Ministry of Transport
The Republic of the Union of Myanmar

The Survey Program for the National Transport Development Plan in the Republic of the Union of Myanmar

Final Report

Pre-Feasibility Study for East West Economic Corridor Relevant Roads Project

September 2014

JAPAN INTERNATIONAL COOPERATION AGENCY

Oriental Consultants Co., Ltd.
International Development Center of Japan
ALMEC Corporation

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Currency Equivalents (average rate from April to June, 2013)
US$1.00=MMK904
US$1.00=JPY98.93
MMK1= JPY0.1094
Source:Bank of Tokyo Mitsubishi UFJ for the JPY-US$ rate
Central Bank of Myanmar for the MMK-US$ rate

The Survey Program for the National Transport Development Plan in the Republic of the Union of Myanmar

Pre-Feasibility Study for the East West Economic Corridor Relevant Roads Project

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Abbreviations

ADB	Asian Development Bank
ASEAN	Association of South East Asian Nations
BOT	Build, Operate and Transfer
BQ	Bill of Quantities
CBR	California Bearing Ratio
EIA	Environmental Impact Assessment
EL	Elevation
EIRR	Economic Internal Rate of Return
EMEC	East West Economic Corridor
ESA	Equivalent Standard Axles
ESCAP	Economic and Social Commission for Asia and the Pacific
GMS	Greater Mekong Subregion
GRDP	Gross Regional Domestic Product
IMF	International Monetary Fund
IWT	Inland Water Transport
JICA	Japan International Cooperation Agency
KNU	Karen National Union
MLIT	Ministry of Land, Infrastructure and Transport
MOECAF	Ministry of Environmental Conservation and Forestry
MYT-Plan	The Survey Program for The National Transport Development Plan In The Republic of The Union of Myanmar
NGO	Non-Governmental Organization
NPV	Net Present Value
ODA	Official Development Assistance
ORN	Overseas Road Note
PC	Precast Concrete
PWD	Public Works Department
ROW	Right of Way
TA	Total Asphalt Pavement
TTC	Traveling Time Cost
VOC	Vehicle Operation Cost

Units

Area

m^2	square meter
km^2	square kilometre
acre	acre (= 4,047 m^2)
ha	hectare (= 10,000 m^2)
ft^2	square feet

Length

mm	millimetre
cm	centimetre
m	meter
km	kilometre
in, "	inch (=2.54 cm)
ft, '	feet (=12 inch or 30.48 cm)
yd	yard (= 3 feet or 0.9144 m)
mi	mile (= 1,760 yard or 1,609 m)

Weight

kg	kilogram
T	tonne (=1,000 kg)

Capacity

l	litre
m^3	cubic meter (= 1,000 litre)

Energy

V	volt
kV	kilovolt

Time

sec, s	second
min	minute
h, hr	hour
d	day

Others

%	percent
mph	mile per hour
°	Degree Celsius
N	Newton
kN	kilo Newton

Currency

JPY	Japanese Yen
Ky., MMK	Myanmar Kyat
US$	United States Dollar

Chapter 1 Introduction

1.1 Background of the Survey

The Republic of the Union of Myanmar (hereinafter “Myanmar”) is achieving high economic growth after democratization of the politics and economy as the result of the election in 2012, supported by the economic assistance from foreign countries. The country will require further development for the shift to the ASEAN Economic Community in 2015 under the slogan of “ASEAN Connectivity.” On the other hand, due to the economic isolation for long years, the infrastructure to revitalize the economy of Myanmar has not been well developed. It is an urgent task for the country to develop the road network, which is indispensable as the means of movement of citizens as well as the primary transportation means to support the economic activities. Among others, the delay of road development in rural areas is remarkable, and it is difficult to transport goods to poverty-stricken areas where many ethnic minorities live. The south-eastern part of Myanmar is internationally important because it has connections to the major cities of neighbouring Thailand. However, due to topographical limitations such as the mountains, and national conflicts for many years, the development of infrastructure in the area has stagnated.

The major arterial roads to the southeast of Myanmar are as follows: (1) Myawaddy --Eindu-Mawlamyine Road positioned as the GMS East-West Economic Corridor; (2) Payagyi－Mawlamyine－Dawei Road to connect the economic city, Yangon, with the southern part of Myanmar; (3) The Three Pagoda Path to connect to the border with Thailand from Thanbyuzayat where the demand for border transportation will remarkably increase as an economic corridor; and (4) the Dawei Port Access Road which is expected to improve the access to the GMS countries on the west coast of the Indochina Peninsula including Thailand in the future. These routes connecting the metropolitan Yangon and Thailand are expected to greatly contribute to the revitalization of trade with ASEAN countries and the economic growth of Myanmar, and also to repatriation of local residents who were forced to evacuate to the neighbouring countries and improvement of their living standards. Though some projects are ongoing for road improvements, other than the sections operated and maintained by some BOT projects currently, most of the roads are two-lane roads of low cost pavement with narrow width without sidewalks and shoulders. The road conditions where large cargo trucks, long-distance buses, pedestrians, light vehicles (for agriculture), and bicycles coexist are very dangerous in terms of traffic safety.

Based on the background described above, this study summarized the current situations of the major arterial roads in the south-eastern part of Myanmar, and the status of assistance and plans promoted by donors. Based on the basic study, the projects that are necessary to be implemented were extracted, the project proposals and estimated project costs were studied, and the appropriateness of the projects in terms of design, construction, economy, environment, etc. was briefly reviewed.

Source: JICA Study Team

Figure 1.1 Major Arterial Roads to the Southeast of Myanmar

1.2 Objectives of the Study

This study selects project proposals that are necessary and possible to be implemented with consideration of the collaborations with other donors including ADB, after reviewing the current road conditions and future development plans concerning Takton-Eindu-Myawaddy Road, Mawlamyine - Eindu Road, and Payagyi-Maulamyine Road that are included in the major arterial roads located in the south-eastern part of Myanmar and are expected to strengthen the access between Myanmar and other ASEAN countries. A pre-feasibility study will be conducted for each selected project proposal to roughly confirm the necessity and reasonableness of the development, and prepare reasonable project implementation plans from the technical, cost, environmental, and social viewpoints.

1.3 The Sections to be Studied

The study covers the roads connected to the GMS East-West Economic Corridors in the south-eastern part of Myanmar (Takton-Eindu-Myawaddy Road, Mawlamyine - Eindu Road, and Payagyi-Maulamyine Road), and the surrounding areas. The sections to be covered by this study are shown in Figure 1.2.

Source: JICA Study Team

Figure 1.2 Locations of the Sections Covered by this Study

Chapter 2 Current Conditions and Issues of the Covered Roads and Bridges

2.1 The Sections of the Covered Routes

The current conditions and issues are summarized concerning the roads and bridges covered by this study, and based on the site survey and the report from the Public Works Department, Ministry of Construction. Due to the breadth of coverage, the summary was made by dividing the roads into 5 sections as shown in Table 2-1.

Table 2-1 The Sections Covered by the Study

	Section	Length	State
1	Takton-Eindu	66km	Mon, Kayin
2	Eindu-Kawkarei	70km	Kayin
3	Kawkarei-Myawaddy	58km	Kayin
4	Eindu-Mawlamyine	40km	Mon, Kayin
5	Payagyi-Mawlamyine	200km	Bago, Mon

Source: JICA Study Team

Source: JICA Study Team

Figure 2.1 Locations of the Sections Covered by the Study

2.2 Summary of the Conditions and Issues of Each Covered Road

2.2.1 The Current Conditions and Issues of Takton-Eindu Section

(1) Current Conditions of the Road

The section of about 60km between Takton and Eindu across Mon and Kayin State borders and Hpa-an plays an important role as a component of the major access roads between Thailand and Yangon and other major cities in Myanmar. The section passes through plains for the most part and crosses Thanlwin River and Donthami River on the way. In terms of alignment, a design speed of 60km/h is secured for the most part, and there are moderate curves and bends in the subsection before and behind Thanlwin Bridge and urban areas. The road two-way, two lanes (3.5m per lane) and the width is 7m. The roadway is paved with low cost asphalt pavement (macadam pavement) but the shoulders are not paved. As motorcycles and oxcarts travel the roadway, and it is difficult to overtake low-speed large vehicles, the running speed is reduced on the whole. The road surface is fine and the ROW is secured all through the section. In Takton, Hpa-an and Eindu, the road goes through the urban areas and some houses and stores encroach on the ROW. In Hpa-an, the capital of Kayin State, the road has the function of an urban road.

The section is managed and maintained now by private concessioners under BOT contracts. Takton-Myainkalay Section (western part of Thanlwin (Hpa-an) Bridge) is maintained by Shwe Than Lwin Highway Company and the Myainkalay-Eindu Section by AyeKo Family (AK). Both of them are private companies in Myanmar.

	
Takton-Hpa-an Section	Hpa-an-Eindu Section

Source: Taken by JICA Study Team (May, 2013)

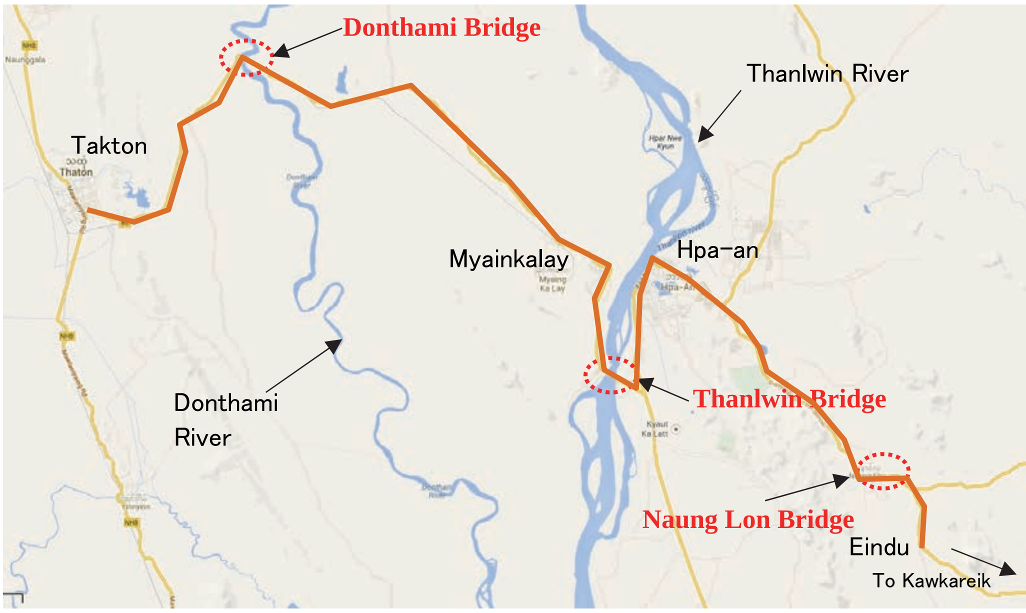
Figure 2.2 Current Conditions of Takton-Eindu Section

On the other hand, Naung Lon-Kawkyaik Bypass has been developed as a two-lane, low cost asphalt pavement (macadam pavement) road over which one can go to Thanlwin (Hpa-an) Bridge from Eindu without passing the city of Hpa-an. This route is managed and maintained by AyeKo Family (AK) also by BOT, and mainly used by large vehicles.

	
Relatively favourable road surface condition	Road surface well maintained

Source: JICA Study Team (May, 2013)

Figure 2.3 Naung Lon-Kawkyaik Bypass



Source: JICA Study Team

Figure 2.4 Location Map of Takton– Eindu Section

(2) Current Conditions of Bridges

There are three major bridges in this section, as shown in the location map. Data of each bridge is summarized in Table 2-2.

Table 2-2 Data of Major Bridges in the Takton – Eindu Section

Bridge Name	Length	Superstructure type	Weight limit	Completion year
Donthami Bridge	183m	PC+RC	50t	1982
Thanlwin (Hpa-an) Bridge	686m	Steel truss	60t	1997
Naung Lon Bridge	115m	RC(I Girder)	30t	1970s

Source: JICA Study Team

① Donthami Bridge

This is a concrete girder bridge built on the boundary of Mon and Kayin States in 1982. Though this has been selected as one of 17 bridges to be reconstructed preferentially by the Public Works Department (PWD), the Ministry of Construction, no particular failure is observed in the current state and the load limit is 50 tons, so that the PWD is not considering specific reconstruction or repair at present for this bridge.

	
Surface condition is comparatively good.	There is no large scale damage on either the superstructure or the substructure.

Source: Taken by JICA Study Team (May, 2013)

Figure 2.5 Current Conditions of Donthami Bridge

On the other hand, the approach section on the west of the bridge passes through the village (Donthami area), in which a mixture of large vehicles and regional traffic presents critical problems in terms of traffic safety. In this context, PWD plans to build a new bridge near the existing one and construct a bypass.

② Thanlwin (Hpa-an) Bridge

This is the two-lane bridge built by PWD, the Ministry of Construction, in 1997, which consists of a steel truss bridge for the five central spans and a concrete girder bridge for the five spans on both ends. No particular failure is observed in the current state, and the weight limit is 50 tons, enough to accommodate traffic of large vehicles. At present, there is no need for specific reconstruction or repair.

	
There is no large scale damage on either the superstructure or substructure.	Surface condition is good.

Source: Taken by JICA Study Team (May, 2013)

Figure 2.6 Current Conditions of Thanlwin (Hpa-an) Bridge

③ Naung Lon Bridge

This is an old bridge built in the 1970s and is less than 7 m wide. In addition, the weight limit is only 30 tons. PWD is planning its reconstruction, and, on May 23, 2013, the study team headed by the Deputy Managing Director visited here for an on-site survey. According to the information available from PWD, it appears that a new bridge with a weight limit of 60 tons may be built independently by PWD.

	
Unevenness of road surface at two-lane road	Large deflection of the superstructure

Source: Taken by JICA Study Team (May, 2013)

Figure 2.7 Current Conditions of Naung Lon Bridge

(3) Issues detected in the current conditions

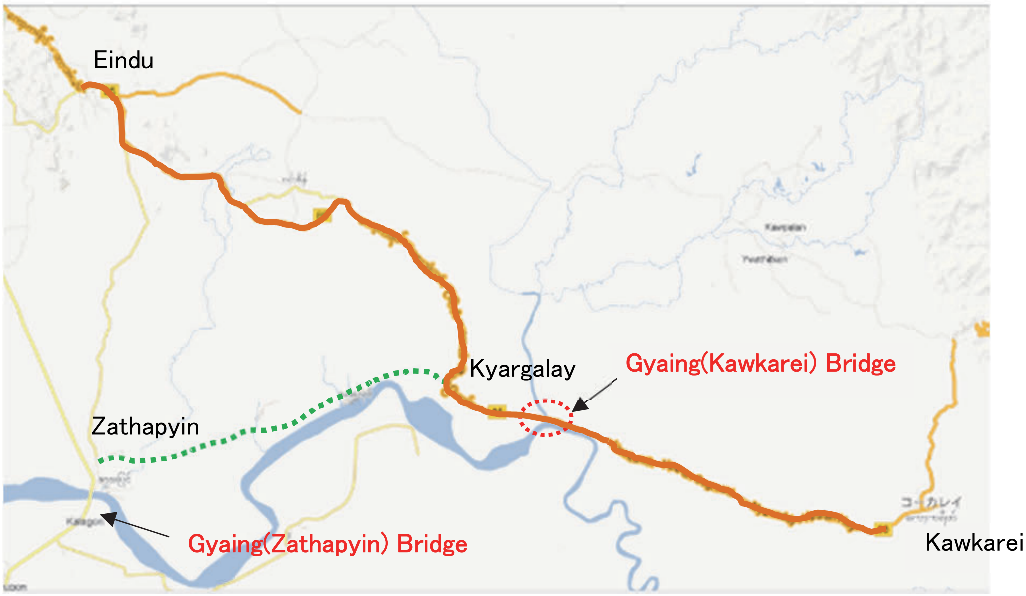
Issues related to the existing roads and bridges in the section concerned are as listed below:

- ✓ Development (paving) of the shoulder
- ✓ Widening of roads for the future traffic volume
- ✓ Review the bypass plan to divert around the urban areas of Takton and Hpa-an
- ✓ Reconstruction of bridges due to insufficient capacity to bear the current traffic loads
- ✓ Reconstruction of Naung Lon Bridge
- ✓ Promotion of pedestrian/vehicle separation through development of shoulders and sidewalks
- ✓ Safety enhancement through development of traffic safety facilities, such as road markings and traffic signs, and by providing super elevation
- ✓ Intensification of regulations against encroaching on the road site (ROW)
- ✓ The alignment through the village section has insufficient site distance and width of road that causes traffic accident between community traffic and through traffic.

2.2.2 Eindu – Kawkareik Section

(1) Current Conditions of the road

This is the cross-border route, connecting Myanmar and Thailand, and crosses over the Hlaibwe River. The width of the two-lane road is 7 m (each 3.5 m), the roadway section is provided with asphalt pavement (macadam pavement), but the shoulder is not paved. This route runs through the flatland with little undulation, but is narrower in width and poorer on the surface than the Hpa-an – Eindu section. The alignment generally ensures the design speed of about 60 km/h, but there are curved and bent sections with small radius curves in the urban area and certain sections. There are a few houses along the entire road and ROW is basically assured, except in the urban area of Eindu and Kawkareik where occupation of the ROW by houses and shops is observed.



Source: JICA Study Team

Figure 2.8 Location Map of Eindu – Kawkareik Section

	
Necessary realignment location in the city	Damaged macadam road surface due to poor road maintenance, without shoulder

Source: Taken by JICA Study Team (May, 2013)

Figure 2.9 Current Conditions of Eindu – Kawkareik Section

(2) Current Conditions of bridge

In this section, there is Gyaing (Kawkareik) Bridge as shown in the above-mentioned location map. Data of this bridge is summarized in Table 2-3.

Table 2-3 Data of the Major Bridges in Eindu – Kawkareik Section

Name of bridge	Length	Superstructure type	Weight limit	Completion year
Gyaing（Kawkarei） Bridge	400m	Suspension	30t	1999

Source: JICA Study Team

This is a 400m long Bailey suspension bridge over the Gyaing River, which was built independently by PWD with support from China. The bridge surface is not paved, but covered with shape steels laid simply. The navigation clearance is 13 m from the design high-water level, which has been determined by taking into account the navigation of the navy's patrol boats. Considering the existing river width, the suspension bridge structure may appear slightly exorbitant. It is presumed that this structure was employed to eliminate as many spans as possible because the water depth in the middle of the river is as deep as 23m and the substructure to be constructed here would be extremely large in scale and thus not economically reasonable. Note that the passage over the bridge is currently limited to a period from 6:00 in the morning to 8:00 in the evening.

Overall view of Gyaing (Kawkarei) Bridge

Moulded steel on the bridge surface

Multiple foundation for main tower of suspension bridge

Navy patrol boat

Source: Taken by JICA Study Team (May, 2013)

Figure 2.10 Current Conditions of Gyaing (Kawkareik) Bridge

This bridge is suffering from age and deterioration and the resultant excessive damage, such as deterioration of the main cables, deformation of the steel shapes over the bridge surface, etc., all suggesting the possible danger of falling. In addition, settlement of the rear-side of the abutment is excessive, causing deformation of the road surface of the approach bridge portion, cracks in the side-wall concrete, etc. The main cable is covered with mortar and repaired. This technique is the conventional common practice of repair of suspension bridges in Myanmar, which however possesses the possible danger of corrosion to the cable by water infiltrating through cracks in the mortar. This bridge showed cracks in the mortar, but, as the mortar must be broken to inspect the cable, it is not known to which degree the cable was corroded.

	
Deformation of road surface and crack generation at side wall because of serious settlement behind abutment	Deformation of moulded steel, difficulty for two-wheeler because of tires catching in the grooves.
	
Mortar crack at main cable (corrosion)	Mortar deficit around suspension member (corrosion)

Source: Taken by JICA Study Team (May, 2013)

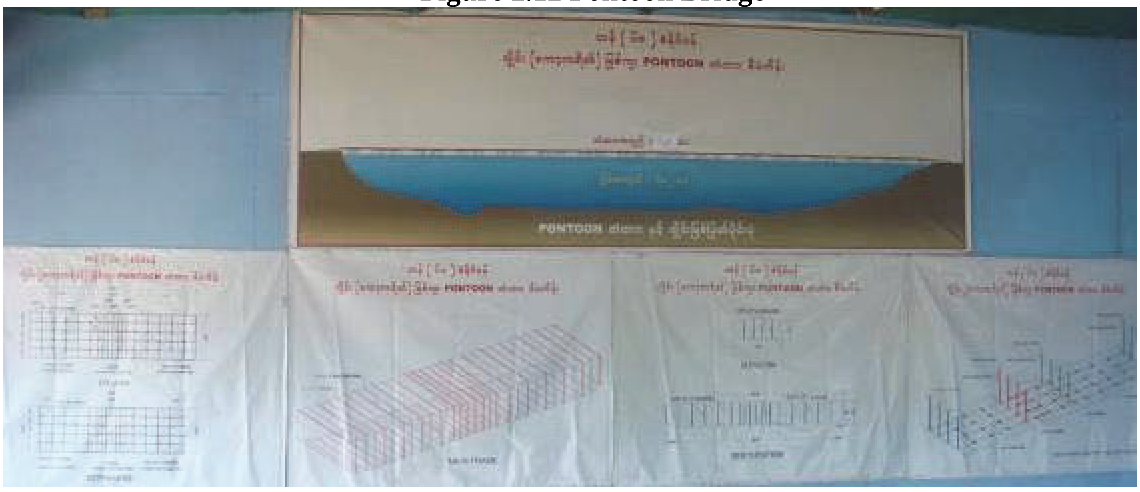
Figure 2.11 Failure in Gyaing (Kawkareik) Bridge

The structure of the bridge main body was not constructed to carry heavy vehicles or large vehicles. At present, the vehicles are weighed at both ends of the bridge, and any vehicles of the weight of 30 tons or more are diverted to the float bridge (pontoon bridge) to cross the river. This pontoon bridge was designed by a Chinese contractor and constructed by a Myanmar contractor, and completed in 2010. The bridge maintenance is carried out by a private company (a company separate from the BOT's road administration company) under contract with the local government, with the company selected by bidding. The average traffic volume per day is 14 to 18 units, and the weigh station is provided on the Thailand side. (Vehicles from the Yangon side are weighed before entering Hpa-an.) At present, vehicles exceeding 30 tons in weight are charged a toll of 30,000 kyats uniformly, which is the profit for the administrative company of the bridge. Since the clearance under the girder of this pontoon bridge is small, vessels other than small boats cannot pass. However, the pontoon bridge can be opened and closed for a 100 feet (= about 30 m) portion in case of emergency (mainly for the passage of the navy's patrol boats).

	
Nearby floating bridge (for over 30 ton vehicles)	Big subduction during heavy vehicle passing and damage to connection steel plate deck due to impact of car bottom

Source: Taken by JICA Study Team (May, 2013)

Figure 2.12 Pontoon Bridge



Source: TAKEN BY JICA STUDY TEAM at site office (MAY, 2013)

Figure 2.13 Design Drawing of the Pontoon Bridge (designed by a Chinese contractor)

	
Measuring weight of truck at weigh station	Meter of weight scale (showing around 51 ton)

Source: Taken by JICA Study Team (May, 2013)

Figure 2.14 Weigh Station

(3) Issues Detected in the Current Conditions

Issues related to the existing road and bridges in the section concerned are as listed below:

- ✓ Development (paving) of the shoulder
- ✓ Widening of roads for the future traffic volume
- ✓ Review of the bypass plan to divert around the urban areas of Eindu and Kawkareik
- ✓ Promotion of pedestrian/vehicle separation through development of shoulders and sidewalks
- ✓ Safety enhancement through development of traffic safety facilities such as road markings and traffic signs and by providing super elevation
- ✓ Intensification of regulations against encroaching on the (ROW)
- ✓ Reconstruction of Gyaing (Kawkareik) Bridge because of deterioration
- ✓ Though the gross weight of vehicles is measured in the weigh station, the axle load is not measured, so that no regulation is made on the overload. Namely, there is a concern that the pavement may be damaged.
- ✓ The mortar insulation of the main cable may be cracked and broken off, exposing the cable. There is a possibility of corrosion being accelerated. If the mortar insulation does not show any remarkable damage, water may penetrate into the mortar, possibly damaging the cable. It is difficult, however, to confirm.

2.2.3 Kawkareik – Myawaddy Section

(1) Current Conditions of the Road

The existing road (about 64 km in length) between Kawkareik and Myawaddy is a cross border road connecting Myanmar and Thailand, including the hilly and rough mountain road for about 40 km between Thingannyinaung and Myawaddy because it has to cross the Dawna Range. It takes about two hours to pass this section. This section is limited to one-way traffic (switched for up bound and down bound day by day), so that it is practically impossible to make a round trip through this section on the same day. In addition, large vehicles face difficulty in traveling because of the surface condition and the road flooding in the wet season. In August, 2008, a large-scale landslide occurred at the 56-km point from the border of Thailand, blocking the road temporarily. For the Myawaddy – Thingannyinaung section of about 18 km, the Thailand government has nearly completed road development. The two-lane asphalted roadway with shoulder is available.

Source: JICA Study Team

Figure 2.15 Kaukareik – Myawaddy Section Location Map

At present, the Thailand vehicles are allowed to travel up to Takton. Actually, large freight vehicles transfer their loads to freight cars of Myanmar at Myawaddy or Thingannyinaung for further transfer toward Yangon. On the other hand, vehicles of Myanmar are allowed to travel, crossing the border, to Mae Sot.

	
Flooded unpaved road due to heavy rain	Mountainous road which was built following the shape of the land

Source: Research report prepared by Hi-Tech Nittsu (Thailand) Co., Ltd. (Beginning January, 2013)

Figure 2.16 Current Conditions of Kaukareik – Myawaddy Section

(2) Current Conditions of Bridges

This section has the Thai – Myanmar Friendship Bridge as shown in the location map. Data of this bridge is summarized in Table 2-4.

Table 2-4 Data of major bridges in Kaukareik – Myawaddy Section

Name of bridge	Length	Superstructure type	Weight limit	Completion year
Thai – Myanmar Friendship Bridge	420m	PC（I Girder）	25t	1997

Source: JICA Study Team

	
Thai – Myanmar Friendship Bridge	Thai – Myanmar Friendship Bridge

Figure 2.17 Current Bridge Conditions of Kaukareik – Myawaddy Section

Source: Survey report by Thai Government (Jan. 2013)

This bridge was constructed under a grant aid project from the Thai Government and completed in 1997. The bridge is currently renovated because of a failure in which the pier foundation piles were allowed to protrude because of scoring due to change in the flow of Moei (Thaungyin) River.

(3) Issues Detected in the Current Conditions

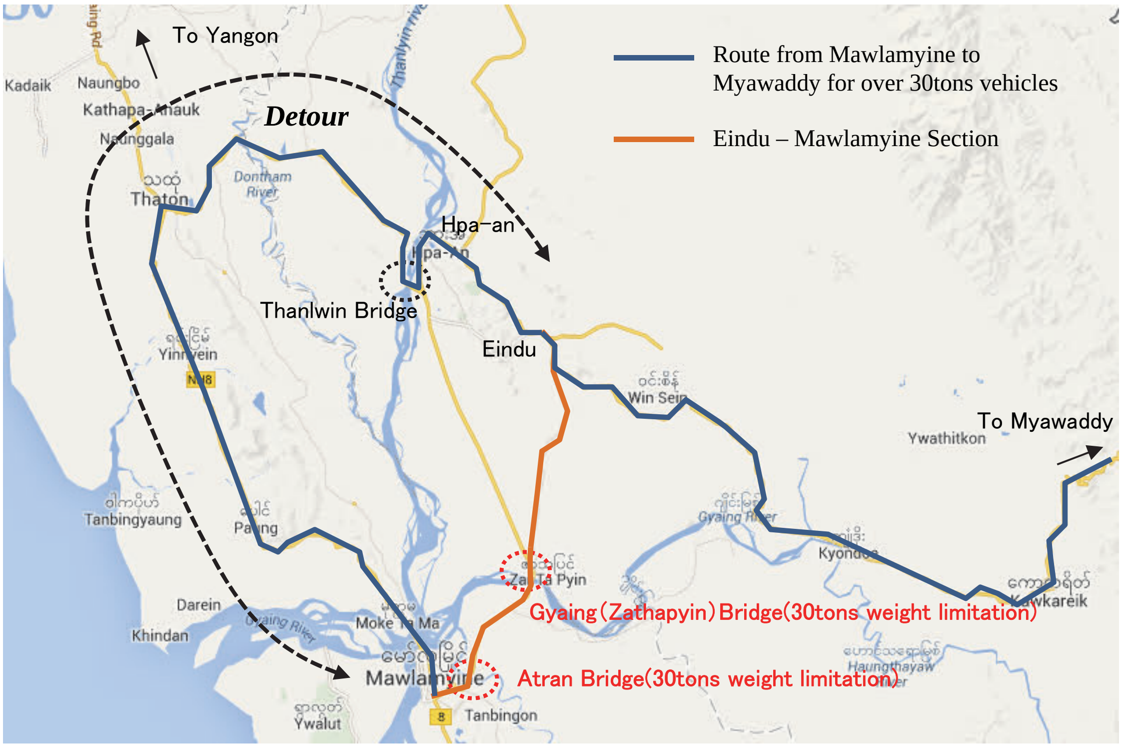
Issues related to the existing road and bridges in the section concerned are as listed below:

- ✓ Being a mountain road, this section requires large-scale structures (retaining wall, long-span bridges, and tunnels) for improvement of the alignment. A considerable amount of funding for the project will also be needed. There is also a concern about the adverse effects of large-scale earthwork on the environment.
- ✓ Elimination of road blocks due to slope collapse and road flooding in the wet season
- ✓ Special land acquisition procedure in Kayin (Karen) State (necessity of coalition with KNU)

2.2.4 Eindu – Mawlamyine Section

(1) Current Conditions of the Road

For this section, the AyeKo Family (AK) concluded the concession agreement with PWD of the Ministry of Construction and is conducting the operation and maintenance according to BOT. As the road passes through flatlands, there is almost no undulation while crossing the Gyaing and Atran Rivers. This is a 1.5-lanes road of about 40 km in length with an asphalted roadway (macadam pavement). Since the shoulder is not paved, it is extremely dangerous in case of overtaking and passing. As compared with the road surface of other neighbouring sections, this section has a badly damaged surface, with the remains of simple repairs observed here and there. Flooding of the road surface during heavy rain in the wet season is considered the most significant cause of damage to the pavement.



Source: JICA Study Team

Figure 2.18 Eindu – Mawlamyine Section Location Map

	
Road maintenance condition (Near Hpa-an)	Road maintenance condition (Near Zathapyin)

Source: Taken by JICA Study Team (May, 2013)

Figure 2.19 Current Conditions of Eindu – Mawlamyine Section

The road (about 35 km in length) connecting Hpa-an and Zathapyin runs parallel to the Eindu – Mawlamyine road on the west side of this section. This road is the shortest route to connect Hpa-an and Mawlamyine. This is a two-lane asphalted (macadam pavement) roadway. This road is similarly operated and maintained by the AyeKo Family (AK) according to BOT. At present, the traffic volume is limited and the road surface is better than that of the Eindu – Zathapyin section.

	
Relatively favourable road surface condition of the two-lane road	Road maintenance is well done by private company (BOT)

Source: Taken by JICA Study Team (May, 2013)

Figure 2.20 Current Conditions of Hpa-an - Zathapyin Section

(2) Current Conditions of Bridges

There are two major bridges in this section, as shown in the above location map. Data of each bridge is summarized in Table 2-5.

Table 2-5 Data of Major Bridges in Eindu – Mawlamyine Section

Name of bridge	Length	Superstructure type	Weight limit	Completion year
Gyaing (Zathapyin) Bridge	884m	Suspension Bridge	30t	1999
Atran Bridge	433m	Cable-stayed bridge	30t	1998

Source: JICA Study Team

Gyaing (Zathapyin) Bridge is a suspension bridge crossing the Gyaing River while Atran Bridge is a cable-stayed bridge crossing the Chaying Hnakwa River to the east of Mawlamyine. Both were constructed in the latter half of the 1990s with material supply and technology aid from China. These two bridges are getting older, so that PWD directly conducted the repair work (repainting, cable sheath, and replacement of steel shapes over the bridge surface), which was completed in April, 2013. Although not much time has passed since the repair, the steel shapes over the surface of Atran Bridge have already developed deformation. In addition, both bridges have a weight limit of 30 tons, so that the vehicles carrying heavy freights exceeding 30 tons from Myawaddy to Mawlamyine are diverted from these bridges toward Thanlwin (Mawlamyine) Bridge (weight limit, 60 tons) via Takton, as shown in Figure 2.18.

During repair（April, 2013）

After repair（May, 2013）

Source: Taken by JICA Study Team

Figure 2.21 Current Conditions of Gyaing (Zathapyin) Bridge

During repair（April, 2013）

After repair（May, 2013）

Deformation of moulded steel, difficulty for two-wheelers because of tires catching in the grooves

Cracks caused by settlement behind abutment

Source:Taken by JICA Study Team

Figure 2.22 Current Conditions of Atran Bridge

(3) Issues Detected Regarding the Current Conditions

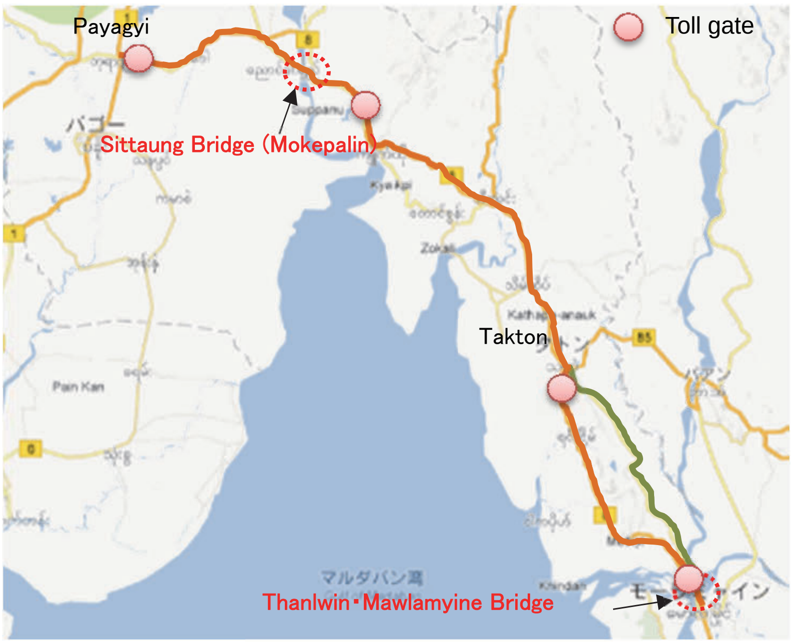
Issues related to the existing roads and bridges in the section concerned are as listed below:

- ✓ As the Eindu – Mawlamyine road does not have sufficient road height determined by taking into account the high water level in the wet season, flooding during the wet season is the problem to solve. As the road improvement requires raising the height of the road surface, it is possible that there will be a large amount of work costs similar to the case of new construction.
- ✓ Both bridges have a weight limit of only 30 tons and the bridge surface is not paved, they do not go much beyond the level of a flying (temporary) bridge. It is necessary to build full-scale structures to cope with the traffic of heavy vehicles.

2.2.5 Payagyi – Mawlamyine Road

(1) Current Conditions of the Road

This is a part of the principal trunk road connecting the capital of Yangon with Mawlamyine, a regional center city of the southern area. This is also a route forming a part of the Asian Highway (AH1), Trilateral Transport Network, and is highlighted as a priority development section by MOC. At present, this is developed as a Class 3 road according to the ASEAN Road Design Standard and has a width of 7 m for two-lane traffic (3.5 m each lane), but the shoulder is not paved. The road surface is in satisfactory condition and the ROW is secured except in the urban areas. Shwe Than Lwin Highway Co., Ltd, a private company in Myanmar, is undertaking maintenance of this route according to BOT. There are toll gates at four points.



Source: JICA Study Team

Figure 2.23 Payagyi – Mawlamyine Section Location Map

This route also passes several urban areas and is used as a community road by wayside residents, so that many pedestrians, bicycles, and motor bikes are using this road. Large vehicles are also running in large numbers. As the shoulder is not paved and the road has one lane each way, it is dangerous for vehicles to overtake and pass the others. In the Takton - Mawlamyine section, this route(brown route) is paralleled by the one-lane (W = 3.5 m) rural road of about 60 km in length developed by the Ministry of Progress of Border Areas, National Races & Development Affairs.

	
Road surface condition is good. Road markings are installed as well.	Toll gate(Toll is collected by BOT by Shwe Than Lwin Highway Co., Ltd.)

Source: Taken by JICA Study Team (May, 2013)

Figure 2.24 Current Conditions of Payagyi – Mawlamyine Section

(2) Current Conditions of Bridges

This section has two major bridges as shown in the above location map. Data of each bridge is summarized in Table 2-6.

Table 2-6 Data of Major Bridges of Payagyi – Mawlamyine Road

Name of bridge	Length	Superstructure type	Weight limit	Completion year
Sittaung Bridge (Mokepalin)	729m	Steel truss	60t	2008
Thanlwin（Mawlamyine）Bridge	3529m	Steel truss	60t	2005

Source: JICA Study Team

① Sittaung (Mokepalin) Bridge

This is a two-lane steel truss bridge built by PWD of MOC in 2008. On its downstream side, there are the substructures of an old bridge left as they are.

	
Overall view of Sittaung Bridge (Mokepalin)	Bridge substructure is existing downstream.

Source: Taken by JICA Study Team (May, 2013)

Figure 2.25 Sittaung (Mokepalin) Bridge

② Thanlwin (Mawlamyine) Bridge

This is currently the longest bridge in Myanmar, which was built by PWD of MOC in 2005. As is often observed in Myanmar, this is a combined road-railway bridge.

	
Gate and symbol of Mawlamyine	Two-lane road and railway bridge

Source: Taken by JICA Study Team (May, 2013)

Figure 2.26 Thanlwin (Mawlamyine) Bridge

(3) Issues Detected in the Section Concerned

Issues related to the existing roads and bridges in the section concerned are as listed below:

- ✓ The traffic volume around Bago section is relatively large (around 1,000 – 2,000 vehicles/day). However, the current average traffic volume of all section is rather small (less than 1,000 vehicles/day), with the demand depending on the progress of development of the East-West Economic Corridor planned by Thailand and ADB.
- ✓ At present, the two-lane structure would present no problem because the traffic volume is small. As this is an international trunk road connecting the East-West Economic Corridor and Yangon and the traffic volume including large freight vehicles is expected to increase in the future, a four-lane structure may become necessary. Issues to overcome in such an event are development of a bypass in the urban area, reconstruction of many bridges, relocation of utilities, etc. In addition, there are ten railway crossings along this road, which will have to be grade-separated while taking into account the railway operation plan in the future. Since this section is covered by a BOT project at present, it will be necessary to review the concession agreement (Shwe Than Lin C., Ltd) and to rearrange the road development policies of Myanmar.
- ✓ Promotion of pedestrian/vehicle separation through development of shoulders and sidewalks
- ✓ Safety enhancement through development of traffic safety facilities, such as road markings and traffic signs, and by providing super elevation
- ✓ Intensification of regulations against encroachment on the (ROW)
- ✓ Reduction of traffic accidents since large freight vehicles running through narrow road section in populated town area

Chapter 3 Road Projects Related to the Area Concerned

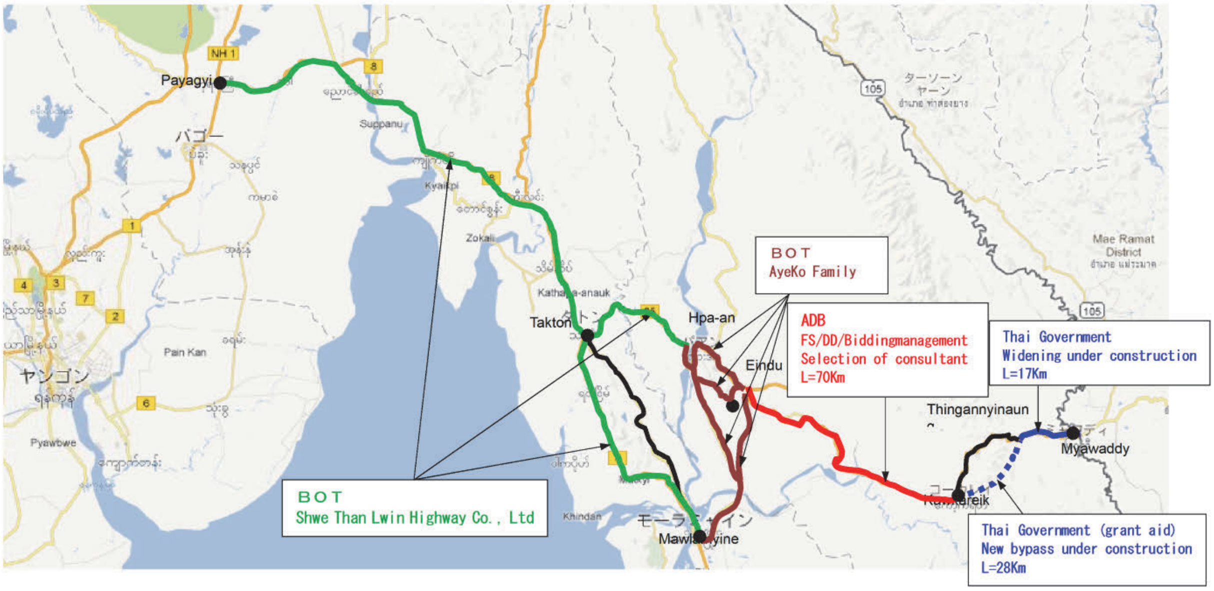
3.1 Existing Road Projects

For the sections concerned, various projects for improvement and maintenance of the roads and bridges are under way or under study for feasibility by PWD of MOC, Myanmar, BOT, the Thai Government, ADB, etc. Principal projects are shown in Table 3-1.

Table 3-1 Existing projects in the section concerned

Project	Type	Implementing agency	Progress
Payagyi-Mawlamyine Road	Maintenance	BOT	in operation
Takton-Eindu Road	Maintenance	BOT	in operation
Mawlamyine-Eindu Road	Maintenance	BOT	in operation
Mawlamyine-Hpa-an Road	Maintenance	BOT	in operation
Naung Lon-Kawkyaik Bypass	Maintenance	BOT	in operation
Takton Bypass	New road development	MOC	Planning
Zathapyin-Kyargalay Bypass	New road development	MOC	Planning
Myawaddy –Thingannyinaung Road	Road improvement	Thai Gov.	under construction
Kawkarei –Thingannyinaung Bypass	New road development	Thai Gov.	under construction
The First Thailand – Myanmar Friendship Bridge	Rehabilitation	Thai Gov.	under construction
The Second Thailand – Myanmar Friendship Bridge	New bridge construction	Thai Gov.	FS stage
Kawkarei-Eindu Road	Road improvement	ADB	Before FS

Source: JICA Study Team



Source: JICA Study Team

Figure 3.1 Location of Existing Projects

3.1.1 Private Sector Participation (BOT)

Within the scope of this survey, the Payagyi – Eindu – Maulamiyine section is maintained and administered by private companies of Myanmar; Shwe Than Lwin Highway and the AyeKo Family (AK). These companies have concluded concession agreements with PWD of MOC for each route. The requirements concerning the technical specifications, responsibilities of contractors, toll setting, etc. are specified in the agreements. The BOT sections and major contents are summarized below.

Table 3-2 Current BOT-based maintenance and administration section

Section	Concessioner
Payagyi-Mawlamyine Road	Shwe Than Lwin Highway
Takton-Eindu Road	Shwe Than Lwin Highway
Mawlamyine-Eindu Road	AyeKo Family
Mawlamyine-Hpa-an Road	AyeKo Family
Naung Lon-Kawkyaik Bypass	AyeKo Family

Source:PW

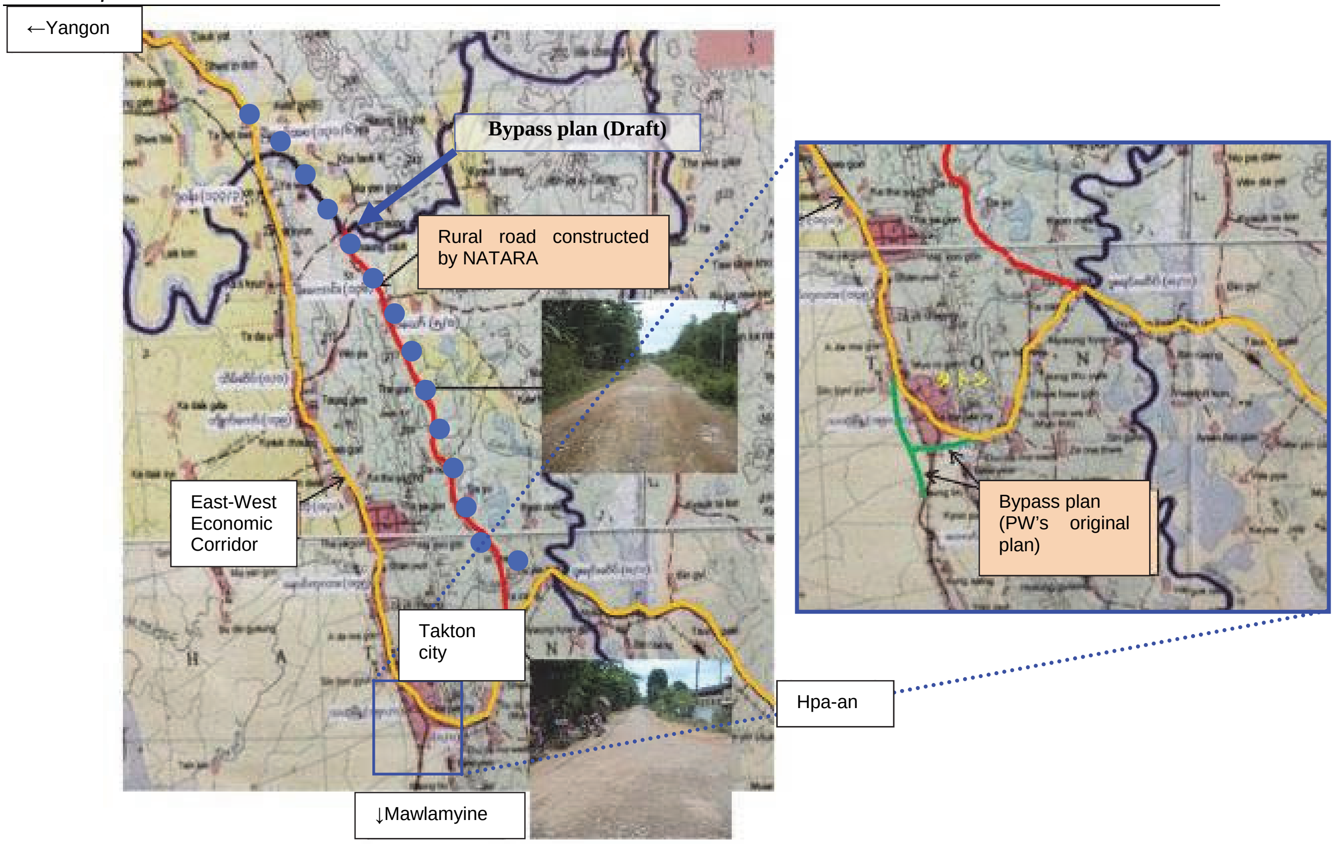
Table 3-3 Typical contents of the BOT agreement

Section	Kyaikto- Takton-Mawlamyine
Concessioner	Shwe Than Lwin Highway Co., Ltd.
Date of contract	July 25, 2010
Concession period	40 years
Major contents	- Development of two-lane (24-foot) road - Improvement by asphalt pavement to be done when the daily traffic volume exceeds 2,000 vehicles/day - Development of the road with the load carrying capacity of 60 tons (the load carrying capacity of bridges as per AASHTO HS 20-44） - Concessioner to collect tolls - Bridges under supervision of PWD to be excluded from the scope of supervision - Tax exempted for three years after contract conclusion. Subsequently, tax increased at a rate of 5% every 10 years - Concessioner to collect annual traffic volume data - Toll gate facilities to be constructed by the concessioner - The toll is to be equal to the product of the toll unit price multiplied by the length.

3.1.2 Public Works Department of the Ministry of Construction (Direct administration)

(1) Takton Bypass Plan

At present, the East-West Economic Corridor passes through the urban area of Takton. Considering that the traffic volume, including mainly large vehicles, will increase in the future, it would be desirable to plan a bypass diverging around the urban area. Actually, PWD of MOC has started a study on the Takton bypass plan in March, 2013, and established center lines (two green routes in following figure) of the bypass plan on the basis of an on-site survey. When we visited the site and proposed another route plan (the red routes in following figure), the PWD staff accompanying the visit reported the proposal to the Minister of MOC. As a result, the proposed route was said to be adopted since the construction of new bypass will shorten the travelling time for short-cut of access approximately 9km as well as be able to divert the large freight vehicles into the populated town area in Takton.



Source: JICA Study Team

Figure 3.2 Takton – East-West Economic Corridor Bypass Plan

To the north of the Takton urban area, there is a rural road developed in 2010 by the Ministry of Progress of Border Areas, National Races & Development Affairs. Though partially surfaced with asphalt, this rural road has many unpaved sections and its road surface condition is poor. All structures, such as culverts, etc., are temporary structures. For development of the Takton bypass, it is considered appropriate to upgrade the main road.

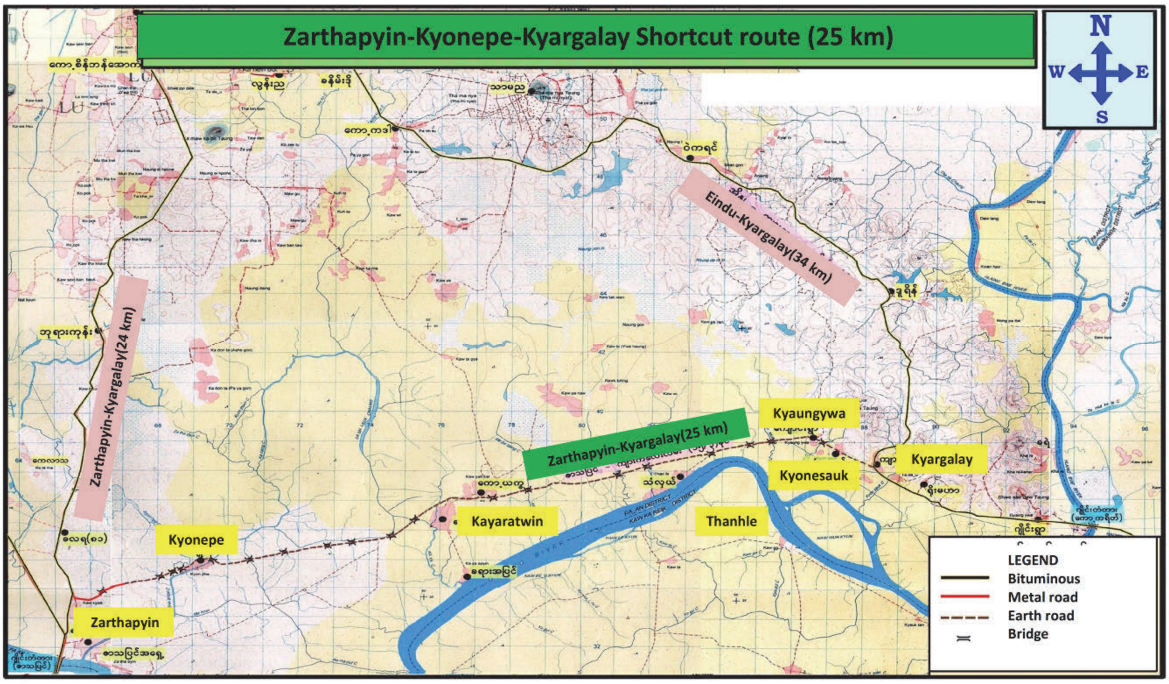
(2) Zathapyin – Kyagale Bypass

This was originally a route running parallel to and on the north side of the Gyaing River, which was developed by the Ministry of Progress of Border Areas, National Races & Development Affairs and completed in 2003. As compared with the existing Kyagale－ Eindu – Zathapyin route, this road can shorten the length by about 33 km. The administration of this road has already been transferred from the Ministry of Progress of Border Areas, National Races & Development Affairs to MOC. At present, PWD is implementing the road widening and base course that will be partially completed until next fiscal year of 2014. There are several bridges along the route, all of which are temporary ones and broken, so that they must be replaced with permanent bridges (the same applies to the box and pipe culverts).

	
Widening and subgrade construction are in operation by PWD.	Temporary bridge needs to be replaced

Source: JICA Study Team

Figure 3.3 Current Conditions of the Zathapyin – Kyagale Bypass

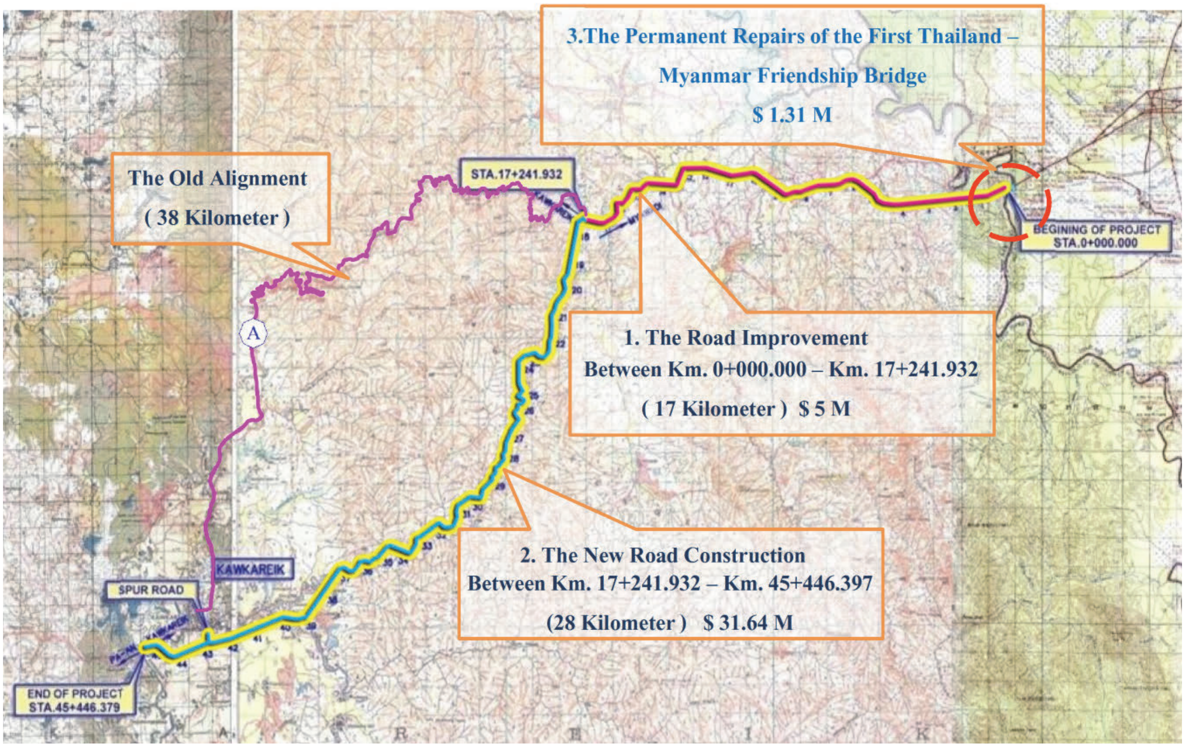


Source: PW

Figure 3.4 Zathapyin – Kyagale Bypass Plan

3.1.3 Thai Government

The Government of Thailand is currently implementing multiple projects in the section from Myawaddy to Kawkareik, as shown in following figure. Each project is outlined below. In all projects, the regulating authority of the Thai Government is the Department of Highways (DOH) and the SEE SANG KARN YOTAH (1979) Co., LTD. of Thailand is undertaking the work under the consignment agreement.



Source: JICA Study Team

Figure 3.5 Projects of the Thai Government in the Section from Myawaddy to Kawkareik

(1) Road Widening Project in Myawaddy-Thingannyinaung Section

At present, an existing road widening project is under way by the Government of Thailand for the section of about 17 km to the Myawaddy-Thingannyinaung section (= Foot of Dawna Range). The project cost is about 151,770,000 baht (= about 5,000,000USD). After widening, the road will be Class 3 (total width of 10 m) in the ASEAN Road Design Standard.

Under construction

After construction

Source: PW

Figure 3.6 Road Widening in Myawaddy-Thingannyinaung Section

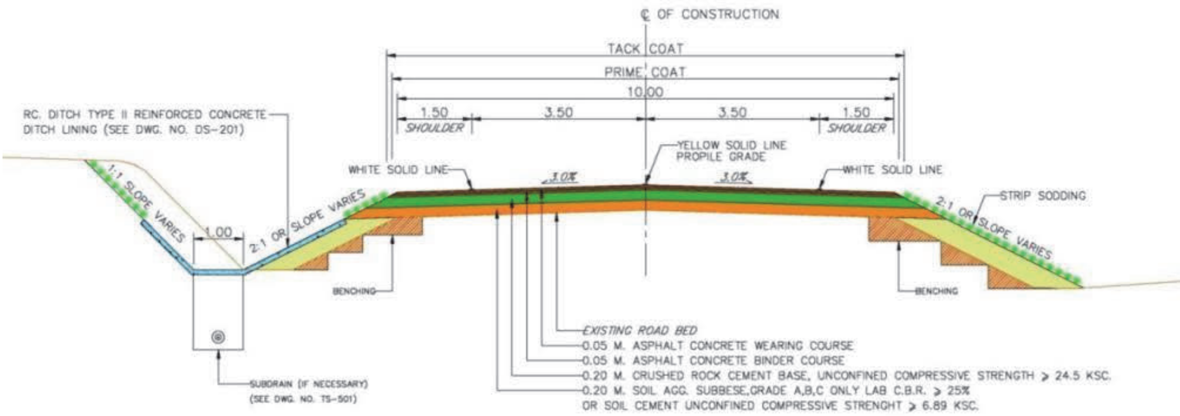
(2) Kawkareik – Thingannyinaung Bypass (Thai Government)

For the Thingannyinaung – Kawkareik section, a new bypass project of about 28 km is under way under financial assistance (soft loan) from the Thai Government. The road will be Class 3 (total width of 10 m) in the ASEAN Road Design Standard. The project cost is about 31,640,000 USD.

	
Widening and subgrade construction are in operation by PWD.	Temporary bridge needs to be replaced

Source : PW

Figure 3.7 Kawkareik – Thingannyinaung Bypass Project (as of March, 2013)



Source : PW

Figure 3.8 Standard Sectional View of Class-3 Road of the ASEAN Road Design Standard

For the land acquisition, the contractor of the project, SEE SANG KARN YOTAH (1979) Co., LTD. is dealing directly with regional residents and the local government. It appears that special methods are used here, in which the Karen National Union (KNU) and Democratic Karen Buddhist Army (DKBA) act as coordinators between both parties. The compensation cost is not included in the project cost and it appears that SEE SANG KARN YOTAH (1979) Co., LTD. is proceeding with land acquisition with its own funds. As of May, 2013, land acquisition is nearly completed, except for about an 8 km section (mainly, paddy fields) from Kawkareik.

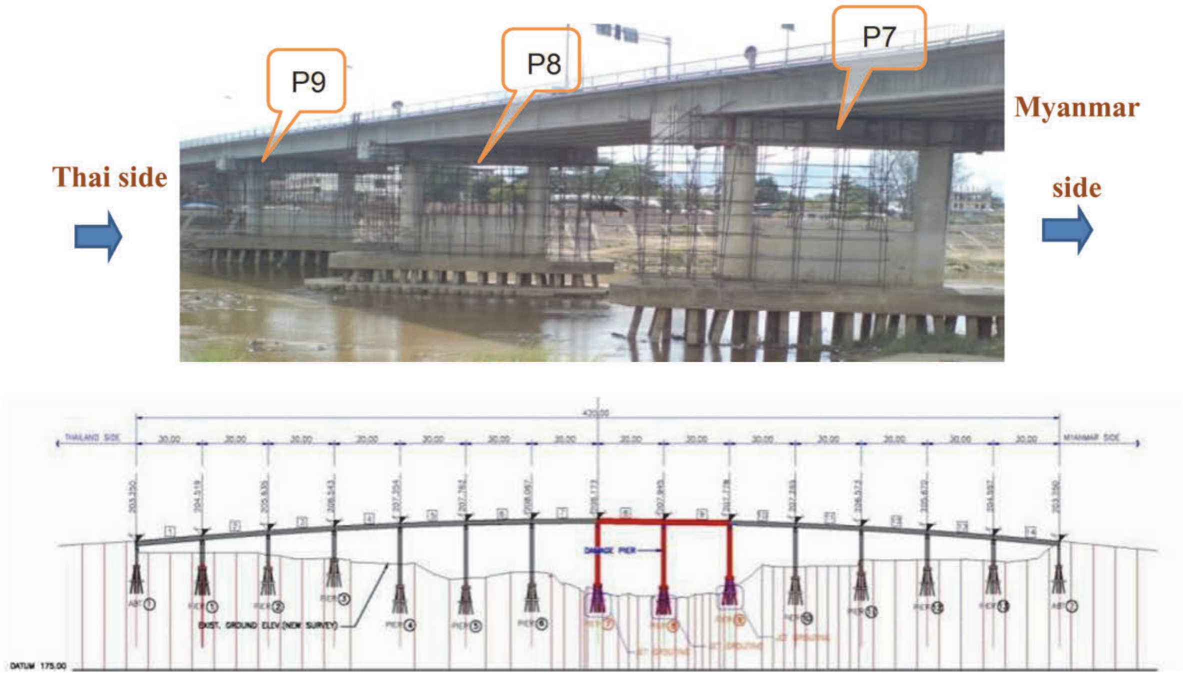
Source : PW

Figure 3.9 Land Acquisition by the Thailand Contractor

At present, SEE SANG KARN YOTAH (1979) Co.,LTD. is undertaking the provisional works and they are about 2% complete as of the end of April, 2013. The completion is scheduled for 2015. Development of the two-lane pavement road is expected to increase the traffic volume and traveling speed while decreasing accidents and vehicle failures. The road is also expected to greatly improve the physical flow access with Thailand.

(3) First Thailand – Myanmar Friendship Bridge Repair Work

The first Thailand – Myanmar Friendship Bridge is about 420 m long (selection of span length,14 x 30 m) and has the skew angle of 45° and the road width of 8 m. The 2.5 m sidewalk is provided on both sides. This was constructed under grant aid from the Thai Government with the project cost of 79,200,000 baht and completed in 1997. As the bridge faces trouble with its pier foundation piles projecting due to scouring as the result of change in the flow of the Moei (Thaungyin) River, repair by jet grouting is currently under way. The work is about 50% complete (as of April, 2013), and the work is scheduled to be completed in July, 2013. The repair work cost is 39,349,740 baht (about 1,310,000USD).



Source: PW

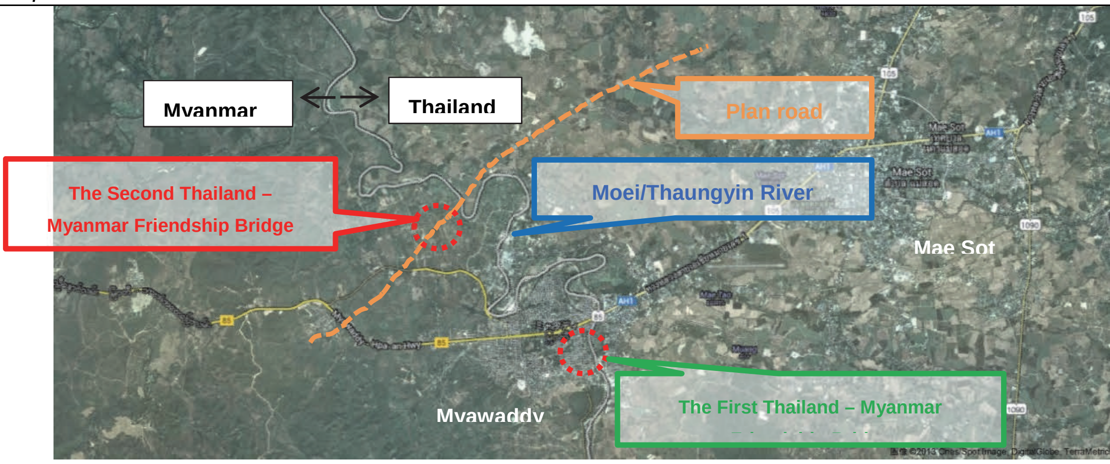
Figure 3.10 Current Conditions and General View of the First Thailand – Myanmar Friendship Bridge

Source: PW

Figure 3.11 Pier (P7) Repair Work for the First Thailand – Myanmar Friendship Bridge

(4) Second Thailand – Myanmar Friendship Bridge

A bypass is planned, which diverts the Myawaddy on its north side to connect to Thailand, and the Second Thailand – Myanmar Friendship Bridge will be constructed at the crossing site of the Moei (Thaungyin) River at the border. As of April, 2013, the Government of Thailand was conducting a feasibility study. Subsequently, the detailed design is scheduled to be done by July, 2014.



Source: JICA Study Team

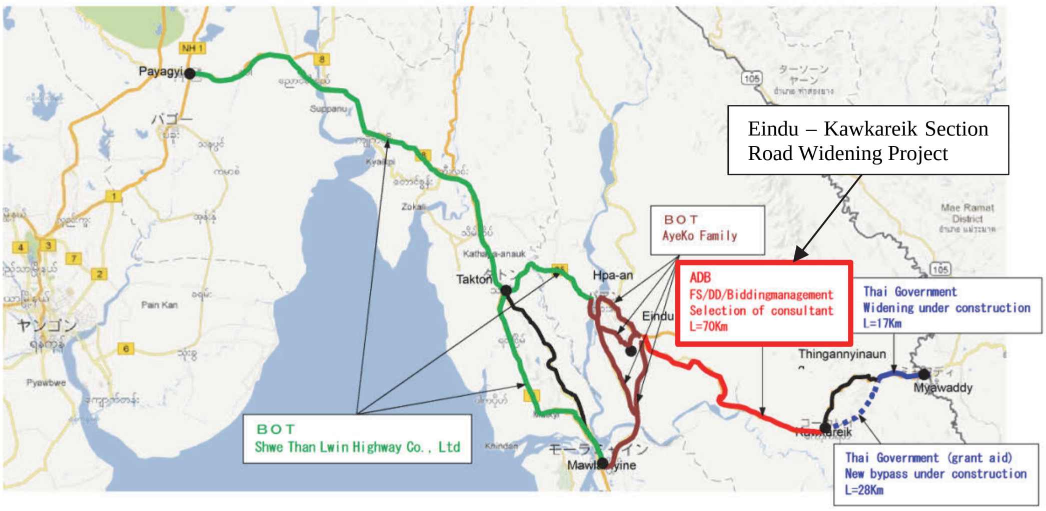
Figure 3.12 Second Thailand – Myanmar Friendship Bridge Plan Location Map

3.1.4 Related ADB Projects

(1) Eindu – Kawkareik Section Road Widening Project

For this section (about 70 km), ADB is proposing the realization of the GMS economic corridor plans to provide funds for road widening to the specified two-lane road as a part of GMS East-West Economic Corridor section. It is scheduled that the project preparation technical assistance (PPTA) including F/S and D/D was supposed to be implemented in August, 2013. Development of the two-lane pavement road is expected to increase the traffic volume and traveling speed while decreasing accidents and vehicle failures. The road is also expected to greatly improve the physical flow access with Thailand.

This section has originally been maintained and administered by the AyeKo Family, a private company of Myanmar, according to BOT. As ADB has assumed responsibility for the Project Preparation Technology Assistance (PPTA), the concession agreement was changed. The starting point of this route is at a connecting point with the Thingannyinaung – Kawkareik bypass currently being developed under grant aid from the Government of Thailand.



Source: JICA Study Team

Figure 3.13 Location of Eindu – Kawkareik Section Road Widening Project

① Scope of Works:

- ✓ The output of the project is improvement of the functions of the 70 km road between Eindu and Kawkareik (including the project development, preparation, implementation and training of the government stuff).
- ✓ TA was started in August, 2013, and is expected to be completed within 10 months.

② Phases:

③ Phase －1: F/S

④ Phase －2: Detailed design and procurement

3.1.5 Construction of Downa Range Tunnel

The construction project of about a 12 km bypass including the Dawna Range Tunnel is about to be started by Thai contractor (SEE SANG KARN YOTAH (1979) CO.LTD). At present, because of the narrowness of the mountain road section, regulation by direction every other day is enforced. This is said to be the worst bottleneck in the East-West Economic Corridor.

In the section of Kawkareilk and Myawaddy, the section of about 38 km is a mountain road crossing the Dawna Range 750 m above sea level and has the following problems:

- There are many sections where vehicles cannot pass, so Taktone-way regulation of either west-bound or east-bound traffic is done every second day. The transport efficiency is reduced to one half.
- The horizontal alignment only allows a traveling speed of 20 km/h because of many hairpin curves and sharp bends and because certain portions have a grade of 7% or more. Two hours are required to pass through this section.
- Large freight vehicles cannot cross the bridge at the border with Thailand, and only small freight cars can cross; a weight limit is enforced on this bridge.
- Poor surface condition plus poor alignment have caused many freight vehicles to fall into the valley, cargo collapses, etc.
- Slope failure occurs in the wet season, blocking the road on many days.

Fundamental measures must be taken so as to allow the East-West Economic Corridor to recover its original functions and to contribute to the economic growth. First of all, the road development targets must be established and it must be determined if it is feasible. The development targets (plan) may be as follows.

Development targets (plan)

①	Elimination of the section where vehicles cannot pass.
②	Improvement of horizontal alignment to enable traveling of large freight vehicles
③	Improvement of grade (6% or less is desirable) to facilitate traveling of large freight vehicles
④	Reduction of the road blocking period due to slope failure
⑤	Introduction of safety measures, such as preventive measures against vehicles running off the road, etc.
⑥	Minimization of the effects on existing traffic during the construction period

Proposed improvement plans may be as follows.

<u>Improvement of existing roads (plan):</u>

Options of ②, ③, and ⑥ among the development targets (plan) are extremely difficult to achieve.

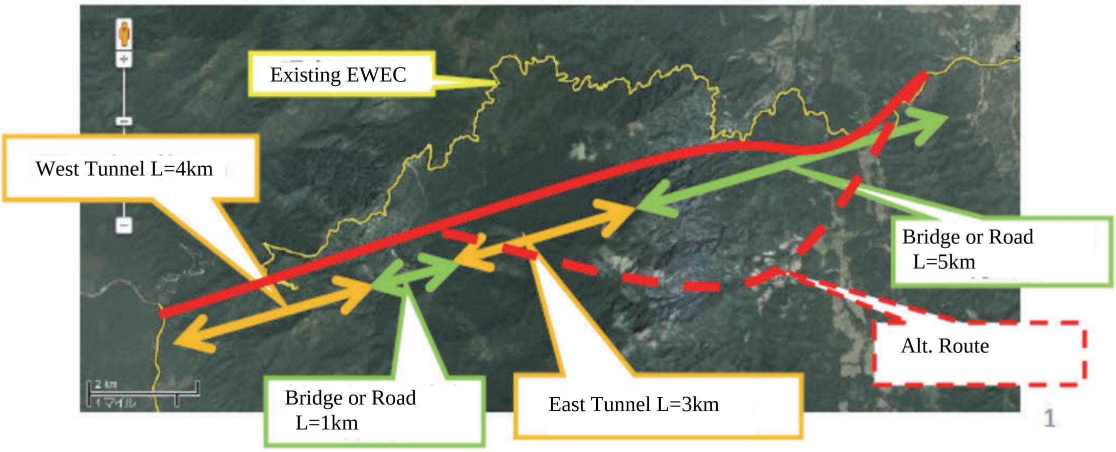
<u>Improvement of existing roads + tunnel construction in a part of the existing roads (plan):</u>

Options of ② and ③ of the targets are partially possible, but difficult to execute over the entire section. In particular, ⑥ is difficult to achieve in the approach section to the tunnel entrance.

<u>New establishment of a bypass route: (including tunnel construction)</u>

The development targets (plan) may be achieved, but with high construction costs.

To implement this operation, the development targets and their achievement timing will be identified on the basis of thorough coordination with the Myanmar counterpart. Then an alternative plan, including various tunnel plans, will be established for final selection of the best plan.



Source: JICA Study Team

Figure 3.14 Development Plan for Dawna Range Tunnel

Particular attention must be paid to the following points during planning:

- Selection of an adequate tunnel entrance (the tunnel length must be as short as possible, therefore, the approach to the tunnel entrance must also be short, and construction must be as easy as possible)
- Implementation of an adequate geological survey (the construction cost increases depending on the precision of the geological survey⇒ground classification by elastic wave exploration)
- Provide power for the equipment in the off the power grid area
- Planning of the work road for transport of excavated soil (selection of excavation on both sides or on one side) and confirmation of the muck disposal yard
- Establishment of a construction plan and environmental measures by taking into account the natural environment and residents living in the vicinity (including ethnic minority)
- Study on Special Terms for Economic Partnership (feasibility of utilization of Japanese technologies) for tunnel construction machinery (comparison with the machine and materials of a third country in terms of economic efficiency)

- Proposal for tunnel maintenance and administration after construction (organization and system, securing of the maintenance and management budget, charging, maintenance and operation through PPP）

3.1.6 Others

WB, China, India, and other donors do not plan any specific survey on the sections concerned. Korea conducted a road survey in the area concerned (including the Kawkareik – Mudon section (about 102 km) last October and submitted the report to PWD of MOC. No progress has been made toward any specific project since then.

Chapter 4 Transport Demand Forecast

4.1 Socio-economic Framework

Transport demand is determined by economic activities and demographic changes in the target area. For the purpose of this project, the demographic estimation has been developed for the regional population and GDP until the time horizon of 2030.

4.1.1 Population

Forecast population is summarized by state/region in Table 4-1. In summary, the population is expected to grow at 0.9% per annum between 2012 and 2030.

Table 4-1 Forecasts of Population by Region and State (thousand)

Region/State[1]	Year			
	2012	2015	2020	2030
Kachin	1,616	1,720	1,805	1,934
Kayah	365	391	424	451
Kayin	1,855	1,987	2,150	2,401
Chin	571	597	629	656
Sagaing	6,655	6,863	7,029	7,181
Tanintharyi	1,756	1,886	2,051	2,301
Bago East	3,379	3,509	3,700	3,986
Bago West	2,746	2,851	2,991	3,275
Magway	5,730	5,914	6,014	6,113
Mandalay	7,423	7,685	7,949	8,370
Mon	3,193	3,324	3,489	3,846
Rakhine	3,371	3,501	3,667	4,017
Yangon	7,171	7,617	8,739	10,446
Shan (South)	2,250	2,321	2,378	2,347
Shan (North)	2,627	2,710	2,789	2,979
Shan (East)	901	930	961	1,052
Ayeyarwady	8,205	8,520	8,684	8,864
Nay Pyi Taw	1,164	1,269	1,434	1,684
Total	60,978	63,595	66,883	71,903

Source: JICA Study Team

[1] Some national statistics combine the divisions of Bago and Shan. In these tables, they are separated for the purpose of additional detail.

4.1.2 GDP

Forecast GDP is summarized by state/region in Table 4-2. The growth in GDP is expected to average 7.1 % per annum resulting in a growth in GDP per capita of 6.1% per annum.

Table 4-2 Forecasts of GDP by Region and State (billion Kyats)

Region/State	Year			
	2012	2015	2020	2030
Kachin	1,097	1,317	1,858	3,466
Kayah	172	227	345	667
Kayin	829	1,032	1,504	3,583
Chin	154	182	253	542
Sagaing	5,509	6,322	7,731	12,321
Tanintharyi	1,679	1,941	2,645	5,862
Bago East	2,295	2,703	3,948	8,757
Bago West	1,732	1,998	2,633	5,367
Magway	4,631	5,172	6,582	9,660
Mandalay	5,185	6,388	9,914	22,781
Mon	2,063	2,502	3,560	7,580
Rakhine	1,856	2,243	3,419	7,676
Yangon	10,294	13,710	21,705	47,163
Shan (South)	1,349	1,483	1,898	3,307
Shan (North)	1,585	1,763	2,317	4,455
Shan (East)	437	507	715	1,425
Ayeyarwady	5,465	6,267	7,771	12,598
Nay Pyi Taw	581	810	1,280	3,290
Total	46,913	56,567	80,078	160,500

Source: JICA Study Team

4.2 Demand Forecast

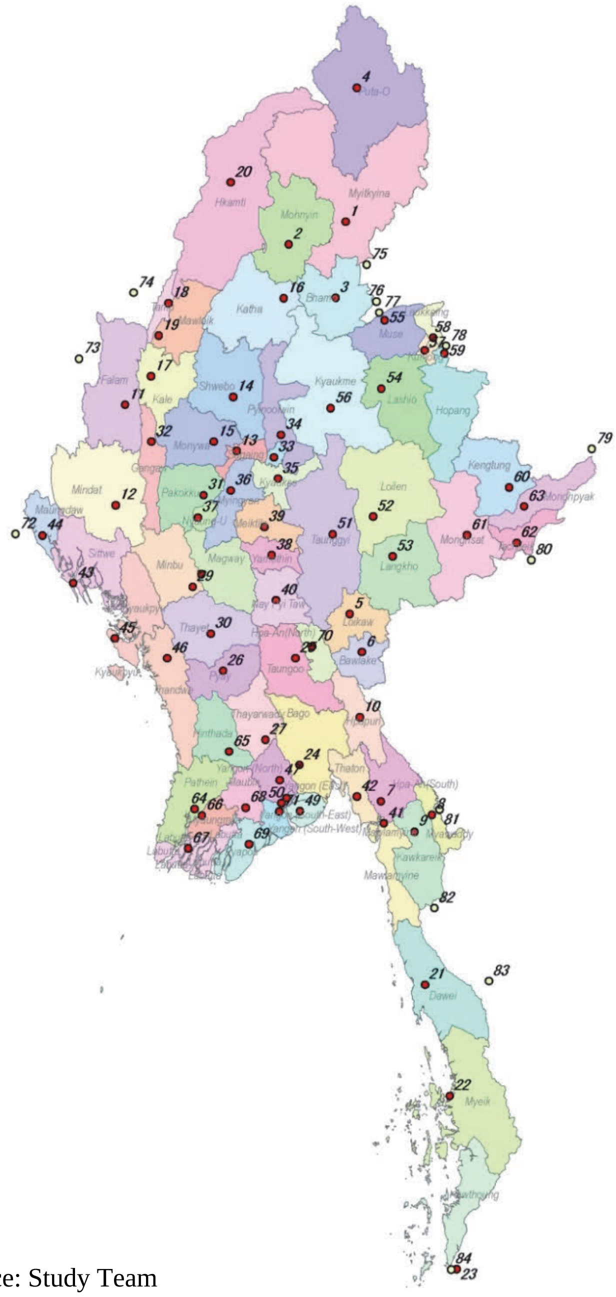
4.2.1 Precondition

(1) Target Year

Considering the data availability of existing traffic volume and the target year of the transport master plan, the base year was set as 2013 and the target years were set at 2015, 2020 and 2030.

(2) Zoning System

Target area for the demand forecast is the whole of Myanmar. Considering the availability of socio-economic data, Traffic Analysis Zones (TAZ) were set to approximate the districts of the Union. Yangon Region was divided into 5 TAZs taking into account the well-developed infrastructure and population density. Hpa-an district was also divided into two zones because of its having a detached territory.



Source: Study Team

Figure 4.1 Traffic Analysis Zones (TAZ)

4.2.2 Passenger Demand Forecast

(1) Methodology

Figure 4.2 shows the flow of passenger demand forecast in this study. Passenger demand is forecast based on the four-step estimation method. Based on the statistical information and traffic survey, existing inter-zonal traffic volume was estimated. Trip generation was estimated as a function of the future socio-economic indicator of each zone. Furthermore, modal share of each transportation mode was estimated comparing travel time and cost of each transportation mode between each zone.

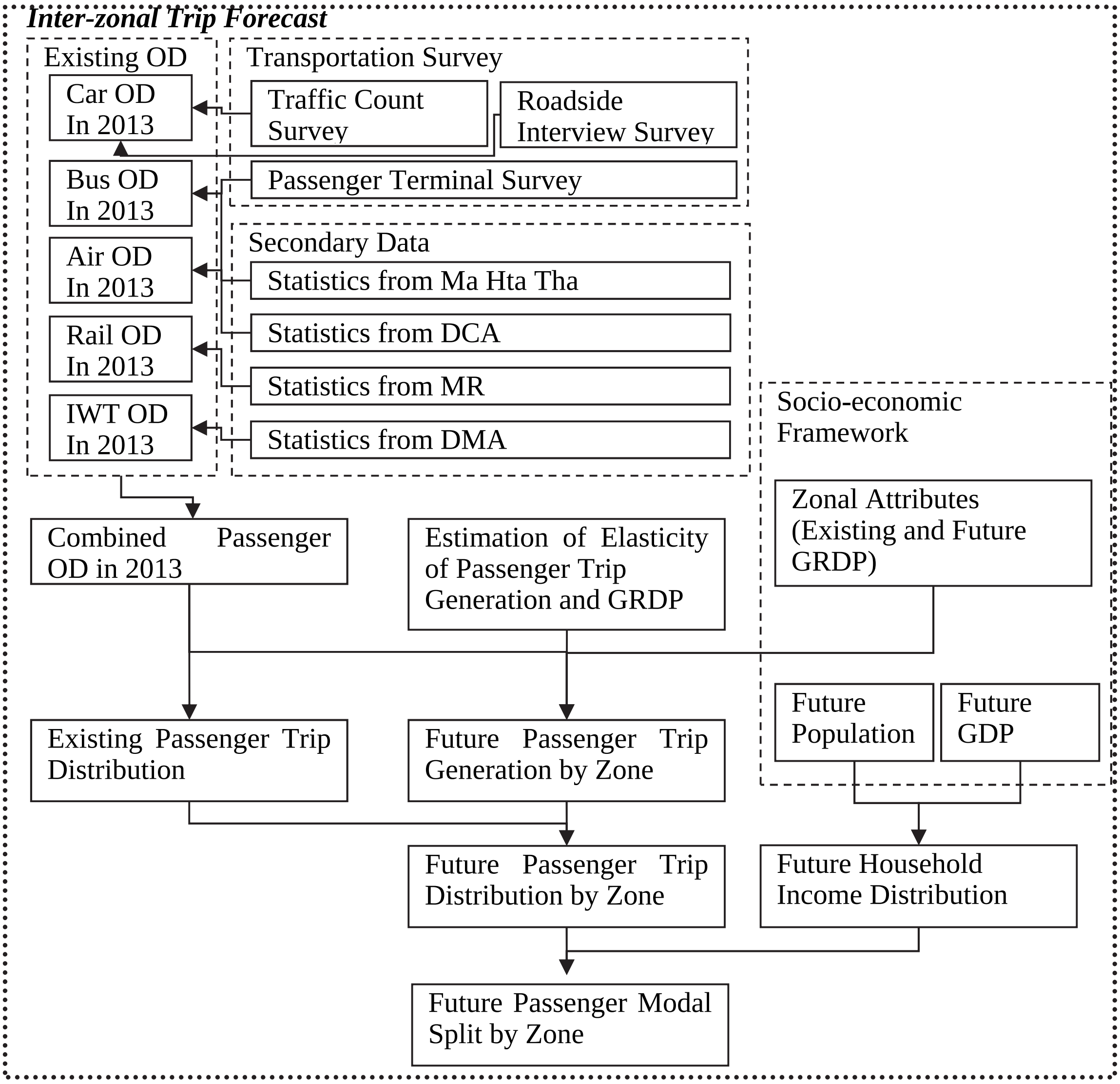


Figure 4.2 Flow of Passenger Demand Forecast

(2) Existing Passenger Movement

Existing passenger movement by car and bus was estimated based on the traffic survey in this study.

1) Bus Passenger Movement

Inter-zonal OD for bus passengers in 2013 was estimated based on a terminal interview survey and traffic count survey at bus terminals.

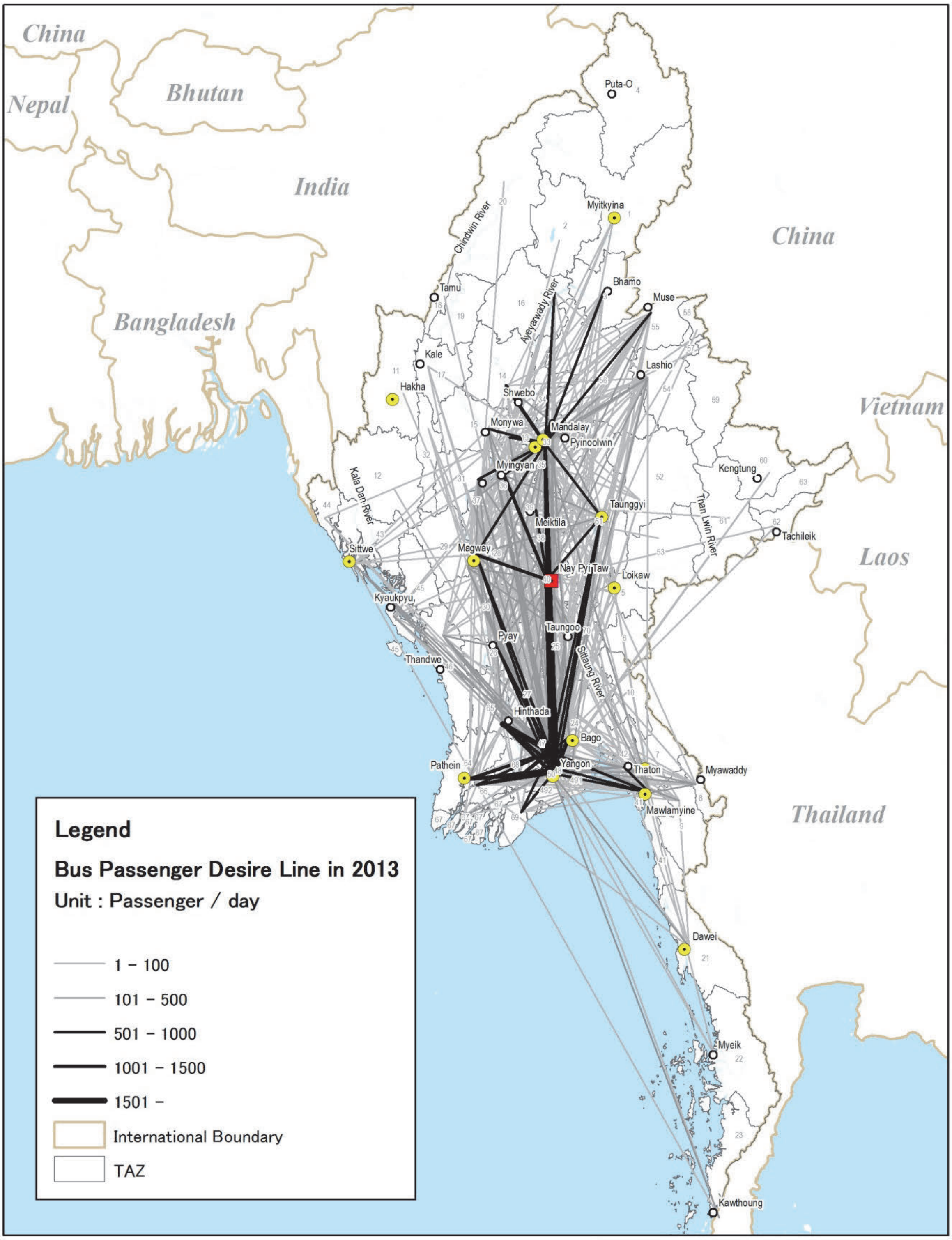


Figure 4.3 Desired Lines for Bus Passengers in 2013

Source: Study Team estimated based on transport survey

MYT-PLAN

0 50 100 200 300 Km

2) Passenger Car Movement

Inter-zonal OD for car passengers in 2013 was estimated based on a traffic count survey and road side interview.

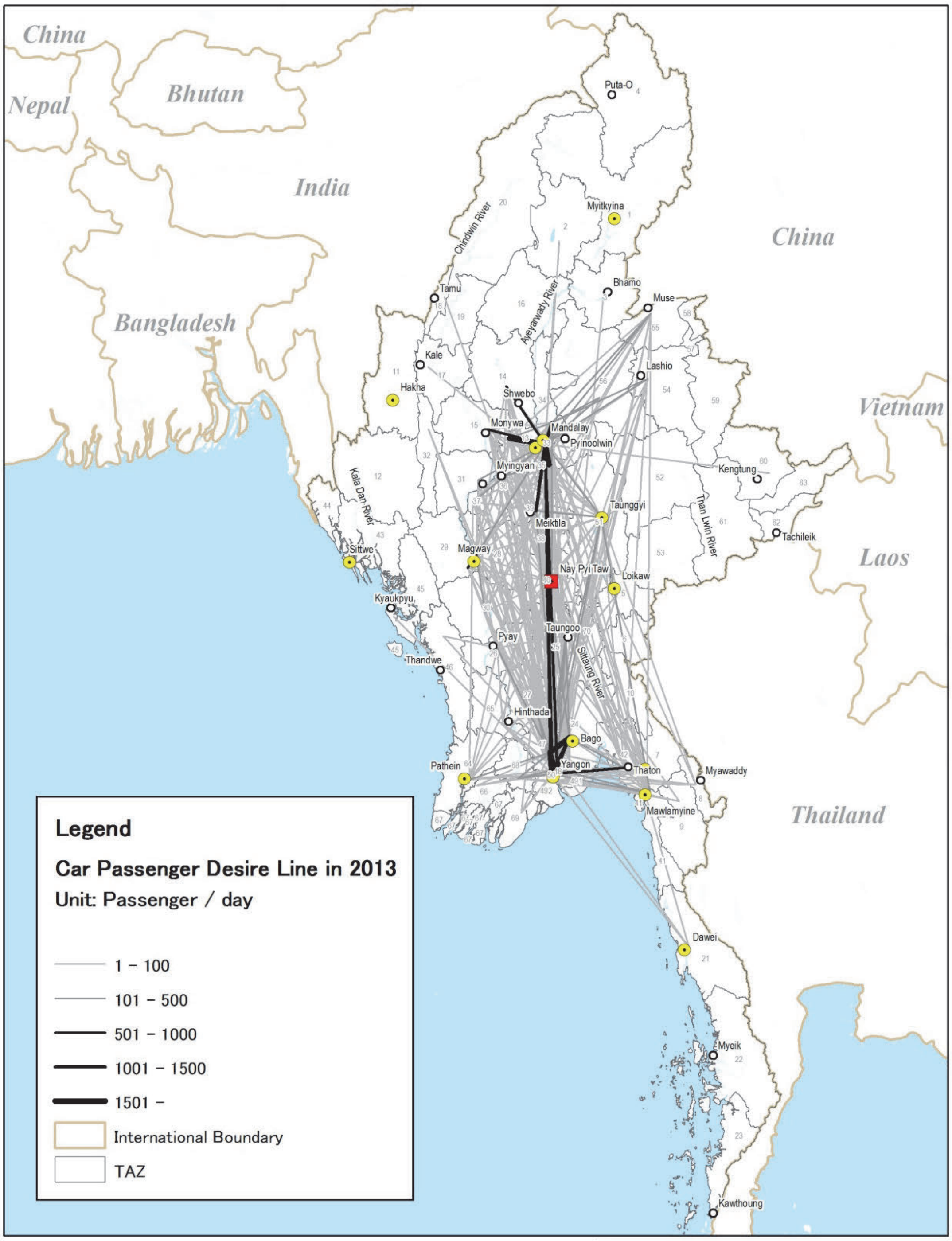


Figure 4.4 Desired Lines for Passenger Cars in 2013
Source: Study Team estimated based on transport survey

MYT-PLAN
0 50 100 200 300 Km

(3) Future Trip Generation

Population growth, economic development and improvement of income level will increase the trip generation volume. Considering examples of economic development and traffic growth in neighbouring countries, the GDP elasticity of trip generation from each zone from 2013 to 2015 and from 2015 to 2030 were defined as 1.0 and 1.2, respectively. Total Trip generation in 2013 is approximately 300 thousand persons per day. Trip generation in 2020 and 2030 is estimated at 0.55 million persons and 1.4 million persons, respectively.

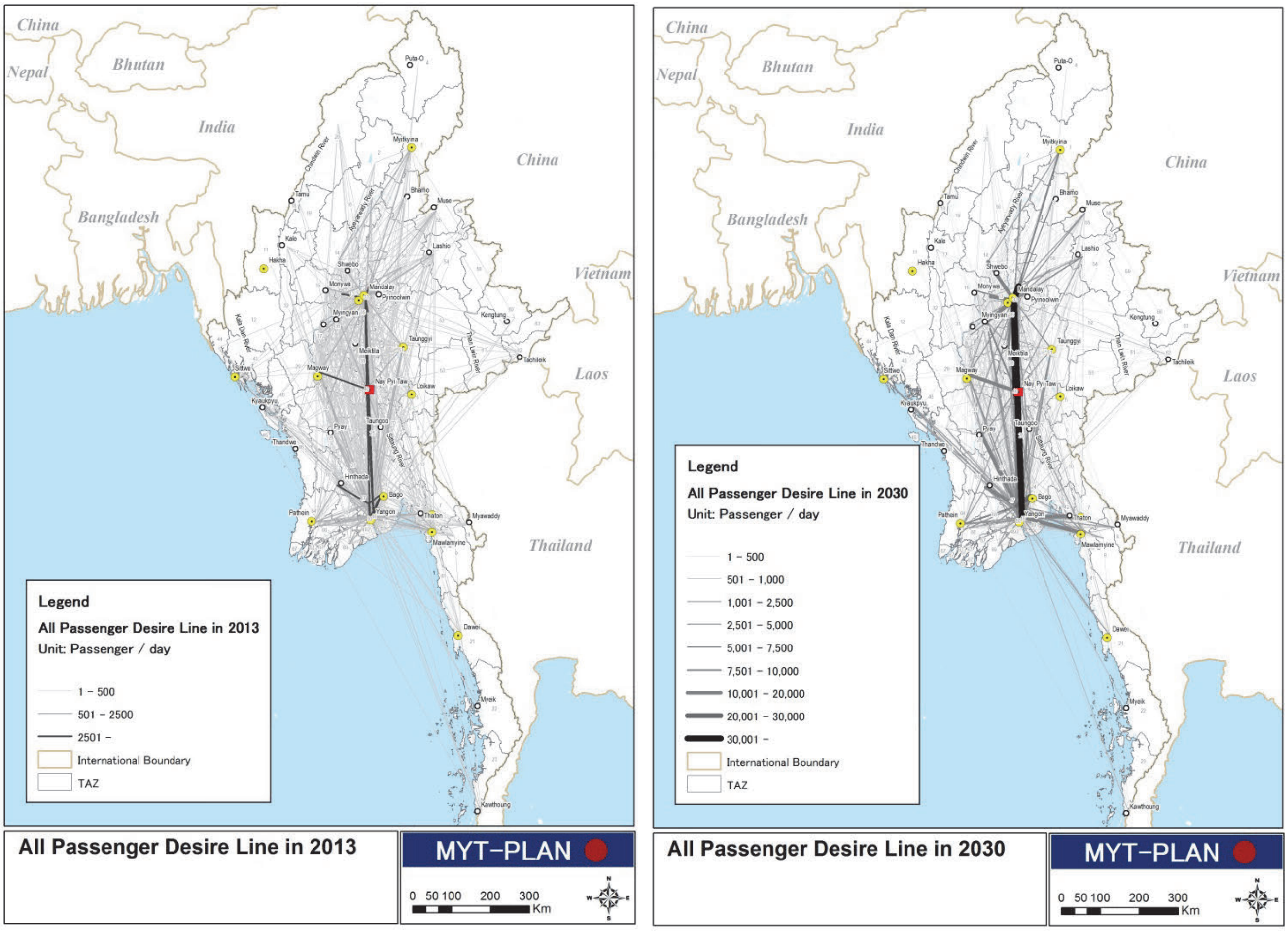
Table 4-3 Total Trip Generation, GDP and GDP Growth Ratio

	Y2013	Y2015	Y2020	Y2030
Total Trip Generation (1,000 Persons / day)	300	347	555	1,397
GDP (Billion Kyat)	49,901	56,567	80,078	160,500
Annual Average GDP Growth Ratio (%)		6.5%	7.2%	7.2%

Source: Study Team

(4) Future Trip Distribution

The person trip distribution for inter zone travel is estimated by the Frater method. Future trip distribution pattern was estimated by the Frater method. Figure 4.5 shows desired Lines as of 2013 and 2030.



Source: Study Team

Figure 4.5 Desired Lines for All Transportation Modes (Left:2013, Right 2030)

(5) Modal Split

The modal structure, that is, hierarchies of person trip types, associated with the person model is depicted in Figure 4.6. The person trips are distributed between five modes (air, private car, IWT, rail and bus) via a hierarchy of binary logic mode splits. This is henceforth referred to as a Hierarchical Binary mode split. In this case it is for three levels with four choices. The proportion of trips between any two zones, i and j that choose Choice one out of the subset of two choices is given as:

$$\frac{1}{1+\exp(-\lambda(C_{ij}^{2}-C_{ij}^{1}))}$$

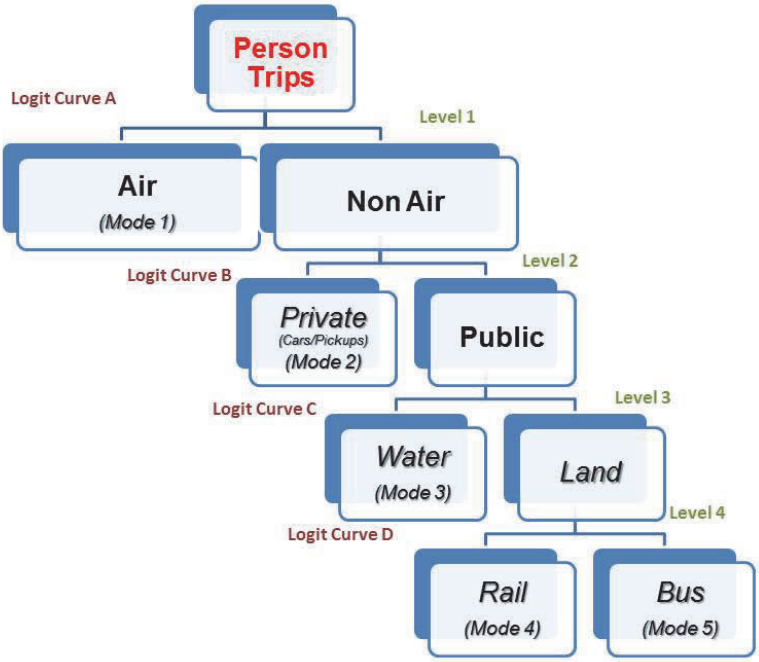
Where:

λ is the scale parameter and is defined in Table 4-4;

C_{ij}^{1} is the generalized cost of travel for hierarchical choice 1 between any two zones i and j; and

C_{ij}^{2} is the generalized cost of travel for hierarchical choice 2 between any two zones i and j.

The generalized cost of travel[2] is defined to include all perceived costs of travelling between any origin and destination. In the case of travel by car, this cost will include time, any tolls and the perceived fuel costs. In the case of non-car travel, the generalized cost includes fare, travel time and waiting time.



Source: Study Team

Figure 4.6 Modal Split Hierarchy

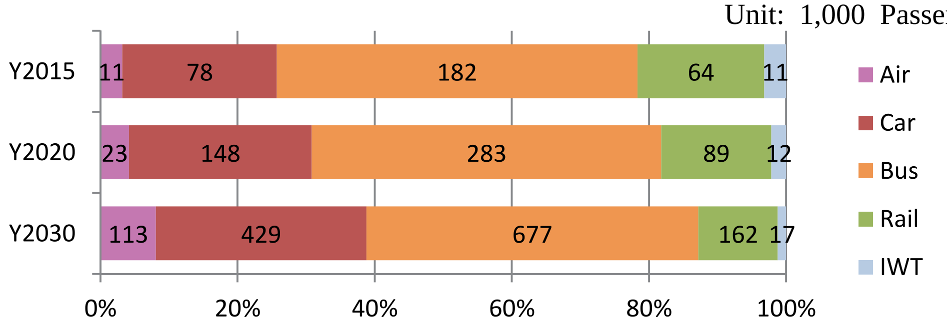
Table 4-4 Modal Choice Scale Parameters

Mode Split Equation Level	Economic Activity Class[3]	Choice 1	Choice 2	Scale Parameter
A	1	Air	Non-Air	0.0046
B	1	Car	Public	0.0033
C	1	IWT	Land Public	0.0072
D	1	Rail	Bus	0.0134
A	2	Air	Non-Air	0.0046
B	2	Car	Public	0.0033
C	2	IWT	Land Public	0.0092
D	2	Rail	Bus	0.0191
A	3	Air	Non-Air	0.0073
B	3	Car	Public	0.0082
C	3	IWT	Land Public	0.011
D	3	Rail	Bus	0.0237

Source: Study Team

[2] This perceived cost is in the form of equivalent minutes.
[3] Household Income Category:
Class 1 ≦150,000 Kyat/ month, 150,000 < Class 2 ≦ 400,000, Class3 < 400,000

Unit: 1,000 Passenger / day

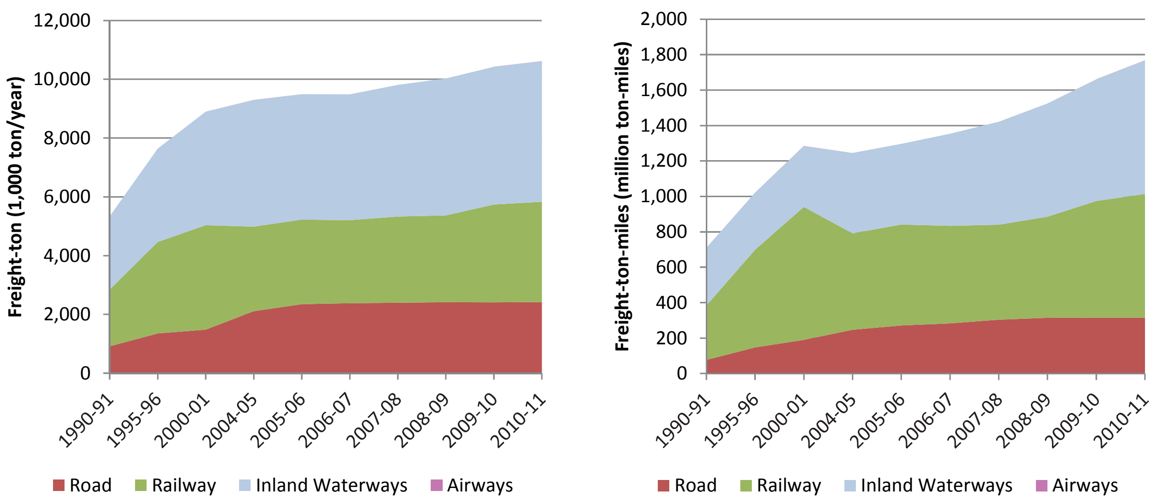


Source: JICA Study Team

Figure 4.7 National Passenger Volume by Transportation Mode

4.2.3 Freight Demand Forecast

Domestic cargo in Myanmar is carried by a wide range of transport modes; inland water transport, coastal transport, railway and road transport. The future freight demand can be estimated by obtaining the freight and transport characteristics of these transport modes.



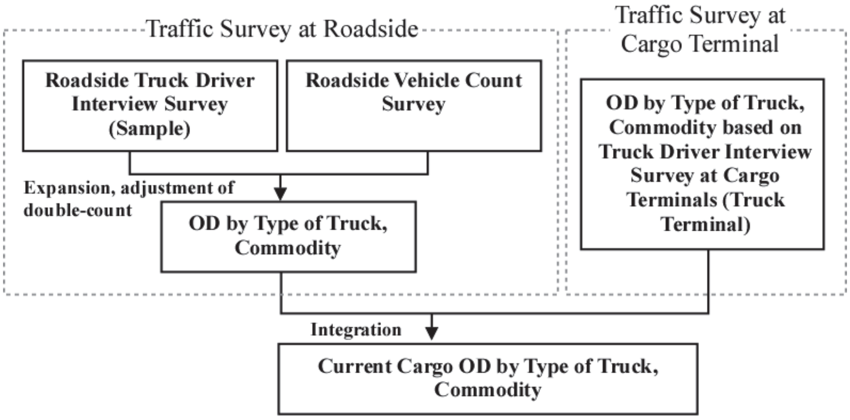
Source: Myanmar Statistical Yearbook 2011

Figure 4.8 Freight Traffic by Transport Mode

(1) Cargo by Truck

Current truck OD and its cargo volume are estimated by the roadside traffic survey and truck terminals, carried out under the MYT-Plan. The roadside traffic survey, consisting of a vehicle count survey and driver interview survey, was carried out at major inter-city arterial roads. The driver interview survey is a sampling survey and the sampled interview result is expanded by the observed number of vehicles in the vehicle count survey. As a result of the analysis, commodity flow and travel characteristics of truck transport, including average loading tons, empty truck ratio, and average travel time, were obtained. The truck driver interview survey was carried out at cargo terminals; major river ports, railway stations and truck terminals.

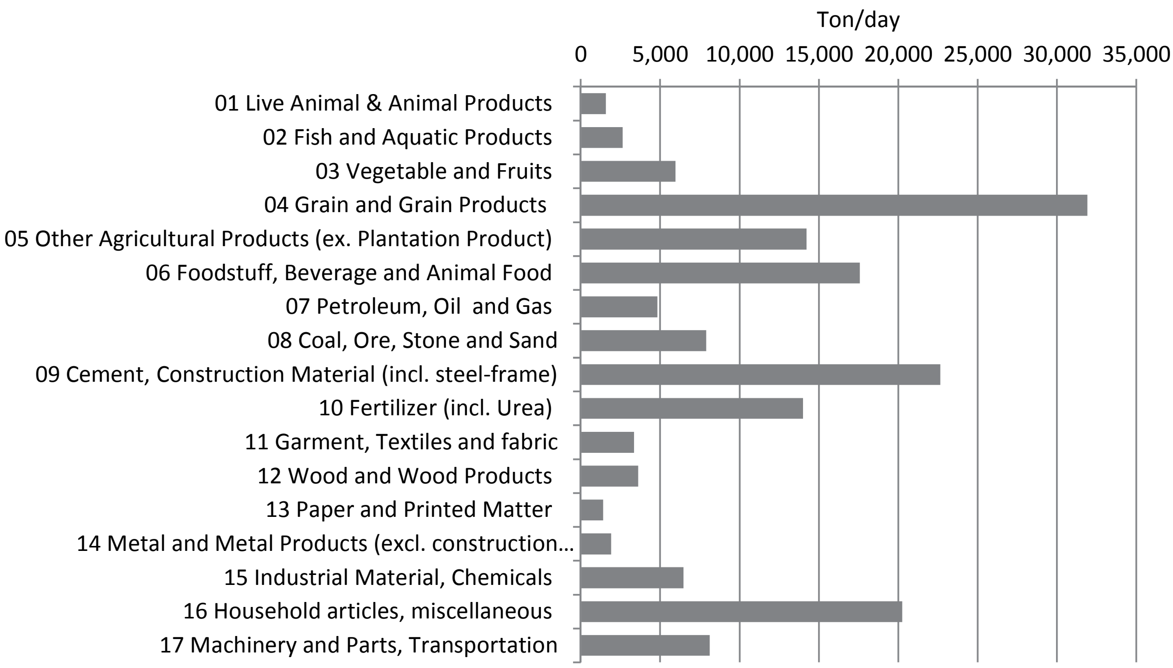
Using the results of the roadside survey and cargo terminal survey, current cargo OD is estimated by truck type and commodity type.



Source: JICA Study Team

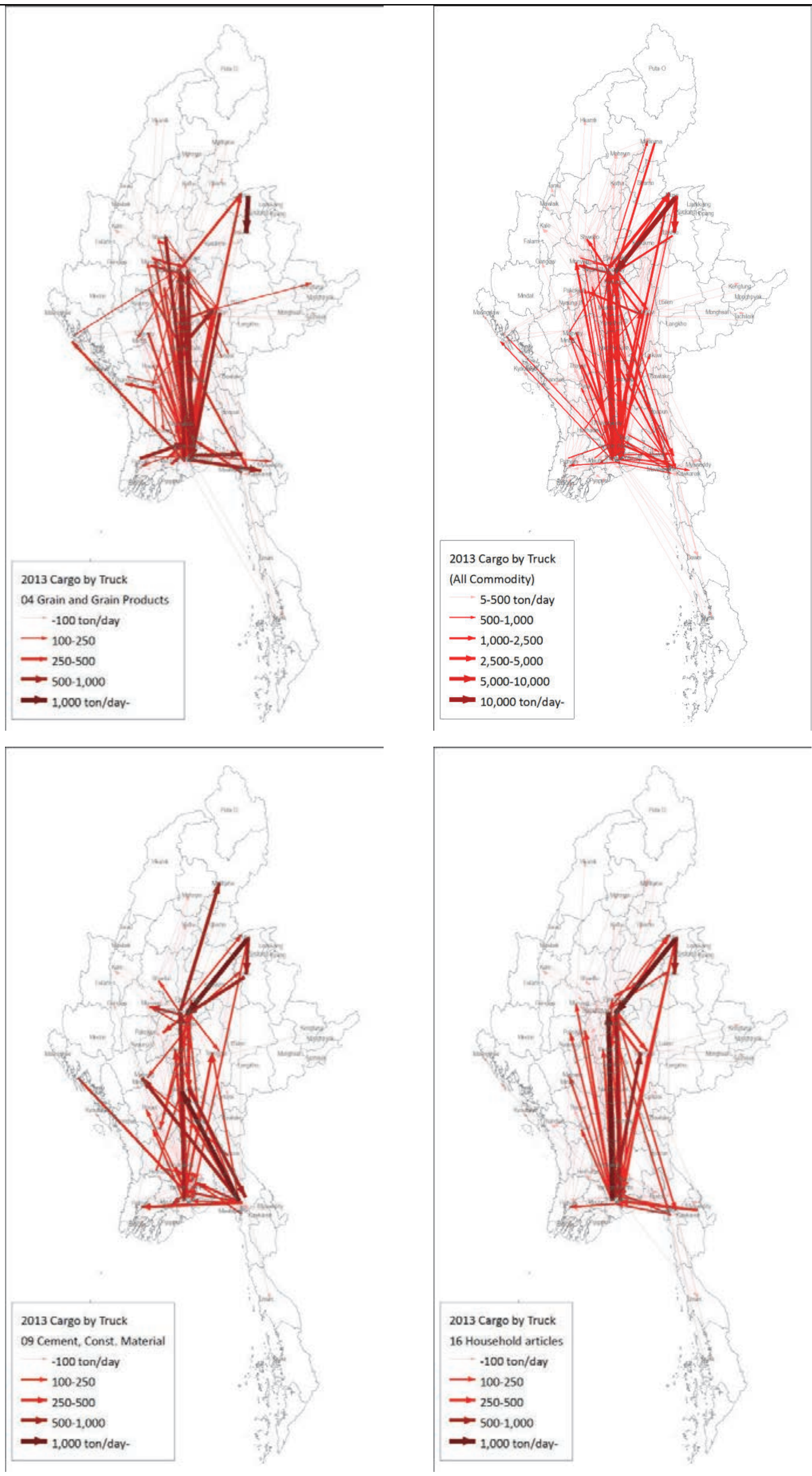
Figure 4.9 Workflow of Current Truck Freight OD Estimation

The volume of the cargo carried by truck is estimated at about 168 thousand ton per day at present. The major cargo carried by the truck includes grains such as rice (19%), construction materials such as cement (13%), miscellaneous (12%), foodstuffs and beverages (10%) as shown in the following figure.



Source: JICA Study Team

Figure 4.10 Estimated 2013 Cargo Volume by Truck



Source: JICA Study Team

Figure 4.11 Desire Lines of 2013 Truck Cargo (Total and Three Major Commodities)

(2) Current Cargo Flow

As a result of preparatory work on the current freight OD matrix, the total of the domestic cargo volume is estimated at 209 thousand tons per day. The share of the truck cargo is dominant and accounts for 81% of the total freight volume, followed by coastal transport (10%), inland water (5%) and railway (5%).

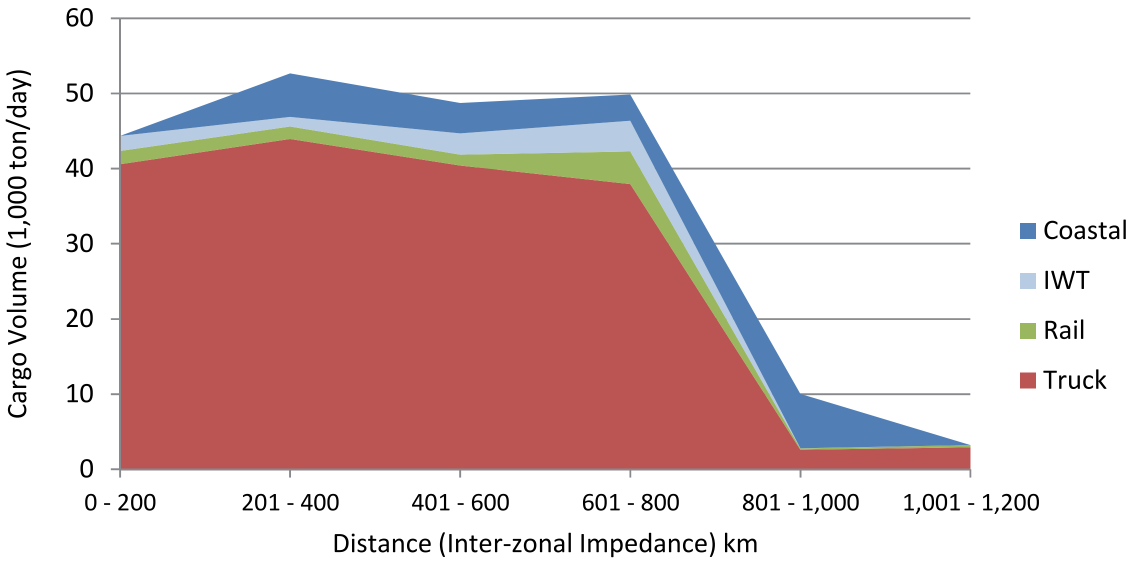
Table 4-5 Estimated 2013 Freight Volume by Mode and Commodity

unit: thousand ton/day

Commodity	Truck	Inland water	Railway	Coastal	Total
1 Live Animals & Animal Products	1.6	0.0	0.0	0.0	1.6
2 Fish and Aquatic Products	2.6	0.0	0.0	0.0	2.7
3 Vegetables and Fruits	6.0	0.0	0.0	0.0	6.0
4 Grain and Grain Products	31.9	0.7	0.4	1.3	34.3
5 Other Agricultural Products (ex. Plantation Products)	14.2	0.6	0.1	0.0	15.0
6 Foodstuffs, Beverages and Animal Food	17.6	1.4	2.5	4.1	25.6
7 Petroleum, Oil and Gas	4.8	3.2	0.3	13.4	21.8
8 Coal, Ore, Stone and Sand	7.9	0.2	0.3	0.0	8.4
9 Cement, Construction Material (incl. steel frames)	22.7	1.5	2.7	1.2	28.0
10 Fertilizer (incl. Urea)	14.0	0.1	0.1	0.0	14.2
11 Garments, Textiles and fabric	3.3	0.1	0.0	0.0	3.5
12 Wood and Wood Products	3.6	0.5	1.7	0.0	5.8
13 Paper and Printed Matter	1.4	0.0	0.1	0.0	1.5
14 Metal and Metal Products (excl. construction material)	1.9	0.1	0.3	0.0	2.3
15 Industrial Material, Chemicals	6.5	0.1	0.5	0.3	7.4
16 Household articles, miscellaneous	20.3	1.3	0.6	0.3	22.5
17 Machinery and Parts, Transportation	8.1	0.2	0.1	0.0	8.4
Total	168.4	10.2	9.6	20.6	208.9
Share	81%	5%	5%	10%	100%

Source: JICA Study Team

The following figure shows distance-wide cargo distribution by transport mode. As illustrated, 94% of domestic cargo travels a distance of less than 800 km. The truck is a dominant transport mode, which carries the majority of the cargo even for longer distances. When the travel distance exceeds 800 km, both truck and coastal transport carry considerable amounts of the cargo.



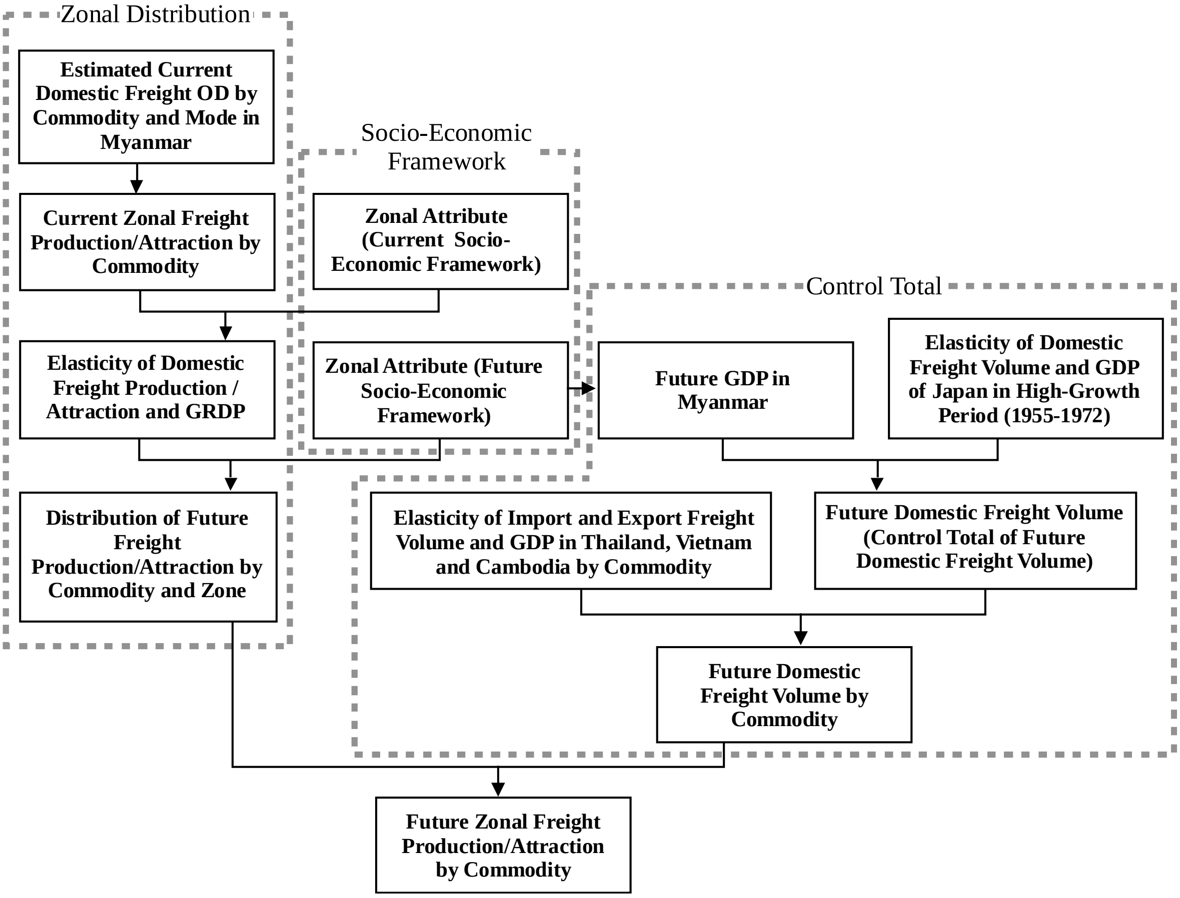
Source: JICA Study Team

Figure 4.12 Cargo Trip Distribution by Travel Distance

(3) Demand Forecast Model

1) Future Cargo Generation

Future cargo generation in the study area is estimated following the workflow illustrated in the figure. The calculation method of the future cargo generation consists of two steps; (i) control total which is the total domestic cargo volume of the entire study area and (ii) zonal distribution which is the cargo production and attraction by traffic analysis zone.



Source: JICA Study Team

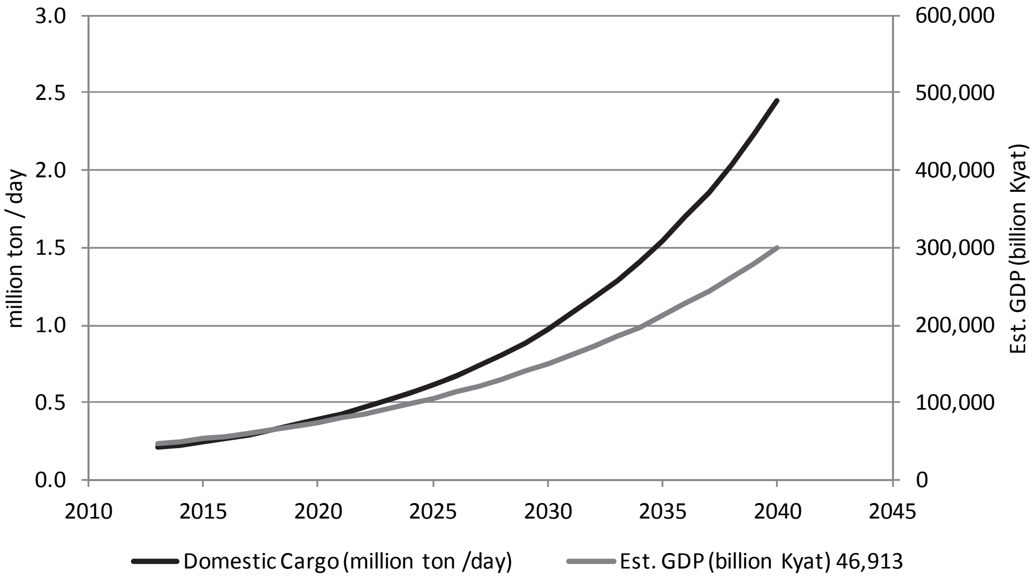
Figure 4.13 Workflow of Future Zonal Cargo Generation

2) Control Total

A control total is the total domestic cargo flow volume of all transport modes and all types of commodities, and is estimated based on the existing total domestics cargo flow volume and an expansion factor calculated based on future GDP growth rate and elasticity of domestic cargo volume to GDP.

Elasticity of domestic cargo volume to GDP is calculated by a regression model in Japan during high-economic growth period (1960 - 1972) and is 1.342 (R^2 = 0.993).

Based on projected future GDP and the elastic factor of domestic cargo flow, future domestic cargo volume in Myanmar is forecast as shown in the following figure. In 2040, total domestic cargo volume in Myanmar is expected to reach 2.45 million tons per year, 11.7 times the total domestic cargo in 2013.



Source: JICA Study Team

Figure 4.14 Estimated Future Domestic Cargo Volume in Myanmar

A control total by type of commodity is also estimated based on the elasticity of import/export volume to GDP in Thailand, Vietnam and Cambodia. The following table gives the defined elasticity factor that was applied for the cargo generation in this study.

Table 4-6 Elasticity of Export / Import Volume by Type Commodities

Commodity	Elasticity to GDP
1 Live Animals & Animal Products	1.22
2 Fish and Aquatic Products	1.76
3 Vegetables and Fruits	1.18
4 Grains and Grain Products	1.74
5 Other Agricultural Products (ex. Plantation Products)	2.13
6 Foodstuffs, Beverages and Animal Food	1.30
7 Petroleum, Oil and Gas	1.84
8 Coal, Ore, Stone and Sand	2.21
9 Cement, Construction Material (incl. steel-frame)	1.93
10 Fertilizer (incl. Urea)	1.09
11 Garments, Textiles and fabric	1.24
12 Wood and Wood Products	1.14
13 Paper and Printed Matter	1.05
14 Metal and Metal Products (excl. construction material)	1.29
15 Industrial Material, Chemicals	1.33
16 Household articles, miscellaneous	1.80
17 Machinery and Parts, Transportation	1.40

Source: JICA Study Team

Based on the estimated control total of future domestic cargo volume and elasticity of each commodity to the GDP, future domestic cargo volume is forecast by commodity type as shown in following table. As a result, major commodities transported in Myanmar include construction material (460,000 ton per day), grains/grain products (408,000 ton), agricultural products (344,000 ton), petrol and gas (305,000 ton).

Table 4-7 Forecast Future Domestic Cargo Flow in Myanmar

unit: 1,000 ton/day

Commodity	2013	2015	2020	2030	2040
1 Live Animals & Animal Products	3.6	1.8	2.4	4.4	7.7
2 Fish and Aquatic Products	7.6	3.2	5.1	13.2	32.6
3 Vegetables and Fruits	14.5	6.7	8.9	15.7	26.5
4 Grains and Grain Products	84.1	41.0	65.7	167.0	408.1
5 Other Agricultural Products (ex. Plantation Product)	40.0	18.7	33.9	110.0	343.6
6 Foodstuffs, Beverages and Animal Food	51.7	28.9	40.1	76.3	139.3
7 Petroleum, Oil and Gas	14.4	26.2	43.4	117.3	304.6
8 Coal, Ore, Stone and Sand	18.0	10.6	19.7	67.1	219.7
9 Cement, Construction Material (incl. steel-frame)	55.8	34.2	58.2	166.8	459.7
10 Fertilizer (incl. Urea)	41.1	15.6	20.3	33.7	53.9
11 Garments, Textiles and fabric	10.2	3.9	5.4	9.9	17.4
12 Wood and Wood Products	11.2	6.4	8.4	14.5	24.0
13 Paper and Printed Matter	4.5	1.6	2.1	3.3	5.2
14 Metal and Metal Products (excl. construction material)	5.0	2.6	3.7	7.0	12.7
15 Industrial Material, Chemicals	19.8	8.4	11.8	22.9	42.9
16 Household articles, miscellaneous	62.1	27.0	44.3	116.9	296.9
17 Machinery and Parts, Transportation	25.9	9.7	13.9	28.4	55.7
Total	208.9	246.5	387.3	974.2	2,450.4

Source: JICA Study Team

3) Zonal Distribution

Based on estimated cargo production/attraction volume and zonal attributes, elasticity of cargo production/attraction to Gross Regional Domestic Product (GRDP) is calculated as shown in the following table. Future cargo production and attraction is prepared by zone (Traffic Analysis Zone), adjusting to the control total after it is computed based on current cargo production and attraction, future GRDP by zone and elasticity of cargo production and attraction to GRDP.

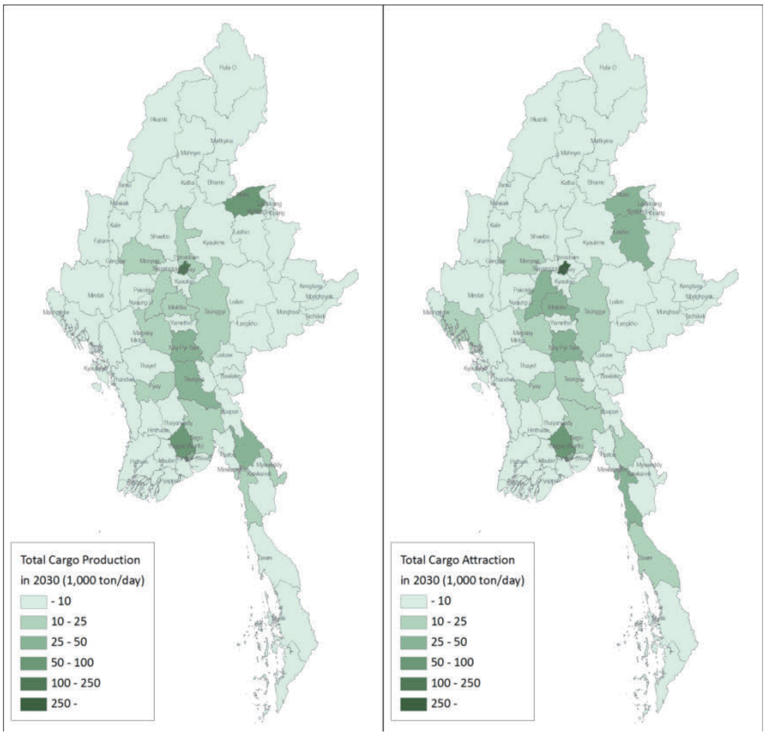
Table 4-8 Elasticity of Domestic Cargo Production and Attraction to GRDP

Commodity	Cargo Production	Cargo Attraction
1 Live Animals & Animal Products	0.315	1.560
2 Fish and Aquatic Products	0.554	2.552
3 Vegetables and Fruits	0.803	0.819
4 Grains and Grain Products	1.274	0.771
5 Other Agricultural Products (ex. Plantation Product)	1.304	0.988
6 Foodstuffs, Beverages and Animal Food	0.942	0.961
7 Petroleum, Oil and Gas	1.178	1.170
8 Coal, Ore, Stone and Sand	0.400	1.512
9 Cement, Construction Material (incl. Steel-frame)	1.024	1.663
10 Fertilizer (incl. Urea)	1.663	1.831
11 Garments, Textiles and fabric	0.850	1.644
12 Wood and Wood Products	0.462	1.757
13 Paper and Printed Matter	0.858	0.579
14 Metal and Metal Products (excl. Construction Material)	1.621	0.384
15 Industrial Material, Chemicals	1.698	0.685
16 Household articles, miscellaneous	1.252	1.030
17 Machinery and Parts, Transportation	0.950	1.013

Source: JICA Study Team

4) Future Cargo Production and Attraction

Future cargo production and attraction is distributed as shown in the following figures.



Source: JICA Study Team

Figure 4.15 Forecast Future Cargo Generation

5) Future Cargo Distribution

The Fratar growth factor method, as shown in the following formula, was applied to forecast future cargo OD by type of commodity.

$$T_{ij} = t_{ij} \cdot \frac{G_i}{g_i} \frac{A_j}{a_j} \cdot \frac{1}{2} \left(\frac{g_i}{\sum_j t_{ij} \cdot A_j / a_j} + \frac{a_j}{\sum_i t_{ij} \cdot G_i / g_i} \right)$$

where, *Tij*: Future cargo distribution at zone i to j,

Gi: Future cargo production at zone i,

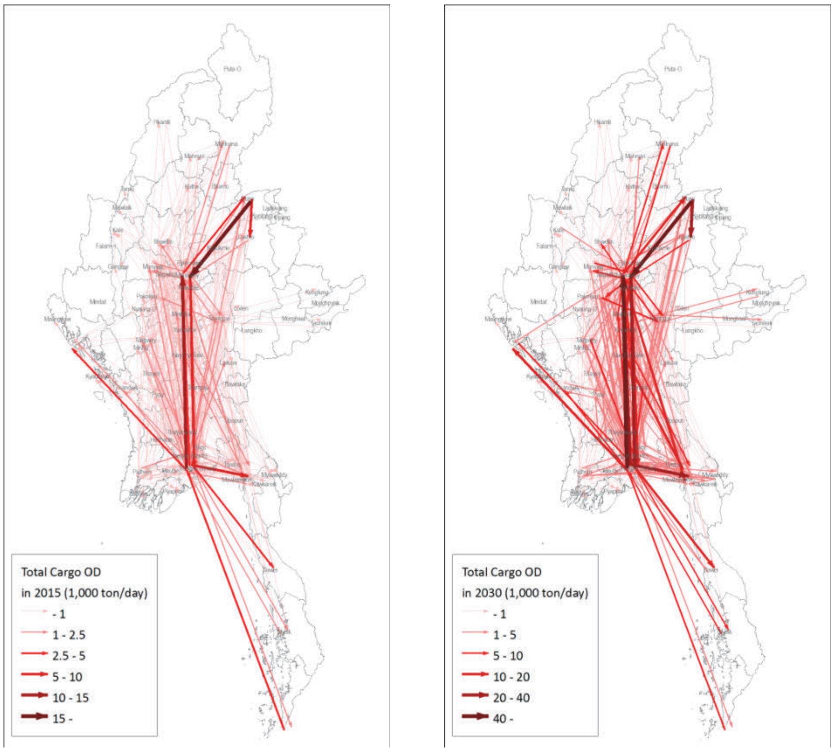
Aj: Future cargo attraction at zone j,

tij: Current cargo distribution at zone i to j,

gi: Current cargo production at zone i, and

aj: Current cargo attraction at zone j.

Estimated future cargo ODs are indicated in the following figures.



Source: JICA Study Team

Figure 4.16 Forecast Future Cargo OD (All Commodities)

6) Future Modal Split

Forecast future cargo by type of commodity is divided into each transport mode; costal, inland water transport, railway and truck by using a logit model.

$$P_i = \frac{\exp(U_i)}{\exp(U_i) + \exp(U_j)}$$

where, $U_i = a \cdot time_i + b \cdot \text{cost}_i$

$$Uj = a \cdot time_j + b \cdot \text{cost}_j$$

Ui: Utility of mode i,

$time_i$: Travel time of mode i,

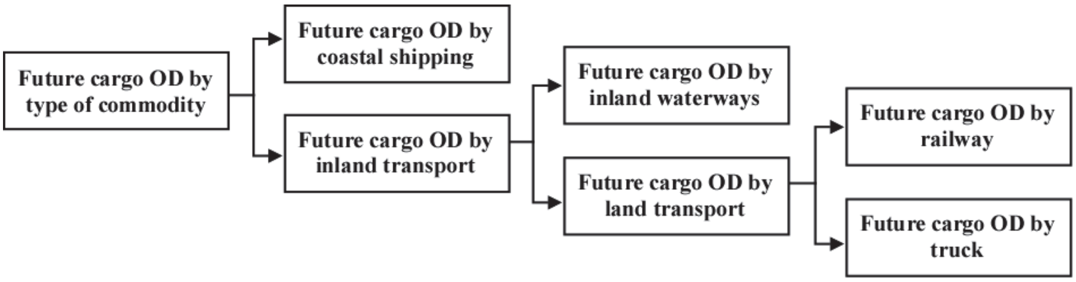
$cost_i$: Cost of mode i,

Uj: Utility of mode j,

$time_j$: Travel time of mode j, and

$cost_j$: Cost of mode j,

The modal split model is developed in the three steps by type of commodity, applying the binary choice model, (i) coastal shipping - inland transport, (ii) inland waterways and land transport, and (iii) railway and truck.



Source: JICA Study Team

Figure 4.17 Binary Choice Type Modal Split Model

The following tables show estimated parameters for the modal split model computed based on current cargo OD by commodity and transport mode.

Table 4-9 Parameters for Modal Split Model 1 (Coastal - Land Transport)

Commodity	intercept	(Time_Land) -(Time_Coastal)	(Cost_Land) -(Cost_Coastal)	R2
1 Live Animals & Animal Products	-	-	-	-
2 Fish and Aquatic Products	-	-	-	-
3 Vegetables and Fruits	-	-	-	-
4 Grains and Grain Products	-4.5860	-0.2244	-0.0001	0.8504
5 Other Agricultural Products (ex. Plantation Product)	-	-	-	-
6 Foodstuffs, Beverages and Animal Food	0.8766	-0.0004	-0.0004	0.7852
7 Petroleum, Oil and Gas	-	-	-	-
8 Coal, Ore, Stone and Sand	-	-	-	-
9 Cement, Construction Material (incl. Steel-frame)	-10.8428	-0.2622	-0.0002	0.8223
10 Fertilizer (incl. Urea)	-	-	-	-
11 Garments, Textiles and fabric	-	-	-	-
12 Wood and Wood Products	-	-	-	-
13 Paper and Printed Matter	-	-	-	-
14 Metal and Metal Products (excl. Construction Material)	-	-	-	-
15 Industrial Material, Chemicals	-1.4294	-0.0858	-0.0004	0.5360
16 Household articles, miscellaneous	1.4364	-0.0355	-0.0004	0.5738
17 Machinery and Parts, Transportation	-9.1314	-0.0847	-0.0001	0.9584

Source: JICA Study Team

Table 4-10 Parameters for Modal Split Model 2 (IWT - Land Transport)

Commodity	intercept	(Time_Land) -(Time_River)	(Cost_Land) -(Cost_River)	R2
1 Live Animals & Animal Products	1.2754	-0.0314	0.0000	0.5787
2 Fish and Aquatic Products	2.3079	-0.0601	-0.0001	0.6536
3 Vegetables and Fruits	3.7516	-0.0142	0.0000	0.4659
4 Grains and Grain Products	1.6748	-0.0194	-0.0001	0.4280
5 Other Agricultural Products (ex. Plantation Product)	0.7821	-0.0158	-0.0001	0.6127
6 Foodstuffs, Beverages and Animal Food	-0.4133	-0.0387	-0.0004	0.6713
7 Petroleum, Oil and Gas	-1.2808	-0.0386	-0.0008	0.6969
8 Coal, Ore, Stone and Sand	0.5921	-0.0741	-0.0006	0.9647
9 Cement, Construction Material (incl. Steel-frame)	1.6728	-0.0087	-0.0003	0.5192
10 Fertilizer (incl. Urea)	2.9320	-0.0283	-0.0003	0.4003
11 Garments, Textiles and fabric	1.6906	-0.0219	-0.0004	0.5049
12 Wood and Wood Products	2.0427	-0.0169	-0.0004	0.9789
13 Paper and Printed Matter	3.9057	-0.0172	-0.0003	0.6502
14 Metal and Metal Products (excl. Construction Material)	-1.1756	-0.0412	-0.0001	0.5042
15 Industrial Material, Chemicals	-0.6727	-0.0732	-0.0006	0.7014
16 Household articles, miscellaneous	0.6300	-0.0173	-0.0001	0.5060
17 Machinery and Parts, Transportation	-0.1859	-0.0628	-0.0006	0.6602

Source: JICA Study Team

Table 4-11 Parameters for Modal Split Model 3 (Railway - Truck)

Commodity	intercept	(Time_Truck) -(Time_Rail)	(Cost_Truck) -(Cost_Rail)	R2
1 Live Animals & Animal Products	-	-	-	-
2 Fish and Aquatic Products	-	-	-	-
3 Vegetables and Fruits	-	-	-	-
4 Grains and Grain Products	-0.8966	-0.3892	-0.0008	0.5338
5 Other Agricultural Products (ex. Plantation Product)	-4.7785	-0.6994	-0.0015	0.5116
6 Foodstuffs, Beverages and Animal Food	-0.7408	-0.2078	-0.0003	0.6553
7 Petroleum, Oil and Gas	-14.4599	-1.2397	-0.0026	0.6679
8 Coal, Ore, Stone and Sand	2.8238	-0.0121	-0.0001	0.5394
9 Cement, Construction Material (incl. Steel-frame)	-3.0991	-0.1828	-0.0010	0.5839
10 Fertilizer (incl. Urea)	1.4067	-0.1803	-0.0006	0.5132
11 Garments, Textiles and fabric	-0.2128	-0.1772	-0.0010	0.5916
12 Wood and Wood Products	-16.5696	-0.5941	-0.0034	0.7840
13 Paper and Printed Matter	-1.3076	-0.1718	-0.0012	0.5996
14 Metal and Metal Products (excl. Construction Material)	-9.2513	-0.6487	-0.0022	0.5597
15 Industrial Material, Chemicals	-1.5760	-0.1760	-0.0008	0.5230
16 Household articles, miscellaneous	-1.9646	-0.5891	-0.0006	0.6127
17 Machinery and Parts, Transportation	2.5323	-0.0287	-0.0004	0.7430

Source: JICA Study Team

(4) Forecast Future Cargo Transport

The following tables and figures show the results of forecast future domestic cargo OD in the case of without any project. The modal share is decided by transport time and cost between different modes, therefore, modal share and OD by mode will change depending on the future transport network improvement.

Table 4-12 Forecast Future Cargo Volume in 2015

unit: 1,000 ton/day

Commodity	Truck	Inland water	Railway	Coastal	Total
1 Live Animals & Animal Products	1.7	0.0	0.0	0.0	1.8
2 Fish and Aquatic Products	3.1	0.0	0.0	0.0	3.1
3 Vegetables and Fruits	6.6	0.0	0.0	0.0	6.6
4 Grains and Grain Products	38.1	0.8	0.5	1.5	40.9
5 Other Agricultural Products (ex. Plantation Product)	17.7	0.8	0.2	0.0	18.6
6 Foodstuffs, Beverages and Animal Food	20.1	1.6	2.8	4.4	28.9
7 Petroleum, Oil and Gas	5.7	4.3	0.4	15.8	26.2
8 Coal, Ore, Stone and Sand	9.9	0.2	0.4	0.0	10.6
9 Cement, Construction Material (incl. Steel-frame)	27.5	1.9	3.3	1.4	34.1
10 Fertilizer (incl. Urea)	15.4	0.1	0.1	0.0	15.6
11 Garments, Textiles and fabric	3.7	0.1	0.0	0.0	3.9
12 Wood and Wood Products	4.0	0.5	1.9	0.0	6.3
13 Paper and Printed Matter	1.5	0.0	0.1	0.0	1.6
14 Metal and Metal Products (excl. Construction Material)	2.1	0.1	0.3	0.0	2.6
15 Industrial Material, Chemicals	7.0	0.7	0.3	0.4	8.4
16 Household articles, miscellaneous	24.3	1.6	0.7	0.3	27.0
17 Machinery and Parts, Transportation	9.3	0.2	0.1	0.0	9.7
Total	197.9	13.1	11.1	23.8	246.0
Share	80%	5%	5%	10%	100%

Source: JICA Study Team

Table 4-13 Forecast Future Cargo Volume in 2020

unit: 1,000 ton/day

Commodity	Truck	Inland water	Railway	Coastal	Total
1 Live Animals & Animal Products	2.3	0.0	0.0	0.0	2.4
2 Fish and Aquatic Products	5.0	0.0	0.0	0.0	5.1
3 Vegetables and Fruits	8.8	0.0	0.0	0.0	8.9
4 Grains and Grain Products	61.6	1.3	0.7	2.1	65.7
5 Other Agricultural Products (ex. Plantation Product)	32.1	1.5	0.3	0.0	33.8
6 Foodstuffs, Beverages and Animal Food	28.8	2.2	4.0	5.2	40.1
7 Petroleum, Oil and Gas	9.5	8.3	0.8	24.7	43.3
8 Coal, Ore, Stone and Sand	18.5	0.3	0.8	0.0	19.6
9 Cement, Construction Material (incl. Steel-frame)	46.7	3.6	5.8	2.0	58.2
10 Fertilizer (incl. Urea)	20.0	0.1	0.1	0.0	20.2
11 Garments, Textiles and fabric	5.1	0.2	0.1	0.0	5.3
12 Wood and Wood Products	5.2	0.7	2.4	0.0	8.4
13 Paper and Printed Matter	1.9	0.0	0.1	0.0	2.0
14 Metal and Metal Products (excl. Construction Material)	3.0	0.2	0.5	0.0	3.6
15 Industrial Material, Chemicals	9.5	0.7	0.5	0.5	11.2
16 Household articles, miscellaneous	40.0	2.7	1.1	0.4	44.2
17 Machinery and Parts, Transportation	13.4	0.3	0.2	0.1	13.9
Total	311.5	22.2	17.4	34.9	386.0
Share	81%	6%	4%	9%	100%

Source: JICA Study Team

Table 4-14 Forecast Future Cargo Volume in 2030

unit: 1,000 ton/day

Commodity	Truck	Inland water	Railway	Coastal	Total
1 Live Animals & Animal Products	4.2	0.1	0.0	0.0	4.3
2 Fish and Aquatic Products	13.0	0.0	0.0	0.0	13.0
3 Vegetables and Fruits	15.5	0.0	0.0	0.0	15.6
4 Grains and Grain Products	157.4	3.2	1.8	4.4	166.9
5 Other Agricultural Products (ex. Plantation Product)	104.0	5.0	0.8	0.0	109.9
6 Foodstuffs, Beverages and Animal Food	56.2	3.5	7.6	8.9	76.2
7 Petroleum, Oil and Gas	30.3	21.0	1.9	63.9	117.1
8 Coal, Ore, Stone and Sand	63.4	0.8	2.6	0.0	66.9
9 Cement, Construction Material (incl. Steel-frame)	136.9	10.1	15.5	4.2	166.7
10 Fertilizer (incl. Urea)	33.3	0.2	0.2	0.0	33.7
11 Garments, Textiles and fabric	9.4	0.3	0.1	0.0	9.8
12 Wood and Wood Products	9.1	1.1	4.2	0.0	14.4
13 Paper and Printed Matter	3.1	0.0	0.1	0.0	3.2
14 Metal and Metal Products (excl. Construction Material)	5.8	0.3	0.8	0.0	6.9
15 Industrial Material, Chemicals	19.6	0.9	1.0	0.9	22.3
16 Household articles, miscellaneous	106.2	7.1	2.8	0.8	116.8
17 Machinery and Parts, Transportation	27.4	0.5	0.3	0.1	28.3
Total	794.9	54.3	39.8	83.1	972.1
Share	82%	6%	4%	9%	100%

Source: JICA Study Team

4.2.4 Traffic Assignment for Pre-Feasibility Study on Road Improvement Project

Based on the estimated passenger and freight distribution described in the previous sections the vehicular OD matrix was developed, applying the average number of passengers (for passenger cars and buses) and average loaded volume (for trucks). The 2013, 2020 and 2030 vehicular OD matrixes were prepared and assigned to the existing and future road networks. The following figures show the result of the traffic assignment.

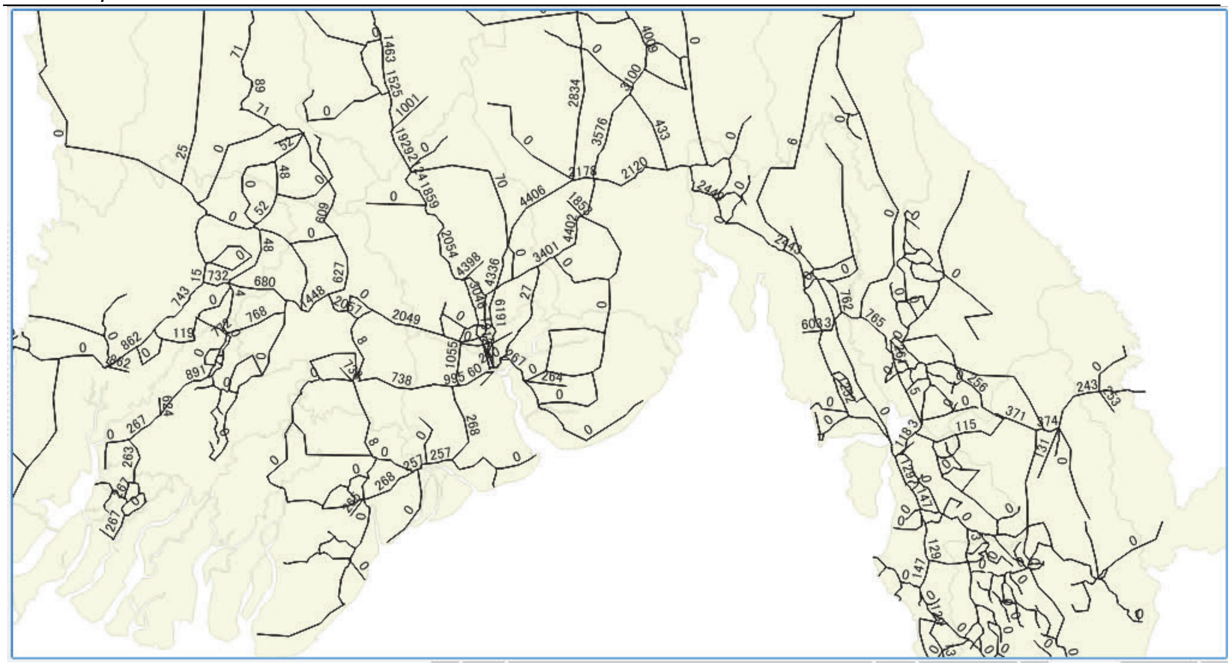


Figure 4.18 2013 Traffic Assignment (Yangon and Southern Regions)

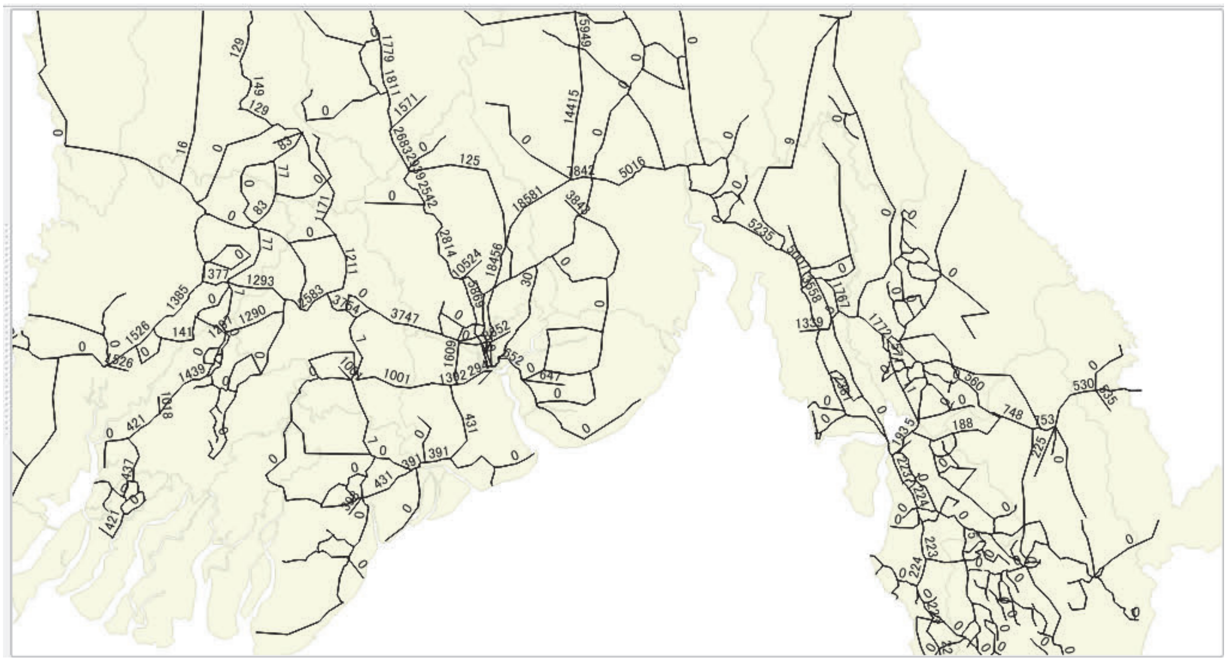


Figure 4.19 2020 Traffic Assignment (Yangon and Southern Regions)

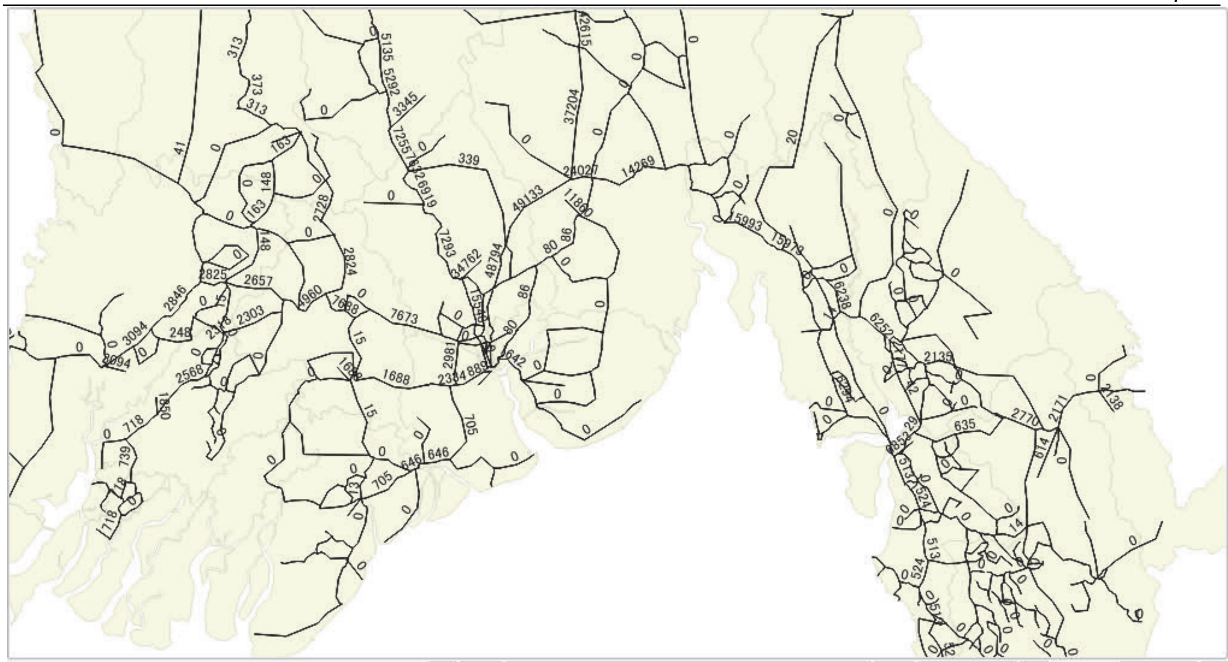


Figure 4.20 2030 Traffic Assignment (Yangon and Southern Regions)

Chapter 5 Selection of Priority Projects

5.1 Selection of Priority Routes

Under the current situation where the existing roads and bridges in the target area are damaged due to lack of maintenance and aging of the structures, several projects are on-going or planned for improvement of these roads and bridges. Since the increase of traffic volume is highly predicted taking into account the scheduled development of the road network and socio-economic development in the region, further road infrastructure will be required to improve the accessibility to other ASEAN countries focused on the economic development of Myanmar. On the other hand, the country of Myanmar has not reserved sufficient capital so that the necessary financial arrangements should be considered for the implementation of the projects supported by the Official Development Assistance from Japan, Multi-lateral Development Bank (ADB, World Bank, etc.) and other foreign aid. The list below shows the necessary projects to be implemented by the external financial assistance.

- Road and bridge projects that are located on the international roads and for which it is predicted that the traffic demands will increase due to the increase in cross border vehicles from other Indochina countries.
- Road projects which require road improvement to meet ASEAN Class-III standards (standard width of road is 10m) taking into account the constraints regarding topography, road alignment, surrounding conditions, maintenance, and the road side environment, etc.
- Bridge projects in which the length is more than 50 m and constrain the traffic flow due to insufficient width, unsuitable alignment, aging, or damage should be replaced.

The projects for which other donors have pledged financial assistance or there are other entities' involvement with the implementation, should be excluded. In addition, the road sections which are being maintained by the private sector under Build & Operation contracts should also be excluded to avoid a conflict of ownership for the road assets. In this regard, PWD clearly expresses the intention for the road improvements on the BOT sections to be implemented by using private finance.

5.2 Listing the Candidate Projects

Based on the selection work, a priority list for roads and bridges will be established to select the candidates for the priority projects to be implemented by the Japanese Government. The listing of the projects will be conducted by a two stage selection method as follows:

- First Stage: Selection of Priority Routes in the target area
- Second Stage: Listing of Priority Projects upon a comparison study of the priority routes

Considering the assessments of the road network mentioned above, the comparison study has been conducted to select the priority projects taking into account the road status as a national highway network, the surrounding environment and the existing plans in the Public Works.

Table 5-1 List of Candidate Sections

Candidate Section			Length	No. Lane	Paved by	Long spanned bridge
1	Payazi- Mawlamyine (200km)	Payagyi－Thaton	130km	2	AC	
		Thaton－Mawlamyine	70km	2	AC	
2	Eindu-Myawaddy (120km)	Eindu－Kawkareik	70km	2	Macadam	Gyaing Kawakareik Br
		Kawkareik－Myawaddy	32km	1	N/A	
			18km	2	AC	
3	Thaton－Eindu		60km	2	AC	DonTami Br, NaugLon Br
4	Mawlamyine- Eindu		40km	1.5	Macadam	Gyaing Zathapyin,Br Atran Br.

Table 5-2 shows the summary of priority projects which are need to be conducted with the necessary financial assistances. Figure 5.1 shows the location of priority projects.

Table 5-2 Priority Projects to be implemented by Financial Assistance (1)

	Project Name	Contents	Length
Bridge	(1) Don ThaMi Bridge	Replace with new two lane bridge	200m
	(2) Naung Lon Bridge	Ditto	180m
	(3) Gyaing Kawakareik Bridge	Ditto	415m
	(4) Gyaing Zathabyin Bridge	Ditto	880m
	(5) Atran Bridge	Ditto	430m

Source: JICA Study Team

Source: JICA Study Team

Figure 5.1 Location of Priority Projects

Table 5-3 Priority Projects to be implemented by Financial Assistance (2)

	Project Name	Contents	Length
Road	(6) Thaton Bypass	Two lane with paved shoulder (Class-II)	30km

Source: JICA Study Team

5.2.1 Priority Projects

(1) Replacement of Five Bridges on East West Economic Corridor

1) Objective

Five candidate bridges, which are located on the East West Economic Corridor (EMEC) running through the Indochina peninsula, are crucially damaged and have a potential risk for collapse. Replacing these bottleneck bridges will ensure a stable logistic corridor by solving the issue of insufficient capacity for supporting the traffic loads that will be expected for positive impact on poverty reduction and economic spill over effect. On the other hand, solving the current constraints for allowable traffic load less than 30 tons will facilitate the development of regional access, Eg. a pontoon bridge across the river that disturbs the inland water traffic.

Public Works expedites the improvement of infrastructure of EWEC with financial assistance from Thailand, ADB and other donors. On the other hand, the existing infrastructure cannot meet the traffic demand by increasing the size of vehicles for cross border freight vehicles. The improvement of the bridge structure has a very significant aspect focused on the integration of ASEAN to take a role for strengthening the links with other partner’s economies.

Beneficial area and population: approximately 3.5 million people in Kayin state will have a direct benefit and approximately 5.0 million in Bago and 5.9 million in Yangon will receive indirect benefits from the project along the EWEC.

2) Contents of Project

ADB is scheduled to provide financial assistance for the improvement of the section between Kawkareik and Eindu (Approximately 70km). The Gyaing Kawkareik Bridge is located in this section, however, the replacement or rehabilitation of this bridge is not clearly intended by the financial assistance of ADB. Public Works intends to replace the existing 17 bridges as a priority in terms of urgency of requirements. These bridges are located in the jurisdiction of Kayin State Government, and therefore, land acquisition isn’t required for their replacement beside the existing bridges. Public Works intends to keep the existing bridges to use for light weight vehicles after renovating the members in the future.

3) Preliminary Cost

Yen Loan Amount: 14,200 Million Yen

4) Execution Period

Detailed Design/ Procurement: Approximately 14 Months

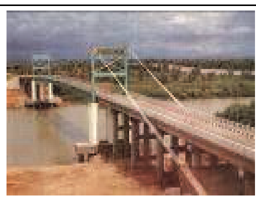
Civil Works (Replacement of 5 Bridges): Approximately 36 Months

5) Outstanding Issue

Public Works intends to build new bridges upstream of the existing bridges between the existing bridge and the temporary pontoon bridge where they will not incur involuntary resettlement.

Project:	Replacement of Five Bridges on East West Economic Corridor





Don Tha Mi	Naung Lon	Gyaing (Kawkareik)	Gyaing(Za ThaPyin)	Atran

<u>Project Description</u>
Project Area: Mon state, Kaying State
Project Cost: 14,200 Million Yen
Implementation Agency: MOC/Public Works Department
Project Contents: Replacement of Five Bridges on EWEC

<u>Current Condition of Bridges</u>

Bridge	Length	Superstructure	Weight Limit	Completion Year
Don Tha Mi	200m	PC+RC Simple Girder	-	1982
Naung Lon	115m	RC Simple Girder	-	1970s
Gyaing(Kawkareik)	400m	Suspension	30 ton	1999
Gyaing (Za Tha Pyin)	870m	Suspension	30 ton	1999
Atran	433m	Cable Stayed	30 ton	1998

<u>Remarks</u>
- Two suspension bridges and one cable stayed bridge on the EWEC have weight limits of 30 tons which does not satisfy the requirements of the international corridor.
- Three bridges were built with the technical assistance of China, however, the main, diagonal, and hanger cables are corroded and the steel slabs are deformed by excess force due to insufficient current capacity.
- ADB will provide the finance to improve the road section between Eindu and Kawkareik (Approximately 70km)
- Gyaing(Kawkareik) Bridge is included in the ADB section and the soundness of the bridge was inspected by an ADB consultant. The recommendation is for replacement of the superstructure only with a new structure.

(2) Thaton Bypass (including partial widening for the existing rural roads)

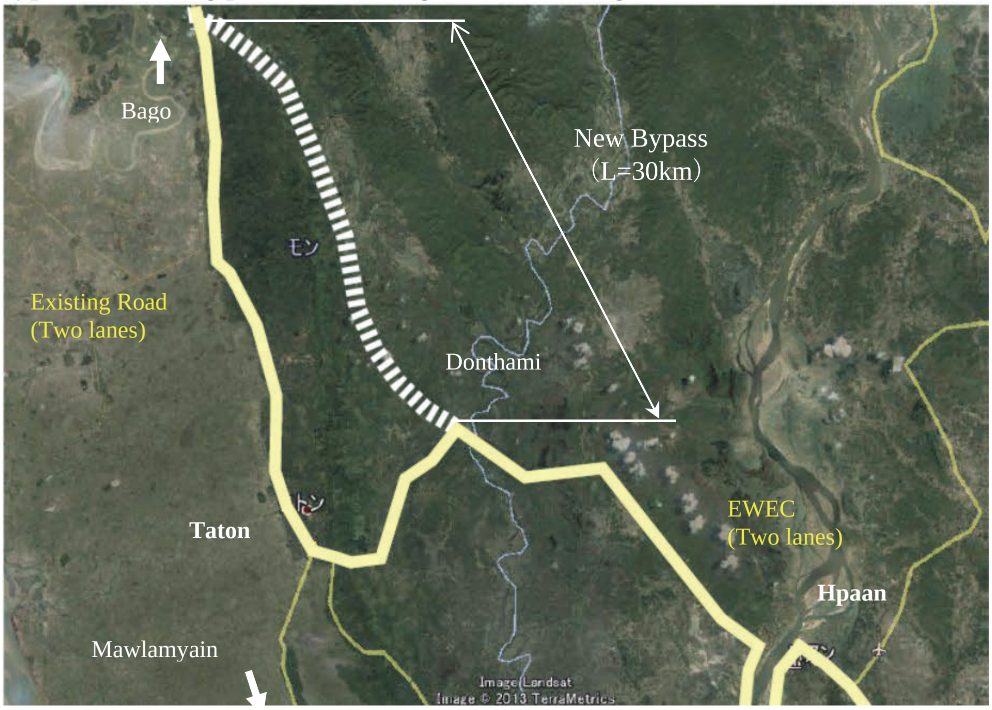


Figure 5.2 Location of the Thaton Bypass Project

1) Objective

The current East-West Economic Corridor can be divided into two sections in this region. The one is the section between Eindu and Mawlamyin as originally sectioned as a GMS EWEC route. The other is the section toward Yangon between Thaton and Eindu. The latter section, which connects directly to Yangon metropolitan region, has higher traffic volume than that of the former section. Especially, the number of freight vehicles occupies more than 50% of current traffic volume. Therefore, it currently causes traffic safety issues since the large freight vehicles run through Thaton, which is the 2nd highest populated town following Mawlamyin in the South East Region of Myanmar.

Under these circumstances, the construction of a new bypass is recommended to detour the traffic from Thaton city in order to redirect the heavy freight vehicles around the local communities. This would solve the problems and enhance the efficiency of the traffic flow on the East West Economic Corridor in the future. The current traffic passing through Thaton city meanders to the south and then turns toward the north. The bypass, which would run through mountainous terrain, will shorten the distance by about 9km, as well as improve the travelling condition.

2) Contents of the Project

Construction of a new bypass on the Ease West Economic Corridor (Approximately 30km)

3) Execution Period

Detailed Design／Procurement: Approx. 14 Month, Civil works: Approx. 42 months.

4) Way Forward

Consensus with PW/MOC, Procedure for RAP, EIA

Chapter 6 Preliminary Study

6.1 Design Standards

6.1.1 Road Geometric Standards

The design standards shall be applied upon consensus via official discussions with PWD. In fact, the design standards of the Pre-feasibility study will be applied after discussing with PWD the results of the comparison study for four alternative geometric design standards in relevant road projects in Myanmar. The standards of both ASEAN Highway and Asian Highway are preferably applied taking into account the extension of the international corridor. Meanwhile, the Thai financed bypass also applies the lane widths of ASEAN highway standards even though the exceptional value for narrow shoulders is applied.

Myanmar standards (Union Highway Standards), which were established in 2004, applies very unique values so that they cannot be used with international standards. It is recommended to have further discussions to decide the design standards before starting the design works.

Table 6-1 Comparison of Road Geometric Design Standards

Major Criteria (Two lane; Hilly)	Optional cross section and criteria			
	Asian Highway Class II	ASEAN Highway (GMS Corridor) Class II	Union Highway (PW) D-III	Thai Bypass
Design Speed (km/h)	60	60-80	50	50
Traffic Lane (m)	3.50	3.50	3.66 (12ft)	3.50
Carriageway (m)	12.0	12.0	12.2 (24ft)	10.0
Paved shoulder (m)	2 x 2.50	2 x 2.50	2 x 2.44 (2x8ft)	2 x 1.50
Max. vertical grade(%)	5	7	4	9
Min. Horizontal radius of curve (m)	115	110	130	120
Cross-fall	Asphalt/ Cement Concrete Pavement			
Carriageway (%)	2-3			
Shoulder (%)	3-6			
Super elevation (%)	10	10 (6)	6	10
Design Live Load (Min.)	HS20-44			
ROW	30m (100ft)*			

* Road accessories are situated in the ROW

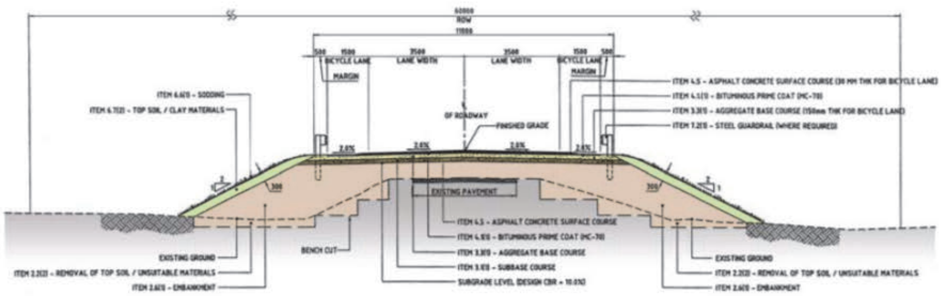
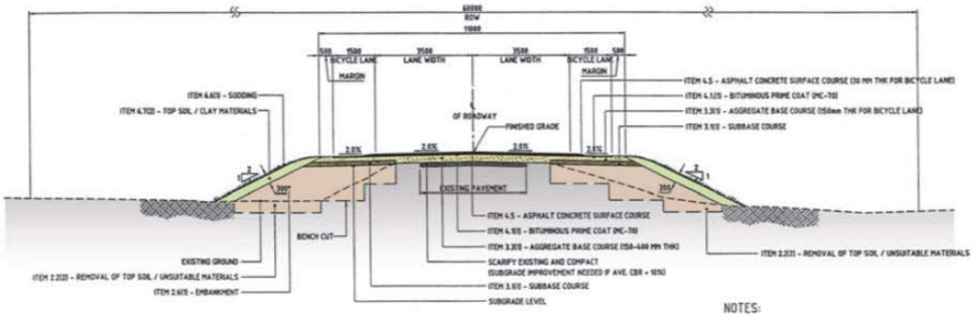
6.2 Road Design (Bypass Construction, Bridge Approach Section)

6.2.1 Road Improvement

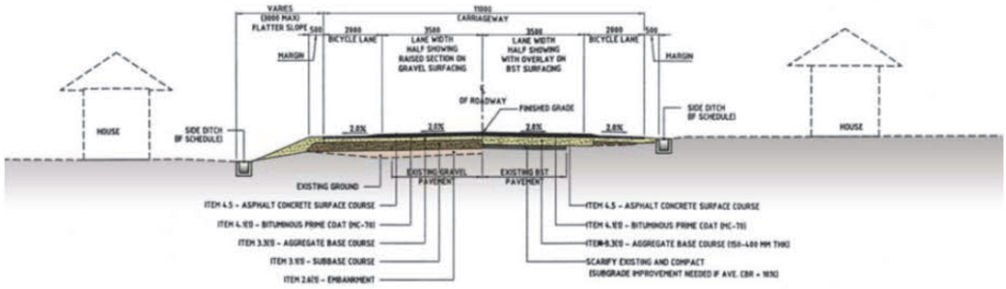
EWEC requires road improvements comprise a complete two lane road with paved shoulders. Upgrading a complete two lane road will be an appropriate improvement taking into account the current traffic conditions. The road improvement includes embankment, pavement, installation of cross drainage and bridge construction and the environmental mitigation measures. The improvement works are summarized below.

- Raising the embankment height so as not to be submerged during the flood
- Secure adequate sight distance around the sections of the bridge approach road by improving the alignment
- Widening to 7.0m carriageway plus 1.5m paved shoulder (Township 2.0m, 0.5m verge)
- Asphalt concrete pavement, cement concrete pavement, and DBST, etc.
- Installation of side ditches and drainage systems considering the erodible slopes
- Installation of safety facilities, dividers between the carriageway and sidewalks
- Road facilities (guidance for control, foot crossing and marking)

Road Improvement plans need to be established taking into account different terrain, land use, and available width of ROW in each respective section.

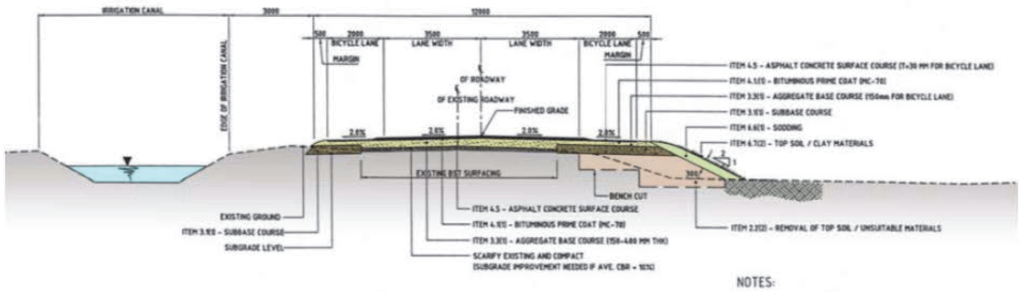
Option	Standard Cross Section with Road Improvement Plan
Type-R1	 Raising the Embankment Sections
Type-R2	 Widening Section with Overlay Section

Type-R3



Populated Area Section

Type-R4



Low land and swampy area Section

Figure 6.1 Standard Cross Sections for Road Improvement Plans

Road Improvements proposed in this study (except the improvement of the approach roads for bridges) are assumed to improve the road alignment with widening of the road width in accordance with the design standards. Note that the preliminary design is provided as the basic improvement plan proposed by the JICA Study Team, therefore, the realignment of the existing roads should be finalized upon discussion with PW in the following stage of the project. The standard cross sections for the road improvement plans applied in this pre-feasibility study is provided in the Figure 6.1.

6.3 Pavement Design

6.3.1 Study of Pavement Structure

The traffic demand for the project road is assumed based on the current traffic volume counted at the toll booth under the operation of BOT. Meanwhile, the pavement structure should be consistent along the EWEC connecting to Thailand. The determination of the pavement structure of the project road should be as required for the appropriate traffic demand forecast based on the actual traffic data. The design standard of the pavement is the "Overseas Road Note 31" in accordance with the current usage in PW. Accordingly, the pavement structure will be selected using the ORN31.

The existing pavement structure between Mywaddy and Thaton is given in Figure.6.2. This structure is "T6/S2" structure in accordance with the diagram in the Granular Road base/Structural Surface in ORN31. The pavement structure of the project road is assumed to apply the same as the existing structure at this stage.

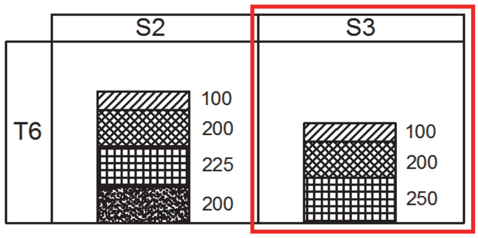


Figure 6.2 Pavement Structure of Road (Myawaddy to Thatong)

6.4 Preliminary Study for Bridges

In this project, as the results of discussion with PWD, the bridges which have a length of more than 180 feet should be considered for the candidate projects to be implemented by the financial assistance of Japan. In the project area, there are five major existing bridges. In this pre-feasibility study, the preliminary studies of the five bridges have been conducted to assess the economic viability of each project. Each bridge type will be selected by comparative study for each bridge crossing point as described below.

6.4.1 Study the Optimum Option

For each bridge site, alternative bridge sites will be reviewed using the satellite map, etc. The comparison and evaluation will also be made on the basis of multi-criteria. The optimum bridge site assumed at present is as shown in Figure 6.3.

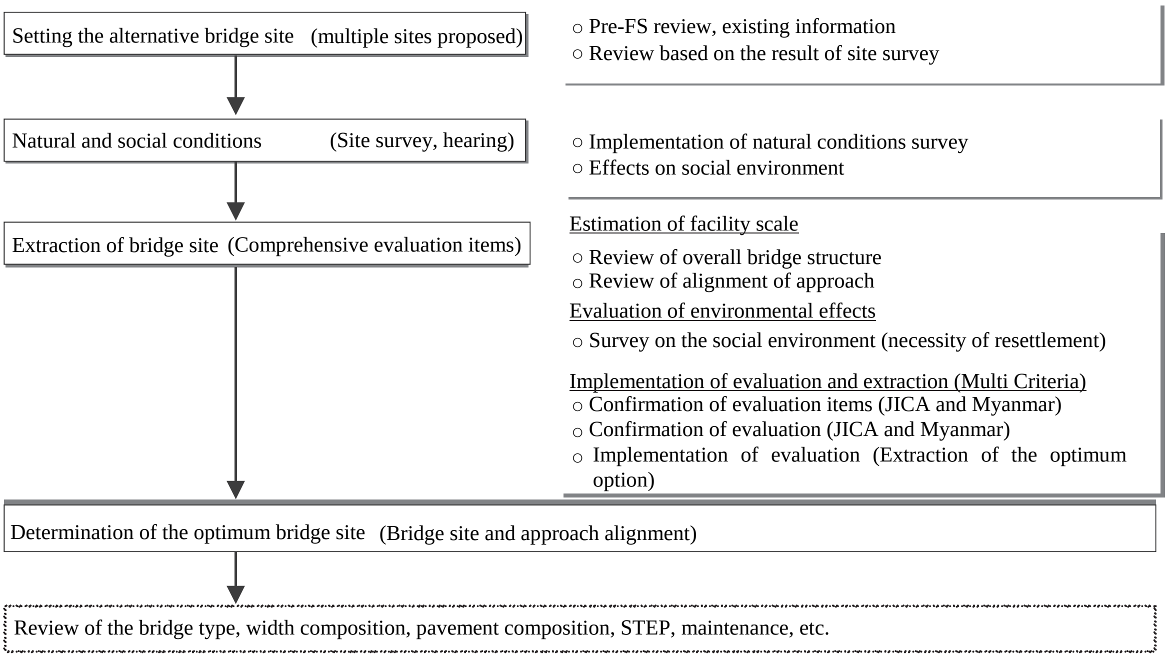


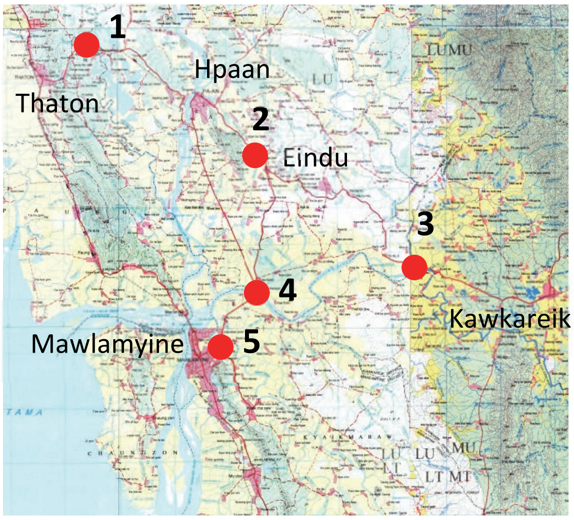
Figure 6.3 Optimum Type Selection Flow

6.4.2 Study of the Optimum Bridge Type

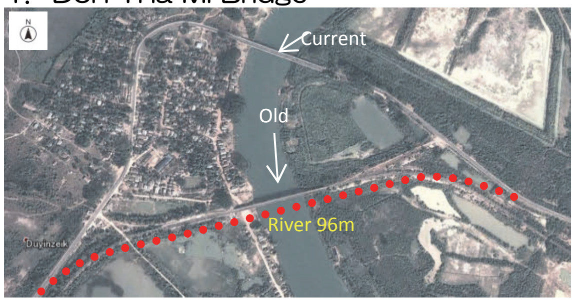
For the selected bridge sites, the optimum bridge type will be selected from among multiple alternatives by means of a comprehensive evaluation using the economic efficiency, workability, effects on the existing bridge, work period, ease of maintenance, and effects on natural and social environments, landscape, and utilization of STEP (Japanese technologies). The main bridge types (draft) selected by the pre-FS are shown in Figure 6.4.

(a) Pile foundation type for both abutment and piers
(b) Height of abutment less than 12m and the length within 80% of its height
(c) Height of abutment less than 10m over shallow depth river considering scouring in the future
(d) Assumed bearing substratum at the level of the deepest point of river considering scouring in the future
(e) Middle fixed pier height less than 10m
(f) Assumed bearing capacity of substratum <5000kN/m^2
(g) Low reaction forces on superstructure is desirable due to insufficient geotechnical data

■Location Map

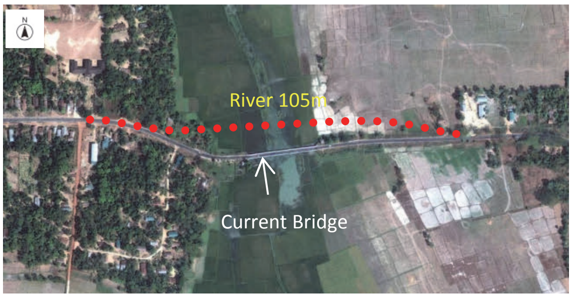


1. Don Tha Mi Bridge



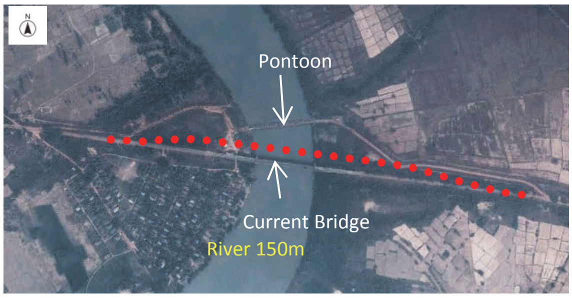
- Length：183m/RC+PC/2 Lane/Max 50t
- Summary：The existing bridge was built in 1982 by PW. No particular damage to the bridge is observed but there is a high risk for traffic safety by heavy freight vehicles running thru the adjacent community.
- Plan: New bypass with bridge beside the existing old bridge 300m downstream
- New bridge：200m/PC/2Lane/Max60t
- Obstacles: Nil (estimated)

2. Naung Lon Bridge



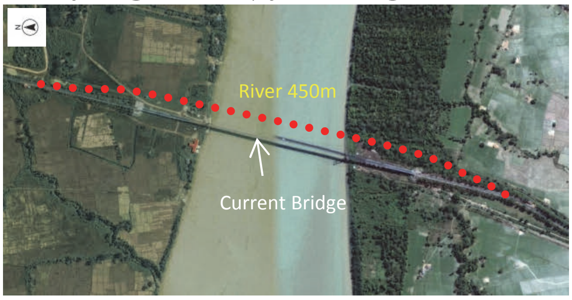
- Length: 130m/PCgirder/2lanes/Max 30t
- Summary: Current bridge was constructed in the 1970s by PW. Both superstructure and substructure are heavily damaged and the slab is deformed. West side of bridge has small radius curve and observed obstacles.
- Plan: Shift the road alignment toward the north and replace with new bridge.
- New bridge: 150m/PC girder/2 lanes/Max 60t
- Obstacle: 1 (estimated)

3. Gyaing (Kawkareik) Bridge



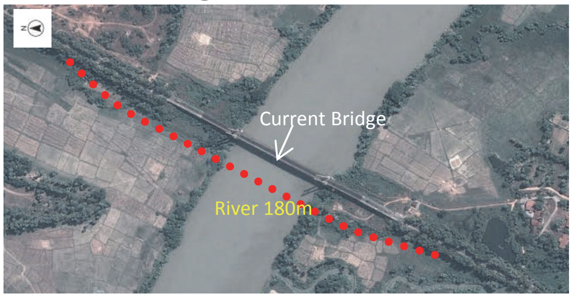
- Length: 400m/Suspension/2 Lanes/Max 30t
- Summary: With Chinese assistances, the bridge was constructed in 1999, however, the structure has insufficient capacity to bear the live load up to 30t and a temporary pontoon bridge was built to divert the heavy vehicles of more than 30t.
- Plan: Shift the road alignment north and build a new bridge between the current bridge and the pontoon bridge.
- New bridge:415m/ PC Extradosed/2 lanes/Max 60t
- Obstacles: Nil (estimated removal of only admin office)

4. Gyaing (Zathapyin) Bridge



- Length: 883m/Suspension/2 lanes/ Max 30t
- Summary: With Chinese assistance, the current bridge was constructed in 1999 by PW. The steel slab and cables are damaged and were partially repaired in April 2013.
- Plan: Shift the bridge location 30m east and replace with a new bridge .
- New bridge: 900m/Cable stayed/2 lanes/Max 60t
- Obstacle: Nil (estimated)

5. Atran Bridge



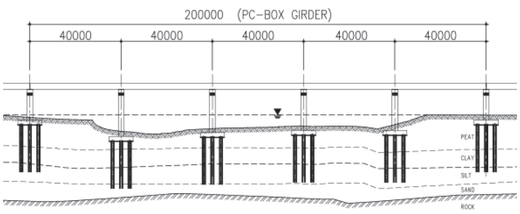
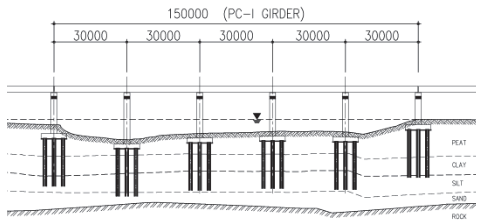
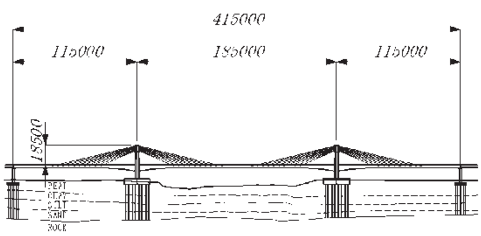
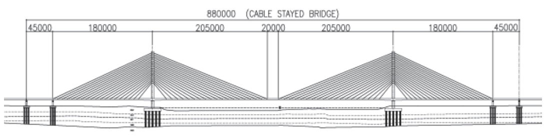
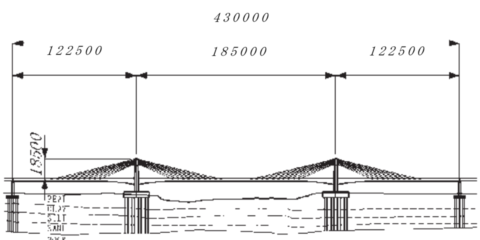
- Length: 433m/Cable stayed/2 lanes/Max 30t
- Summary: With Chinese assistance, the current bridge was constructed in1998 by PW. The steel slab and cables are heavily damaged and were repaired partially in April 2013.
- Plan: Shift the bridge location 30m west and replace with a new bridge.
- New bridge: 430m/PC Extradosed/2 lanes/Max 60t
- Obstacle: Nil (estimated)

Figure 6.4 Priority Project: Replacement of Five Bridges on EWEC

6.4.3 Replacement Feature of Each Bridge

As the results of the studies, the replacement features of each bridge are shown in Table 6.2.

Table 6-2 Main Bridge Types of Five Bridges in the East-West Economic Corridor (draft)

Main bridge type as selected by the pre-FS	Features
【Don Tha Mi Bridge】L=200 (5x40m) 	• Structural type: 5-span continuous pre-stressed concrete box-girder bridge (span length: 40m, bridge length: 200m) • Constructive property: General bridge type. The girder height of uniform section is about 2.5m so that the girder height increases with increasing span length. • Workability: Foundation and substructure are to be constructed under water, so that due care must be taken on the timing of construction. For superstructure, all-staging construction is assumed. • Maintenance: Concrete bridge, whose maintenance is easy to perform • Economy: Inexpensive • Japanese technologies: Rotary all-casing method (pile driving method) • Construction costs: 1.2 billion yen
【Naung Lon Bridge】L=150m (5x30m) 	• Structural type: 5-span continuous pre-stressed concrete I-girder bridge (span length: 30m, bridge length: 150m) • Constructive property: General bridge type. The girder height is about 2.2m. • Workability: Workability is good in dry season because the foundation and substructure can be constructed in almost dry state. The superstructure will be constructed using a crane. • Maintenance: Concrete bridge, whose maintenance is easy to perform • Economy: Most inexpensive • Japanese technologies: Rotary all-casing method (pile driving method) • Construction costs: 1.0 billion yen
【Gyaing (Kawkareik) Bridge】L=415m (115+185+115) 	• Structural type: 3-span continuous pre-stressed concrete extradosed bridge (center span length : 185m, bridge length: 415m) • Constructive property: Extradosed Bridge with the whole of superstructure constructed as a pre-stressed concrete box girder structure. Main girder will be erected as cantilever on sides from the main tower, achieving suspension on two sides. • Workability: Foundation work will be done on the river edge, so that a cofferdam is necessary. Superstructure to be erected as cantilever. • Maintenance: Concrete, except for the cable, so that maintenance is easy to perform. • Economy: Medium • Landscape: Main tower has a symbolic value and may become a landmark. • Japanese technologies: Extradosed bridge, steel pipe sheet pile open-caisson foundation • Construction costs: 2.0 billion yen
【Gyaing (Zathapyin) Bridge】L=880m (45+180+430+180+45) 	• Structural type: 2-span continuous pre-stressed concrete cable stayed bridge (main bridge section: span length: 430 m, side span length: 225m) • Constructive property: Cable stayed bridge with the whole of superstructure constructed as a steel box girder structure. Main girder will be erected as cantilever on both sides, achieving suspension on one side. Girder height is about 3.0 m. • Workability: Foundation and substructure works and main tower will be large-scale underwater construction work. The superstructure to be erected as cantilever. • Maintenance: Maintenance of bracing cable necessary • Economy: Most expensive • Landscape: Main tower has a symbolic value and may become a landmark. • Japanese technologies: Steel pipe sheet pile open-caisson foundation, weather-resistant steel plate (steel girder) • Construction costs: 7.0 billion yen
【Atran Bridge】L=430m (122.5+185+122.5) 	• Structural type: 3-span continuous pre-stressed concrete extradosed bridge (center span length: 185m, bridge length: 430m) • : Extradosed bridge with the whole of the superstructure constructed as a pre-stressed concrete box girder structure. Main girder will be erected as cantilever on sides from the main tower, achieving suspension on two sides. • Workability: Foundation work will be done on the river edge, so that a cofferdam is necessary. Superstructure to be erected as cantilever. • Maintenance: Concrete, except for the cable, so that maintenance is easy to perform. • Economy: Medium • Landscape : Main tower has a symbolic value and may become a landmark. • Japanese technologies: Extradosed bridge, Steel pipe sheet pile open-caisson foundation • Construction costs: 2.5 billion yen

a) Application to the long-span bridge (cost reduction measure)

It is considered that an extradosed bridge, which is more economical than a cable-stayed bridge and for which the Japanese contractors can demonstrate their technical capacity fully, is employed for the main bridge section. Reducing the number of piers to be constructed within the river will not only minimize the impact on the fairway and on the natural environment in the river, but also prove effective in mitigating the effect of scouring of piers of the nearby existing bridge. In addition, reduction of the number of piers can minimize the foundation and pier works in the wet season, which in turn leads to reduced construction risk and shorter work period (smaller costs). Since the applicable span length of an extradosed bridge is 100m-200m, this bridge type can be employed for two bridges; the Gyain – Kawkareik Bridge and Atran Bridge. Figure 6.5 and Figure 6.6 show CG photo-montages of the extradosed bridges. Note that this type of bridge offers superior landscape and may become a landmark.

Figure 6.5 Perspective of Gyaing (Kawkareik)
(Right: Existing Bridge)

Figure 6.6 Perspective of Gyaing(Kawkareik) Bridge (Side View)

b) Study of utilization of other STEP (Japanese technologies)

Application of STEP (Japanese technologies), as shown below, concerning the present traffic during work, effects on rivers, execution of efficient and effective foundation work integrated with temporary facilities (photos (1) and (2)), improvement of durability of the superstructure by rust inhibition (photo (3)),), etc. will be reviewed during preliminary design. (See Figure 6.7)

<table>
<tr><th>(1) Steel pipe sheet pile open-caisson foundation</th><th>(2) Rotary all-casing method (pile driving method)</th></tr>
<tr><td>
</td><td></td></tr>
<tr><td>Steel pipe piles are driven in a complete caisson (cylindrical or rectangular caisson) and the caisson heads are connected by footing on which the piers are constructed. This is advantageous in large bearing power and reduced plan size.</td><td>In this process, the hydraulic jack turns and pushes the casing tube into the ground under pressure. The carbide bit at the tube end cuts the ground. Then, the hammer grab excavates inside the casing tube and discharges excavated soil out of the tube. This is expected to be used for rapid pile driving.</td></tr>
</table>

Application of these Japanese technologies concerning the work method, materials, etc. is expected to provide various benefits. STEP (feasibility of utilizing Japanese technologies) will be reviewed on the basis of comprehensive judgement by considering not only the difference in the initial costs, but also the impact on the environment, workability, safety, landscape, maintenance, and technology transfer effects for Myanmar while considering the ODA loan (e.g., "JUMP") in a new framework.

(3) Weather-resistant steel plate (main girder)

Weather-resistant steel plate has a protective rust (also called stable rust) formed over the steel surface to prevent growth of rust. This proves effective when used for bridge girders, except that the protective rust gives the appearance that the girders are actually rusted, which may be said to hamper the landscape.

Figure 6.7 List of feasible STEP in the survey (Draft)

Chapter 7 Construction Plan

7.1 Construction Plan

7.1.1 Formation of Construction Package (Contract Package）

The replacement of five bridges on the EWEC should be divided into two contact packages taking into account the efficiency of work arrangements during the implementation. The contract packages should be decided based upon discussion with PW in the following feasibility study.

In this pre-feasibility study, the contract packages have been decided based on the assumption of bridge scale, bridge type, and both procurement and construction conditions. If the bridges are located on the same road close to each other, the trucks hauling the materials will interfere with one another and affect the efficiency of the works. Package-1 comprising the bridges which are located more than 130km from each other is inefficient but helps to avoid the interference between the various works. The construction of Thaton bypass is presumed to separate the project from the 5 bridge replacements, however, it is assumed to include the parts of the contract in this pre-feasibility study. Accordingly, in this pre-feasibility study for 5 bridge replacements and construction of Thaton bypass, the contract package is assumed to be as shown in Table 7-1.

Table 7-1 Construction Package

Package	Length (distance of each bridge)	Candidate Bridges	No. of Bridges
Package-1	Approx. 130km	①Don Tha Mi ②Naoung Lon ③Gyaing (Kawkareik)	3
Package-2	Approx. 15km	④Gyaing (Zathabyin) ⑤Atran	2
Package-3	Approx. 28km	Thaton Bypass	Small scaled bridges (6)

7.2 Construction Plan for Five Bridge Replacements

It is assumed that three bridges will be constructed in Package-1 and two brides will be constructed in Package-2. The construction schedule will be established for each bridge.

Table 7-2 Bridge Replacement Plan

Package / Contents	Location	Bridge type	Width	Length
Package-1 (Thaton – Eindu)				
Don Tha Mi Bridge	34km	Five span continuous PC box girder bridge	W=10.0m	L=200m
Naulong Bridge	42km	Five span continuous PC girder bridge	W=10.0m	L=150m
Gyain (Kawkareik) Bridge	79km	PC Extradosed Bridge	W=10.0m	L=415m
Package-2 (Eindu – Mawlamyin)				
Gyain (Zathabyin) Bridge	85km	PC Cable Stayed Bridge	W=10.0m	L=880m
Atran Bridge	87km	PC Extradosed Bridge	W=10.0m	L=430m

The establishment of a bridge construction schedule should consider the following points.

- Include 1-2 month mobilization at the beginning of the contract and 1-2 month demobilization at the end of the contract
- Execute foundation and substructure works in the dry season
- Execute the bridge construction in accordance with the respective work sequence taking into account the hauling route for materials from the plant.

The works schedule is shown in Table 7-5 considering the above nodes.

7.3 Construction Plan for Thaton Bypass

The construction yards (base camps) should be located at the beginning and end points of the bypass section connecting with the existing road (EWEC) due to the following reasons.

- Desirable access for the procurement of materials and equipment near the connecting points with the existing road (EWEC)
- Shortening the access distance to each of the plants (asphalt and rock crushing) and stockyard (borrow material)
- Possibly sharing the plants if both Package-1 and -2 are executed simultaneously together with Package-3.

Each of plants and stockyards located in construction yard are assumed in Table 7.3.

Table 7-3 Plant and Stockpile in Construction Yard

Beginning and end of bypass	Asphalt plant
	Crushing plant
	Stockpile (borrow)

Average hauling distances for each of the materials are shown in Table 7.4.

Table 7-4 Average Distances for Each Material

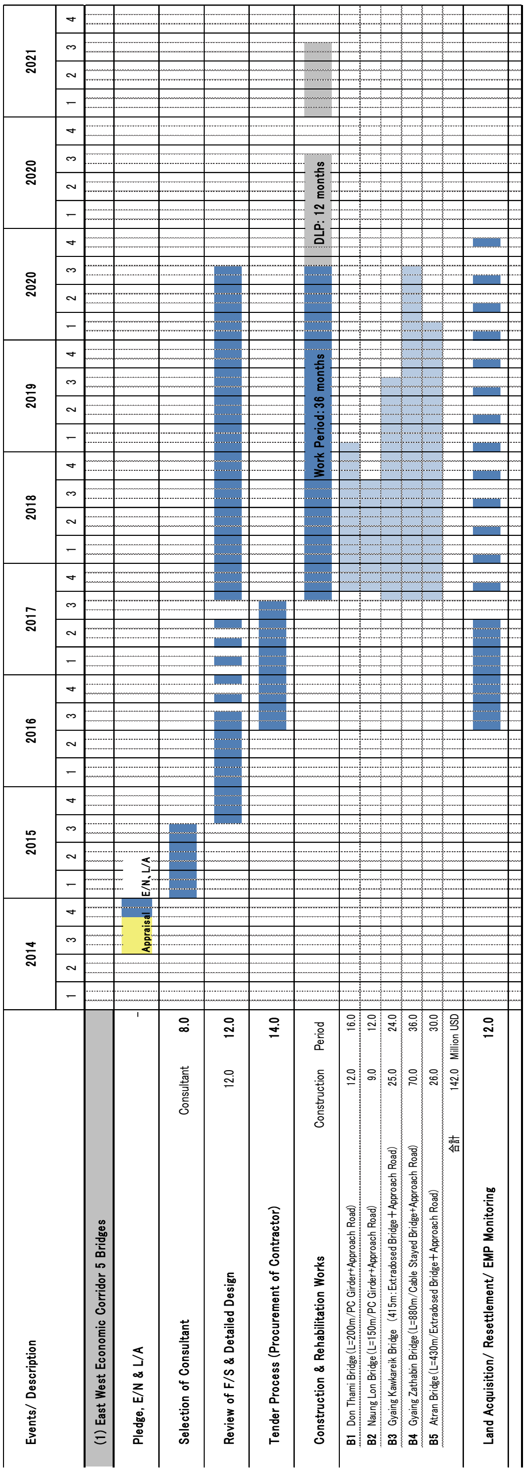
Contract Package	Materials	Borrow site, rock quarry ⇔Plants	Average distance from plant	Remarks
Package-3	Borrow	10km	15km	
	Crusher run	20km	35km	
	Asphalt	-	0～28km	
	Concrete	10km (Crusher run)	15km	For 6 minor bridges

Table 7-5 Work Schedule for the Construction of the Five Bridges

Year		2017			2018						2019						2020						Remarks
Cumulative month		1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	
Month		7	9	11	1	3	5	7	9	11	1	3	5	7	9	11	1	3	5	7	9	11	
①Donthami Bridge	Length: 200m Five Span Continuous PC Box																						
Mobilization	2																						*
Foundation & Substructure	3																						
Superstructure	8																						
Slab	2.5																						
Bridge Accessories	1.5																						
Demobilization	1																						
②Nauglon Bridge	Length: 150m Five Span PC Continuous Girder Bridge																						
Mobilization	2																						*
Foundation & Substructure	2																						
Superstructure	6																						
Slab	3																						
Bridge Accessories	2																						
Demobilization	2																						
③Gyaing (Kawkareik) Bridge	Length: 415m Three Span PC Extradosed Bridge																						
Mobilization	3																						*
Foundation & Substructure	9																						
Superstructure	10																						
Slab	5																						
Bridge Accessories	3																						
Demobilization	1.5																						
④Gyaing (Zathabyin) Bridge	Length: 880m Three Span PC Cable Stayed Bridge																						
Mobilization	3																						*
Foundation & Substructure	15																						
Superstructure	10																						
Slab	5																						
Bridge Accessories	3																						
Demobilization	2																						
⑤Atran Bridge	Length: 430m Three Span PC Extradosed Bridge																						
Mobilization	3																						*
Foundation & Substructure	14																						
Superstructure	10																						
Slab	5																						
Bridge Accessories	3																						
Demobilization	1.5																						

7.4 Implementation Schedule

The project implementation schedule is separately provided below since the construction of Thaton bypass is to be separately conducted as shown in Table 7-6.



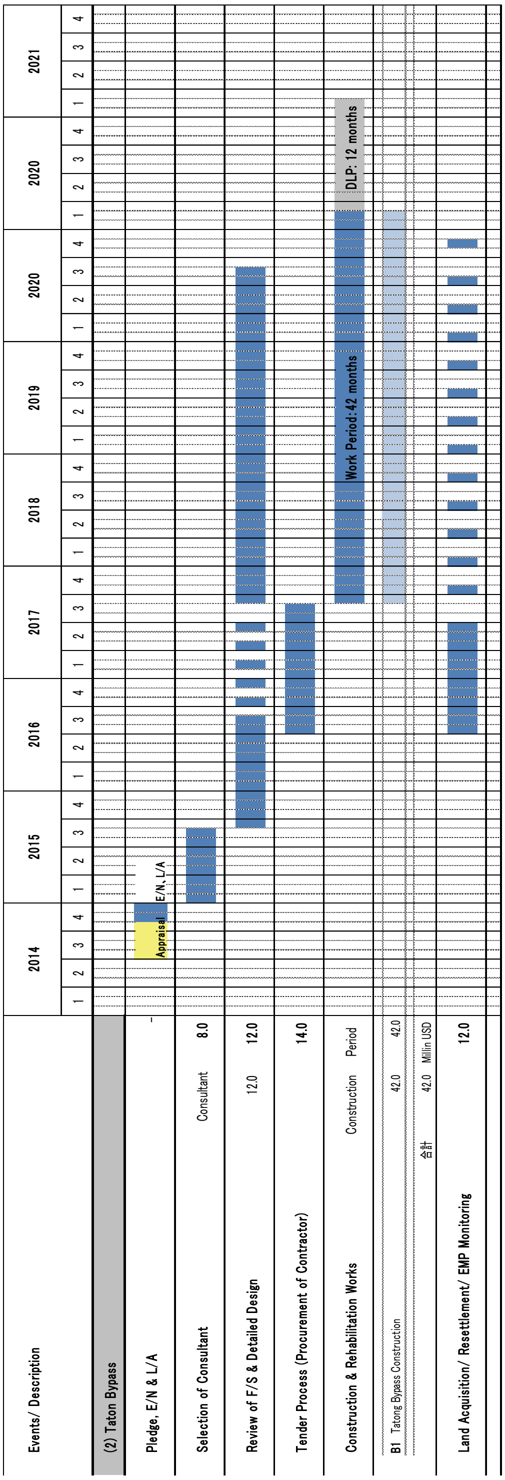


Table 7-6 Implementation Schedule (Package 1, 2 & 3)

Chapter 8 Preliminary Cost Estimation

8.1 Estimation of Project Cost

(1) Compensation Cost

The following cost items are excluded from the project costs because the Myanmar side should be responsible for the relevant compensations costs, price escalation and contingencies.

- Land acquisition cost
- Compensation for removal of buildings
- Price escalation and physical contingency

(2) Construction Cost

Construction cost should be estimated based on the technical specification prepared at the stage of detailed design. Some indirect costs such as contractor's administration cost, which shall be appropriately distributed and added on each "pay item", are also calculated as individual items at this pre-F/S stage.

(3) Engineering Costs (Consultant Fee)

The following costs are estimated as the engineering cost of each stage.

- Detailed design costs
- Tender assistance cost
- Construction supervision cost

(4) Operation and Maintenance Costs

The operation and maintenance costs shall include the cost of daily maintenance and periodic maintenance of the bridges and roads including overlay of pavement, replacement of bridge bearing shoes and expansion joints.

8.2 Conditions of Cost Estimate

8.2.1 Premise Conditions

(1) Term of Cost Estimation

The unit prices of resources (labourers, material and equipment) adopted for this cost estimation are those prices as of May 2013. The commencement year of implementation for the project is assumed to be 2017.

(2) Exchange Rate (Reference Conversion)

- JPY/USD= 100.00

- JPY/MMK=0.10
- MMK/USD=1000

(3) Taxes and Duties

(a) Custom duty: Only for the imported goods, 2% tax rate will be adopted.
(b) Commercial tax: For service from overseas including the imported goods, 5% tax rate will be adopted.
(c) Withhold tax: For domestic service, 2% tax rate will be adopted.
(d) Price escalation: Price escalation of 9.25% per year by IMF rate will be applied.
(e) Contingency: As contingency, 5.0% of total construction cost will be applied.
(f) Administration cost of PWD: For PWD administration, 10% of direct construction cost will be applied
(g) Base year for cost escalation: The base year is May 2013, and construction work will start from February 2014 for Section 1 and the end of December 2016 for Section 2.

8.2.2 Unit Costs

PWD has the unit costs for reference in the cost estimate of this pre-F/S which are quoted from the market prices in Myanmar. These unit prices are shown in Table 8-1and Table 8-2.

Table 8-1 Unit Costs of Labours

ID	ITEM	STANSARD	UNIT	RATE (MMK)
LA001	Foreman/Ganger		day	7,500
LA002	Skilled Labour		day	7,500
LA003	Bridge Skilled Labour		day	5,500
LA005	Scaffolder		day	9,000
LA006	Rebar Worker		day	9,000
LA007	Machine Operator		day	7,500
LA008	Driver		day	7,500
LA009	Carpenter		day	9,000
LA010	Carpenter		day	9,000
LA012	Mason		day	9,000
LA013	Painter		day	9,000
LA016	Mechanic		day	9,000
LA018	Guard man		day	5,500
LA019	Bridge Foreman		day	7,500
LA020	Bridge Labour		day	7,500
LA021	Engineer A	20 years	mth	2,200,000
LA022	Engineer B	15 years	mth	1,650,000
LA023	Engineer C	10 years	mth	1,320,000
LA024	Engineer D	5 years	mth	1,100,000
LA029	Surveyor		mth	550,000
LA030	Survey Assistant		mth	330,000
LA031	Draftsman		mth	220,000
LA032	Accountant		mth	1,320,000
LA034	Driver		mth	220,000
LA035	Guard man		mth	110,000
LA036	House Keeper		mth	88,000
LA037	Electrician (Special Grade)		day	11,000

Table 8-2 Unit Costs of Materials

ID	ITEM	STANDARDED	UNIT	RATE (MMK)
MT001	Portland Cement (OPC)		t	180,000
MT002	Concrete Admixture	Pozolith	kg	13,000
MT003	High Yield Steel Bars	D13-D25,GRADE 460	t	1,344,000
MT004	High Yield Steel Bars	D29-,GRADE 460	t	1,120,000
MT005	Rubble	150 mm-225 mm	m^3	6,356
MT006	Quarry Stone	150 mm-229 mm	m^3	9,888
MT007	Crushed Stone	51 mm-102 mm	m^3	12,360
MT008		25 mm-51 mm	m^3	18,715
MT009		13 mm- 19 mm	m^3	24,014
MT010		3 mm-6 mm	m^3	24,014
MT011	River Sand for Road Surface		m^3	35,310
MT012	River Sand for Concrete		m^3	21,186
MT013	Borrow Pit Soil	Filling	m^3	5,000
MT014	Plywood(WBP)for Formwork	15 mm Coating	m^2	3,283
MT015	Road Marking Paint	WHITE	kg	4,400
MT016	Marking Solublizer	WHITE	kg	-
MT017	Bitumen	60/70 (EX-STOCK)	l	2,000
MT018	Prim Coat		l	2,500
MT019	Tack Coat		l	3,000
MT020	PVC Pipe	P.V.C. Pipe Ø 75mma	m	7,218
MT021	Traffic Signs	Ø 900	no.	50,000
MT022	Caution Signs	Ø 900	no.	50,000
MT023	Rubber Shoe	410x310x44 (Fix)	no.	50,000
MT024	Expansion Joint (Metal)	Road Width 7.31m	m	478,800
MT025	Desel		l	1,000

8.3 Preliminary Project Cost

(1) Construction Cost

The construction cost for each respective work section is shown in Table 8-3.

Table 8-3 Breakdown of Project Cost

Unit: Million USD

Project Cost	Bridge Replacements on EWEC		Thaton Bypass Construction (Package-3)
	Section -1 (Donthami) (Naulong) (Gyaing･Kakareik) (Package-1)	Section-2 (Gyaing･Zathapyin) (Atran) (Package-2)	
Construction	42.78	89.28	39.06
Design & Supervision:7%	3.22	6.72	2.94
Contingency (Administration Cost: Myanmar side)：2%	0.92	1.92	0.84
Total Project Cost	50.14	104.64	42.84
	154.78		

(2) Operation and Maintenance Cost

The maintenance cost to be borne by the Myanmar side is shown in Table 8-4. The costs vary depending on the specifications of the pavement structure and type of structure, therefore, these costs should be reviewed at the following design stage and confirm the maintenance costs concretely.

Table 8-4 Operation and Maintenance Cost

Items		Cost (Million USD)
Routine maintenance (Road & Bridge) costs per year	Bridge replacement on EWEC	0.04
	Thaton Bypass	0.06
Periodic maintenance (road & bridge) costs per year (Rehabilitation)	Bridge replacement on EWEC	0.71
	Thaton Bypass	6.30

* The above cost should be reviewed in accordance with the maintenance expenditures of PW

Chapter 9 Environmental and Social Considerations

9.1 Scope of Preliminary Environmental Assessment

9.1.1 Survey Area

A preliminary environmental assessment was carried out for identifying environmental and social impacts likely to be caused by the road development. The output was reflected to design the proposed project as explained in this Pre-feasibility Study. The survey area covers the following three routes:

1) Payagyi – Mawlamyine Route

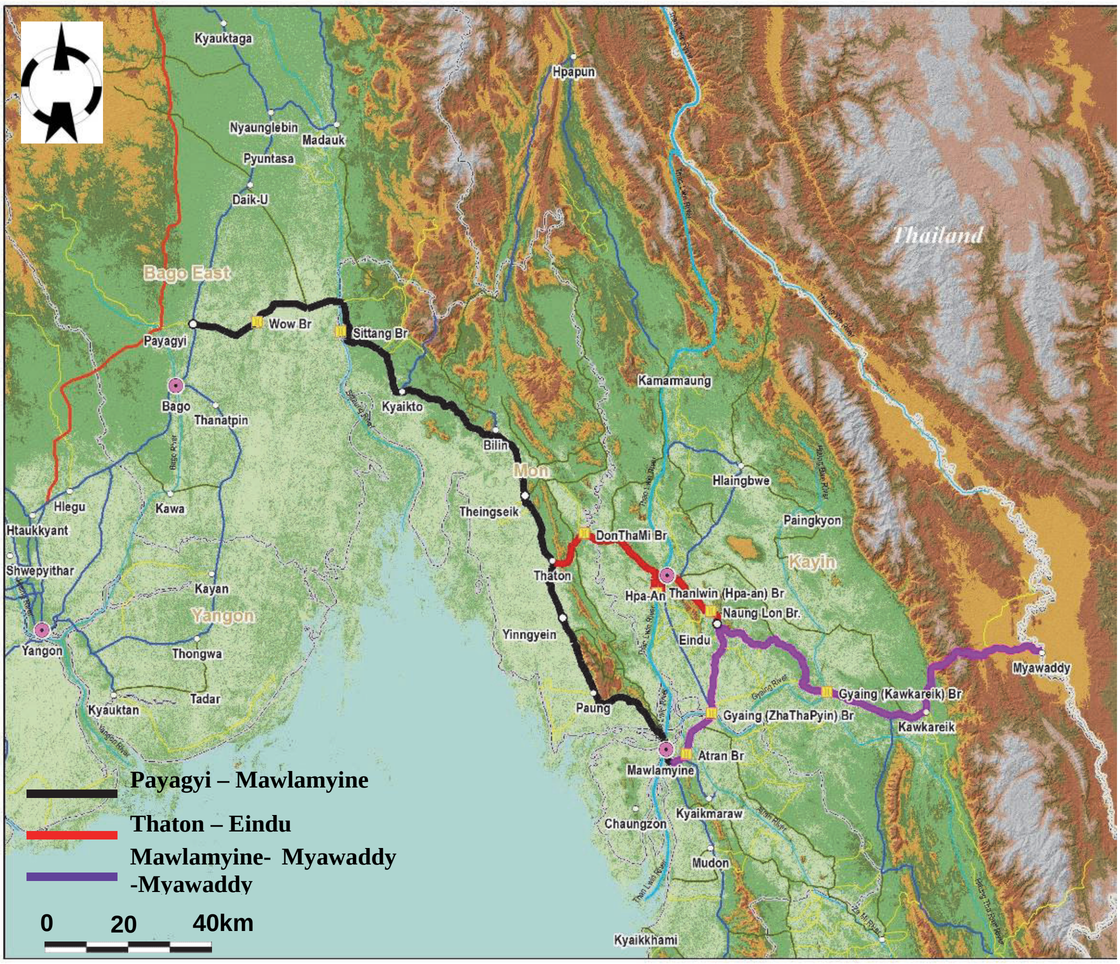
2) Thaton – Eindu Route and

3) Mawlamyine – Myawaddy Route.

Main components to be assessed are summarized below:

- Road improvement with pavement and renovation of road shoulders;
- Road widening to up to four lanes;
- Construction of by-pass roads (e.g. Kyaikhto, Theingseik, Thaton, and Yinngyein);
- Reconstruction of bridges (e.g. Don Tha Mi Br., Naung Lon Br., Gyaing (Kawkareik) Br. and Gyaing (Za Tha Pyin) Br.) and renovation.

As a result of the preliminary evaluation, construction of a by-pass road in Thaton and re-construction of the above five bridges are selected as a proposed project.



Source: JICA Study Team

Figure 9.1 Location Map

9.1.2 Survey Method

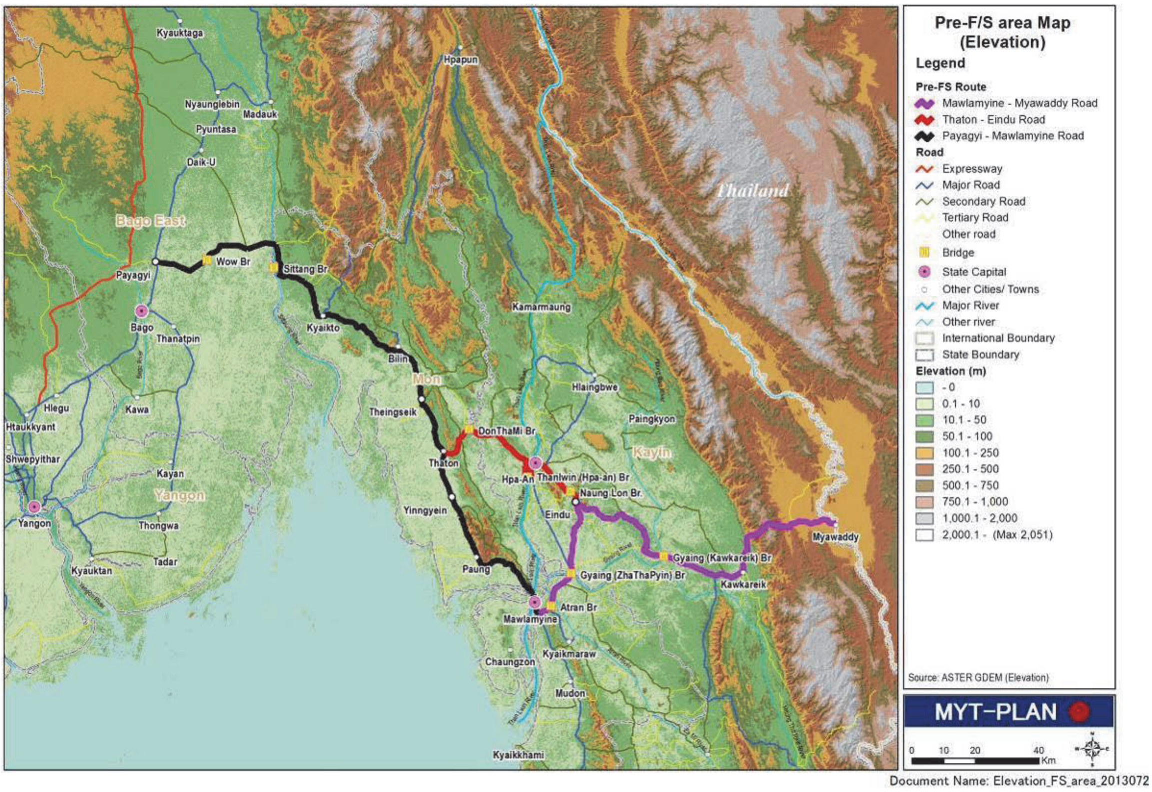
The survey was conducted by secondary data analysis, site observation, interviews with line government, local communities, etc.

9.2 Current Environmental Condition along the Roads

9.2.1 Natural Environment

(1) Topography

Figure 9.2 shows the topographic conditions in the survey site. Generally, those routes pass lower and flat areas to avoid mountainous and steep area; the elevation ranges approximately 50 m or less except near the border between Myanmar and Thailand.



Source: JICA Study Team

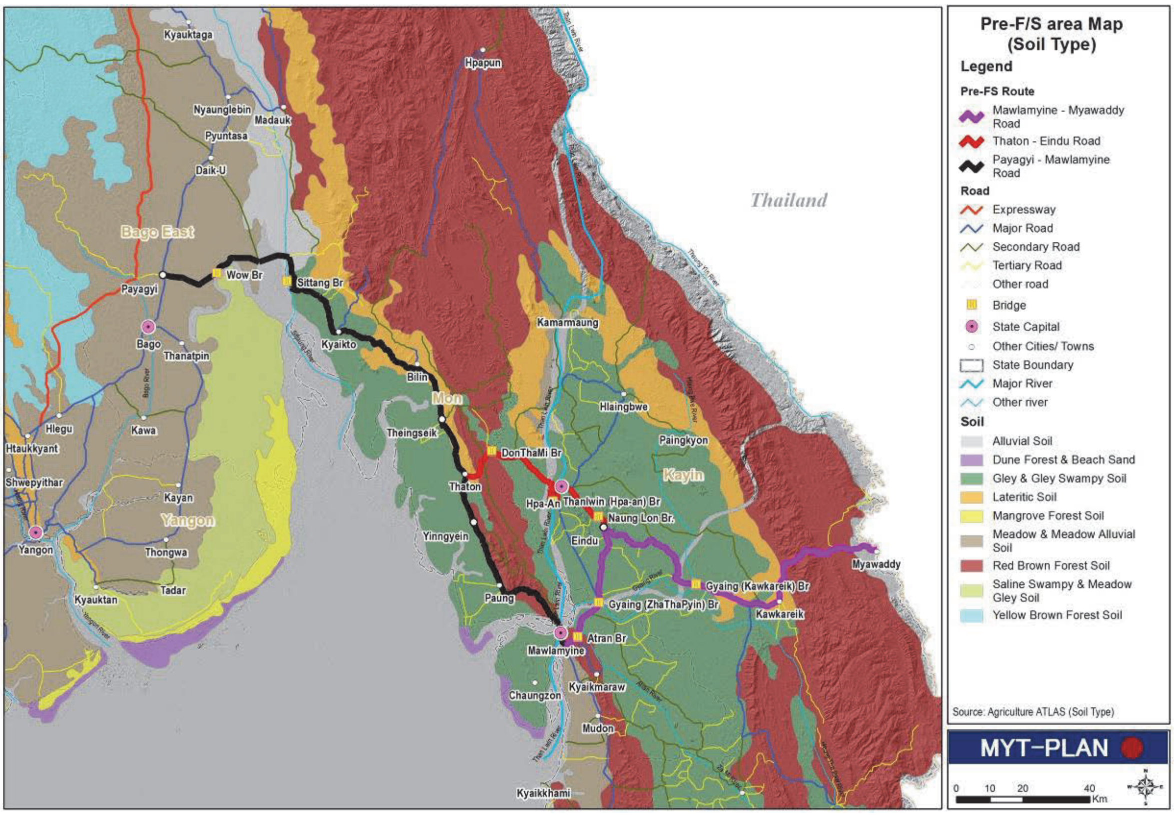
Figure 9.2 Topographic Condition

(2) Geology (Soil Type)

Figure 9.3 shows the soil type in the project site. While alluvial soil is dominant in Bago Region, a large part of the proposed routes lie on swampy soil with less on lateritic soil and forest soil.

Soil type along the road between Eindu and Kawkareik is Gley swampy soil for both the road between Hpa-An and Eindu, and that between Mawlamyine and Eindu. While forest soil, rich in humus constitutes the soil in the mountain ranges.

Soil type along the road is classified as Gley swampy soil, red brown forest soil and lateritic soil. Alluvial soil spreads along Than Lwin River.



Source: JICA Study Team

Figure 9.3 Soil Type

(3) Hydrology

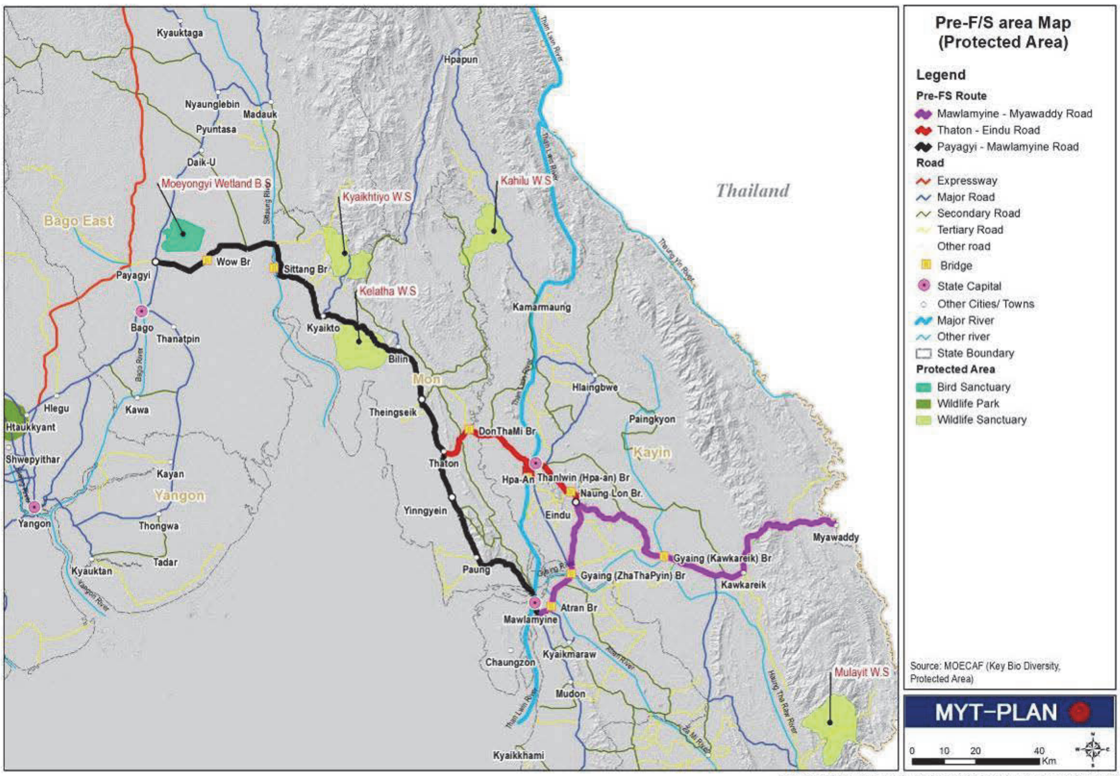
Those roads pass Sittang River, Salween River, Atran River, Gyaing River, Than Lwin River and Salween River as shown in the above figure.

Based on a site observation and interviews with local residents, the surrounding situation near the rivers is summarized below:

- Rivers are used for fishing and washing but not for cooking or drinking;
- The surrounding areas are mostly rice fields;

(4) Ecosystem and Biodiversity

As shown in Figure 9.4, Kelatha Wildlife Sanctuary is located on the southern side of the road. But the ROW is secured to allow expansion to up to four lanes. Aside from this sanctuary, no protected area lies adjacent to the road; and no important habitat of endangered, threatened or rare species has been identified. The existing road is located at a reasonable distance from any protected area, reserved forest or others.



Document Name: KBA_Protected AREA_FS_area_20130729

Source: JICA Study Team

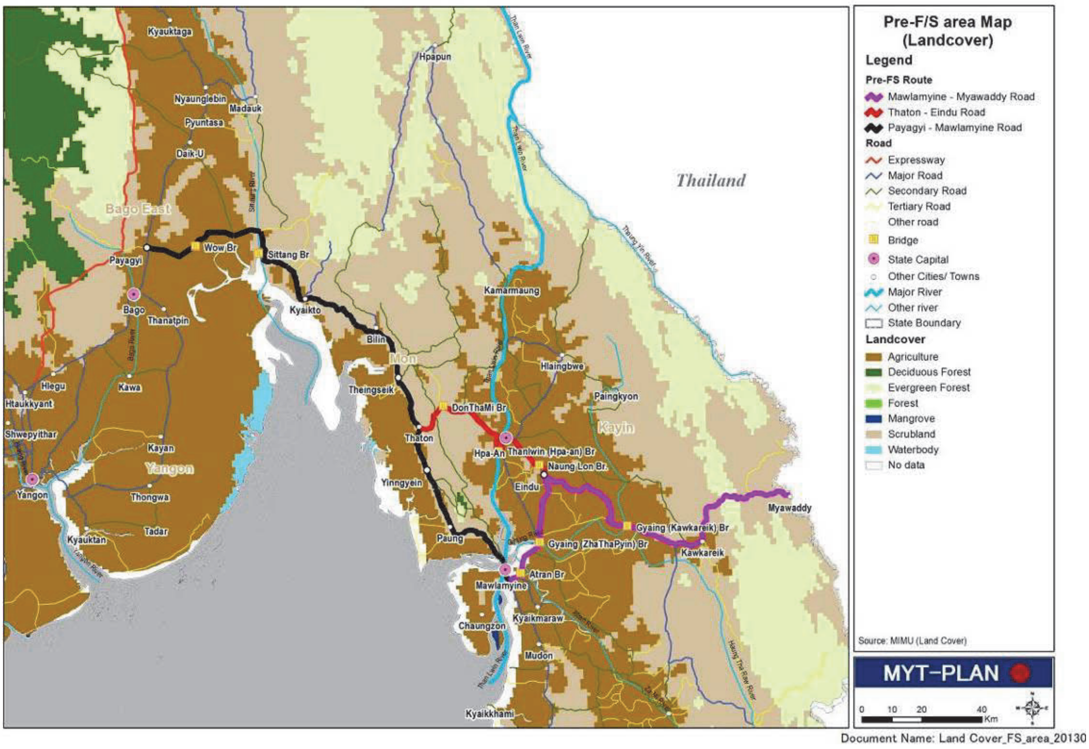
Figure 9.4 Protected Areas

(5) Land Use (Land Cover)

Aside from the towns / villages, the major form of land use is agricultural land (example rice fields); while a large number of rubber plantations are developed in Mon State.

Source: JICA Study Team

Figure 9.5 Typical Land use
(Left: Rice field in Bago Region, Right: Rubber Plantation in Mon State)



Source: JICA Study Team

Figure 9.6 Land Cover

(6) Pollution

It is assumed that no monitoring for air quality, noise and water quality has been previously undertaken in the study area. Major sources of pollutions can be considered to be as below:

Table 9-1 Major Sources of Pollution along the Roads

Type of Pollution	Major Sources
Air Pollution	Vehicles (emission), dust diffusion
Noise Disturbance	Vehicles (running and horns)
Water Pollution	Soil spread caused by heavy rain, oil leakage
Soil Contamination	Oil leakage

Source: JICA Study Team

9.2.2 Social Environment

(1) Land Acquisition and Resettlement

The ROW of 100 feet is secured along most parts of the road in between the towns and villages.

Source: JICA Study Team

Figure 9.7 A School beside the Road Located between Theingseik and Thaton (ROW is secured)

A large number of residential and/or commercial facilities exist within the ROW in the urban area. Notably, space is not secured in the major towns (i.e. Thaton) to allow widening. Even though the area within the ROW is officially controlled by the government; there are significant social constraints and they will cause problems unless adequate compensation is made for land acquisition and resettlement.

Therefore, the by-pass road is recommendable to avoid said social problems. The proposed area for the by-pass road is mostly occupied by farm land. Recently, a land occupation system for agricultural land has been amended; it has been registering farmland cultivated by farmers. Therefore; it is recommended to further include a land status survey to identify the land owner status.

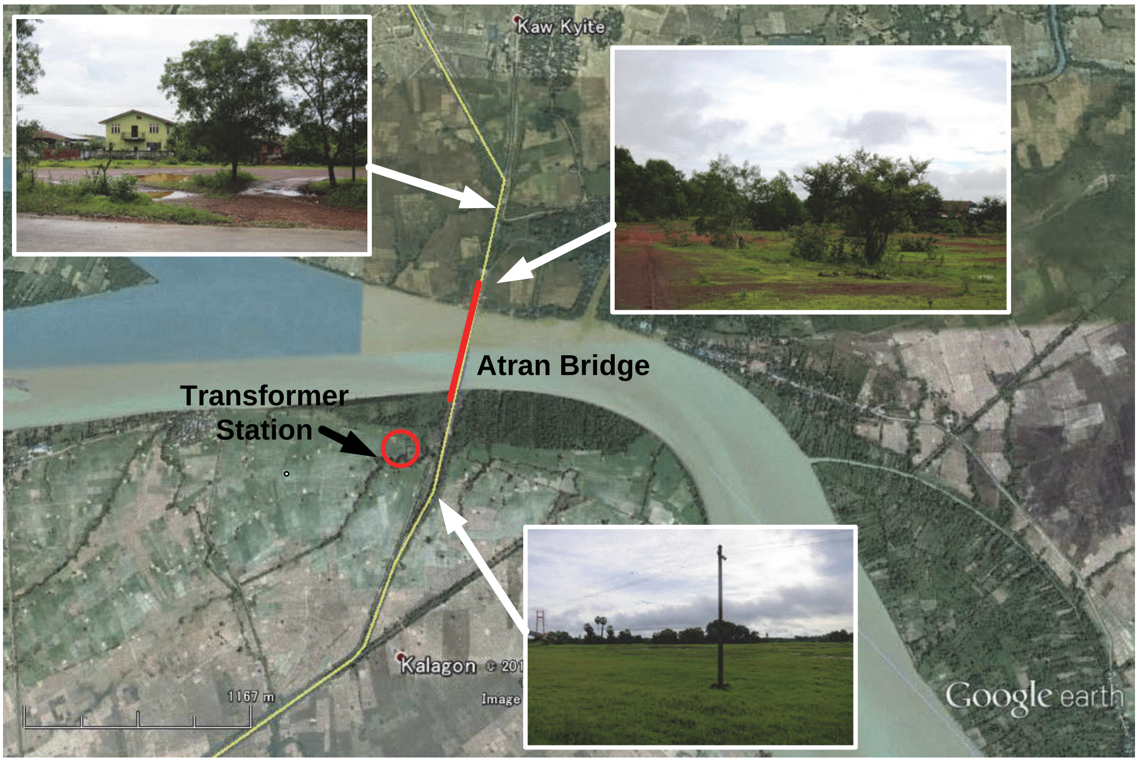
Source: JICA Study Team

Figure 9.8 Facilities along the Road in Thaton (more than 200 buildings are located near the road)

The project involves building five new bridges. Since the new bridges are to be built near the existing bridges, probably upstream, some land outside of the ROW may also be subject to acquisition. The area surrounding the bridges was, therefore, explored to identify if there is any occupied land.

a) Atran Bridge

The land around Atran Bridge is mostly used for agricultural purposes if not vacant land. Though several community facilities exist, they are located outside of the ROW. A transformer station is located on the south-eastern side of the road but it is more than 300m away. It is concluded that very limited resettlement is required.



Source: JICA Study Team

Figure 9.9 Condition related to Land Acquisition and Resettlement around Atran Bridge

b) Gyaing (Zha Tha Pyin) Bridge

Land condition around Gyaing (Zha Tha Pyin) Bridge is similar to that around Atran Bridge and no major resettlement is expected.

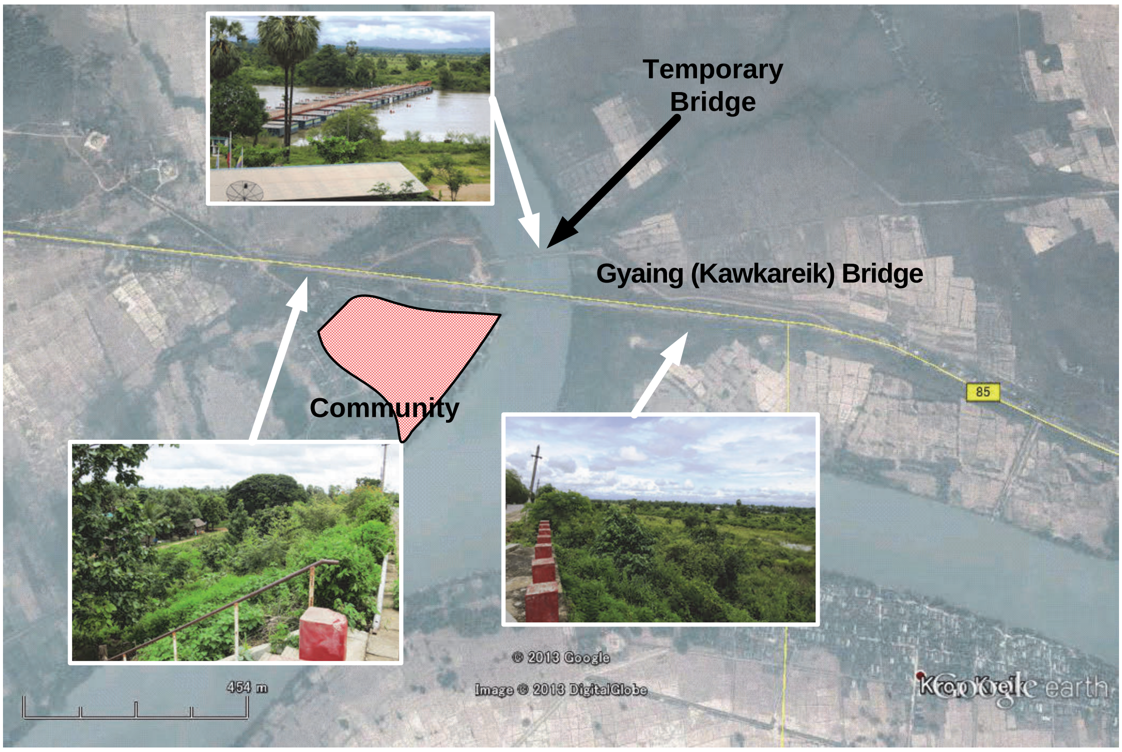
Source: JICA Study Team

Figure 9.10 Condition related to Land Acquisition and Resettlement around Gyaing (Zha Tha Pyin) Bridge

c) Gyaing (Kawkareik) Bridge

The eastern side of the bridge (left bank) is mostly farm land. On the western side (right bank), a large community was found but it is more than 100m from the bridge so resettlement is not expected.

There is a kind of temporary bridge (Pontoon Bridge) located 100m upstream of where Gyaing Bridge is located. The project is not expected to physically affect this bridge. Nevertheless, attention should be given so as to avoid disturbing the traffic flow on this road.

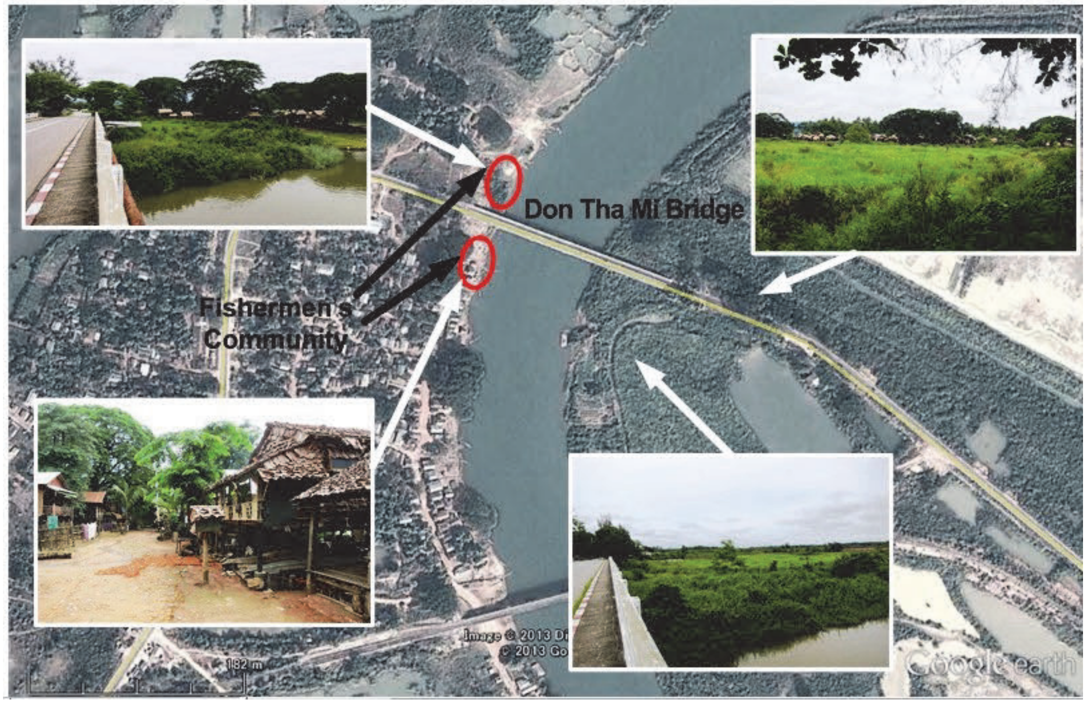


Source: JICA Study Team

Figure 9.11 Condition related to Land Acquisition and Resettlement around Gyaing (Kawkareik) Bridge

d) Don Tha Mi Bridge

The land in the eastern side (left bank) is mostly vacant or occupied by rice fields and no residence was found. On the other hand, on the western side (right bank), fishermen's villages exist along both sides of the bridge, the distance being 50 – 70m from the bridge. The total number of households was estimated to be approximately 100 units or more. It is predicted that relocation of some parts of those villages is required. In addition, construction works can disturb fishermen's work and some compensation is required to recover their income.

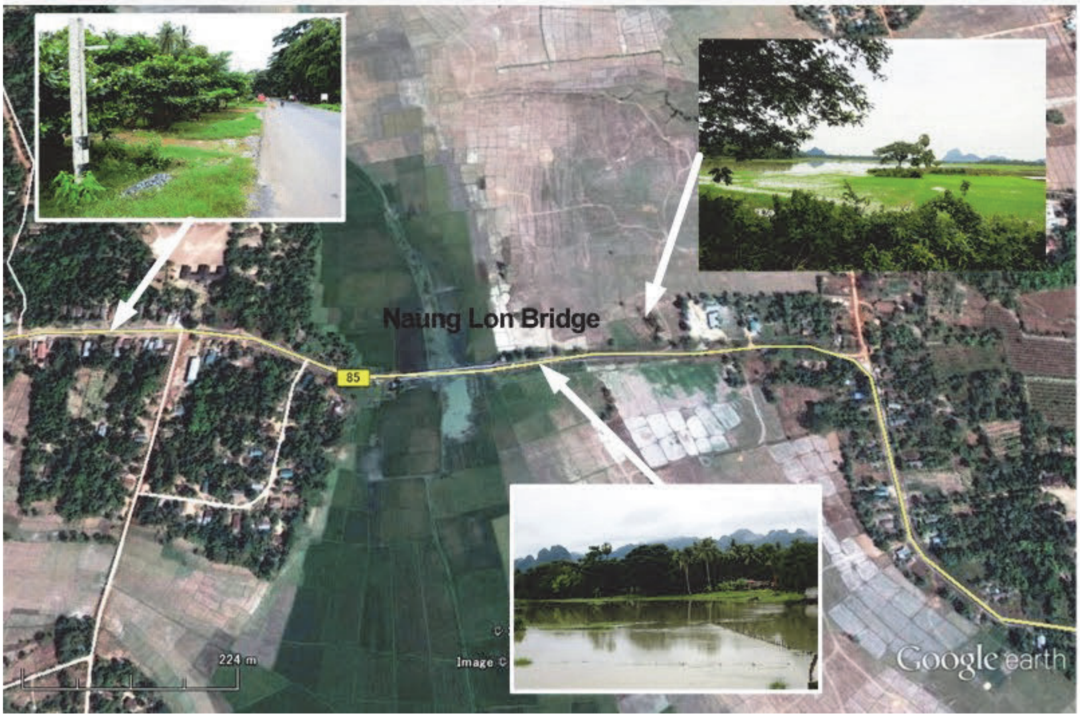


Source: JICA Study Team

Figure 9.12 Condition Related to Land Acquisition and Resettlement around Don Tha Mi Bridge

e) Naung Lon Bridge

The land around and under the bridge is used as a rice field during the dry season. It is flooded in the rainy season. Some street shops exist but no permanent residential site has been observed. Involuntary resettlement is not expected but compensation for farmers may be required.



Source: JICA Study Team

Figure 9.13 Condition related to Land Acquisition and Resettlement around Naung Lon Bridge

(2) Religious Facilities and Others

Many pagodas as well as monasteries were observed along the road, most of which are located within 2 to 3 m from the road side. Schools are mostly placed in the suburban areas and the ROW in front of them is mostly secured.

Source: JICA Study Team

Figure 9.14 Pagoda and Primary School Located near the Road (Kyaikhto)

No major utility was identified above ground between Payagyi and Waw. In Waw, Kyaito, and Thaton, however, power poles would need to be relocated or removed by the project.

Source: JICA Study Team

Figure 9.15 Power Poles in Thaton

9.3 Environmental Impacts

Environmental impacts are assessed for the following two divided components:

- By-pass road construction in Thaton
- Replacement of five bridges

9.3.1 By-pass road Construction in Thaton

Table 9-2 Environmental Impacts by By-Pass Road Construction in Thaton

	No.	Impacts	Design	Construction	O&M
Social Environment:	1	Land Acquisition, Involuntary Resettlement	A-	D	D
	2	Local Economy Such as Employment, Livelihood, etc.	C-	B+	B+
	3	Land Use and Utilization of Local Resources	C-	C-	D
	4	Social Institutions Such as Social Infrastructure and Local Decision-Making Institutions	C-	D	D
	5	Existing Social Infrastructures and Services	D	D	D
	6	Traffic Congestion	D	C-	C+
	7	Community Division	D	B-	B-
	8	Indigenous and Ethnic People	D	D	D
	9	Misdistribution of Benefits and Damages	C-	C-	D
	10	Natural / Cultural Heritages	D	D	D
	11	Local Conflict	D	C-	C-
	12	Water Usage, Water Rights and Rights of Common	D	D	D
	13	Sanitation	D	C-	D
	14	Hazards (Risk) of Infectious Diseases Such as HIV/AIDS	D	C-	D
Natural Environment	15	Topography and Geological Features	D	D	D
	16	Soil Erosion	D	C-	D
	17	Ground Water	D	C-	D
	18	Hydrological Condition	D	D	D
	19	Ecosystem, Flora, Fauna	D	D	D
	20	Meteorology	D	D	D
	21	Landscape	D	D	D
	22	Global Warming	D	D	D
Pollution	23	Air Pollution	D	C-	B-
	24	Water Pollution	D	B-	D
	25	Soil Contamination	D	B-	D
	26	Waste	D	B-	D
	27	Noise and Vibration	D	C-	B-
	28	Ground Subsidence	D	D	D
	29	Offensive Odour	D	D	D
	30	Bottom Sediment	D	D	D
	31	Accidents	D	C-	B-

Rating:
A+/-: Significant positive/negative impact is expected
B+/-: Positive/negative impact is expected to some extent
C+/-: Scale of impact is unclear, needs further study
D : No / slight impact is expected

(1) Environmental Impacts in Design Stage

1) Land Acquisition, Involuntary Resettlement (Impact Level A-)

Construction of the by-pass road in Tahton may result in land acquisition of farmland, and probably small scale resettlement along the existing local road. Regardless of the land owner status in the construction site, it is possible to raise social complaints unless land acquisition and resettlement is done with adequate compensation.

(2) Environmental Impacts in Construction Stage

1) Local Economy (Impact Level B+)

Labour demand as well as demand on local supply for construction materials, food services, etc. is expected for the local people during construction although only for a short period of time.

2) Community Division (Impact Level B-)

Construction works may prevent local villagers from easily crossing from one side of the road to the other.

3) Air Pollution (Impact Level B-)

Vehicles used for construction and mobilization will temporarily increase air pollutants through emission and by stirring up silted soil on the ground.

4) Water Pollution (Impact Level B-)

Bulk materials such as sand may cause turbid water by spreading, which can degrade agricultural land. Workers generate human waste which also degrades agricultural land and sanitary conditions.

5) Soil Contamination (Impact Level B-)

Excavated soil, waste water discharge and oil leakage could lead to soil contamination.

6) Waste (Impact Level B-)

Various residue and wastes will be generated as a result of the project.

(3) Environmental Impacts in Operation and Maintenance Stage

1) Local Economy (B+)

Economic activities could be stimulated by the increased traffic and number of visitors as a result of the road improvement. Rice and other agricultural products produced in the area are likely to have better access to the market.

2) Community Diversion (Impact Level B-)

Increase of traffic on the new road may prevent local villagers from easily crossing from one side of the road to the other.

3) Air Pollution (Impact Level B-)

Air pollutants from vehicle emissions will increase as the traffic increases. Pollution will also newly affect the areas along the by-pass road; however its impact may be small because of the low population.

4) Noise Disturbance (Impact Level B-)

Noise disturbance due to the increase in traffic volume may also increase. Noise will also newly affect the area along the by-pass road; however its impact may be small because of the low population.

5) Accident (Impact Level B-)

Traffic accidents could increase due to an increase in traffic volume in general, and at level crossings in particular.

9.3.2 Replacements of Five Bridges

Table 9-3 Environmental Impacts by Re-building Five Bridges

	No.	Impacts	Design	Construction	O&M
Social Environment:	1	Land Acquisition, Involuntary Resettlement	A-	D	D
	2	Local Economy Such as Employment, Livelihood, etc.	C-	B+	D
	3	Land Use and Utilization of Local Resources	C-	C-	D
	4	Social Institutions Such as Social Infrastructure and Local Decision-Making Institutions	C-	D	D
	5	Existing Social Infrastructures and Services	D	D	D
	6	Traffic Congestion	D	C-	C+
	7	Community Division	D	B-	B-
	8	Indigenous and Ethnic People	D	D	D
	9	Misdistribution of Benefits and Damages	C-	C-	D
	10	Natural / Cultural Heritage	D	D	D
	11	Local Conflict	D	C-	C-
	12	Water Usage, Water Rights and Rights of Common	D	C-	D
	13	Sanitation	D	C-	D
	14	Hazards (Risk of) Infectious Diseases Such as HIV/AIDS	D	C-	D
Natural Environment	15	Topography and Geological Features	D	D	D
	16	Soil Erosion	D	B-	D
	17	Ground Water	D	C-	D
	18	Hydrological Condition	D	B-	D
	19	Ecosystem, Flora, Fauna	D	C-	D
	20	Meteorology	D	D	D
	21	Landscape	D	D	D
	22	Global Warming	D	D	D
Pollution	23	Air Pollution	D	C-	D
	24	Water Pollution	D	B-	D
	25	Soil Contamination	D	B-	D
	26	Waste	D	B-	D
	27	Noise and Vibration	D	C-	D
	28	Ground Subsidence	D	D	D
	29	Offensive Odour	D	D	D
	30	Bottom Sediment	D	D	D
	31	Accidents	D	C-	B-

Rating:
A+/-: Significant positive/negative impact is expected
B+/-: Positive/negative impact is expected to some extent
C+/-: Scale of impact is unclear, need further study
D : No / small impact is expected

(1) Environmental Impacts in Design Stage

1) Land Acquisition, Involuntary Resettlement (Impact Level A-)

Land use around four of the bridges (except Don Tha Mi Bridge) is mostly agricultural land; it is not expected to require large scale resettlement. However, compensation for lost crop production must be considered.

On the other hand, there are fishermen's communities existing on the western side (right bank) of Don Tha Mi Brigde. The total number of households was estimated at approximately 100 units or more. Part of the village will be occupied by bridge construction; so that resettlement will be necessary.

(2) Environmental Impacts in Construction Stage

1) Local Economy (Impact Level B+)

Labour demand as well as demand on local supply for construction materials, food services, etc. is expected for the local people during construction although only for a short period of time.

On the other hand, since the river bed under Naung Lon Bridge is used for agricultural purposes during the dry season construction may cause disturbance to those agricultural activities.

2) Soil Erosion (Impact Level B-)

Improper civil works can generate soil erosion near bridges. It may cause degradation of water quality in the form of turbid water.

3) Hydrological Condition (Impact Level B-)

Construction of the new bridges may change the hydrological condition in the rivers during construction. Communities around Don Tha Mi Bridge are making their living by catching fish; therefore, the impact on fishing by the construction must be considered.

4) Ecosystem, Flora and Fauna (Impact Level B-)

In the preliminary survey, no specific endangered fauna and flora was identified; so that impact on ecosystem can considered to be minor. While it shall be highlighted that fishing around the construction site for Don Tha Mi Bridge can be affected by soil erosion and change of hydrological condition because of change of the fish's habitat condition.

5) Water Pollution (Impact Level B-)

Bulk materials such as sand may cause turbid water by spreading out which can degrade agricultural land and river condition. Workers generate human waste which also degrades agricultural land and sanitary conditions.

6) Soil Contamination (Impact Level B-)

Excavated soil, waste water discharge and oil leakage could lead to soil contamination.

7) Waste (Impact Level B-)

Various residues and wastes will be generated as a result of the project.

8) Environmental Impacts in Operation and Maintenance Stage

Because the new bridges are built adjacent to the existing bridges; impact during the operation and maintenance stage will be minor and comparable with the current condition.

9.4 Environmental Management

Environmental mitigation and monitoring are proposed as below:

Table 9-4 Proposal for Environmental mitigation and monitoring

Impact	Environmental Mitigation	Environmental Monitoring
Land acquisition, resettlement	- Public consultation with resettled households - Clear compensation process based on a RAP study - For farmland, acquisition of land and property (e.g. crops) after harvesting	- Site reconnaissance - Interviewing resettled persons regarding their living condition after relocation - Consultation meetings with academics, NGOs, etc.
Local Economy	- Priority given to local residents/communities for employment	- Interviews with residents regarding their perception and complaints - Direct observation
Community Diversion	By-pass road - Install level crossing - Public awareness for safety on crossing road, e.g.	- Interviews with residents regarding their perception and complaints - Direct observation
Soil Erosion	Bridge construction - Install drainage canal to control water flow - Reinforce river bank with masonry, fence, e.g.	- Direct observation - Interviews with residents
Hydrological Condition	Bridge construction - Install drainage canal to control water flow and to avoid turbid water directly discharging into the river	- Direct observation - Survey on fishing productivity - Interviews with residents
Water Pollution	- Install temporary drainage culvert for smooth water flow - Closed drainage canal development for wastewater - Prohibition of discharging domestic water from construction sites without adequate treatment	- Measurement (e.g. water quality, turbidity, pH, oil content) - Direct observation - Interviews with local residents on their perception and complaints
Soil Contamination	Bridge construction - Prohibition of discharging domestic water from construction sites without adequate treatment - Collection of oil residues, including lubricating oil	- Direct observation - Interviews with local residents on their perception and complaints
Waste	- Preparation of a temporary waste dumping site during storage - Development of a closed drainage canal for wastewater and prohibition of discharging without adequate treatment - Installation of a signboard to prohibit waste dumping in inappropriate areas - Collection of oil residues, including lubricating oil - Prohibition of placing materials (e.g. soil, gravel, and sand) on roadside or any other areas outside the project site - Installation of a fence to clarify the boundary between the project site and the area beyond - Reuse of sand materials for road improvement and others	- Site observation, - Examination of record of type and volume of waste, proportion of recycling/reuse

Source: JICA Study Team

9.5 Procedure for Environmental Impact Assessment (EIA)

Concrete steps for undertaking an EIA are stipulated in the EIA Procedures. While it is yet to be finalized, a draft of the document and results of the interview with ECD (Environmental Conservation Department) in MOECAF (Ministry of Environmental Conservation and Forestry) officers reveal the EIA process in Myanmar to be generally as follows:

(a) All development projects in Myanmar are subject to an environmental screening process through which projects will be judged to decide if they require any environmental review and if so, at which level (i.e. IEE or EIA).

(b) EIA includes an environmental management plan and a social impact assessment report.

(c) Public participation is required, when deemed necessary, for an Initial Environmental Examination (IEE), Environmental Impact Assessment (EIA) and preparation of an Environmental Management Plan (EMP).

(d) The project’s executing agency forms an EIA Review Committee, which gives recommendations to the Minister of MOECAF from an environmental point of view whether to approve the EIA reports or not. The Minister makes the final decision based on this recommendation. The review period is 50 days for IEE and 90 days for EIA.

(e) Members of the EIA Review Committee will be selected by the Minister of MOECAF and include persons from industry, academia, and civil society as well as government officials.

(f) Involuntary resettlement is carried out under the responsibility of respective regional governments and hence will not be included in the EIA Procedures.

(g) Costs involved in conducting an EIA are to be covered by the project proponent.

(h) EIA can be carried out in Myanmar only by firms that are registered under ECD/MOECAF.

9.6 Conclusions and Recommendations

9.6.1 Conclusions

Conclusions of the preliminary survey are summarized as follows:

- The ROW is basically secured along the target roads except in the towns / villages. Certain areas along the roads in the towns and villages are occupied by residential and commercial uses. Construction of a by-pass road in Thaton can avoid large scale resettlement; farmland shall be adequately compensated.
- Fishermen's villages exist beside Don Tha Mi Bridge. New bridge construction requires relocation of some houses in such villages. Similarly, reconstruction of some small bridges in the towns and villages may result in relocation of certain facilities.
- No protected area or sensitive zone with a valuable ecosystem is identified adjacent to the roads.

9.6.2 Recommendations

Recommendations for further assessment are described below:

- Major impact is expected to be that related to land acquisition and resettlement, especially the bridge construction site for the replacement of Don Tha Mi Bridge. Land acquisition of farmland in the by-pass road construction site shall also be compensated for. The following is recommended in order to avoid and minimize the impact:

  - PAPs (Project Affected Persons) should be informed well in advance about the planned project. In particular, the process, schedule and others related to land acquisition, resettlement and compensation need to be explained well in accordance with the applicable statutory and customary laws that apply to the area.

  - A mechanism should be set up to properly collect PAPs opinions, complaints, etc. Those comments shall be reflected in designing the way in which compensation or other forms of relief or supporting measures are carried out.

  - The level and content of compensation as well as support for resettlement should be fair; reflective to the extent possible of the needs of each PAP, and sufficient to allow the PAPs to restart their living at the same or higher level than their previous standards.

  - In providing alternative sites for resettlement, such sites should be selected from available lands that are close to the location of the original residence or occupation.

- Since some ethnic minority groups live in Mon State and Kayin State and Myanmar has granted their political autonomy, the procedure of land acquisition and resettlement as well as social environmental management shall be in consideration of the viewpoints stipulated above.

Chapter 10 Project Evaluation and Conclusion

10.1 Economic Analysis

10.1.1 Preconditions

Table 10-1 shows the preconditions for the economic analysis of the project. Items of investment cost such as taxes and price escalation are deleted from financial prices in order to introduce economic cost. The standard Conversion Factor (SCF) which is used for transformation from financial cost to economic cost was set at 0.85. This level is generally employed in the same kind of economic analysis in developing countries in the Southeast Asia.

Table 10-1 Preconditions for Economic Analysis

Items	Conditions	Remarks
Project life	30 years (including design and construction)	Starting year of design: 2017 Opening year: 2021 (Replacement of 5 bridges); 2022 (Thaton bypass)
Exchange rate	1US dollar = 100 Japanese yen 1US dollar = 1,000 Myanmar kyat	Reference Exchange Rate
Social discount rate	12%	–
Economic cost	85% of financial cost	–

Source: JICA Study Team

10.1.2 Investment Cost

Investment cost, which is calculated in chapter 8Table 10-2, is disbursed annually in accordance with an investment plan that is shown in Table 10-3, which indicates the annual investment cost of the project for the replacement of 5 bridges and Thaton bypass. Table 10-4 shows annual maintenance cost and periodic maintenance cost.

Table 10-2 Annual Disbursement of Investment Cost

	2017	2018	2019	2020	2021
Replacement of 5 bridges	21%	36%	26%	17%	–
Thaton bypass	10%	30%	30%	20%	10%

Source: JICA Study Team

Table 10-3 Annual Disbursement of Investment Cost

(Unit: US Dollar million)

Items		2017	2018	2019	2020	2021	Total
Investment cost	Replacement of 5 bridges	30.5	51.0	36.3	24.2	–	142.0
	Thaton bypass	2.8	8.4	8.4	5.6	2.8	28.0
	Total	33.3	59.4	44.7	29.8	2.8	170.0

Source: JICA Study Team

Table 10-4 Annual Maintenance Cost and Periodic Maintenance Cost

Items	Cost	Frequency of disbursement
Annual maintenance cost	0.03% of investment cost (Replacement of 5 bridges) 0.10% of investment cost (Thaton bypass)	Annually
Periodic maintenance cost	0.5% of investment cost (Replacement of 5 bridges) 10.0% of investment cost (Thaton bypass)	Every 10 years

Source: JICA Study Team

10.1.3 Traffic Volume

Future traffic volumes of the project (replacement of 5 bridges and Thaton bypass) in both cases of with-project and without-project are presented from Table 10-5 to Table 10-8. Annual traffic volumes from 2021 to 2046 in both cases are calculated by employing an interpolation method.

Table 10-5 Future Traffic Volume (Replacement of 5 Bridges, vehicle-kilometres)

Vehicle class		2 axle trucks - small	2 axle trucks - large	3 axle trucks	More than 4 axle trucks	Trailers	Passenger cars	Buses	Total
2013		264,939	613,228	465,316	1,860,365	1,035,713	4,960,539	2,830,892	12,030,993
With-project	2015	331,960	764,442	565,782	2,200,315	1,232,645	6,083,508	3,329,711	14,508,364
	2020	506,297	1,182,565	876,707	3,435,341	1,951,618	11,568,576	5,419,176	24,940,279
	2030	1,389,743	3,208,449	2,344,338	8,912,620	5,123,571	32,673,072	12,827,210	66,479,002
Without-project	2015	331,960	764,442	565,782	2,243,108	1,255,565	6,083,508	3,329,711	14,574,078
	2020	506,297	1,182,565	876,707	3,509,494	1,991,208	11,568,576	5,419,176	25,054,021
	2030	1,389,743	3,208,449	2,344,338	9,149,209	5,250,705	32,673,072	12,827,210	66,842,726

Source: JICA Study Team

Table 10-6 Future Traffic Volume (Replacement of 5 Bridges, vehicle-hours)

Vehicle class		2 axle trucks - small	2 axle trucks - large	3 axle trucks	More than 4 axle trucks	Trailers	Passenger cars	Buses	Total
2013		12,495	28,941	22,059	88,444	49,271	178,219	81,454	460,883
With-project	2015	13,540	30,550	19,995	70,993	39,298	229,023	105,998	509,398
	2020	13,539	30,548	19,994	72,988	40,367	229,027	106,003	512,468
	2030	19,668	44,753	28,513	99,426	55,663	402,072	150,610	800,704
Without-project	2015	19,666	44,745	28,508	102,897	57,516	402,075	150,618	806,025
	2020	51,861	117,673	73,890	244,820	138,266	1,070,238	322,984	2,019,731
	2030	51,911	117,819	73,979	256,121	144,338	1,071,850	323,324	2,039,342

Source: JICA Study Team

Table 10-7 Future Traffic Volume (Thaton Bypass, vehicle- kilometres)

Vehicle class		2 axle trucks - small	2 axle trucks - large	3 axle trucks	More than 4 axle trucks	Trailers	Passenger cars	Buses	Total
With-project	2015	472,724	1,281,334	1,118,590	4,992,818	3,116,358	6,055,937	3,318,481	20,356,242
	2030	2,010,529	5,472,983	4,751,087	20,733,872	13,264,415	32,486,515	13,081,235	91,800,636
Without-project	2015	472,942	1,282,208	1,119,163	4,994,439	3,117,326	6,057,751	3,318,880	20,362,709
	2030	2,011,340	5,475,810	4,752,933	20,739,456	13,267,774	32,495,512	13,083,056	91,825,881

Source: JICA Study Team

Table 10-8 Future Traffic Volume (Replacement of 5 Bridges, vehicle- hours)

Vehicle class		2 axle trucks - small	2 axle trucks - large	3 axle trucks	More than 4 axle trucks	Trailers	Passenger cars	Buses	Total
With-project	2015	22,110	59,956	52,421	234,185	146,194	216,832	95,461	827,159
	2030	101,110	275,841	241,660	1,059,540	677,851	1,455,087	566,698	4,377,787
Without-project	2015	22,120	59,996	52,447	234,260	146,239	216,916	95,480	827,458
	2030	101,138	275,933	241,719	1,059,722	677,959	1,455,383	566,766	4,378,620

Source: JICA Study Team

10.1.4 Economic Benefit

Economic benefit of the project consists of saving of Vehicle Operating Cost (VOC) and reduction of travel cost. Economic benefit of replacement of 5 bridges will be begin in 2021, and that of the Thaton bypass project will be provided from 2022 after opening of the new bridges and the bypass route.

(1) Vehicle Operating Cost

Vehicle operation cost includes purchasing and maintenance cost of the vehicles, fuel cost and insurance cost, etc. In this project, VOC data prepared in the “Feasibility Study of Economics, Engineering, and Environmental Impacts of the Four-Lane Highway Widening Project (Phase II), Route No. 12, Section Lom Sak – Consan Intersection,” which was conducted in Thailand in 2010 was employed because data for estimating VOC of inter-city transportation is limited in Myanmar. The figures of VOC mentioned above are adjusted to the value in 2013 by use of the inflation rate of Thailand and exchanged into US dollar amounts. Table 10-9 indicates adjusted VOC data by road conditions and vehicle classification. Data of VOC at 30 kilometres per hour in “rolling roads” is utilized in order to calculate savings of VOC.

Table 10-9 VOC by Vehicle Classification (US dollars per kilometre)

Road condition	Speed (km/h)	Passenger cars	2 axle trucks - small	2 axle trucks - large	3 and 4 axle trucks	Trailers	Buses
Flat roads	10	0.441	0.510	0.938	1.514	1.721	1.598
	20	0.272	0.284	0.543	0.919	1.089	0.929
	30	0.218	0.211	0.418	0.728	0.888	0.711
	40	0.193	0.177	0.361	0.642	0.801	0.609
	50	0.180	0.158	0.331	0.599	0.756	0.552
	60	0.172	0.147	0.316	0.581	0.740	0.522
Rolling roads	10	0.443	0.514	0.952	1.554	1.806	1.678
	20	0.274	0.287	0.566	0.963	1.232	1.024
	30	0.220	0.215	0.443	0.787	1.049	0.810
	40	0.195	0.180	0.384	0.706	0.967	0.708
	50	0.181	0.160	0.351	0.659	0.918	0.648
	60	0.174	0.149	0.331	0.633	0.863	0.599
Mountainous roads	10	16.44	0.522	1.015	1.680	2.166	1.861
	20	9.52	0.302	0.635	1.142	1.603	1.212
	30	7.28	0.231	0.513	0.969	1.430	1.004
	40	6.20	0.197	0.456	0.890	1.246	0.863
	50	5.54	0.176	0.422	0.840	1.215	0.812
	60	5.14	0.163	0.390	0.781	1.208	0.786

Source: Calculation by JICA Study Team

Table 10-10 shows the savings in VOC per day during 2021 and 2046 calculated from Table 10-6 and Table 10-8. The 2nd column and the 4th column are the saving volume of VOC per day in the 5 bridges replacement and Thaton bypass, and the 3rd and the 5th columns are those converted to volume per year. Annual saving volumes are calculated from daily reduction volume times 300 days.

Table 10-10 Saving of VOC (5 Bridges Replacement and Thaton Bypass)

Year	5 bridges replacement		Thaton bypass	
	Saving of VOC per day (US dollar)	Saving of VOC per year (US dollar million)	Saving of VOC per day (US dollar)	Saving of VOC per year (US dollar million)
2021	134,326	40.298	–	–
2022	151,106	45.332	7,917	2.375
2023	169,904	50.971	8,629	2.589
2024	190,955	57.287	9,404	2.821
2025	214,524	64.357	10,247	3.074
2026	240,904	72.271	11,165	3.349
2027	270,421	81.126	12,163	3.649
2028	303,441	91.032	13,250	3.975
2029	340,369	102.111	14,432	4.330
2030	381,658	114.497	15,719	4.716
2031	427,812	128.344	17,118	5.135
2032	479,392	143.818	18,639	5.592
2033	537,022	161.107	20,294	6.088
2034	601,399	180.420	22,093	6.628
2035	673,297	201.989	24,049	7.215
2036	753,578	226.073	26,174	7.852
2037	843,201	252.960	28,484	8.545
2038	943,233	282.970	30,995	9.298
2039	1,054,864	316.459	33,722	10.117
2040	1,179,413	353.824	36,684	11.005
2041	1,318,352	395.506	39,901	11.970
2042	1,473,315	441.994	43,395	13.019
2043	1,646,121	493.836	47,188	14.156
2044	1,838,793	551.638	51,305	15.392
2045	2,053,580	616.074	55,774	16.732
2046	2,292,981	687.894	60,622	18.187

Source: JICA Study Team

(2) Reduction of Travel Time

Reduction of travel time is regarded as an economic benefit by employing the idea that the reduction time could be used for generating income. Therefore, the produced income would be the same as a Myanmar person's income per time unit. According to IMF's World Economic Outlook Database October 2013, nominal GDP per capita was 915 US dollars in Myanmar in 2013. Hourly income amounts to 0.13 US dollar assuming that Myanmar people work 300 days per year.

Hourly income will increase gradually in accordance with Myanmar's economic development. Table 10-11 shows the annual growth rate of GDP per capita in 5 years (in the 2nd row) and hourly income in every 5 year period (in the 3rd row). The growth rate of GDP per capita is calculated from the GDP growth rate and population growth rate which are used for the transport demand forecasts. GDP growth rate will stay at 7.2% after 2016, while the population growth rate will decrease gradually. As a result, the growth rate of GDP will increase gradually. Table 10-12 shows the number of passengers per vehicle.

Table 10-11 Changes in Income per Hour

	2013–15	2016–20	2021–25	2026–30	2031–35	2036–
Growth rate of GDP per capita per year	4.2%	4.8%	5.1%	5.4%	5.7%	6.0%
Income per hour (US dollar)	0.138 (2015)	0.174 (2020)	0.223 (2025)	0.290 (2030)	0.382 (2035)	0.510 (2040)

Source: JICA Study Team

Table 10-12 Number of Passengers per Vehicle

Vehicle class	2 axle trucks - small	2 axle trucks - large	3 axle trucks	More than 4 axle trucks	Trailers	Passenger cars	Buses
Number of passengers	1.5	1.8	2.0	2.0	2.5	3.1	33.6

Note: The figures include drivers and assistants

Source: JICA Study Team

Table 10-13 indicates the reduction of travel time during 2021 and 2046 which is calculated from the figures in Table 10-6, Table 10-8, Table 10-11 and Table 10-12. Figures of the 2nd column and the 4th column of Table 10-13 are the reduction of travel time per day in the 5 bridges replacement and Thaton bypass, and the figures of the 3rd column and the 5th column are those converted to volume per year. Annual reduction volumes are calculated from daily reduction volume times 300 days in those conversions.

Table 10-13 Reduction of Travel Time (5 Bridges Replacement and Thaton Bypass)

Year	5 bridges replacement		Thaton bypass	
	Reduction of travel time per day (US dollar)	Reduction of travel time per year (US dollar million)	Reduction of travel time per day (US dollar)	Reduction of travel time per year (US dollar million)
2021	2,588	0.776		
2022	3,223	0.967	448	0.134
2023	3,987	1.196	509	0.153
2024	4,905	1.472	578	0.173
2025	6,006	1.802	655	0.196
2026	7,344	2.203	743	0.223
2027	8,947	2.684	842	0.253
2028	10,866	3.260	952	0.286
2029	13,156	3.947	1,075	0.322
2030	15,889	4.767	1,210	0.363
2031	19,196	5.759	1,363	0.409
2032	23,143	6.943	1,530	0.459
2033	27,847	8.354	1,713	0.514
2034	33,448	10.034	1,911	0.573
2035	40,111	12.033	2,123	0.637
2036	48,165	14.449	2,354	0.706
2037	57,756	17.327	2,596	0.779
2038	69,170	20.751	2,845	0.853
2039	82,743	24.823	3,095	0.928
2040	98,872	29.662	3,336	1.001
2041	118,025	35.408	3,557	1.067
2042	140,755	42.227	3,741	1.122
2043	167,715	50.315	3,866	1.160
2044	199,674	59.902	3,901	1.170
2045	237,540	71.262	3,807	1.142
2046	282,380	84.714	3,535	1.061

Source: JICA Study Team

10.1.5 Calculation of EIRR

Table 10-14 and Table 10-15 show annual cash flows of the 5 bridges replacement and Thaton bypass calculated from economic costs and economic benefits. Economic Internal Rates of Return (EIRR) of both projects account for 30.0% (5 bridges replacement) and 13.0% (Thaton bypass), respectively.

The calculated figures exceed 12%, which is commonly used for a benchmark of social discount rate in developing countries. Therefore, the project is feasible from the point of national economic development.

Table 10-14 Cash Flow of 5 Bridges Replacement

(Unit: US dollar million)

Project lifetime	Year	Cash outflow				Cash inflow	Net cash flow
		Investment	Annual maintenance	Periodic maintenance	Total cost	Economic benefit	Net benefit
1	2017	30.500			30.500		-30.500
2	2018	51.000			51.000		-51.000
3	2019	36.300			36.300		-36.300
4	2020	24.200			24.200		-24.200
5	2021		0.043		0.043	41.074	41.032
6	2022		0.043		0.043	46.299	46.256
7	2023		0.043		0.043	52.167	52.125
8	2024		0.043		0.043	58.758	58.716
9	2025		0.043		0.043	66.159	66.116
10	2026		0.043		0.043	74.474	74.432
11	2027		0.043		0.043	83.811	83.768
12	2028		0.043		0.043	94.292	94.249
13	2029		0.043		0.043	106.058	106.015
14	2030		0.043	0.710	0.753	119.264	118.512
15	2031		0.043		0.043	134.103	134.060
16	2032		0.043		0.043	150.760	150.718
17	2033		0.043		0.043	169.461	169.418
18	2034		0.043		0.043	190.454	190.412
19	2035		0.043		0.043	214.023	213.980
20	2036		0.043		0.043	240.523	240.480
21	2037		0.043		0.043	270.287	270.245
22	2038		0.043		0.043	303.721	303.679
23	2039		0.043		0.043	341.282	341.240
24	2040		0.043	0.710	0.753	383.486	382.733
25	2041		0.043		0.043	430.913	430.870
26	2042		0.043		0.043	484.221	484.179
27	2043		0.043		0.043	544.151	544.108
28	2044		0.043		0.043	611.540	611.498
29	2045		0.043		0.043	687.336	687.293
30	2046		0.043		0.043	772.608	772.566
						EIRR	30.3%

Source: JICA Study Team

Table 10-15 Cash Flow of Thaton Bypass

(Unit: US dollar million)

Project lifetime	Year	Cash outflow				Cash inflow	Net cash flow
		Investment	Annual maintenance	Periodic maintenance	Total cost	Economic benefit	Net benefit
1	2017	2.800			2.800		-2.800
2	2018	8.400			8.400		-8.400
3	2019	8.400			8.400		-8.400
4	2020	5.600			5.600		-5.600
5	2021	2.800			2.800		-2.800
6	2022		0.028		0.028	2.510	2.482
7	2023		0.028		0.028	2.741	2.713
8	2024		0.028		0.028	2.994	2.966
9	2025		0.028		0.028	3.271	3.243
10	2026		0.028		0.028	3.572	3.544
11	2027		0.028		0.028	3.902	3.874
12	2028		0.028		0.028	4.261	4.233
13	2029		0.028		0.028	4.652	4.624
14	2030		0.028		0.028	5.079	5.051
15	2031		0.028	2.800	2.828	5.544	2.716
16	2032		0.028		0.028	6.051	6.023
17	2033		0.028		0.028	6.602	6.574
18	2034		0.028		0.028	7.201	7.173
19	2035		0.028		0.028	7.851	7.823
20	2036		0.028		0.028	8.558	8.530
21	2037		0.028		0.028	9.324	9.296
22	2038		0.028		0.028	10.152	10.124
23	2039		0.028		0.028	11.045	11.017
24	2040		0.028		0.028	12.006	11.978
25	2041		0.028	2.800	2.828	13.038	10.210
26	2042		0.028		0.028	14.141	14.113
27	2043		0.028		0.028	15.316	15.288
28	2044		0.028		0.028	16.562	16.534
29	2045		0.028		0.028	17.874	17.846
30	2046		0.028		0.028	19.247	19.219
						EIRR	13.0%

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10.1.6 Sensitivity Analysis

Table 10-16 and Table 10-17 show the results of sensitivity analyses. Figures in the 2nd columns are FIRR under different changes of conditions. Increases in investment cost and drop of economic benefit make a certain level of impact on EIRR. However, EIRR stays at more than 12% if construction and procurement cost increases by 10%. Impact of changes in annual and periodic maintenance costs on EIRR is limited.

Table 10-16 Results of Sensitivity Analysis (Replacement of 5 Bridges)

Unit: Percent

Cases	EIRR
Base case	30.3
10% increase of investment cost	28.9
10% reduction of economic benefit	28.8

Source: JICA Study Team

Table 10-17 Results of Sensitivity Analysis (Thaton Bypass)

Unit: Percent

Cases	EIRR
Base case	13.0
10% increase of investment cost	12.2
10% reduction of economic benefit	12.0

Source: JICA Study Team

10.2 Expected Effects of the Project

The following effects will be expected after completion of the project.

10.2.1 East-West Economic Corridor (Replacement of 5 Bridges)

- Travel time between Thailand (Bangkok) and Myanmar (Yangon) would be shorter.
- Reduction of time and savings for transhipment of cargo which is caused by the lack of strength of the existing bridge would be expected.
- Tourism demand from Myanmar to Tak Province of Thailand would increase.
- Transport demand from the western part of Thailand to Myanmar would increase.
- Myanmar citizens who were forced to emigrate by the civil war would return to their original places.
- Regional economic development along the East-West Economic Corridor, in the border area and the southern part of Myanmar would be promoted. For example, UMH Industrial Zone, which is located at Hpa an, have a potential to attract labour-intensive factories from Thailand.

10.2.2 East-West Economic Corridor (Thaton Bypass Construction)

- Vehicles bypassing Thaton town could save cost for fuel and travel time.
- Residents of Thaton town can live safely because of reduction of traffic volume at Thaton downtown.

10.3 Way forward

10.3.1 Recommendations for Road Design in the Feasibility Study

(a) Roads should satisfy the international standards for the EWEC for future development
(b) Detailed flood analysis is required to determine the height of the road level taking into account the remarkable heavy rainfall in 2013
(c) Coordination with private BOT projects and increase capacity level of PWD maintenance
(d) Create a future development plan for infrastructure scheduled by PWD
(e) Conduct an accurate traffic demand forecast
(f) Review of pavement structure based on the accurate traffic demand forecast
(g) Collect the topographic maps based on ground surveys and geotechnical information such as CBR, etc.

10.3.2 Recommendations for Bridge Design in the Feasibility Study

(a) Conduct accurate topographic surveys for preliminary design
(b) Design bridges to satisfy international standards for the EWEC for future development of the international corridor
(c) Conduct necessary hydrological surveys to decide the locations of the bridges
(d) Confirmation of facilities and utilities required to be installed on the bridges prior to design