Vientiane	126,833	34,490	165	7,200
Borikhamxay	65,590	16,545	443	2,507
Khammouane	83,987	39,699	295	8,573
Savannakhet	567,939	113,482	683	12,037
Saravane	52,727	13,238	120	1,332
Sekong	15,825	3,625	58	730
Champasack	280,511	65,030	1,079	6,876
Attapeu	23,778	6,509	223	985
Xaisomboun	1,414	241	2	18

4. : Outline of road condition survey results

Outline of Road Condition Survey Result

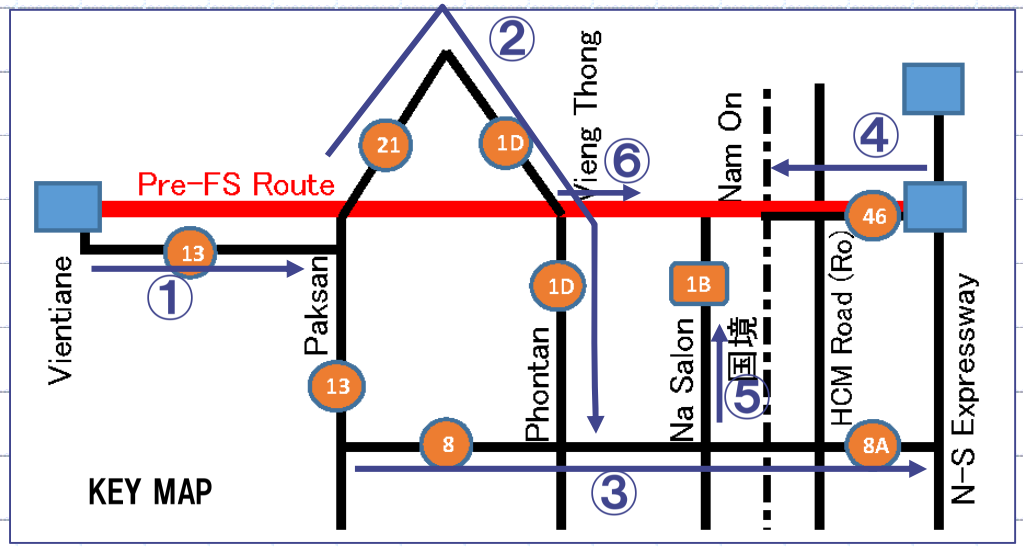
(1) Road condition survey route map



Outline of Road Condition Survey Result

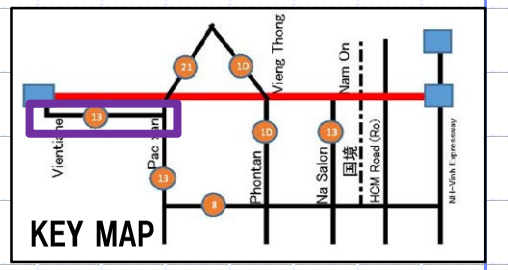
(2) Road condition, route map and section

No.	Route	Section	Travel Distance
1	Laos National Road 13	Vientiane－Pakxan	147 km
2	Laos National Road 21, 1D	Paksan－Vieng Thong－Phontan	226 km
3	Laos National Road 8, Vietnam National Road 8 A	Vieng Kham －Phontan－Border-North-South Expressway	200 km
4	Vietnam National Road 46	Border（Thanh Thuy）－Border-North-South Expressway	61 km
5	Laos Prefectural Road 1B（5110）	Na Salom－Nam On(under construction)	14 km
6	Laos prefectural Road 5117	Vieng Thong—Nam On	12 km



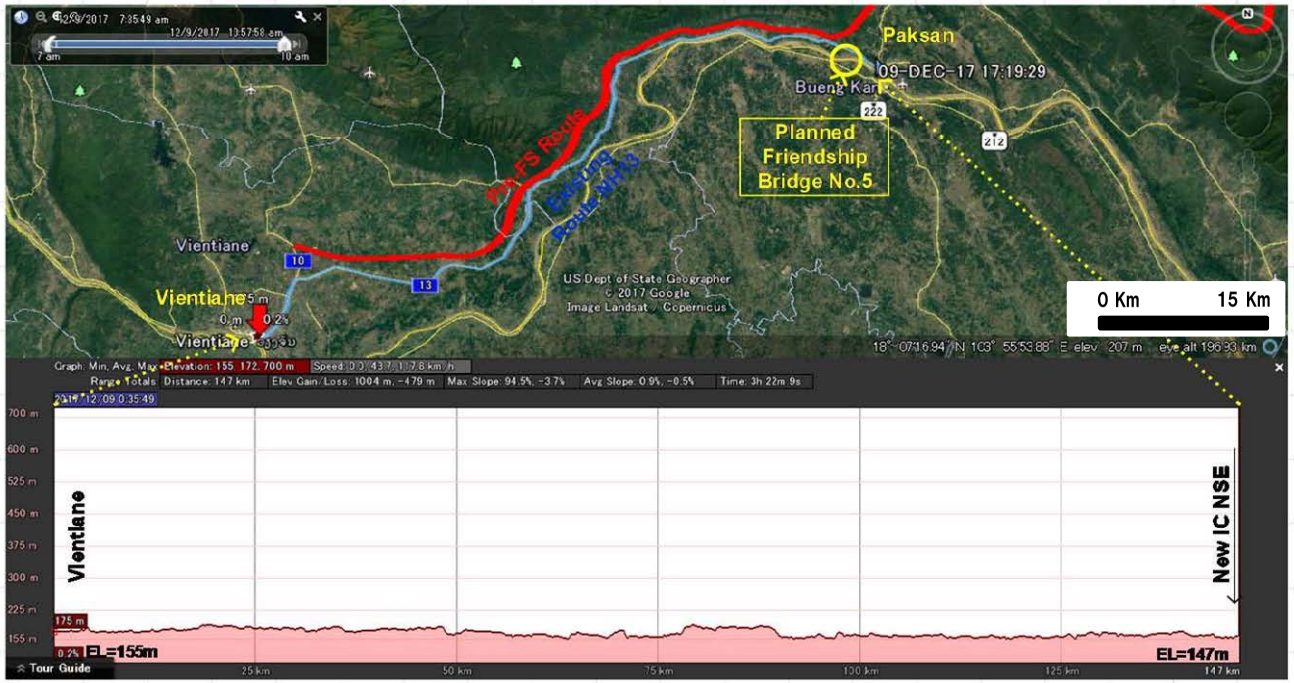
Outline of Road Condition Survey Result

(3) implementation of road condition survey



(1) Laos National Road13(Vientiane～Pakxan)

Route No.	Vientiane/Laos							Borikhamsai/Laos				
	NH13											
Station	KM 0 Vientiane		KM 13		KM 23		KM 65 Provincial Boundary			KM 140 Planned Friendship Bridge No.5		KM 147 Paksan
Distance	13km		10km		42km		75km				7km	
Lane/ Pavement	4-lane/AC				4-lane/AC					Repair		4
Ave. Slope	<3%											
Ave. Speed	50km/h		60km/h<									
Terrain	Level											



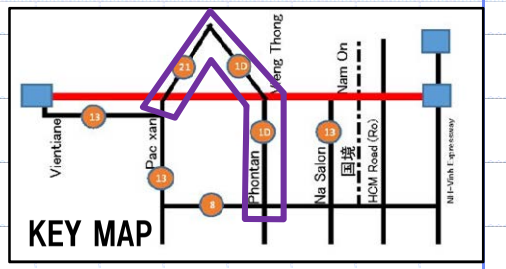
KM 12

KM 25

KM 143

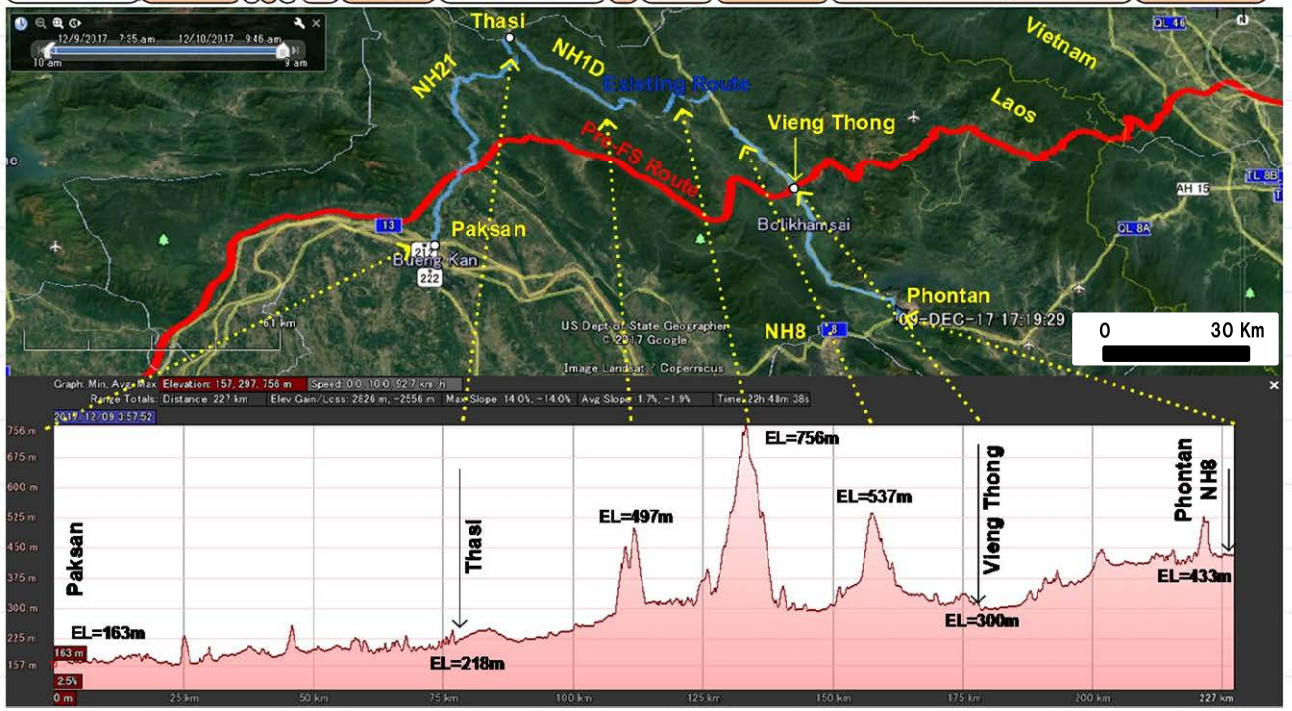
Outline of Road Condition Survey Result

(3) implementation of road condition survey



(2) Laos National Road 21 1D route (Pakxan～Phontan)

Route No.	Borikhamsai/Laos																								
	NH21											NH1D													
Station	KM 0 Paksan	NH13	KM 24	KM 30	KM 42	KM 45	KM 48	KM 53	KM 60	KM 68	KM 77	Thasi	KM 107	KM 113	KM 127	KM 137	KM 148	KM 164	KM 178 Vieng Thong	KM 203	KM 217	KM 222	KM 226	Phontan, NH8	
Distance	24km		6	12	3	3	5	7	8	9	11km		6	14km	10	27	16km	14km	25km	14km	5	4			
Lane/ Pavement	4	2-lane/DBST																							
Ave. Slope	<3%												6<	<3%	8%	<5%	<3%				8	3			
Ave. Speed	60km/h<		50km/h<								70km/h<		30	40km	30	50km/h	60km/h<								
Terrain	Level		Mount.		L	N	L	R	M		Level		M	R	M	Rolling					R/M				

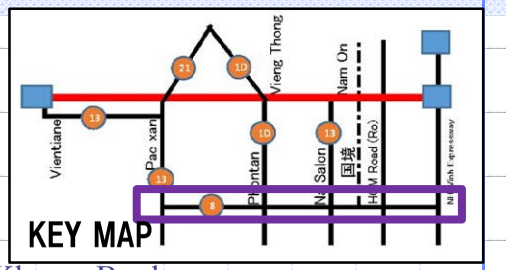



KM 110


KM 130

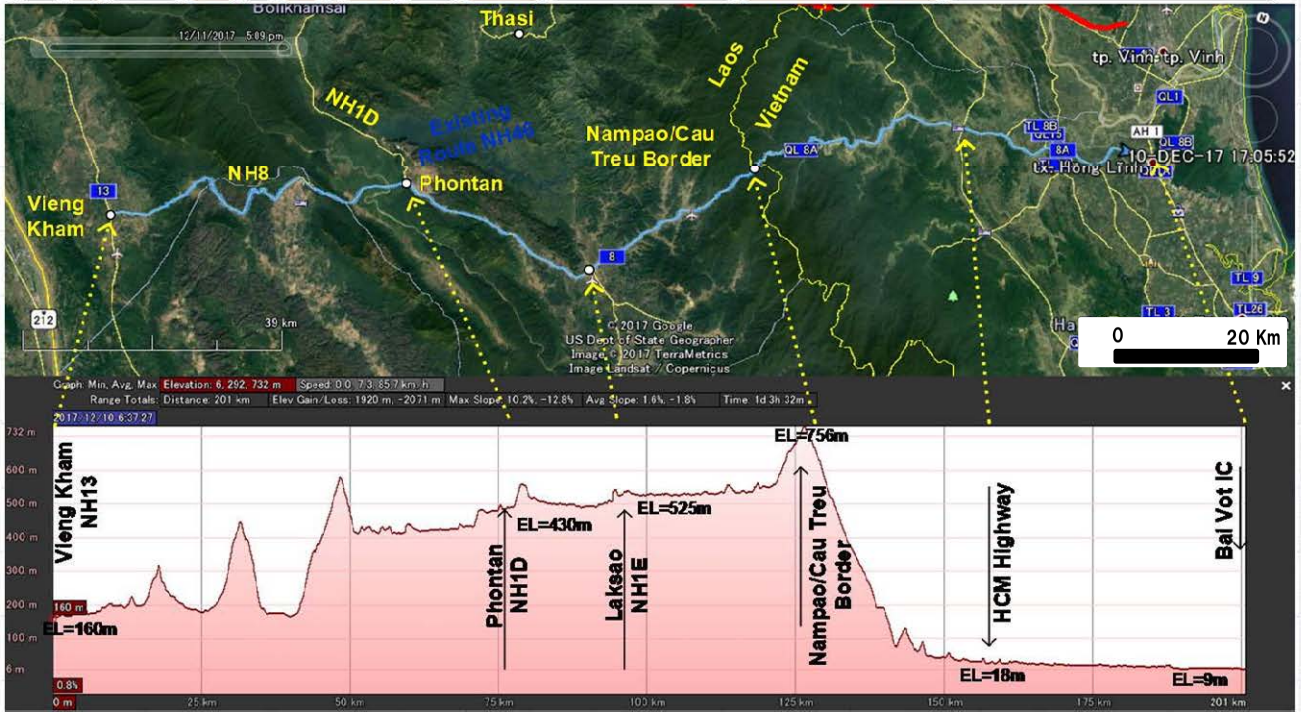

Vieng Thong

Outline of Road Condition Survey Result
(3) implementation of road condition survey



(3) Laos National Road 8,Vietnam National Expressway 8 A(Vieng Kham~ Border ~ North-South Expressway)

Route No.	Borikhamsai		Khammouan				Borikhamsai/Laos							Ha Thinh/Vietnam								
	NH8													NH8A								
Station	KM 0 Paksan	NH13	KM 7	KM 14	KM 19	KM 26	KM 35	KM 41	KM 50	KM 61 Phontan	NH1D	KM 70	KM 83	KM 94 Laksao	KM 114	KM 121	KM 127 Nampao / Cau Treu Border	KM 147	KM 171 M Highway	KM 186	KM 200	Bai Vot IC, NSE
Distance	7	7	5	7	9	6	9	11	9	13km		11	20km		17km		20km	24km	15km	14km		
Lane/ Pavement						Dam aged		2-lane/DBST									2-lane/AC (partially DBST)			4/AC		
Ave. Slope	<3%		<5%		7%	3	7%	<3%								5	7%	<3%				
Ave. Speed	60	40	60		40	60	40	60km/h					50km/h		40		30km/h	40km/h	50km/h	60km/h		
Terrain	L	R	L		M	L	M	M	L	M			Level				Mountainous	Level				




KM 8

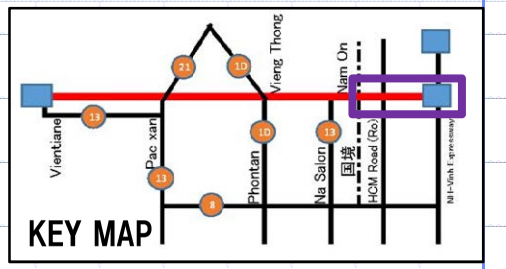

KM 125


KM195

5

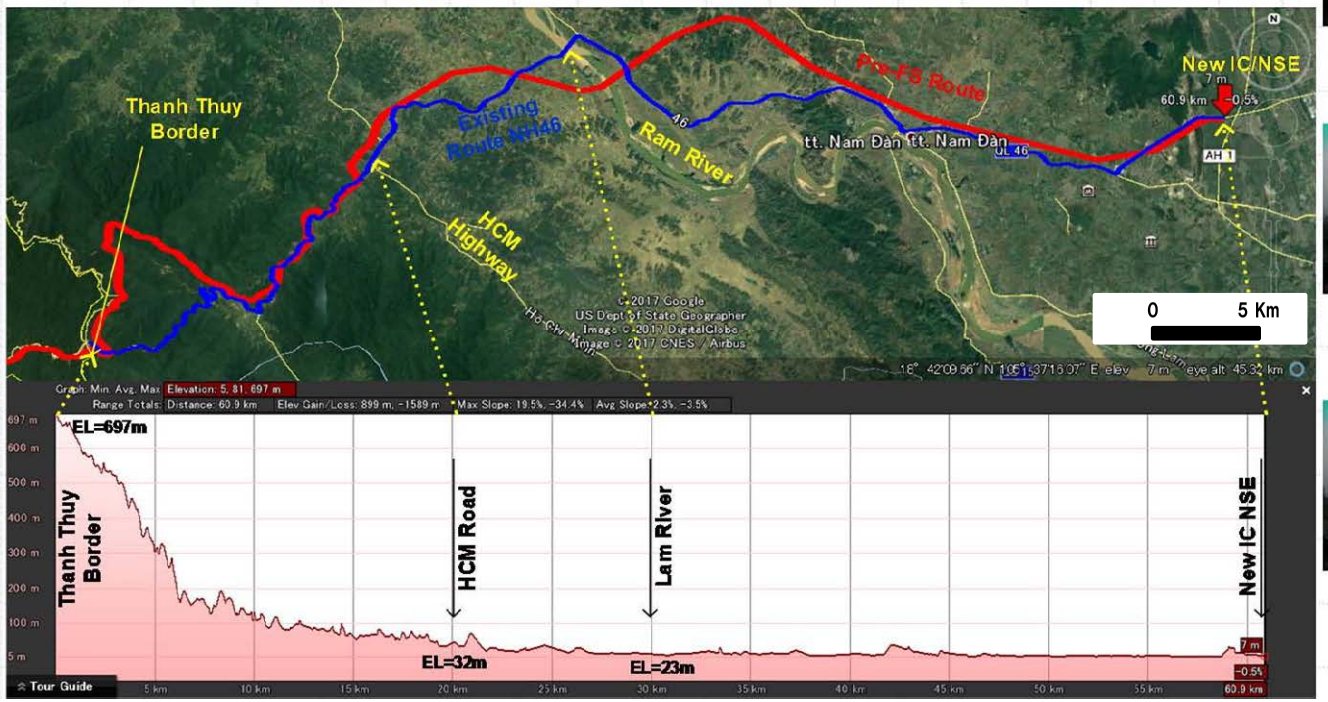
Outline of Road Condition Survey Result

(3) implementation of road condition survey



(4) Vietnam National Road 46 (Border(Thanh Thuy)～NSE)

Nghe An/Vietnam										
Route No.	NH46A									
Station	KM 0 Thanh Thuy Border	KM 7	KM 10	KM 20 HCM Road	KM 31 Lam River	KM 46	KM 49	KM 56	KM 61 New IC NSE	
Distance	7km	3km	10km	11km	25km			5km		
Lane/ Pavement	2-lane/AC Pavement					4/AC	2-lane/AC	4/AC		
Ave. Slope	10%<	5%<	<5%							
Ave. Speed	35km/h		50km/h	60km/h						
Terrain	Mountainous			Level						



KM 5

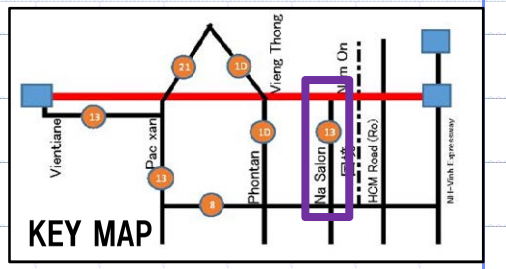
KM 32

KM 59

Outline of Road Condition Survey Result

(3) implementation of road condition survey

(5) Laos prefectural Road 1B (Na Salom～Nam On)



Route No.	Borikhamsai/Laos		
	Provincial Road 1B		
Station	KM 0 Na Salon	KM 13.0	KM 13.9 Crossing Point with Pre-FS Route
Distance	13.9km	0.9km	
Lane/Pavement	2-lane/Dirt Road	Rough	
Ave. Slope	<5%		
Ave. Speed	40km/h	<30	
Terrain	Mountainous		

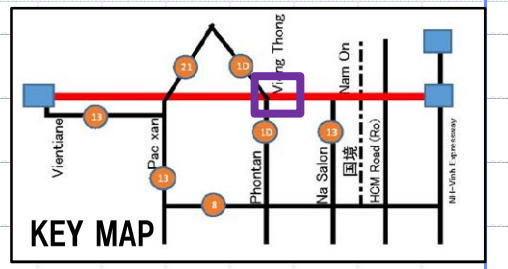
KM 3

KM 8

KM10

Outline of Road Condition Survey Result

(3) implementation of road condition survey



(6) Laos prefectural and village Road (Vieng Thong)

Route No.	Borikhamsai/Laos		
	Village Road		
Station	KM 0 Vieng Thong	KM 3.5	KM 8	KM 12.5 Crossing Point with Pre-FS Route
Distance	3.5km	5.0km	4.5km
Lane/ Pavement	2-lane/DBST		Rough dirt road
Ave. Slope	<10%	<3%	10%
Ave. Speed	40km/h	50km/h	<30km/h
Terrain	Mountainous	Level	Mountainous

KM 3

KM 9

KM12.5

Outline of Road Condition Survey Result

(4) challenges by section

No.	Route	Challenges
1	Laos National Road 13	• Partially, there is damage in the pavement • Frequent lane changes with the intention to overtake the vehicle in front at high relative vehicle speeds are especially challenging.
2	Laos National Road 21, 1D	• Partially, there are unpaved sections. • A steep slope with average longitudinal gradient of about 8% in the mountains section. • Although this route passes through many villages, there are few vehicle to decelerate and it is dangerous.
3	Laos National Road 8, Vietnam National Road 8 A	• Lots of pavement damage in the mountain section can been seen • From the border to the Vietnam side there is a steep slope with range up to 20 km. • On the survey day, the visibility was bad due to fog density close to the border (especially Vietnam side), and • A large number of modified trailers are passing.
4	Vietnam National Road 46	• There is a sudden slope section with an average slope of 10%, about 7 km from the border • On the day of the survey, the fog is dense in the mountainous section, and the field of view is around 20 m near the border.
5	Laos Prefectural Road 1B (5110) Route	• Maintenance (unpaved) of about 55 km length of section, from line 8 to 14 km has been done. However passage of the vehicles on the remaining part of the road is not possible due desire path. • Oftentimes erosion and collapse occurs due to rainfall on the slope.
6	Laos Prefectural Road 5117	• Although 8km from Vieng Thong has been developed, however, due to 8km to 12 unpaved area the passage of vehicles are difficult. • in the remaining part, the vertical grade is about 10% therefore the lope is very steep.