PART 3
REHABILITATION PROJECT

CHAPTER 8

Overview of Rehabilitation Project

Chapter 8 Overview of Rehabilitation Project

8.1 Selected Road & Bridge Section for Rehabilitation Project

In the Northern and Eastern Provinces, where cumulative capital investment is relatively low, damage from the tsunami is perceived as being more serious. Therefore, when possible, the aim of rehabilitation should not only be to restore facilities to the state they were in before the disaster, but to improve the overall level of infrastructure as well. Given this, it was decided in negotiations between JICA and RDA that a rehabilitation program to improve existing trunk roads on the East Coast of Sri Lanka, which consists of AA004 from Akkaraipattu to Batticaloa (65 km) and AA015 from Batticaloa to Trikkandimadu (35 km), as well as the Kallady Bridge on AA004 to the south of Batticaloa, be taken up in a feasibility study. The total length of this Project road (including the bridge) is about 100 km and passes through such towns as Karativu, Kalmunai and Batticaloa and is as shown in Figure 8.1.1.

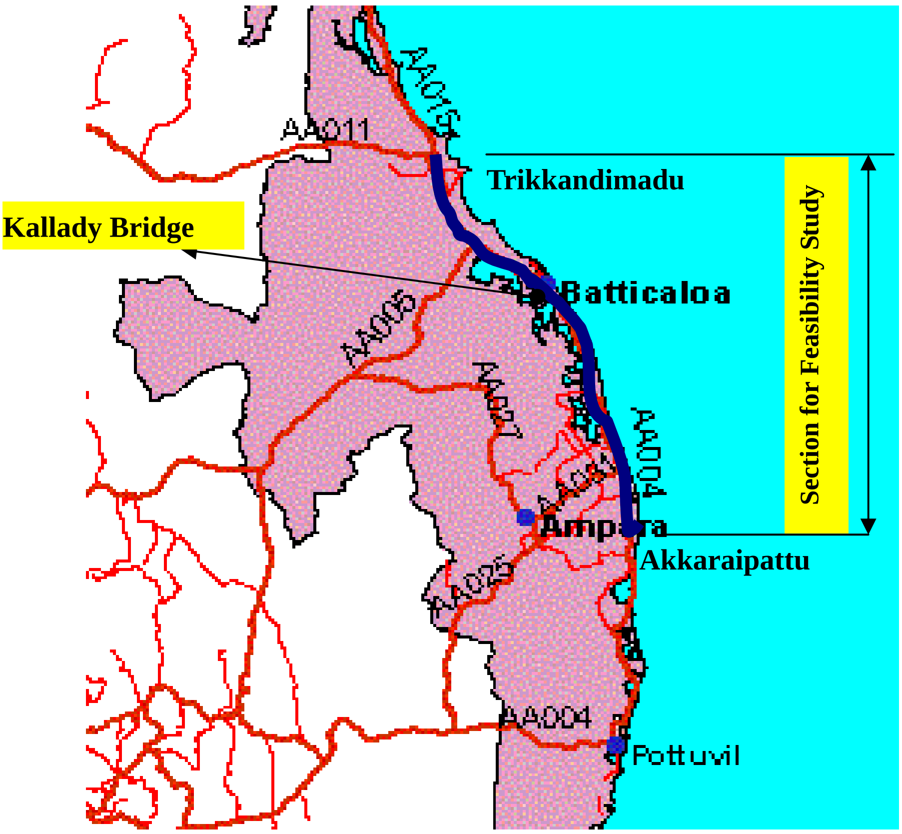


Figure 8.1.1. Road & Bridge Sections for Rehabilitation Project

In addition to the above rehabilitation, which is the object of examination for this Project, another undertaking located on the Project road at the 33 kmp on AA0015 near Trikkandimadu and most probably to be funded by Spain is being considered. This undertaking consists of building a new Oddaimavadi Bridge for road traffic. Note that the existing bridge is a composite road/rail bridge.

8.2 Existing Road Conditions

8.2.1 General

The Project road is the only north-south arterial on the East Coast of Sri Lanka, and is therefore an important route for the transportation of goods and passengers in the area. However, portions of it were damaged by the tsunami, with the Peria Kallar and Koddaia Kallar Causeways in particular sustaining severe damage. Note that there are many temporary camps of people whose homes were either destroyed or damaged by the tsunami located along the Project road (i.e., AA004 and a part of AA015), which needs to be rehabilitated quickly because of its importance as the sole north-south arterial.

8.2.2 Road Conditions

1) Road Alignment

The Project road is situated in an area less than 50 m above sea level, and some sections are located on sandbars. Therefore, the vertical alignment is almost flat and only the vertical gradients of causeway bridge sections are 2% to 3%. The horizontal alignment, on the other hand, is sufficiently wide for design speeds of 50 km/hr to 60 km/hr and there are very few curves. Note that there are a few curves with a mild gradient at the edge of some towns, bridges, and causeways.

As for flooding along the Project road, RDA records indicate this occurs on the following sections:

- South of Kalmunai town on AA004
- North of Batticaloa town on AA015
- North of Eravur town on AA015

The calculated high water level (HWL) for 1- to 50-year return periods for the Batticaloa Lagoon and Valachchenai Lagoon are shown in Table 8.2.1. The centerline profile of the existing road (road elevation) and the HWL in the lagoon area for a 50-year return period are shown in Figure 8.2.1, 8.2.2, and 8.2.3. Note that the Project road sometimes comes under the HWL.

Table 8.2.1. Existing High Water Levels

Area	High Water Level (m, M.S.L.)				
	1-year Return Period	5-year Return Period	10-year Return Period	25-year Return Period	50-year Return Period
Batticaloa Lagoon	0.55	0.93	1.08	1.26	1.35
Valachchenai Lagoon	1.74	2.39	2.80	3.06	3.30

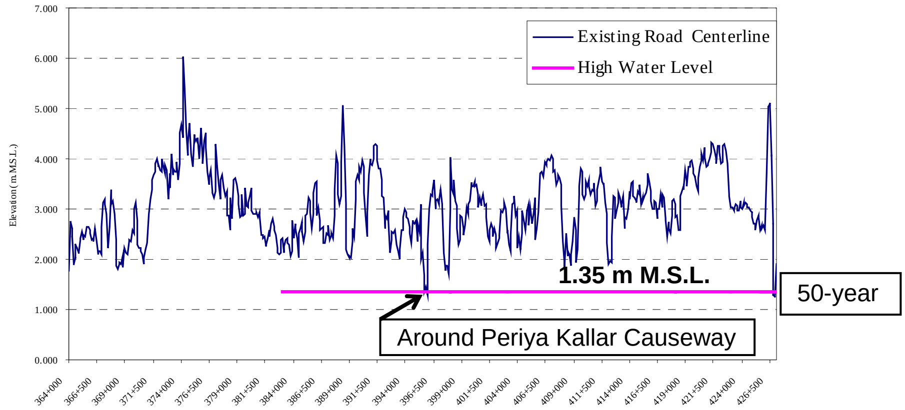


Figure 8.2.1. Centerline Profile of Existing Road & HWL for 50-Year Return Period (Batticaloa Lagoon Side - 1)

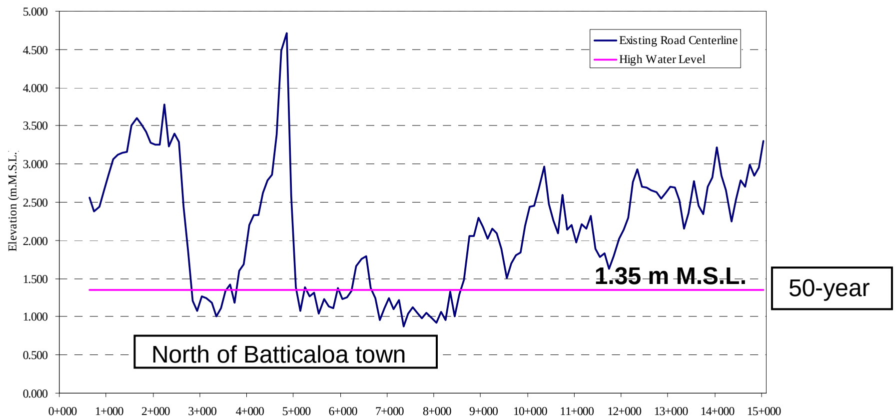


Figure 8.2.2. Centerline Profile of Existing Road and HWL 50-year Return Period (Batticaloa Lagoon Side - 2)

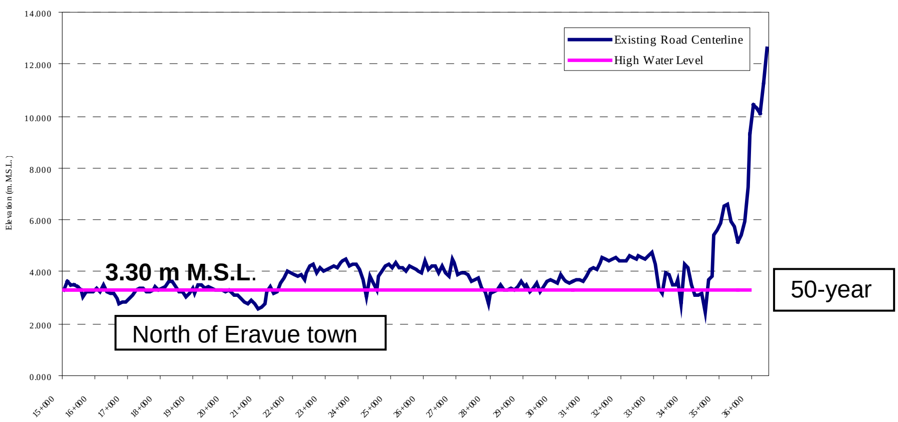


Figure 8.2.3. Centerline Profile of Existing Road & HWL for 50-Year Return Period (Valachchenai Lagoon Side)

2) Road Width

The Project road is basically a two-lane highway. However, in some towns such as Akkaraipattu, Eravur and Valaichchenai, the Project road consists of a four-lane carriageway + sidewalks, while in other towns such as Kalmunai, Kattankudi and Batticaloa, it consists of a two-lane carriageway + parking lanes + sidewalks. As there are many kinds of shops along the road in these towns, the carriageway is crowded with vehicles and pedestrians. On the other hand, in the suburbs between Kalmunai and Talankuda and between Batticaloa and Eravur, the Project road can be as narrow as 9 m due to the influence of houses or walls/fences. Note that on average the paved width of the existing Project road is approximately 6.1 m for the section from Akkaraipattu to Batticaloa and 8.5 m for the section from Batticaloa to Trikkandimadu.

There are two long-span bridges on the Project road (i.e., the Kallady Bridge for crossing the Batticaloa Lagoon and Oddaimavadi Bridge for crossing the Valaichchenai River), and the carriageway of both these bridges has only one lane 4.7 m in width. The gateways of these bridges are especially congested during peak hours and are therefore a bottleneck to existing traffic. A breakdown of Project road width is given in Figure 8.2.4.

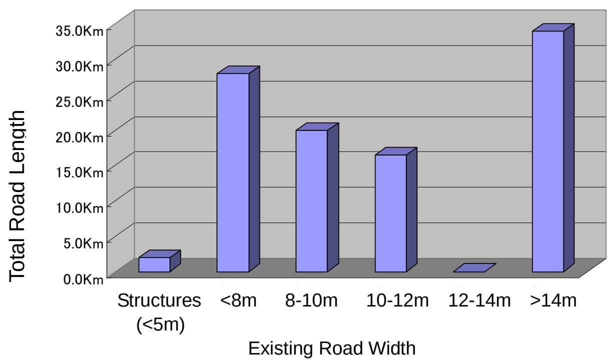
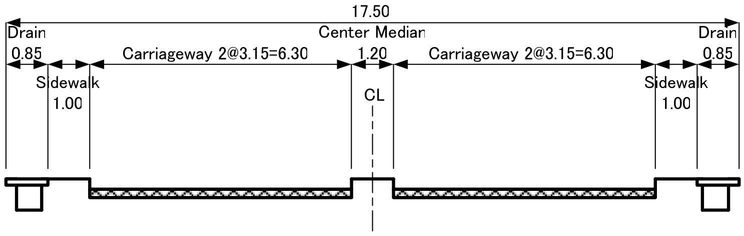
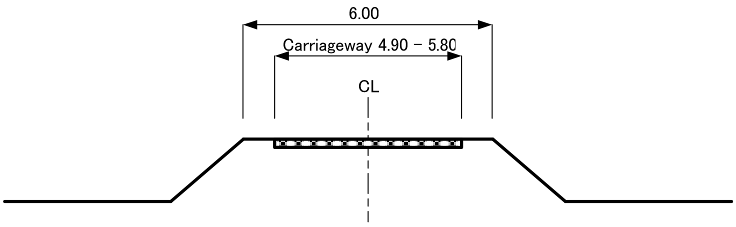


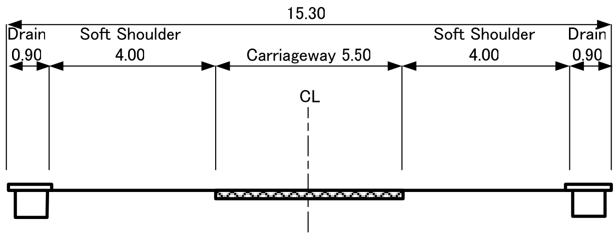
Figure 8.2.4. Total Road Length in Terms of Road Width



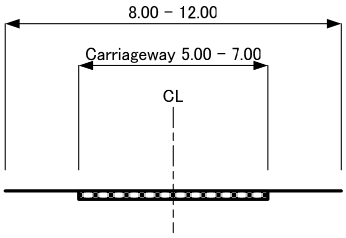
Akkaraipattu Town (A04: Km 364+840 – Km 366+720)



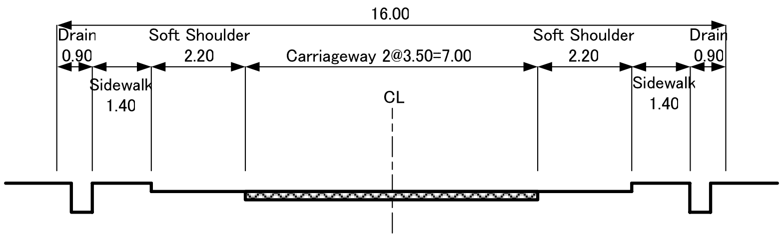
Akkaraipattu – Kalmunai (A04: Km 366+720 – Km 383+590)



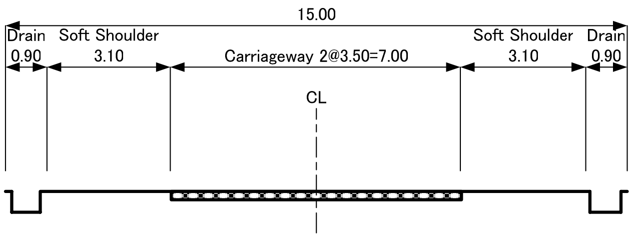
Kalmunai Town (A04: Km 383+590 – Km 388+020)



Kalmunai – Kattankudi (Ao4: Km 388+020 – Km 423+420)

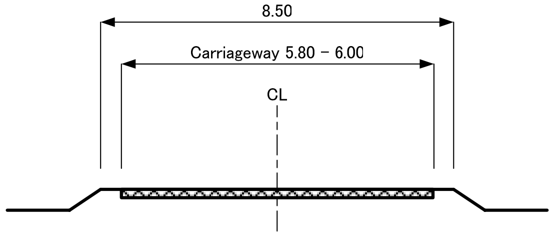


Kattankudi Town (A04: Km 423+420 – Km 425+080)

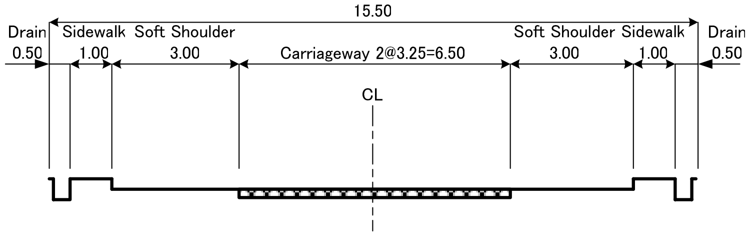


Batticaloa Town (A04: Km 426+960 – A15: Km 1+570)

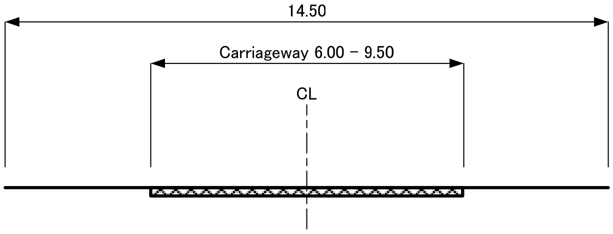
Figure 8.2.5. (1) Existing Road Width



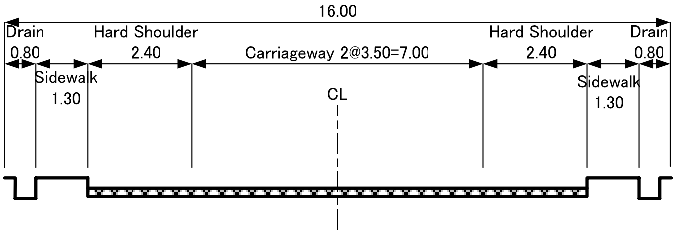
Batticaloa – Eravur (A15: Km 1+570 – Km 12+690)



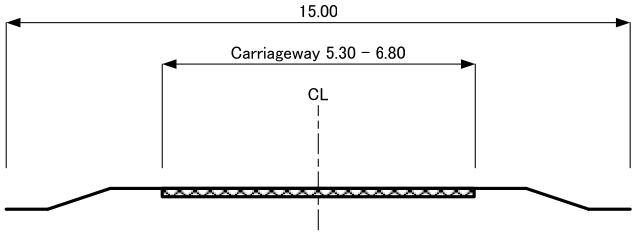
Eravur Town (A15: Km 12+690 – Km 14+630)



Eravur – Valaichchenai (A15: Km 14+630 – Km 31+690)



Valaichchenai Town (A15: Km 31+690 – Km 33+250)



Valaichchenai – Trikkandumadu (A15: Km 33+250 – Km36+530)

Figure 8.2.5 (2) Existing Road Width

3) Road Pavement

The existing pavement type is macadam, and the road surface is experiencing cracking and potholes at both the center and edge of the carriageway. The Study Team has estimated that the international roughness index for the Project road varies approximately from a minimum value of 7 to a maximum value of 10, and therefore the surface smoothness of the pavement is not good. This means that many sections of the Project road require an overlay, as the condition of the pavement is a hindrance to smooth traffic flows. Note also that pavement width is quite narrow on paddy field sections between Akkaraipattu and Kalmunai, as well in the suburban area between Kalmunai and Kattankudi, and is only 4.5 m in width.

4) Drainage Facilities

As the Project road passes mostly over flat land the road is slightly embanked. There are also some existing U-type side ditches and others are either being construction or planned for urban roadside areas. Other areas have no drainage facilities, as the foot of the slope is sandy and therefore not necessary.

5) Land Use

Town sections of the Project road account for approximately 24 % of its entire length, with suburb, narrow section of suburb, and paddy and lagoon field sections making up about 58%, 4%, and 14 %, respectively (see Figure 8.2.6).

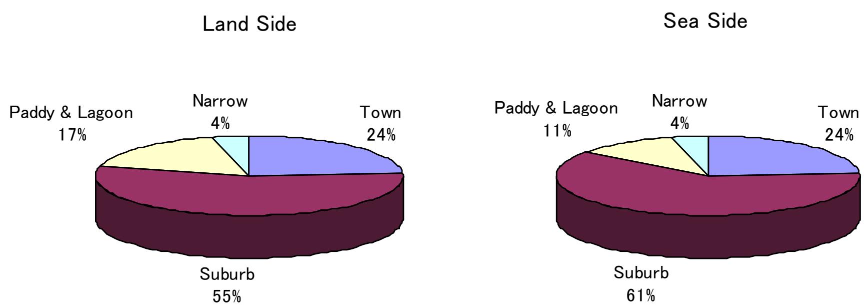


Figure 8.2.6. Land Use

8.3 Outline of Rehabilitation Project for Eastern Trunk Roads

8.3.1 Outline of Feasibility Study

The Rehabilitation Project for the 100 km long trunk road on the East Coast between Akkaraipattu and Trikkandimadu, which is less developed than the Western and Southern regions of Sri Lanka, consists of a feasibility study that is also intended to stimulate the recovery of the local area from the damage inflicted by the tsunami. The feasibility study is supposed to lead to a project that will eventually be implemented with a JBIC Yen Loan.

The study is to consist of the following work for the Project road:

i) Collection and analysis of information and data about the present status of the area and its facilities, such as socioeconomic indexes, natural conditions, present and planned land use, relevant development plans, traffic flows, technical standards, topographic maps, etc.

ii) Natural condition surveys
  - Topographic survey
  - Geological survey
  - Hydrological survey

iii) Traffic surveys

iv) Initial Environmental Examination based on JICA/JBIC guidelines

v) Travel demand forecast

vi) Selection of design standards and criteria

vii) Preliminary design for roads and structures
  - Road design
  - Bridge design
  - Minor structure design
  - Drainage design
  - Accessory design

viii) Construction plan
  - Investigation of local contractor capabilities
  - Plan for procurement of construction materials
  - Plan for disposal of construction waste
  - Optimization of construction plan

ix) Project cost estimate

x) Economic project evaluation

xi) Development of mechanism to revitalize communities along the Project road via road-oriented schemes in the township plan

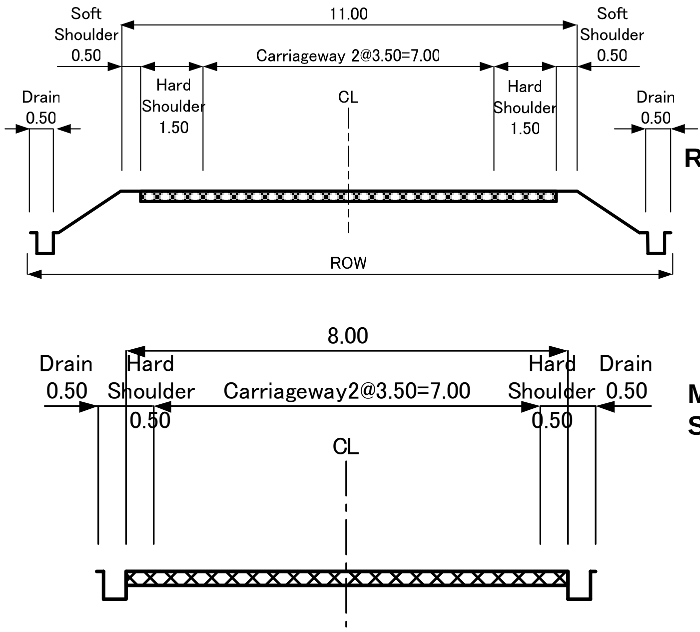
xii) Maintenance plan for rehabilitated roads
  - Maintenance organization/system
  - Budgetary requirements

xiv) Project implementation plan

8.3.2 Prospective Road Width

Based on the concept that only readily available space would be used, the Study Team discussed the prospective road width of the Project road with the Technical Committee.

As a result of this, road width in rural areas (e.g., places with paddy fields) was set at 10.0 m, with minimum road width set at 8 m for relatively densely populated suburban areas. As for urban areas, existing road width is used (see Figure 8.3.1).



Road Width in Rural Areas

Minimum Road Width in Suburban Areas

Figure 8.3.1. Prospective Road Width

8.4 Outline of Rehabilitation Project for New Kallady Bridge

8.4.1 Present Condition of Existing Kallady Bridge

The existing Kallady Bridge is a six-span steel-truss bridge, and its southern end point is located on AA004 at Km 426+500 south of Batticaloa. The bridge, which has a single-lane carriageway that has been used by road traffic since its construction in 1920, crosses the lagoon between Kattankudi and Batticaloa and is 288 m long and 4.90 m wide (see Figure 8.4.1). Note that the superstructure was apparently originally designed and fabricated as a railway bridge, but was later converted to be a road bridge during the construction stage. Strangely, a 100 m long embankment that juts into the water from the north bank is combined with the Kallady Bridge to cross the approximately 390 m wide lagoon. This has resulted in a narrow one-lane carriageway insufficient to accommodate daily peak-hour traffic flows, where vehicles coming from opposite directions have to take turns crossing the structure.

Figure 8.4.1. Existing Kallady Bridge from North Embankment

8.4.2 Outline of Feasibility Study

The Rehabilitation Project for the New Kallady Bridge provides for a feasibility study for the construction of a new bridge to be located in parallel to the existing Kallady Bridge to be about 20 m away to the west. Note that the new bridge will have the same total length and span lengths as the existing bridge (see Fig.8.4.2). The approach road sections on both banks will be tapered to the existing road with a curve length and maximum radii to accommodate a design speed of 70 km/h. The total effective width of the bridge and approach roads will be 14.00 meters and consist of a two-way two-lane 7.4 m carriageway, with a 1.8 m sidewalk and 1.5 m cycle lane on either side.

The feasibility study is supposed to eventually lead to a project that will be implemented with a JBIC Yen Loan. The study is to consist of the following work components:

i) Natural condition surveys
  - Topographic survey
  - Geological survey
  - Hydrological survey

ii) Initial Environmental Examination based on JICA/JBIC guidelines

iii) Selection of design standards and criteria

iv) Preliminary facility design
- Bridge design
- Approach road design
- Drainage design

v) Construction plan
- Plan for procurement of construction materials
- Plan for disposal of construction waste
- Optimization of construction schedule

vi) Project cost estimate

vii) Project implementation plan

Figure 8.4.2. Basic Plan for New Kallady Bridge

CHAPTER 9

Environmental and Social Considerations for Rehabilitation Project

Chapter 9 Environmental and Social Considerations for Rehabilitation Project

9.1 Background

The feasibility study for rehabilitation of the East Coast road section between Akkaraipattu and Trikkandimadu was based on the Scope of Work agreement signed between JICA and the Ministries with the responsibility of recovery, rehabilitation and development of the tsunami affected trunk roads on the East Coast of Sri Lanka. The feasibility study for the construction of the New Kallady Bridge was added subsequently to the scope of the above study.

At the meeting held at the Central Environmental Agency (CEA) on 11th May, 2005, where the draft of the *Basic Information Questionnaire* (BIQ) was discussed, the CEA expressed their view that the Recovery, Rehabilitation and Development Project would not require to undergo the environmental assessment process (IEE or EIA) since the Project does not include any relocation and resettlement of people. Accordingly CEA issued the approval letter (see Appendix 1) on 13th May, 2005, pursuant to the perusal of BIQ. In their letter of approval CEA advised that it may be necessary to seek approval from the Coast Conservation Department (CCD) since the project included areas falling within the coastal zone. RDA submitted an Application for a *Permit to Engage in a Development Activity* to CCD and then obtained the Permit for the development on 26th July, 2005 (see Appendix 2). With regard to the new Kallady Bridge Project, the CEA advised that the CCD was the Project Approving Agency (PAA) since the project site was located within the coastal zone. The RDA submitted an Application for a *Permit to Engage in a Development Activity* to CCD and the permit was issued by CCD on 19th July, 2005. (see Appendix 3)

Thus, according to the environmental regulations of Sri Lanka, it was not necessary to conduct any environmental assessment for the above two projects. The complete procedure followed in obtaining environmental clearance for the two projects is presented in Figure 9.1.1.

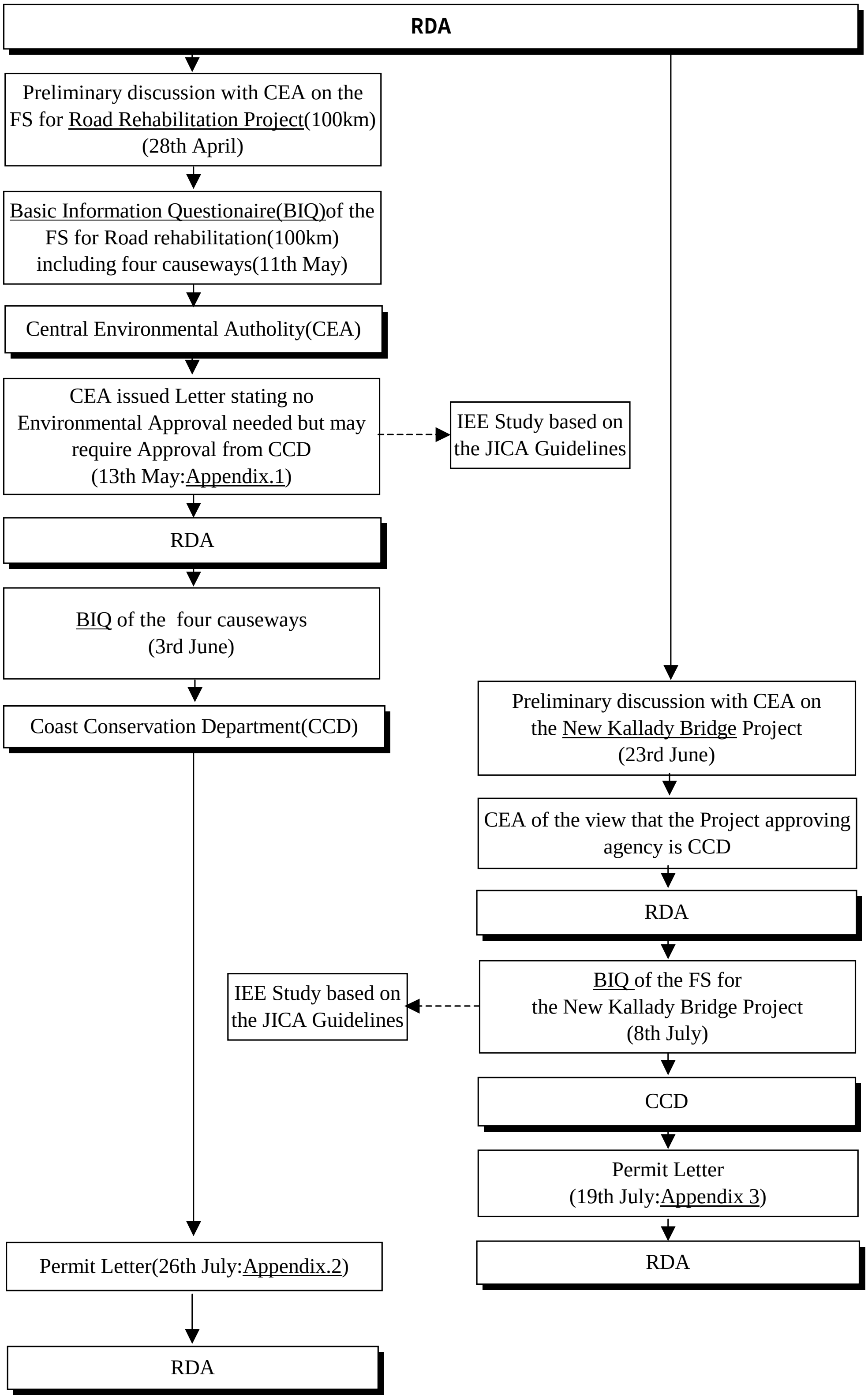


Figure 9.1.1 Procedure Flows for Environmental Clearance

9.2 Project Categorization Based on JICA Guidelines

The two components of the Project, namely, the rehabilitation of Eastern Trunk Road between Akkaraipattu and Trikkandimadu, and the construction of New Kallady Bridge have been excluded from IEE and EIA studies as per the environmental regulations of Sri Lanka. JICA, however, encourage the recipient countries to give due consideration to environmental and social aspects as specified in the "JICA Guidelines for Environmental and Social Consideration".

According to the Guidelines, proposed projects could be classified into three categories: A, B and C. Proposed projects classified as Category A are likely to have significant adverse impacts, whereas proposed projects classified as Category B are likely to have less adverse impacts than those of Category A projects. Category C projects are likely to have minimal or no adverse impacts.

In order to decide the category, the characteristics of the two Projects have been examined using the check items contained in the said Guidelines. The result of the overall examination for both Projects is shown in Table 9.2.1.

Table 9.2.1. Overall Examination for Both Projects

Check Items	Remarks
Project sector	Roads, railways and bridge
Description of the Project:	-Recovery, rehabilitation and development of existing trunk road, approx.100km in length -Construction of new bridge parallel to existing bridge, approx. 280m in length
Involuntary resettlement	Not included
Groundwater pumping	Not included
Land reclamation, land development and land-clearing	Not included
Logging	Not included
Names of laws or guidelines	- National Environmental Act -Guidance for Implementing EIA Process -Environmental Guidelines for Road and Rail Development -Coast Conservation Act

Check Items	Remarks
Is EIA, including IEE required for the project according to the laws or guidelines in the country?	Not required because the project is a rehabilitation project
National park, protected area designated by the government and areas being considered for national parks or protected areas	Not included
Virgin forests, tropical forests	Not included
Ecological important habitat areas	Not included
Habitat of valuable species protected by domestic laws or international treaties	Not included
Likely salts cumulus or soil erosion areas on a massive scale	Not included
Remarkable desertification trend areas	Not included
Archaeological, historical or cultural valuable areas	Not included
Living areas of ethnic, indigenous people	Not included
Does the project have adverse impacts on the environment and local communities?	Not significant
Outline of related impacts:	Impact on aquatic fauna, Water quality, Air quality, Noise and vibration levels etc. during the construction period

Through above overall examination both Projects could be classified as "*Category B*" because their potential adverse impacts on the environment and society are insignificant and normal mitigation measures can be designed readily. Thus, Initial environmental examinations (IEE) of the Projects have been conducted, in accordance with the "*JICA Guidelines for Environmental and Social Consideration*".

9.3 Summary of Initial Environmental Examination

The initial environmental examination reports consist of the following items.

- Introduction
- Description of the Project
- Description of the environemnt
- Potential environmental impacts and mitigation measures

- Findings and recommendations
- Conclusions

In this chapter, the reports are summarized focusing on the description of the environment, potential environmental/mitigation measures and conclusions of each IEE report.

9.3.1 Initial Environmental Examination of Rehabilitation of the Project Road

1) Description of the Environment

a. Physical Characteristics

Topography

The Project road traverses the two districts of Batticaloa and Ampara in the Eastern Province of Sri Lanka. Topographically Batticaloa and Ampara districts represent Sri Lanka's eastern and south eastern coastal plain. Its landscape is featured by bays, lagoons, head lands and very few isolated mountains.

While Batticaloa lies between longitudes 81^{0}13' and 81^{0}49' East and latitudes 7^{0} 24'and 8^{0}15' North, Ampara is situated between North latitude 60^{0}3' and 7^{0}45' and East longitude 81^{0}0' and 81^{0}52'.

More than 75% of the land in the two districts is flat terrain. Batticaloa District comprises land gently rising from sea level in the East to about 100 m in the western part of the districts, lagoons, villus, forests, streams, rivers and a few isolated hillocks. Although there are a few high striking ridges towards the westward and southwestward boundaries their elevation does not exceed 300 m MSL. The average relief of the terrain of the Ampara district varies from 0 – 100 m from MSL. The western half is relatively higher than the eastern half. The average elevation of the western part is above 100 m and in the north western parts bordering the Badulla and Matale districts the elevation is close upon 500 m.

Geology

The greater part of the Batticaloa district constitutes of Precambrian, essentially gneissic and crystalline rocks. The Precambrian rocks in the district belong to the Vijayan series and the lithological types identified in the area are granitic gneisses, augen gneisses, biotite gneisses, hornblende biotite gneisses and migmatite, feldspar granite, calc-granulite or gneisses and minor marble. Of the collections of rock found in the Ampara district formed by metamorphosis of sedimentary layers in geological basins in pre–Cambrian times the most widely distributed are again those of the Vijayan complex. These are granite gneiss, augen gneiss, biotite gneiss, hornblende biotite gneiss and migmatic feldspar graphite calc granutite or gneiss and crystalline Precambriann rocks.

Soil

The main types of soil in the Batticaloa District are Regosol, Solodized solonates and Solochacks, non calcic brown, Reddish brown and Alluvium. The principal soil groups found in the Ampara district are Red-brown with Low-humic gley, Red-brown with immature loam, Non-calcic brown earth with low humus gley, Red brown with solodized solonates, Solodized solonates, solochack and recent oceanic sedimentary soil and Alluvium.

Climate

Considering the climatological regions of the country, Batticaloa and Ampara districts represents the Dry Zone of Sri Lanka. The outstanding feature among the climatological characteristics of this region where dry weather prevails is the seasonal fluctuation of rainfall. Batticaloa and Ampara districts located in the Dry Zone of Sri Lanka receive insufficient rain and during the greater part of the year it experiences dry weather. The dispersed nature of the rain received and its seasonal changes render all the waterways here, including rivers and their tributaries, seasonal. A general feature of Batticaloa and Ampara districts, both, is their temperature being uniform with only minor fluctuations throughout the year.

Hydrology

There are no major river basins in the project area. The Mahaweli river, the largest river in Sri Lanka with a catchment area of 10,320 km^2 drops from the central mountain and flows through the north-eastern part, several kilometers away from the project area and meets the sea at Trincomalee. However, there are many waterways flowing to the project area mostly with small catchment areas comprising of different types of land topography consisting of floodplains, wetlands, paddy fields and hilly terrain.

The Project area close to the sea indicates a local and discontinuous but productive aquifer in intergranular rocks made up of sand, gravel and alluvial formations. The water table is in the range of 3m to 5m. The yield varies from 0.8 to 3.7 liters per second and the quality of water is generally good, apart from a few sporadic areas which contain brackish water.

b. Ecological Resources

Ecosystems in the Study Area

Several types of ecosystems both terrestrial and wetlands exist in the study area. The Project road traverses mainly through home gardens, built up area, scrublands, wetlands such as paddy fields and marshy areas, and lagoons. About 23% of the study area is built up area which mainly comprises permanent buildings.

Fauna

Paddy fields in the low country dry zone harbour several species of reptiles, small mammals, birds and amphibian species. Among the reptiles, *Xenochrophis asperimus* (Diya naya) *Varanus salvator* (water monitor), *Varanus cepidinus* (Land monitor) and *Lissemys punctatus* (Land monitor) are endemic (IUCN, 2000) and protected by Fauna and Flora Protection Ordinanace (FFPO) (Ekaratne et al, 2003). These habitats are abundant in the Batticaloa district which also falls within the category of low country dry zone, and therefore the probability of these species being found in the study area is very high, too.

The study area does not include any protected areas such as wildlife reserves, conservation forests, RAMSAR sites, Man and Biosphere reserves, world heritage sites, forest reserves and proposed forest reserves declared under Forest Ordinance or Flora and Fauna Ordinance.

Flora

Low country dry zone forests, home gardens and scrublands are rich in flora with a large number of endemic species. In home gardens of Batticaloa and Ampara districts along the project road side, about 30 species of plants were observed which are endemic. However, these are very abundant plant species distributed widely in the dry zone and also in the wet zone.

Water plants were also observed in paddy fields and small canals associated with them. In stagnant waters *Cryptocoryn*e (Ketala) and invasive aquatic weeds such as *Pistia stratiotes* (water lettuce), *Eichhornia crassipes* (water hyacinth) and *Salvinia molesta* (japan pasi) are found.

Marsh vegetation is utilized by local communities for various purposes: i.e. sedges are used for weaving mats and food container covers (*Cyperus haspan*, *Fimristylis miliaceae* and *Schoneplectus grosus* and *Pandanus odorotissima* (wetakeiyya). Some species are used as vegetables: e.g. *Ipomea aquatica* (kankun), *Lasia spinosa* (kohila), *Anona glabra* (wel atta); and *Cerbera manghas* (gon kaduru) is used to obtain poles for fishing (Eastern University, unpublished data).

Twenty three species of mangroves, including true mangroves and mangrove associates are recorded in Sri Lanka. Mangrove plants have adaptations to live on the water's edge and on saline and poorly aerated soils. In marshes and lagoon ecosystems, habitat specific floral diversity is observed. As Batticaloa lagoon is the third largest lagoon in Sri Lanka, most of the lagoonal plant species would be present in the lagoon. About 20 species of marsh and mangrove plants were observed in the lagoon along the project road.

c. Human and Economic Conditions

Population and Demographic Characteristics

Batticaloa is predominantly a Tamil dominated district while Ampara is a district with mixed ethnicity where all three main ethnic groups are present in more or less equal percentages. The estimated population of Ampara is reported as 629,674 and Batticaloa 545,4772. One of the salient features of the demography of the district is the internally displaced population (IDP) which constitutes approximately 20% in Batticaloa and 8% in Ampara. Another aspect of the population is the high number of female headed households in these two districts. Due to the two decade old civil conflict many women have lost their male counter parts or guardians and have become chief householders.

Employment and Income Sources

Of the total population in the eastern province, the economically active segment makes up little over 40% of which nearly 63% is male and 18% female indicating heavy gender imbalance in employment. The majority of the labor force is engaged in agriculture and fisheries sectors. In Batticaloa, the percentage of the population engaged in agriculture and agriculture related casual work is around 36% while this is high as around 40% in Ampara. Fishing is the second major income source for the people in these two districts; nearly 14% of the economically active labour force in Batticaloia and 12% in Ampara engage in fishing and related industries such as dry fish production. While Batticaloa reported a high level of unemployment (18%), unemployment is comparatively low in Ampara (10%).

Quality of Life and Social Capital

The population in the project area is primarily rural. More than 90% of the population live in rural areas. The urban population is mainly confined to townships of Ampara, Nindavur, Batticaloa, Kalmunai and Sammanthurai.

Quality of life in terms of access to safe drinking water, electricity, health and sanitation is relatively better in these townships compared to marginal and conflict affected rural areas. Pradeshiya Sabas provide basic services to townships but not to rural areas and villages far from the main road. Thus, not only rehabilitation of the coastal trunk road but also linking villages through access roads will enhance the quality of the life of poor and disadvantaged communities affected by tsunami and civil war.

Poverty and Vulnerability

The two districts constitute one of the most underdeveloped and poverty stricken regions in the country. The main reason for such underdevelopment is lack of basic infrastructure including adequate and improved roads, transport system, access to market, and education and health facilities in the area. The two decade old ethnic conflict not only disrupted the agriculture, fishing and other livelihood modes of these communities but also caused loss of human life, displacement, and damage to housing and education of the children. The most affected area is Batticaloa where still a significant number of families are displaced and live without adequate basic social infrastructure.

Basic Social Infrastructure

The percentage of houses categorized as “temporary” and “semi permanent” is higher in Batticaloa district. Only one third of the housing units have been categorized as permanent houses. In comparison, more than half of the housing units except the coastal villages in Ampara are categorized as permanent houses. The percentage of temporary housing is considerably low in Ampara and it is reported as less than 10%. The number of houses without toilet facilities is also very high in Batticaloa and around half of the housing units does not have proper toilet facilities. This situation is different in Ampara where the number of houses without toilet facilities is less than 20%. However, most of the people in areas such as Kattankudy, Manmunai and Vaharei have no proper housing and toilet facilities.

2) Potential Environmental Impacts and Mitigation Measures

a. Impacts of Pre-construction Phase

The general environmental impacts of the pre-construction phase activities as relocation /resettlement and change in hydrological regime were considered in the screening process but were found not significant in this project.

Land Acquisition and Relocation/Resettlement

In the present project there is no significant land acquisition or relocation because the ROW of the proposed road will be planned avoiding significant impact on house plots and other infrastructure and paddy cultivations as well. However, RDA will have to move a small number of fences in certain sections of the road.

Changes on Water Regime

Designing the road to avoid inundation will require the raising of the road at some sections with new elevations. This will lead to slightly increased water levels in the lagoon during the flooding season as the elevated new road level prevents overflow for a designed return period. In order to minimize the marginal increase in flood levels along the project road, the following design criteria will have to be adopted in the design of cross drainage structures.

- The standard return periods specified for bridges and culverts should be applied.
- In addition to the application of mathematical approach for analyzing the high water level for a given return period, observed flood levels for previous floods should be recorded and compared.
- The parameters used in analysis such as coefficient of run off should be established based on existing land use and future urbanization of the catchment area.
- Both short duration and long duration rainfall events for design return period should be taken into account and the critical rainfall event should be adopted in the design of the cross drainage structures.
- Existing drainage pattern should be maintained as much as possible to maintain the pre-project conditions.

b. Impacts of Construction Phase

Erosion and Siltation

Erosion, siltation and sediment runoff due to earthwork and temporary diversion of the drainage canals may adversely affect the existing hydrological regime. Due to the low elevations of the road level at several sections, earth work will be required for the formation of the road. Therefore, if the construction activities are not properly planned, it will lead to erosion of materials stockpiled for road construction leading to siltation of low lying areas. Further, the construction of culverts and bridges will require temporary diversion of storm water which could lead to erosion and siltation in the lower areas. As there are many paddy fields on either side of the road, it is essential to prevent the siltation of irrigation canals that provide drainage for paddy cultivation.

The mitigatory measures proposed for minimizing erosion and silt runoff during construction are:

- All disposable materials should not be stockpiled in the paddy / marsh area and should be transported directly to the disposal sites.
- During the construction of cross drainage structures, an applicable method for diversion of water to minimize soil erosion during the diversion works should be adopted.
- Weather conditions should be taken into consideration in planning out construction activities such as foundation preparation and cross drainage culvert construction works.
- Suitable silt traps along the drainage paths shall be provided, where necessary, in case of high levels of silt in runoff.

<u>Dust/Air Pollution</u>

Dust will be stirred up by road construction equipment in various construction activities, and could impart a significant impact on air quality during construction phase. The suggested mitigation measures are as follows.

- Water the road near the settlements when dust occurs, particularly in the dry season.
- Maintain all construction vehicles to minimize toxic vehicle emission.
- Appropriate, scheduled road maintenance will be needed to retain a sealed surface.

<u>Noise and Vibration</u>

Construction activities such as excavation, cutting and filling, ditching, drilling and compaction require heavy machinery and heavy vehicle operation which generates high noise levels and vibrations. Although this is temporary impact mitigation may be necessary for reducing the impact. The mitigation measures suggested are as follows.

- All road construction vehicles will have working mufflers and be properly maintained.
- Inform people of possible damage from vibration before using Vibrating Rollers near settled areas.
- Stringent monitoring and allowing only efficient plant and machinery to be used will not only reduce the noise and vibration levels but also minimize the level of particulate matter and odor being released to the atmosphere.

Changes in Water Quality

Surface runoff contaminated by the excavated material, construction material and cut and fill areas along the project road could affect the water quality of the water bodies including the lagoons if required precautions are not taken. Further, water bodies could be contaminated by mortar and asphalt waste and wash water. Construction material and solid waste would directly contaminate and change the quality of water which will have a direct effect on the flora and fauna of the eco-system unless it is properly collected and disposed. The suggested mitigation measures are as follows.

- Wash water and waste from the concrete and asphalt mixing plants will have to be treated and allowed to settle before disposal.
- Solid waste will have to be properly disposed making use of existing disposal sites.
- Locate storage areas for diesel and bitumen at least 500 meters from watercourses
- Employ safe practices in filling bitumen distributor tanks and in heating bitumen.
- Collect and recycle all lubricants and take precautions to prevent accidental spills
- Prohibit road asphalting activities during rainfall
- Develop and implement plans for safe storage of all toxic and potentially toxic materials.

Damage to Existing Roads and Disruption to Travel and Access

Damage to existing roads during haulage of construction materials would be significant if required precautions as weight limitations and use of well serviced vehicles are not taken, especially as the road network in the area has not been planned and maintained to withstand heavy load haulages. Further, vibration generated by heavy vehicles could also damage roadside properties. The suggested mitigation measures are as follows.

- Strict guidelines in use of heavy vehicles for material transport will have to be enforced. This would also ensure that disruption to other vehicular traffic is also minimized.
- Access and use of the trunk road being repaired will be curtailed and alternative road ways will have to be planned to minimize this impact.
- Employ “flag men” to regulate the traffic flow.
- Where possible, as in flat areas, provide enough edge space for one-way traffic flow.
- To the extent possible, avoid the mobilization of heavy equipments at night.
- Over-width and over-length vehicles should display adequate warnings such as flashing lights, signs, and flags on extending parts.

Waste Disposal

In the construction phase, various types of construction waste, such as removed asphalt and concrete, etc., will be regenerated from the construction activities. Without systematic management of such wastes, there could be serious adverse environmental impacts. Solid waste generated by construction camps such as waste from daily life of workers, can cause adverse impacts on the environment, if proper disposal is not planned. The mitigation measures suggested are as follows.

<Construction Waste>

- Select areas designated for disposal.
- No disposal into watercourses.
- No disposal in or adjacent to cultivated and settled area.

<Solid Waste of Construction Camps>

- Provide garbage tanks and sanitary facilities for workers. Waste in the specific tanks should be cleared periodically
- Special attention should be paid to the sanitary condition of camps.

Outbreak of Diseases

An influx of workers during the construction phase and exogenous traffic during operation phase will bring local population into contact with a larger number of outsiders than previously encountered. This may cause outbreak of exogenous disease if the people of the Project area are not aware of disease outbreaks. The mitigation measures are as follows.

- The Contractor will have all his workers undergo a regular medical check on their arrival on Site.
- Site construction camps at least 50 m away from watercourses and as far as possible from local communities.
- Provide enough water supplies for workers, and ensure sufficient sanitation for the camp: proper drainage systems, and proper locations for solid waste disposal.
- Make medical treatment available for workers. Provide workers mosquito nets and malaria-prevention medication. If needed, periodically spray around camp against mosquitoes.

c. Beneficial Impacts

Beneficial impacts of road projects as improvements to air quality due to lower levels of emissions, reduced wear and tear of vehicle parts and tires and reduction in noise levels were not found to be of high significance although the project may contribute to these. Significant beneficial impacts of the project were identified as decrease in level of resource use, less dust generation and sediment run off. Considering the social impacts, the significant benefits are as detailed below.

- Encouraging Economic Development and Urbanization
- Improvements to Quality of Life of People
- Better Access to Educational and Health Services
- Strengthening of Social Capital
- Better Access to Government Services

3) Conclusions

In this initial environmental examination, all the adverse impacts of the road rehabilitation and recovery project have been considered in detail during the process of screening of potential environmental impacts. It was determined that very few adverse environmental impacts result from the proposed action for the rehabilitation of the Project road from Trikkandimadu to Akkaraipattu. Furthermore, the significance of these adverse impacts is mostly low and is mitigated by the recommended mitigation measures. Inevitable adverse effects of construction activities are also low and these are temporary, too. Therefore, the necessity for further environmental assessment does not arise.

Therefore, the rehabilitation and recovery of the Project road from Trikkandimadu to Akkaraipattu is environmentally acceptable.

9.3.2 Initial Environmental Examination of Construction of New Kallady Bridge

1) Description of the Environment

a. Physical Characteristics

<u>Topography</u>

The proposed Kallady bridge on the AA04 road crosses the Batticaloa lagoon which is situated in Batticaloa district of the Eastern Province. Batticaloa, lies between longitudes $81^0$13’ and 81^0 49’ East and latitudes 7^0 24’and 8^0 15’ North. More than 75% of the land in the district is flat terrain. Batticaloa District, where the land gently rises from sea level in the East to about 100 m in the western part of the district, comprises lagoons, villus, forests, streams, rivers and a few isolated hillocks. Although there are a few high striking ridges close to westward and southwestward boundaries their elevation does not exceed 300 m MSL.

Geology

The project area is composed of Vijayan Complex. The Vijayan Complex (VC) occupies the lowland to the east of the central Highland Complex (HC). VC consist of granitic gneisses, granitoid rocks, migmatites and calc-silicate rocks. The rock age of the VC is estimated to be about 1,100 million years old.

Soil

The Project area located in the coastal belt of the eastern province is composed of Regosols on recent beach and dune sands in flat terrain. Solodized Solonetz, Solonchaks and Soils on recent marine calcareous sediments are distributed along a strip close to the lagoon. The alluvial soils are distributed throughout the lowland in flat terrain surrounding the area of existing waterways.

Climate

Considering the climatological regions of the country, Batticaloa district represents the Dry Zone of Sri Lanka. The outstanding feature among the climatological characteristics of this region, where dry weather prevails, is the seasonal fluctuation of rainfall.

Hydrology

The Batticaloa lagoon is interconnected with several other lagoons such as Periya Kallar and Koddai Kallar. The interconnected entire lagoon extends from Karativu to Chenkalady through Batticaloa along the coast. There are many waterways flowing to the lagoon mostly with small catchment areas that consist of different types of land topography such as floodplains, wetlands, paddy fields and hilly terrains. Along its way, a considerable portion of the total discharge is retained by the existing reservoirs, lakes, wetlands and floodplain areas within the catchment basin. The sand bar formation close to the lagoon mouth obstructs and retards the water discharge from the lagoon to the sea.

b. Ecological Resources

Ecosystems in the Study Area

Several types of aquatic ecosystems exist in the study area which includes the proposed bridge and the surrounding area. These are lagoons associated with mangroves, marsh, and coastal ecosystems as coral reefs, sea grass beds and sand bar. A few small home gardens are also found in the area.

Fauna

The literature survey and the research findings of the Eastern University establish that the eastern province provides diverse habitats for many faunal species. Batticaloa area is rich in avifauna, too. A large number of rare, very common and common bird species were found in the area. Seven of these birds are endemic. Altogether, about 44 species of birds have been reported from the Batticaloa lagoon area.

The study area does not include any protected areas such as wildlife reserves, conservation forests, RAMSAR sites, Man and Biosphere reserves, world heritage sites, forest reserves and proposed forest reserves declared under the Forest Ordinance or Flora and Fauna Protection Ordinance.

Flora

Low country dry zone forests, home gardens and scrublands are rich with a large number of endemic floral species. In the home gardens of Batticaloa district about 30 species of endemic plants were observed. These, however, are also very abundant and widely distributed in both dry and wet zones.

Twenty three species of mangroves are recorded in Sri Lanka including true mangroves and mangrove associates. Mangroves range in size, from small shrubs to tall trees. Mangrove plants have specialized adaptations to live on the water's edge and on saline and poorly aerated soils. In the marshes and lagoon ecosystems, habitat specific floral diversity is observed. As Batticaloa lagoon is the third largest lagoon in Sri Lanka, most of the lagoonal plant species may be present in the lagoon. About 20 species of marsh and mangrove plants could be observed in the lagoon.

Marsh vegetation is utilized by local communities for various purposes: i.e. sedges (*Cyperus haspan, Fimristylis miliaceae* and *Schoneplectus grosus* and *Pandanus odorotissima* (wetakeiyya) are used for weaving mats and food container covers. Some species are used as vegetables; e.g. *Ipomea aquatica* (kankun) , *Lasia spinosa* (kohila), *Anona glabra* (wel atta): while *Cerbera manghas* (gon kaduru) provides poles for fishing (Eastern University, unpublished data).

c. Human and Economic Conditions

The Kallady Bridge is located approximately 1 km south of the Batticaloa town. Although it comes under the Batticaloa Urban Council area the local administration is handled by Manmunai North Divisional Secretariat office. Since the proposed new Kallady Bridge will be constructed over the lagoon parallel to the existing bridge, no additional impacts on the socioeconomic environment of the area is anticipated. However, this is one of the areas in the district that experience severe socioeconomic hardships and poor living conditions.

Manmunai North DS area has 48 Grama Niladhari (GN) divisions. The total current population is 18,622 persons and it is the largest DS division of the Batticaloa District. Women constitutes more than men in the DS division population. The Kallady Bridge is in the Kallady GN division. The majority of the families are involved in fishing and day to day labour work related to fishing and trades. Further, a significant number of persons work in the government institutions as salaried employees. Manmunai North where the proposed bridge is located is considered as one of the poorest DS division of the district. About half of the families (9,706) in the division receive government poverty relief (Samurdi). Only one third of the households live in permanent houses and the majority live in semi-permanent or temporary houses along the coast and road side.

2) Potential Environmental Impacts and Mitigation Measures

a. Impacts of Pre-construction Phase

<u>Land Acquisition and Relocation/Resettlement</u>

The Construction of the new bridge at Kallady will only require small scale land reclamation at both ends of the bridge and as these locations are not inhabited there will be no requirement for relocation of people. However, notwithstanding that significant land acquisition and relocation of people is not anticipated, a small land area from the premises of the St Anthony’s church may have to be acquired in order to provide linkage from the proposed bridge to the AA04 road.

<u>Changes to Water Regime</u>

The flow pattern or flow regime around the Project site will not be changed as the proposed bridge will be constructed in parallel and close to the existing bridge. The rise in flood levels resulting from the construction of the bridge is insignificant. Nevertheless, in order to maintain the status quo with regard to the water regime and to avoid or minimize unforeseen adverse impacts, the following design criteria are to be adopted.

- The standard return periods specified for bridges and culverts should be applied.
- In addition to the application of the mathematical approach for analyzing the high water level for a given return period, observed flood levels for previous floods should be recorded and compared.
- The parameters used in analysis such as coefficient of runoff should be established based on existing land use and future urbanization of the catchment area.
- Both short duration and long duration rainfall events for design return period should be taken into account and critical rainfall events should be adopted in the design.
- Existing flow pattern should be maintained as much as possible to maintain the pre-project conditions.
- During the construction of the bridge, the high water level should be carefully determined and standard navigation clearance should be maintained.

b. Impacts of Construction Phase

Erosion and Siltation

Erosion, siltation and sediment runoff are considered as some of the inevitable adverse impacts associated with construction projects. In the Project, too, cut and fill and other earth work will be required. In addition, construction of temporary cofferdams and/or partial blockings of water flow during the construction of the Bridge will also be needed. Therefore, if the construction activities are not properly planned, it could lead to sediment runoff through erosion of cut and fill areas and stockpiled material. This would lead to siltation and water quality deterioration in the lagoon. Therefore, the following mitigatory measures are recommended to be adopted to minimize the erosion, siltation and sediment runoff.

- Weather conditions should be taken into consideration in planning out construction activities; it would be advisable to construct the foundation and substructure of the bridge in the dry season.
- All disposable materials should be stockpiled properly in identified locations and covered.
- Soil should be covered while being transported and disposed in designated disposal sites.
- Suitable silt traps along the drainage paths shall be provided, where necessary, in case of high levels of silt in runoff.

Dust/Air Pollution

Dust and sediments generation is unavoidable during construction activities. In order to minimize the generation of dust and sediments containment at the construction sites will be necessary. The mitigation measures suggested are as follows.

- Covering the stock piles and taking reasonable care in loading and unloading
- Covering spoil and material during transport
- Watering the road in the area where dust is a problem

Noise and Vibration

Construction activities such as excavation, cutting and filling, blasting, drilling and compaction require heavy machinery and heavy vehicle operation which generates high noise levels and vibrations. Although this is a temporary impact, mitigation may be necessary for reducing the adverse effects. The mitigation measures suggested are:

- All road construction vehicles will have working mufflers and be properly maintained.
- Inform people of possible damage from vibration before using Vibrating Rollers near to settled area.
- Stringent monitoring and allowing only efficient plant and machinery to be used will not only reduce noise and vibration but also minimize the level of particulate matter and odor being released to the atmosphere.

Changes in Water Quality

The impact on groundwater due to the construction of the Proposed Bridge is minimal as the construction is basically limited to the lagoon area and also as it is to be located very close to the existing Kallady Bridge. The excavation for pile foundations and abutments of the bridge close to the coastal belt, though, can cause salinity intrusion. However, it will not be very significant because deep cutting beyond the depth of existing piles and abutments is to be limited. Moreover, groundwater in the surrounding areas of a brackish water lagoon naturally consists of saline water and, therefore, construction activities would not deteriorate the prevailing situation. Nonetheless, it is advisable to investigate whether saline water penetrates to dug wells in the vicinity. Thus, it is recommended that the water quality of the dug wells located close to the bridge site, should be monitored periodically, during the pre construction and construction period to investigate the intrusion of seawater from the deep excavation for bridge foundations and abutments.

In addition, material excavated from the pile foundations needs to be disposed properly without allowing loose materials to be washed off to the lagoon which may deposit in the lagoon and also affect the water quality. Other mitigation measures recommended to minimize pollution of water bodies in the area are:

- Wash water and waste from the concrete and asphalt mixing plants will have to be treated and allowed to settle before disposal.
- Solid waste will have to be properly disposed making use of existing disposal sites.
- Locate storage areas for diesel and bitumen at least 500 meters from watercourses
- Employ safe practices in filling bitumen distributor tanks and in heating bitumen.
- Collect and recycle all lubricants and take precautions to prevent accidental spills
- Limit road asphalting activities during rainfall
- Develop and implement plans for safe storage of all toxic and potentially toxic materials.

Waste Disposal

In the construction phase, various types of construction waste will be regenerated from the construction activities. In the absence of systematical management of such wastes, serious and adverse environmental impacts could result. Solid waste generated by construction camps, such as waste from daily life of workers, can cause impacts on the environment, if proper disposal is not facilitated. The mitigation measures suggested are as follows.

<Construction Waste>

- Select designated areas for disposal.
- No disposal into watercourses.
- No disposal in or adjacent to cultivated and settled area.

<Solid Waste of Construction Camps>

- Provide garbage tanks and sanitary facilities for workers. Waste in the specific tanks should be cleared periodically
- Special attention will be paid to the sanitary condition of camps.

Outbreak of Disease

Influx of workers during the construction phase and exogenous traffic during operation phase will bring local population into contact with a larger number of outsiders than previously encountered. This may cause outbreak of exogenous disease if the people of the Project area are not aware of disease outbreaks. The mitigation measures suggested to avoid such impacts are as follows.

- The Contractor will have all his workers undergo a regular medical check on their arrival on Site.

- Site construction camps at least 50 m far away from watercourses and as far as possible from local communities.
- Provide adequate water supplies for workers, and ensure sufficient sanitation for the camp: proper drainage systems, and proper locations for solid waste disposal.
- Make medical treatment available for workers. Provide workers with mosquito nets and malaria-prevention medication. If needed, periodically spray around camp against mosquitoes.

<u>Damage to Existing Roads and Disruption to Travel and Access</u>

Damage to existing roads during haulage of construction materials would be significant especially as the road network in the area has not been planned and maintained to withstand heavy load haulages. Further, vibration generated by heavy vehicles could also damage roadside properties. Strict guidelines such as weight limitations and use of well serviced vehicles will have to be enforced in the use of heavy vehicles for material transport. This would not only curtail damage to the local road network but also ensure that disruption to other vehicular traffic is minimized.

<u>Disruption of Existing Local Navigation</u>

Community consultations revealed that there were around 10 to 12 boats that used the waterway underneath the bridge for fishing and water transportation. However, during the survey period, none of the boats were observed to be using this waterway for water transportation, fishing or fish transport. The survey interviews established that only two or three fishermen occasionally use this waterway, at present. Although there will be some disturbance to these boats due to use of machinery for the bridge construction it will not seriously affect the fishing economy and the livelihoods of the people.

3) Conclusions

During the initial environmental examination it transpired that very few adverse environmental impacts result from the proposed action for the construction of the new Kallady Bridge. Furthermore, the significance of these adverse impacts is mostly low. Adverse impacts which can be categorized as moderate result only from construction activities and these temporary impacts can be minimized through adherence to best practices in construction works.

Therefore, the construction of the New Kallady Bridge is environmentally acceptable.

9.4 Summary Conclusions

The two components of the Project, namely, the rehabilitation of Eastern Trunk Road between Akkaraipattu and Trikkandimadu, and the construction of New Kallady Bridge were scrutinized in the IEE studies in terms of anticipated impacts and mitigation measures. As for the rehabilitation of Eastern Trunk Road, it has been found that very few adverse environmental impacts result from the proposed action of the Project. The significance of these adverse impacts is mostly low and is mitigated by the recommended mitigation measures. Inevitable adverse effects of construction activities are also low and these impacts can be easily mitigated. Thus, the rehabilitation of the Project road from Trikkandimadu to Akkaraipattu is environmentally acceptable.

The construction of the new Kallady Bridge will also result in very few adverse environmental impacts. Furthermore, the significance of these adverse impacts is low. The temporary adverse impacts of construction activities are also mitigated by adopting best practices in construction works. Therefore, the construction of the new Kallady Bridge is environmentally acceptable.

Based on the findings of the two IEE studies it can be safely concluded that no further environmental assessment is required for either of the two Projects.

CHAPTER 10

Natural Condition Survey for Rehabilitation Project

Chapter 10 Natural Condition Survey for Rehabilitation Project

10.1 Topographic Survey

10.1.1 Scope of Work

1) General

A topographical survey of the Project road, which stretches from Akkaraipattu to Trikkandimadu, was carried out with the purpose of preparing a base map for the required engineering drawings of the Study. In addition to this survey, a second topographical survey for the New Kallady Bridge, which was included at a later date in the Study at the request of JICA, was also executed.

2) 1st Topographical Survey

The first topographic survey, which gathered data on the Project road, divided said road into two sections as follows:

- Section 1: Route A004 from the 364th kmp to the 427th kmp = 63 km
- Section 2: Route A015 from the 0 kmp to the 38th kmp = 38 km

3) 2nd Topographical Survey

The second topographical survey, which focused on the New Kallady Bridge, consisted of the following:

- A plan survey for a 900m section that included the Kallady Bridge with a 100m wide corridor (50m from the centerline on either side).
- A survey of three cross sections to traverse the lagoon near the Kallady Bridge, with one cross section being along the centerline of the Bridge and the two other cross sections being 25m on either side of the centerline of this structure.
- Plan survey on a 300m short-cut route that connects A004 with A015 that leads to the center of Batticaloa having a width of 40m (20m from the centerline on either side).

10.1.2 Survey Specifications

1) Datum

Horizontal Data: Based on National Grid
Vertical Data: Mean Sea Level

2) Survey Control Points

- Primary Survey Control Points
  Primary survey control points were established at 5km intervals via GPS observations. Each survey point was fixed using two primary GPS control points provided by the Sri Lanka Survey Department.
- Secondary Control Points
  Secondary control points were established by running a series of closed traverses between the primary control points.
- Leveling Control
  The leveling survey data prepared by the Study Team was connected to the Survey Department benchmarks (BM). A couple of these benchmarks had to be re-established by the Study since they were washed away by the Tsunami, and BM elevation was set using mean sea level datum.

3) Establishment of Benchmark

Temporary benchmarks were established at 500m intervals along the Project route.

10.1.3 Survey Method

The topographical survey for the Project road was carried out applying the Total Station Method using survey stations established by the Study. Note that the road centerline and cross section were surveyed at 20m intervals, with additional spot heights measured as necessary due to abrupt changes in terrain. All survey observations have X, Y, and Z coordinates.

10.2 Geological Survey

10.2.1 Scope of Work

1) General

The first geological survey for the Project road was executed with the purpose of determining existing sub-grade strength, pavement layer condition, and confirming the bearing layer of bridges except for the Oddaimauadi Bridge and New Kallady Bridge (via the standard penetration test). At the site of the New Kallady Bridge, three borehole investigations were carried out in a subsequent second geological survey. Note that both of these surveys were performed in accordance with latest international standards, including the British Standards (BS), American Society for Testing and Materials (ASTM) Standards, and the American Association of State Highway and Transportation Officials (AASHTO) Standards.

2) 1st Geological Survey

The 1st geological survey consisted of:

- Ten borehole investigations at the following bridge sites

Table 10.2.1. Location of Boring Sites

Km-Post	BH-No.
371km (A004)	BH-1
377km (A004)	BH-2
378km (A004)	BH-3
381km (A004)	BH-4
400km (A004)	BH-5
420km (A004)	BH-6
426km (A004)	BH-7
12km (A015)	BH-8
30km (A015)	BH-9
32km (A015)	BH-10

- Fifty-one dynamic cone penetration (DCP) tests at approximately 2km intervals
- Excavations of six test pits at selected locations along the road

Table 10.2.2. Location of Test Pits

Km-Post	TP-No.
371km (A004)	TP-1
380km (A004)	TP-2
400km (A004)	TP-3
420km (A004)	TP-4
12km (A015)	TP-5
32km (A015)	TP-6

- Related laboratory tests

3) 2nd Geological Survey

The 2nd geological survey for the New Kallady Bridge consisted of:

- One borehole investigation on shore
- Two borehole investigations in the lagoon using a barge

Table 10.2.3. Location of Boring Sites for New Kallady Bridge

Location	BH-No.
Land	BH-01
Lagoon	BH-02
Lagoon	BH-03

- Related laboratory tests

10.2.2 Testing & Investigation Methods

1) Standard Penetration Test (SPT)

The results from a SPT are the major factor in assessing subsoil conditions via a borehole investigation. In accordance with the specifications of the Study, a SPT was conducted at each borehole at 1.0 m intervals.

2) Dynamic Cone Penetration (DCP) Test

The DCP test was carried out using PARNELL Model A2465 in accordance with UK Transport Research Laboratory (TRL) specifications. The DCP Test is used for a quick measurement of the structural properties of existing road pavement with unbound granular materials.

The underlying principle of the DCP is the rate of penetration of the cone. The boundaries between layers are easily identified by the change in the rate of the penetration. Note that numerous authors have described the relationship between a DCP reading and the California Bearing Ratio (CBR). In this Project, the following commonly used formula for a tropical country is applied to convert a DCP reading into a CBR value.

$$\mathbf{Log_{10}(CBR) = 2.48 - 1.057Log_{10}(mm/blow)}$$

Source: TRRL, Overseas Road Note #8

3) Test Pit Excavation

Test pit excavation was carried out to help determine the layer thickness of the existing pavement and collect samples from the base, sub-base and sub-grade. Test pits were located at the edge of the pavement on the road shoulder. The dimensions of the test pits were approx. 1.0m x 1.0m x 1.5m.

10.2.3 Survey Results

1) Subsurface Conditions based on SPT

The geological conditions of the Project road slightly change in the vicinity of the New Kallady Bridge. That is, the section from Akkaraipattu up to the Bridge consists largely of sand, while the section from the Bridge up to Trikkandimadu comprises mostly weathered rock found at shallow depths. The offshore boring for the New Kallady Bridge also found the bearing layer to be located at a shallow depth. A summary of the subsurface condition based on the SPT is described in Table 10.2.4.

In order to ensure that the community support in the Project is implemented as intended, appropriate monitoring and evaluation mechanisms have been incorporated in the Project.

Table 10.2.4. Subsurface Condition based on SPT for the Project Road

BH-No.		N Value: Less than 10	10 to 30	30 to 50	50-plus	Total Length
BH-1	Distribution (m)	0.0 – 4.0	4.0 – 5.0	-	5.0 – 8.9	8.9m
	Soil Name	Sand	Sand	-	Weathered Rock	
BH-2	Distribution (m)	1.0 – 9.0 10.5 – 13.0 14.0 – 19.0	9.0 – 10.5 13.0 – 14.0 19.0 – 20.0	-	-	20.0m
	Soil Name	Sand, Sandy Clay	Sand, Clay Sand	-	-	
BH-3	Distribution (m)	7.0 – 9.0	0.0 – 7.0 9.0 – 10.0 14.0 – 15.5	10.0 – 14.0 15.5 – 18.0	18.0 – 20.0	20.0m
	Soil Name	Sandy Clay	Sand, Sandy Clay	Sand	Sand	
BH-4	Distribution (m)	0.0 – 2.5 4.0 – 9.0 10.0 – 11.0	2.5 – 4.0 9.0 – 10.0 10.0 – 13.5 14.5 – 16.0	13.5 – 14.5 16.0 – 17.0	17.0 – 20.0	20.0m
	Soil Name	Silty Sand	Sand, Sandy Clay	Weathered Rock, Sand	Sand	
BH-5	Distribution (m)	0.0 – 3.0 4.0 – 10.0 16.5 – 18.0	3.0 – 4.0 10.0 – 14.0 15.0 – 16.0 18.0 – 20.0	14.0 – 15.0 16.0 – 16.5	-	20.0m
	Soil Name	Sandy Clay, Silty Sand	Sandy Clay, Sand	Sand	-	
BH-6	Distribution (m)	0.0 – 3.0	3.0 – 6.0	8.5 – 10.0 10.5 – 12.5 14.0 – 16.0	6.0 – 8.5 10.0 – 10.5 12.5 – 14.0 16.0 – 20.0	20.0m
	Soil Name	Sand	Silty Sand, Sand	Silty Sand, Sand	Silty Sand, Sand	
BH-7	Distribution (m)	0.0 – 8.0	8.0 – 20.0	-	-	20.0m
	Soil Name	Silty Sand	Weathered Rock, Sand	-	-	
BH-8	Distribution (m)	0.0 – 6.0 16.0 – 20.0	15.0 – 16.0	6.0 – 7.0	7.0 – 15.0	20.0m
	Soil Name	Sand, Sandy Clay	Sandy Silt	Silty Sand	Silty Sand	
BH-9	Distribution (m)	0.0 – 3.5 6.0 – 9.0	3.5 – 6.0	-	9.0 – 11.6	11.6m
	Soil Name	Weathered Rock, Sand	Sand	-	Highly Weathered Rock	
BH-10	Distribution (m)	-	0.0 – 2.0	-	2.0 – 4.4	4.4m
	Soil Name	-	Sandy Silt	-	Weathered Rock	

Table 10.2.5. Subsurface Condition based on SPT for New Kallady Bridge

BH-No.		N Value				Water Depth & Total Length
		Less than 10	10 to 30	30 to 50	50-plus	
BH-01	Distribution (m)	0.0 – 4.0	4.0 – 8.0	-	8.0 – 15.8	0.0m (Land) 15.8m
	Soil Name	Sand	Sand	-	Weathered Rock	
BH-2	Distribution (m)	0.0 – 2.0	2.0 – 4.0	-	4.0 – 11.8	8.5m 11.8m
	Soil Name	Silty Sand	Silty Sand	-	Weathered Rock	
BH-3	Distribution (m)	0.0 – 2.0	2.0 – 3.0	-	3.0 – 11.1	6.1m 11.1m
	Soil Name	Sand, Silty Sand	Sand	-	Weathered Rock	

Table 10.2.6. Summary of CBR Values based on DCP Test

Km-P	364		366		368		370		372		374		376		378		380		382		384		386		388	
Area situation	Akkaraipattu		Akkaraipattu town		to Kalmunai		to Kalmunai		to Kalmunai		to Kalmun		to Kalmunai		Allimulai Jct.		Nintavur		Karativu		Kalmunnai town		Kalmunai town		Kalmunai town	
Base or Subbase Layer	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR
Base or Subbase Layer-1	61.0	12.1	29.0	29.4	12.0	48.0	40.0	13.5	28.0	22.4	10.0	101.7	7.0	80.3	14.0	61.6	35.0	35.9	11.0	80.3	37.0	67.8	25.0	78.7	20.0	40.4
Base or Subbase Layer-2	6.0	26.5	17.0	16.7	46.0	20.4			30.0	25.7	38.0	47.1	9.0	228.9	20.0	28.0			27.0	42.5			23.0	37.5	34.0	88.3
Base or Subbase Layer-3													20.0	73.7												
Subgrade Layer	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR
Sub Grade Layer-1	100.0	9.0	100.0	11.5	52.0	6.6	66.0	10.7	100.0	8.4	100.0	5.1	39.0	26.5	24.0	23.1	25.0	23.1	24.0	27.7	20.0	34.9	28.0	18.6	25.0	32.3
Sub Grade Layer-2					48.0	13.4	34.0	15.2					61.0	6.4	25.0	32.3	75.0	9.9	19.0	20.6	31.0	17.5	72.0	11.1	75.0	17.3
Sub Grade Layer-3															51.0	8.7			57.0	12.1	49.0	14.3				

Km-P	390		392		394		396		398		400		402		404		406		408		410		412		414	
Area situation	Maruth town		Maruth		Kallar		Kotte Kallar		Onthac madam		Kaluwa ndikudi		Thettatium		Kaluwa wellei		Thettatium		Seththi palyam		Kurukal mabam		Kirankulam		Puthukku diyiruppu	
Base or Subbase Layer	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR
Base or Subbase Layer-1	46.0	34.0	34.0	50.8	35.0	27.4	38.0	24.2	21.0	33.2	34.0	46.3	19.0	69.8	30.0	20.7	31.0	49.8	22.0	58.8	18.0	66.3	30.0	31.8	19.0	49.0
Base or Subbase Layer-2													19.0	38.6			19.0	18.8	32.0	35.4	20.0	48.0			10.0	32.1
Base or Subbase Layer-3																									19.0	23.5
Subgrade Layer	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR
Sub Grade Layer-1	28.0	7.1	21.0	15.9	17.0	15.1	12.0	15.0	34.0	17.5	21.0	18.6	30.0	14.6	40.0	8.1	22.0	9.1	50.0	11.1	20.0	22.9	28.0	10.8	100.0	16.7
Sub Grade Layer-2	11.0	16.4	79.0	10.4	83.0	10.4	33.0	11.5	66.0	13.6	44.0	7.9	70.0	10.1	60.0	7.9	27.0	7.3	50.0	14.2	31.0	14.9	72.0	7.8		
Sub Grade Layer-3	61.0	7.9					55.0	4.7			45.0	11.5					32.0	25.7			49.0	9.9				

Km-P	416		418		420		422		424		426		0		2		4		6		8		10		12	
Area situation	Puthukku diyiruppu		Thalankuda		Areimbathi		Kattankudy town		Kattankudy town		Kallady		Batticaloa town		L.G.puram		Satturu kondam		Satturu kondam		Mahilam pawadi		Kudiruppu		Eravur town	
Base or Subbase Layer	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR
Base or Subbase Layer-1	20.0	29.3	14.0	84.7	36.0	26.5	15.0	12.7	24.0	24.2	12.0	6.1	14.0	84.7	17.0	56.8	18.0	39.1	31.0	43.0	32.0	19.5	20.0	32.1	20.0	25.1
Base or Subbase Layer-2			24.0	33.5			32.0	16.1			24.0	17.3	16.0	49.6	21.0	10.8	8.0	118.7			44.0	15.2			43.0	16.8
Base or Subbase Layer-3																	17.0	55.1								
Subgrade Layer	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR
Sub Grade Layer-1	28.0	8.0	19.0	19.2	38.0	17.0	100.0	9.5	100.0	20.2	12.0	10.5	26.0	26.5	17.0	13.5	23.0	11.0	27.0	14.2	100.0	13.4	20.0	4.8	43.0	8.1
Sub Grade Layer-2	56.0	4.3	81.0	11.5	62.0	11.0					88.0	7.2	74.0	13.5	83.0	11.9	77.0	27.1	20.0	4.8			80.0	12.1	57.0	14.5
Sub Grade Layer-3	16.0	5.7																	53.0	10.3						

Km-P	14		16		18		20		22		24		26		28		30		32		34		36	
Area situation	Commonthurai		Vantharumoolai		Mavadivembu		Morakothn Chennai		Santhiwadi		Kerahan		Kumburumunnai		Kondahenkani		Oddaimavudi		Oddaimavudi Bridge		Namaladi		Mehankulam	
Base or Subbase Layer	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR
Base or Subbase Layer-1	7.0	94.6	22.0	94.6	24.0	31.6	21.0	52.0	44.0	23.7	23.0	44.1	37.0	17.0	21.0	21.6	10.0	26.5	46.0	37.5	15.0	37.4	56.0	41.2
Base or Subbase Layer-2	29.0	295.8	26.0	41.8	9.5	16.3	21.0	25.2			16.0	30.0			25.0	14.4	19.0	36.9			24.0	20.7		
Base or Subbase Layer-3					8.0	37.1											14.0	110.4						
Subgrade Layer	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR	Thickness	CBR
Sub Grade Layer-1	100.0	12.7	26.0	24.4	100.0	25.3	17.0	15.1	20.0	15.4	19.8	20.6	16.0	16.1	20.0	7.4	26.0	41.8	34.0	19.9	35.0	13.1	20.0	19.5
Sub Grade Layer-2			74.0	9.9			83.0	9.6	80.0	10.8	80.2	12.7	84.0	12.3	80.0	5.1	74.0	13.3	66.0	6.6	12.0	77.1	30.0	25.6
Sub Grade Layer-3																					53.0	15.4	50.0	15.0

Table 10.2.7. Summary of Test Pit Excavation

TP-No.	Pavement Thickness (cm)	Base or Sub-base Thickness (cm)	Remarks
TP-1	-	50	Unpaved
TP-2	5 - 10	50	Macadam
TP-3	-	40	Unpaved
TP-4	5 - 10	40	Macadam
TP-5	5 - 10	35	Macadam
TP-6	-	40	Unpaved

10.3 Hydrological Survey

10.3.1 Basic Hydrological Conditions of Project Area

The Project area receives considerable rainfall during the Northeast Monsoon season from November to February. Monthly average rainfall in Batticaloa for the last 30 years is as shown in Figure 10.3.1. In December, rainfall is the heaviest and the water level of the lagoon can rise up rapidly and inundate surrounding areas, overflowing onto the causeway and other road sections thereby obstructing road traffic. Note that a sandbar has formed at the mouth of the lagoon and hinders the discharge of excess water to the sea, increasing the severity of flooding.

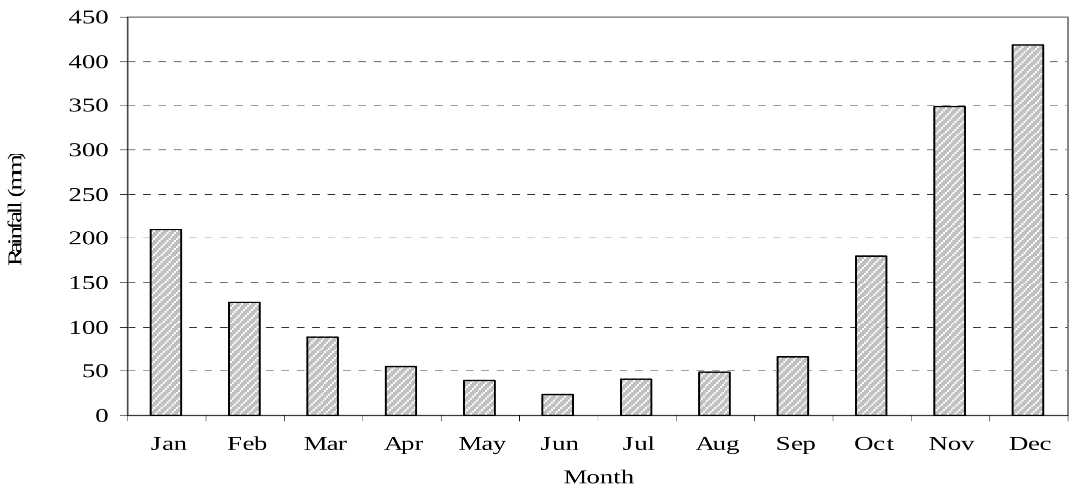


Figure 10.3.1. Monthly Average Rainfall in Batticaloa for

10.3.2 Rivers, Tributaries and Lagoons in Project Area

There are no major river basins in the Project area. Although, the Mahaweli River, the largest river in Sri Lanka with a catchment area of 10,320 sq. km. that originates from the mountains in the center of the country, flows through the northeast several kilometers away from the Project area and meets the sea at Trincomalee. On the other hand, there are many small waterways that flow through the Project area, with most of them emptying into the lagoons along the coast. These flows result in the creation of sandbars at the mouths the lagoons, and obstruct the drainage of water from the lagoons into the sea, which makes the area prone to flooding. Given that the Project road is located near the coast and lagoons, this situation has to be taken sufficiently into account.

10.3.3 Determination of High Water Level

1) Hydrological / Hydraulic Analysis

In the hydraulic analysis for the Project, the hydrograph was divided into very small time intervals (e.g. 10 seconds) in order that variation of the discharge would not be significant for any given time interval. For a specific time interval, the water level of a lagoon is calculated, with the discharge through bridges/culverts/channels to the sea also being calculated. At the beginning of the calculation process, the base water level of a lagoon is assumed to be 0.25m MSL. This procedure is iterated over the other time intervals and updated in a step-by-step approach. Note that in order to exclude numerical instability during unsteady flow analysis, the calculation time interval has been carefully determined.

The basic equation applied in the analysis of discharge flows through bridges/culverts is Bernoulli's equation. As for overflow discharge, this is calculated by applying the Broad-Crested Weir equation, while the discharge into the sea is calculated using the Manning equation.

2) High Water Level

High water levels under prevailing conditions for 1-, 5-, 10-, 25-, and 50-year return periods were calculated as part of the hydrological and hydraulic analysis. According to this analysis, the high water level for the Batticaloa Lagoon, where the New Kallady Bridge is located, is 1.35m for a 50-year return period. As for the Valachchenai Lagoon, it is 3.30m for the same return period. These results are useful in determining the necessary elevation of the proposed road alignment, clearance under the bridge girder and the placement of culverts. The results for each return period are summarized in Table10.3.1 below.

Table 10.3.1. High Water Level for Existing Conditions

Road Section		High Water Level (MSL) by Return Period				
		1-year RP	5-year RP	10-year RP	25-year RP	50-year RP
1	A004 (387-427km) & A015 (0-15) (Batticaloa Lagoon)	0.55m	0.93m	1.08m	1.26m	1.35m
2	A015 (15-37km) (Valachchenai Lagoon)	1.74m	2.39m	2.80m	3.06m	3.30m

CHAPTER 11

Traffic Demand Forecast

Chapter 11 Traffic Demand Forecast

11.1 Objective

The main objective of this chapter is to describe the Project's traffic surveys, their results, and how these results are applied together with socioeconomic information for forecasting the traffic demand of the Project road. The output from this work is applied in latter chapters to help determine the most suitable preliminary design for said road, which is mainly a costing issue, as well as the reductions in such indices as travel time and vehicle operating cost (VOC), which are benefits that would flow from Project road improvement. These data are ultimately considered together in determining the cost effectiveness of the Project in the economic analysis of Chapter 11 of this report.

11.2 Traffic Surveys

Due to the tense political situation that has existed for more than two decades in the area surrounding the Project road, there is no existing traffic data to speak of. For this reason, it was necessary for the Project to carry out numerous rapid surveys to determine the actual status of traffic and transport in the area, which are listed below and were executed over a 2-week period from mid-June 2005.[1] Note that the overall purpose of the surveys was to obtain data that would help determine traffic flows for a "typical day" on the Project road.

- Roadside origin-destination (OD) survey (for both passenger and goods vehicles)
- Traffic volume survey
- Bus passenger survey
- Bus terminal survey
- Road condition survey
- Travel speed survey
- Turning movement survey
- Rail terminal survey

The locations of these surveys are as indicated in Figure 11.2.1, with a brief description of the methodologies applied for each survey given afterwards.

[1] Engineering Consultants Ltd. of Sri Lanka executed the traffic survey under the guidance of the JICA Study Team.

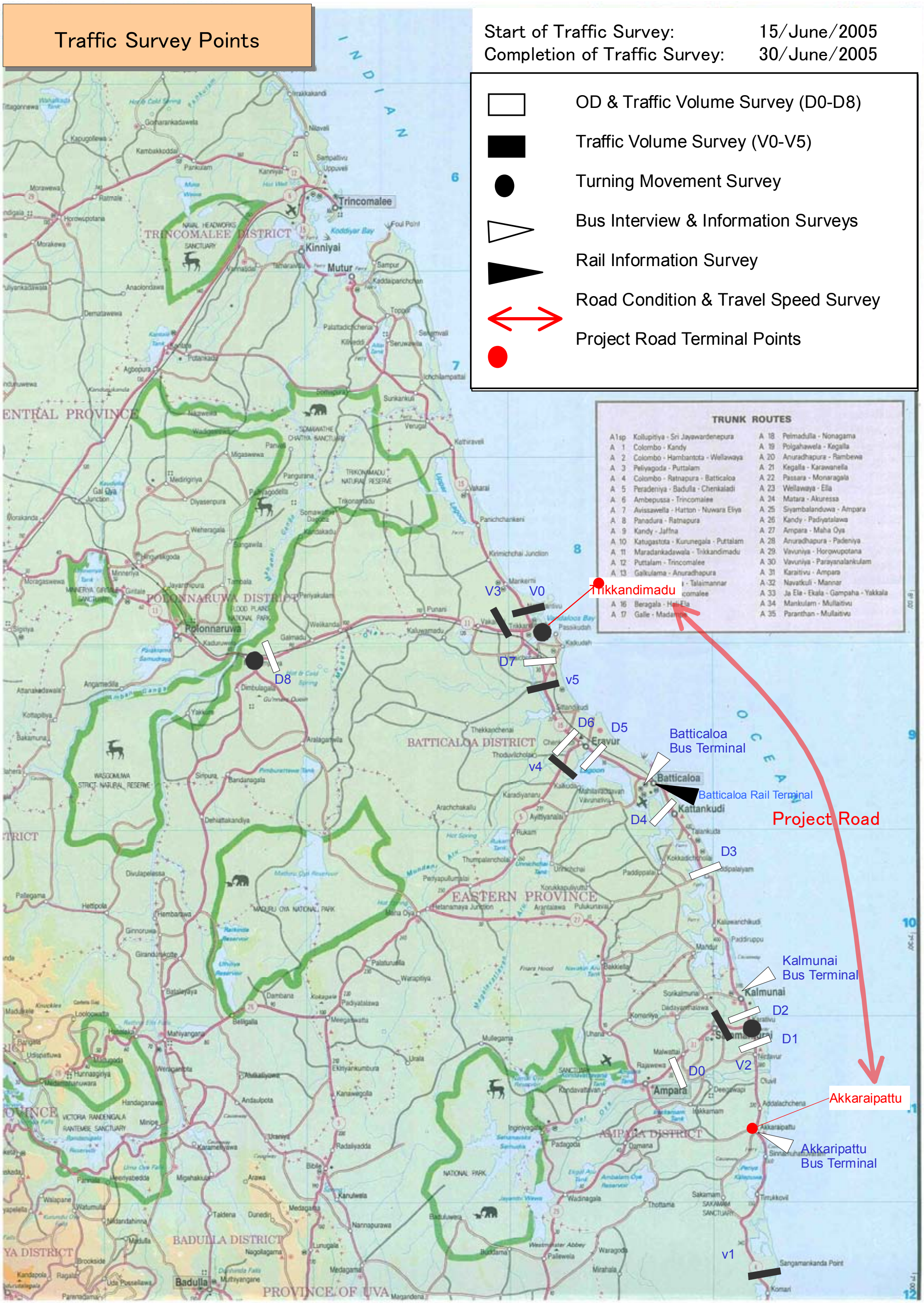


Figure 11.2.1. Locations of Traffic Survey Points

1) Roadside OD Interview Survey

- Survey Time: 12 hours (6am – 6pm) for a single day.
- Survey Items:
  For Passenger Vehicles: Place of origin/destination, mode of transport, purpose of trip, number of trips/week, number of occupants, whether number of trips will increase with improvement of Project road.
  For Freight Vehicles: Place of origin/destination, mode of transport, type of commodity carried, number of trips/week, number of occupants, load, capacity, whether trip is for tsunami relief, whether number of trips will increase with improvement of Project road.
- No. of Survey Stations: 7 on Project road and 1 near Mannampitiya.
- Survey Methodology: Occupants of passenger vehicles and drivers of freight vehicles were interviewed for both directions and their answers recorded on site, with the aim of obtaining a minimum sampling rate of 10%.

2) Traffic Volume Survey

- Survey Time: For most survey stations, 12 hours for one day of the week and one day of the weekend, together with 24-hour surveys at a limited number of strategic locations.
- Measurement Intervals: 15 minutes (total of 48 or 96 observations per day depending on the survey period).
- No. of Survey Stations: 16 on or near the Project road for the 12-hour surveys and 6 for 24-hour surveys.
- Survey Methodology: Manual classified counts were carried out for 9 motor vehicle classes (i.e., passenger cars, motorcycles, 3 wheelers, minibuses, buses, small trucks, medium trucks, large trucks, and tractors).

3) Bus Passenger Survey

- Survey Time: 12 hours for a single day.
- No. of Survey Stations: 3 major bus terminals (Akkaraipattu, Kalmunai, Batticaloa) located on Project road.
- Survey Items: Ownership [private/public], place of origin/destination, access mode of transport to the place of origin/from the destination, gender, purpose of trip, number of trips/week, income level of the passenger, whether the passenger owns a personal car,

whether number trips will increase with improvement of Project road.

- Survey Methodology: Passengers were interviewed and their answers recorded on site.

4) Bus Terminal Survey

- No. of Survey Stations: 3 major bus terminals (Akkaraipattu, Kalmunai, Batticaloa) located on Project road.
- Survey Items: Place of origin/destination, ownership [private/public], type [large, micro/mini], load factor [full, 2/3, 1/2 or 1/3], departure time, expected time of reaching destination.
- Survey Methodology: Data obtained from the bus schedules displayed at the three major bus terminals and from visual observations.

5) Road Condition Survey

- Survey Time: 9.00 am to 2.30 pm for a single weekday.
- No. of Measurements: Once in one direction (Akkaraipattu to Trikkandimadu) for every 1.0 km interval for the entirety of the 100 km Project road.
- Survey Methodology: A test car was used and roughness in terms of the international roughness index (IRI) was recorded based on visual inspection and actual vehicle free flow speeds (i.e., road serviceability).

6) Travel Speed Survey

- Survey Time: 9.00 am to 2.30 pm for a single weekday.
- No. of measurements: Once in one direction (Akkaraipattu to Trikkandimadu) with speeds recorded at 1.0 km intervals along the entirety of the 100 km Project road.
- Survey Methodology: A test car was used and speeds every 1.0 km recorded along the route by traveling along with the traffic flow (i.e., the floating car method was applied).

7) Turning Movement Survey

- Survey Time: 12 hours for a single day.
- Measurement Intervals: 15 minutes (total of 48 observations per day).
- No. of Survey Stations: 3 stations, with two located on the Project road and one at a strategic intersection located outside but near to the Project area.

- Survey Methodology: Measurements were carried out for all intersection movements (left, right, and straight) by a single team of enumerators for 9 motor vehicle classes.

8) Rail Terminal Survey

- No. of Survey Stations: One major terminal in Project area (Batticaloa Rail Station).
- Survey Items: Place of origin/destination, number of trains per day, number of passenger tickets issued per day (1st, 2nd and 3rd class tickets).
- Survey Methodology: Data obtained from the records of the railway station covering a period of 7 weeks.

11.3 Results from Traffic Surveys

The results that have been derived from each of the above-mentioned traffic surveys are described below.

11.3.1. Trip Making Patterns

The number of vehicles that were sampled and the sampling rates for the 7 OD survey stations in order to assess trip making patterns are as described in Table 11.3.1. As the table indicates, a total of 24,692 vehicles passed the survey stations and of these 6,488 were interviewed for an average sampling rate of 26.1%, which is more than the 10% target set by the Study Team.

Table 11.3.1. OD Survey Sampling Rates (12 Hours)

Survey Station	No. of Vehicles Sampled	Total Traffic Volume	Sampling Rate	Date of Execution	Remarks
D0	360	2,471	14.6%	28 Jun 05	Passenger & goods vehicles surveyed
D1	411	2,415	17.0%	28 June 05	Same
D2	338	1,856	18.2%	28 June 05	Same
D3	639	3,186	20.1%	28 June 05	Same
D4	746	3,940	18.9%	30 June 05	Same
D5	1,561	3,287	47.5%	16 June 05	Only passenger vehicles surveyed
D6	1,094	2,513	43.5%	16 June 05	Same
D7	894	2,107	42.4%	15 June 05	Same
D8	405	2,917	13.9%	30 June 05	Passenger & goods vehicles surveyed
Total	6,448	24,692	26.1%	-	-
Average	716	2,744	-	-	-

Based on the above sampling, it is possible to determine the purpose of vehicle trips for passenger vehicles other than buses (i.e., cars, motorcycles, and 3 wheelers). As shown in Figure 11.3.1, the proportion of work, school, and other trips for these vehicles is 58%, 4%, and 38%, respectively, with work-related trips representing the majority of trip making.

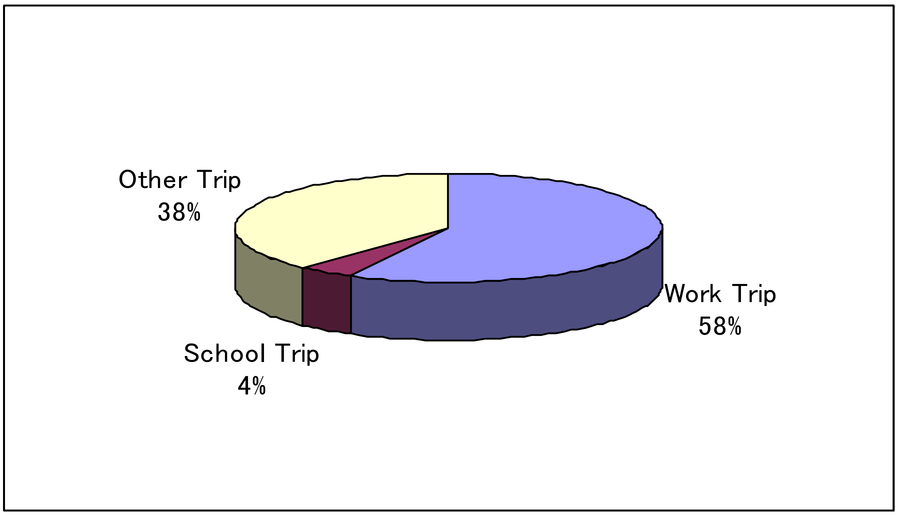


Figure 11.3.1. Vehicle Trip Composition by Purpose

As for trips by goods vehicles, excluding 25% of those trucks that were empty, the most ferried items were construction materials at 31% and then industrial products and processed food with each accounting for 12% of the total trucks interviewed (see Figure 11.3.2).

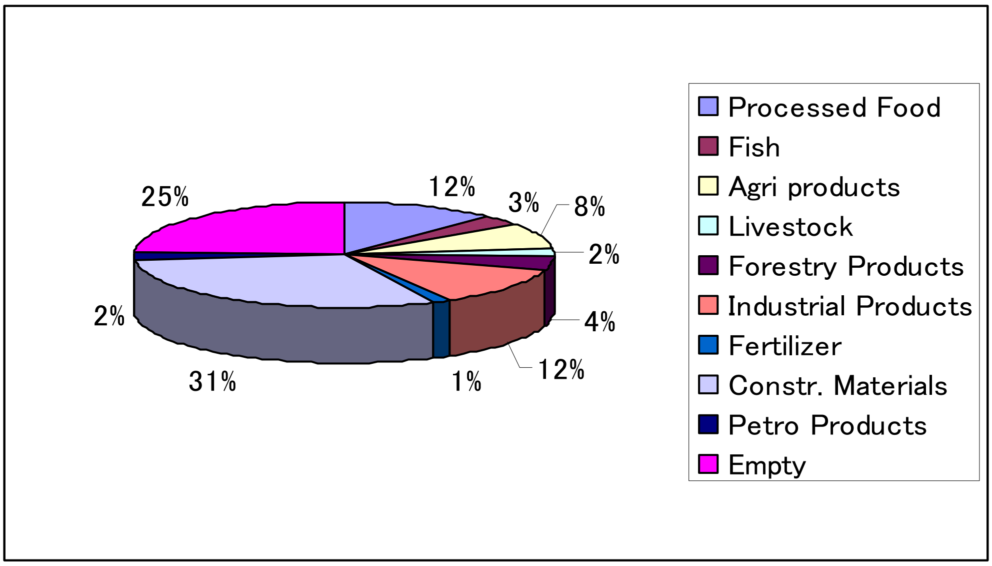


Figure 11.3.2. Commodities Carried by Goods Vehicles

The general pattern of trip making by vehicles is as shown in Figure 11.3.3. As the figure clearly indicates, the vast majority of trips by passenger vehicles (including buses) and goods vehicles originate and terminate in the Project area (i.e., the districts of Ampara and Batticaloa of Eastern Province). Note that the number of through trips (i.e., trips with their origin and destination outside of the Project area) only account for about 3% of the total vehicle trips in the Project area.

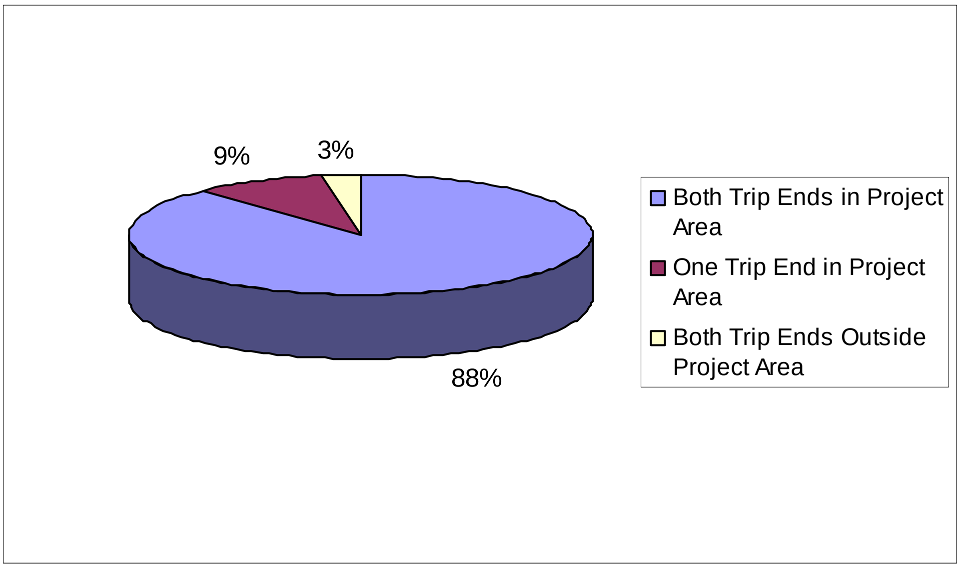


Figure 11.3.3. Outline of Vehicle Trip Movements

11.3.2. Traffic Flow Characteristics & Average Vehicle Occupancy

The composition of actual weekday traffic that was counted and classified by the traffic volume survey at all survey stations for the 12-hour period from 6 am to 6 pm is as shown in Figure 11.3.4.

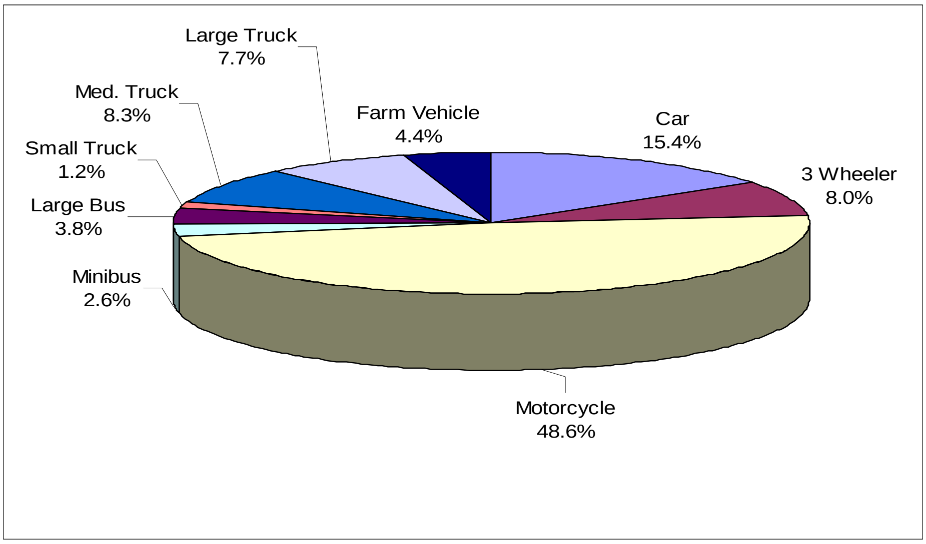


Figure 11.3.4. Average Daytime Traffic Composition

As the above figure indicates, the vast majority of daytime traffic consists of motorcycles, accounting for about 49% of the total. Passenger cars were the next most numerous mode of transport with a share of approximately 15%. As for the other modes of transport, all of them accounted for less than 10% of total traffic. Note, on the other hand, that if the shares of all the different types of goods vehicles are combined trucks account for about 17% of traffic, while buses and minibuses together represent a share of about 6%.

Daily traffic flows for the road links of the Project road (see Figure 11.3.5) are estimated assuming that the weekdays that the traffic volume survey was carried out (i.e., Tuesday to Thursday) represent an "average" day of the year in regards to traffic, with 12-hour traffic counts converted to 24-hour counts by applying 24-hour expansion factors based on collected data shown in tables 11.3.2 and 11.3.3. Note that total 24-hour traffic volumes were on average 1.23 times larger than that for 12 hours. From a vehicle-specific perspective, goods trucks (all types) and large buses both had relatively a large daily/daytime traffic ratio of 1.32, indicating a certain amount of nighttime operation. Excluding farm vehicles, which had a daily/daytime traffic ratio of 1.19, the ratio for other vehicles was in the range of 1.21 to 1.26.

Table 11.3.2. Ratio of Daily to Daytime Traffic for All Vehicle Types

Survey Station	12-Hour Traffic Vol. (A)	24-Hour Traffic Vol. (B)	A/B Ratio
D0	4455	5362	1.20
D1	5099	6107	1.20
D2	7192	8607	1.20
D3	3186	3776	1.19
D4	3940	5184	1.32
D5	3287	4270	1.30
Average	4527	5551	1.23

Table 11.3.3. Ratio of Daily to Daytime Traffic by Vehicle Type

Vehicle Type	Daily/Daytime Traffic Ratio
Car	1.24
3 Wheeler	1.26
Motorcycle	1.23
Minibus	1.21
Large Bus	1.32
Small Truck	1.47
Med. Truck	1.27
Large Truck	1.23
Farm Vehicle	1.19
Average	1.27

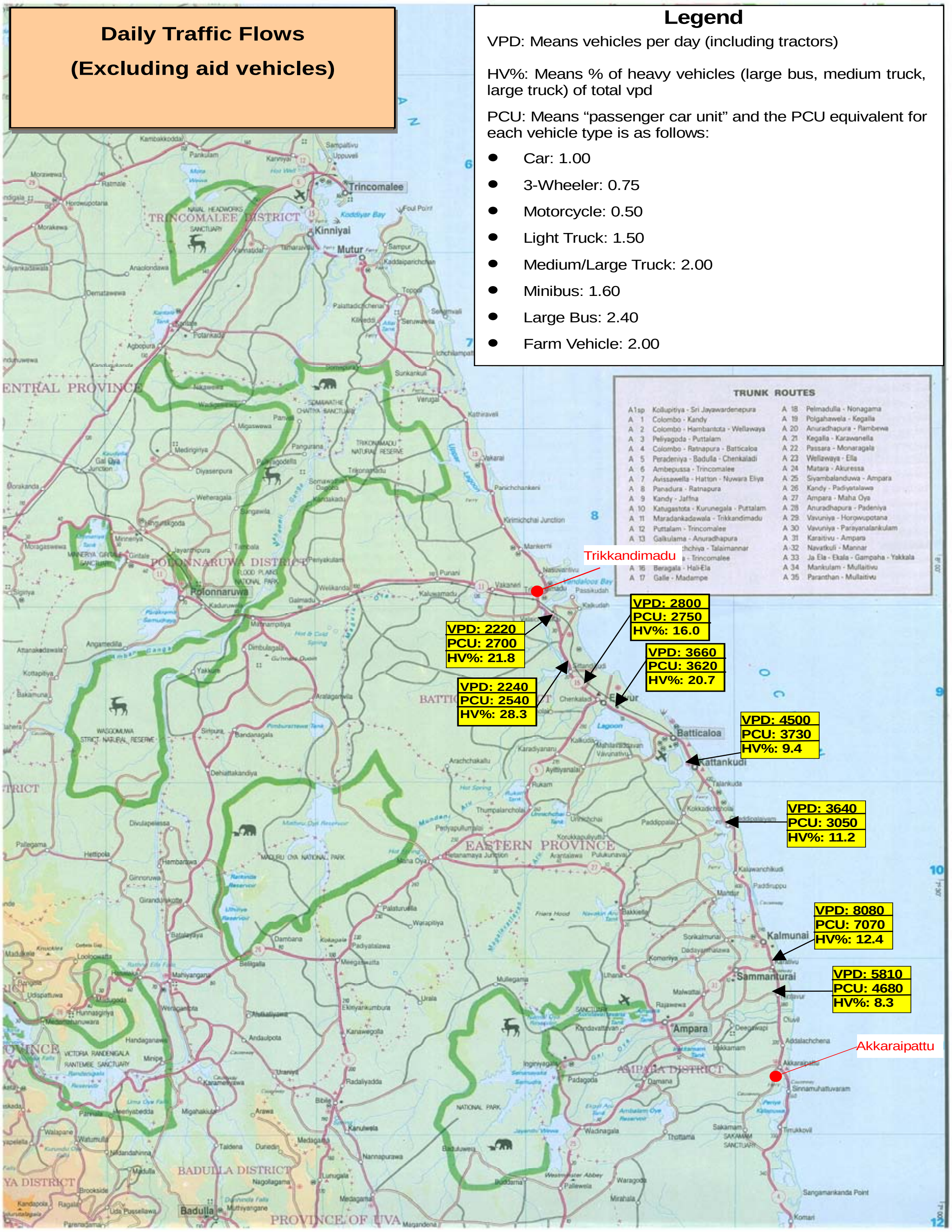


Figure 11.3.5. Daily Traffic Flows for Project Road (excl. aid vehicles)

As the previous figure indicates, the area near Kalmunai has the largest daily traffic flow with a total of 8080 vehicles per day (vpd). The average vpd for the Project road is about 4120, with about 16% of this traffic being heavy vehicles (i.e., large buses, medium trucks, and large trucks). In terms of passenger car units (pcu), the relatively busy Kalmunai area has a daily flow of 7070 pcu, with the average daily pcu flow for the Project road being about 3770, indicating that the there is a large number of small-sized vehicles such as motorcycles. In fact, as Figure 11.3.4 indicates, 72% of existing traffic is that having a pcu of 1.00 or smaller (i.e., passenger cars, 3 wheelers, and motorcycles).

Note that the above daily traffic flows exclude aid vehicles for the Tsunami relief effort, as this is considered to be temporary traffic. The percentage of aid vehicles by vehicle type is as shown in Table 11.3.4. Excluding 3 wheelers and motorcycles, the percentages are significant and range from a low of 10% for small trucks to a high of 35% for medium trucks.

Table 11.3.4. Percentage of Aid Vehicles on Project Road by Vehicle Class

Vehicle Type	% Tsunami Aid Vehicles
Passenger Car	15%
Motorcycle	3%
3 Wheeler	3%
Small Truck	10%
Medium Truck	35%
Large Truck	30%
Farm Vehicle	25%

Excluding buses, the average vehicle occupancy for the different types of vehicles (including the driver) is as shown in Figure 11.3.5. Passenger cars had the highest occupancy of 3.61 with 3 wheelers next at 2.92. Motorcycles, of course, had the lowest occupancy value, which was 1.48.

Table 11.3.5. Average Occupancy by Vehicle Type

Vehicle Type	Average Occupancy (incl. driver)
Passenger Car	3.61
Motorcycle	1.48
3 Wheeler	2.92
Small Truck	2.86
Medium Truck	2.67
Large Truck	2.53
Farm Vehicle	2.48

11.3.3. Bus Travel

The characteristics of bus travel as determined by the bus passenger and terminal surveys are summarized below in figures 11.3.6 to 11.3.8. As Figure 11.3.6 indicates, the vast majority (or 93%) of all buses with trips originating in the Project area of Ampara and Batticaloa stay within the area, with the other 7% traveling mostly to other provinces and a few to Trincomalee.

The types of buses, in terms of size, providing transport services consist of 47% minibuses and 53% large buses (see Figure 11.3.7). The passenger load of these buses, which was derived via the visual inspection of vehicles arriving to and departing from bus terminals, is quite high. That is, 78% of all buses are two-thirds full or fuller, with 46% of all buses being full (see Figure 11.3.8).

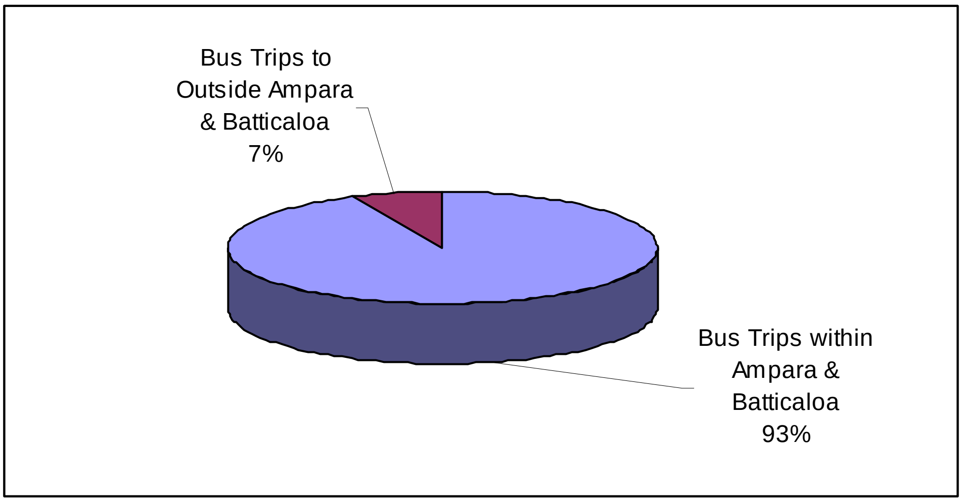


Figure 11.3.6. Bus Travel Patterns

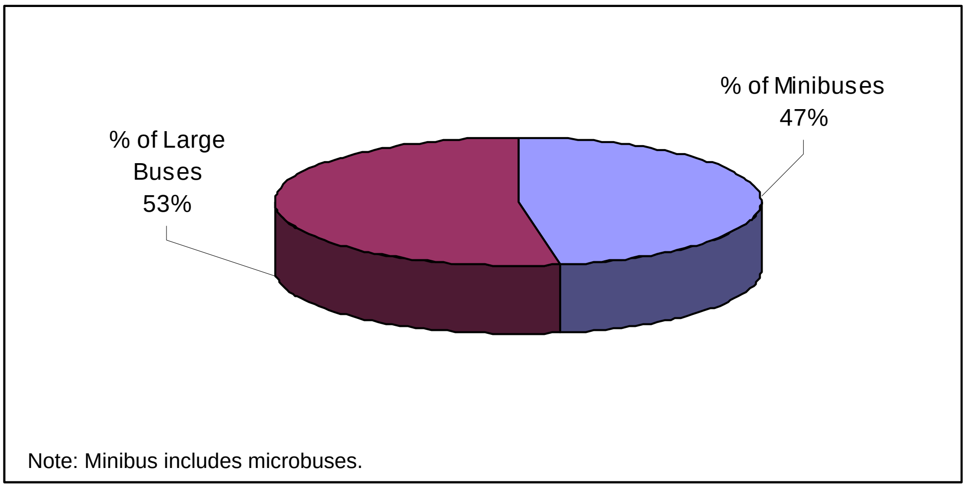


Figure 11.3.7. Types of Buses in Terms of Size

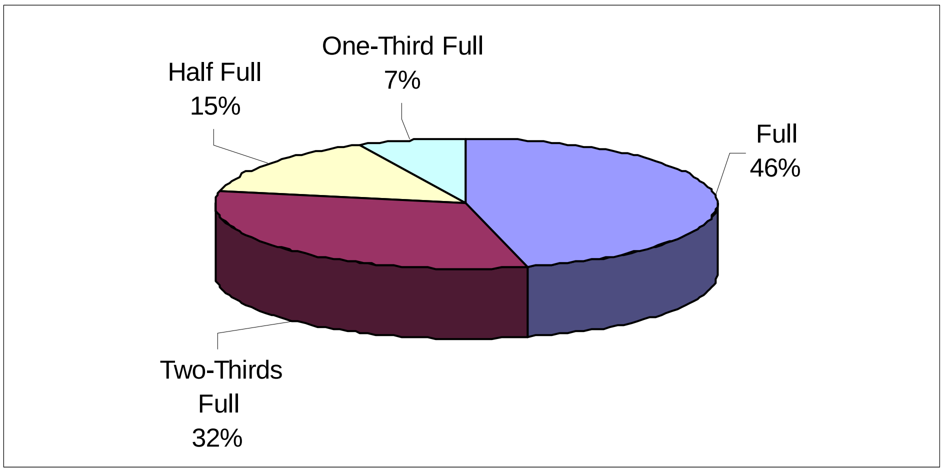


Figure 11.3.8. Bus Passenger Loads

The most widely utilized modes of transport to access and egress bus terminals are as shown in Figure 11.3.9 and 11.3.10. As Figure 11.3.9 indicates, a feeder bus is the most common way of arriving at a bus terminal (41% of bus riders), with foot being the next most popular method (31% of riders). As for egress, foot is by far the most common mode (52% of riders), with feeder buses and 3 wheelers being next and accounting for 17% and 15% of all egress trips, respectively. Note that most bus users (88%) do not own a car. This seems to indicate that most people who ride the bus are captive users. That is, they use the bus not as a matter of choice but as a matter of necessity, which has been shown to be the case in other studies in Sri Lanka.[2]

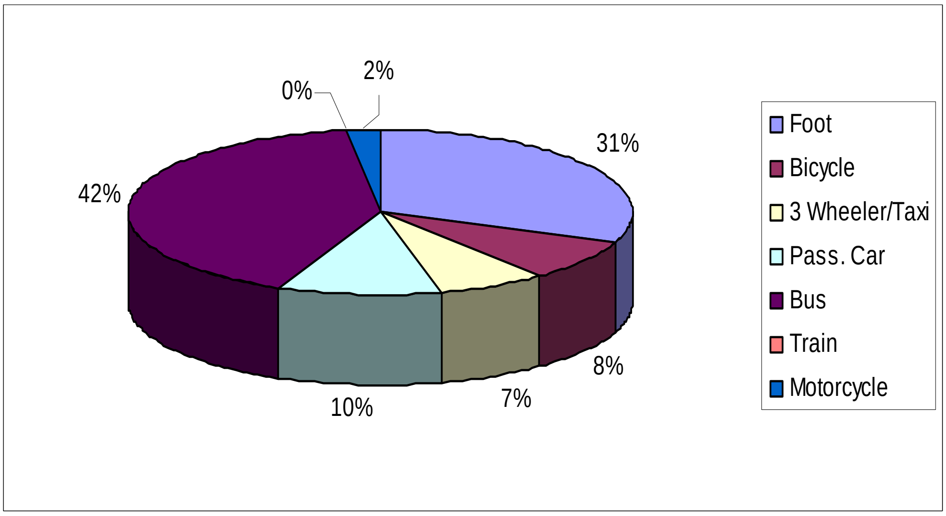


Figure 11.3.9. Access Modes to Bus Terminals

[2] *The Study on The Outer Circular Highway to the City of Colombo*, Final Report, Main Text I, Page 5-28, JICA Study Executed by Oriental Consultants, February 2000.

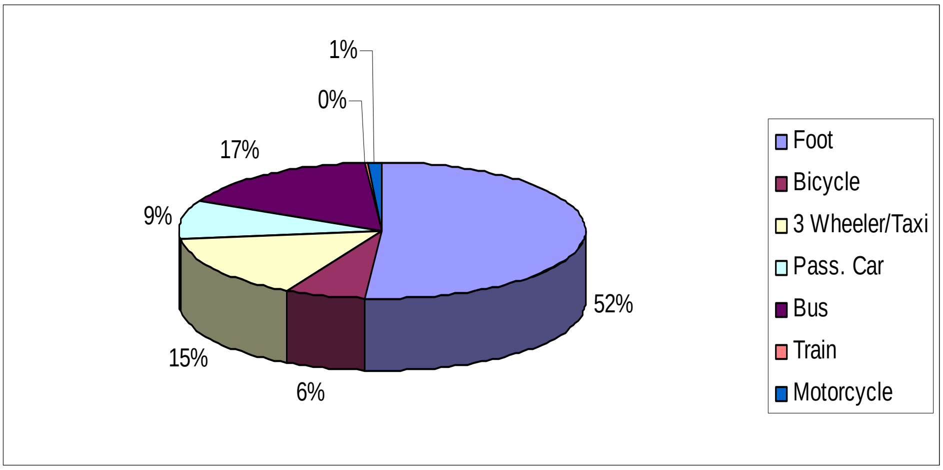


Figure 11.3.10. Egress Modes to Bus Terminals

11.3.4. Project Road Condition & Travel Speed

A simple estimate of the condition of the Project road in terms of roughness via the application of the IRI was carried out via a drive-through survey using the relationships described in Table 11.3.6. Note that this work also included the measurement of vehicle running speed as well.

Table 11.3.6. Relationship between Road Serviceability & IRI

Road Serviceability Description for Paved Roads	IRI (m/km)
Ride comfortable over 120km/h. Undulation barely perceptible at 80 km/h in range 1.3 to 1.8. No depressions, potholes, or corrugations are noticeable: depressions <2mm/3m. Typical high quality asphalt 1.4 to 2.3. High quality surface treatment 2.0 to 3.0.	1.5-2.5
Ride comfortable up to 100-120 km/h. At 80km/h, moderately perceptible movements or large undulations may be felt. Defective surface: occasional depressions, patches or potholes (e.g., 5-15mm/3m or 10-20mm/5m with frequency 1-2 per 50m) or many shallow potholes (e.g., on surface treatment showing extensive raveling). Surface without defects: moderate corrugations or large undulations.	4.0-5.5
Ride comfortable up to 70-90 km/h, strongly perceptible movements and swaying. Usually associated with defects: frequent moderate and uneven depressions or patches (e.g., 15-20mm/3m or 20-40mm/5m with frequency 5-3 per 50m). Occasionally potholes (e.g., 1-3 per 50m). Surface without defects: strong undulations or corrugations	7.0-8.0
Ride comfortable up to 50-60 km/h, frequent sharp movements or swaying. Associated with severe defects: frequent deep and uneven depressions and patches (e.g. 20-40mm/3m or 40-80mm/5m with frequency 3-5 per 50m) or frequent pot-holes (e.g. 4-6 per 50m).	9.0-10.0
Necessary to reduce velocity below 50 km/h. Many deep depressions potholes and severe disintegration (e.g., 40-80 mm deep with frequency 8-16 per 50m).	11.0-12.0

A summary of the results of the drive-through survey are as shown in Table 11.3.7. As the table indicates, the IRI for all sections is at best 7 and at worst 12, meaning that many sections (if not most) of the road require an overlay and that the current condition is hindering the smooth flow of traffic. In addition, approximately 62% of the Project road's carriageway has a width less than the standard of 7m.

Table 11.3.7. Road Condition & Running Speed from Pottuvil to Pannicchankeni

Road Section		Distance (km)	IRI Range	Av. Road Width (m)	Av. Running Speed (km/h)
Origin	Destination				
Akkaraipattu	Batticaloa	62.4	7-10	6.12	57
Batticaloa	Trikkandimadu	35.6	7-8	8.57	59

11.3.5. Turning Movement

A 12-hour survey on turning movements at three strategically located intersections (i.e., Kalmunai, Mannampitiya, and Trikkandimadu) was carried out as a check on overall traffic flows. The results of this survey are summarized in figures 11.3.11 to 11.3.13.

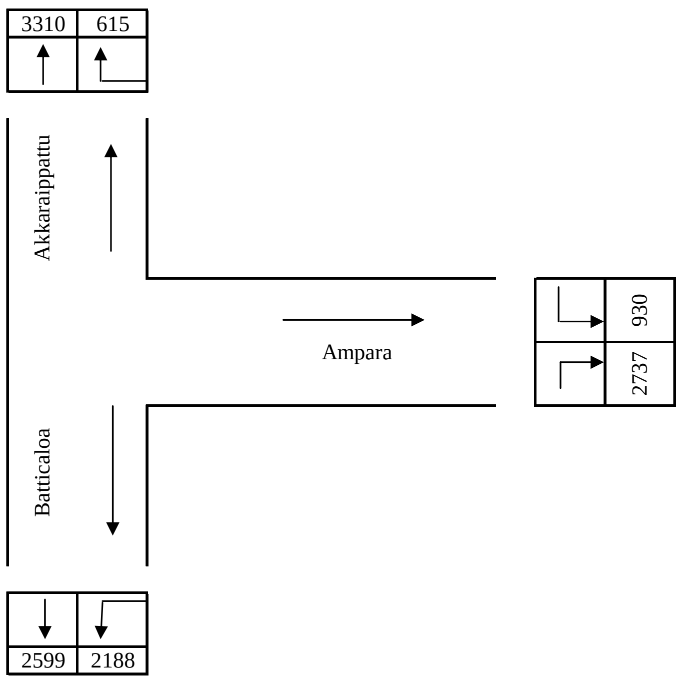


Figure 11.3.11. Kalmunai Jct. Traffic Flows
(6 am - 6 pm)

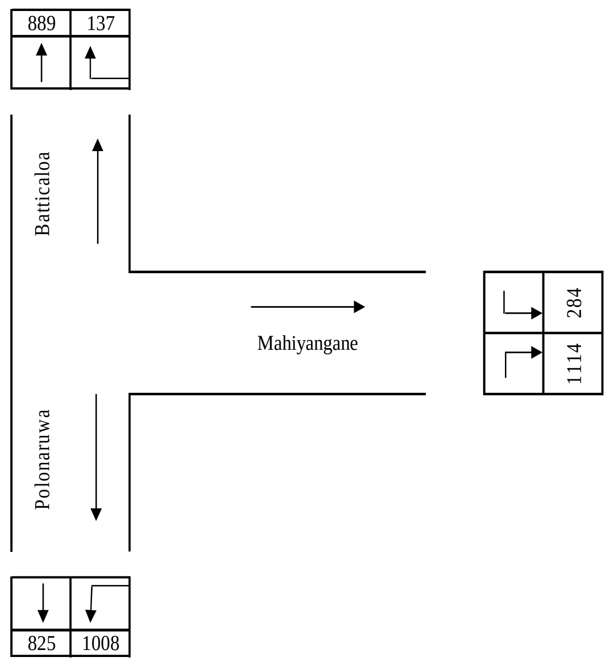


Figure 11.3.12. Mannampitiya Jct. Traffic Flows (6 am - 6 pm)

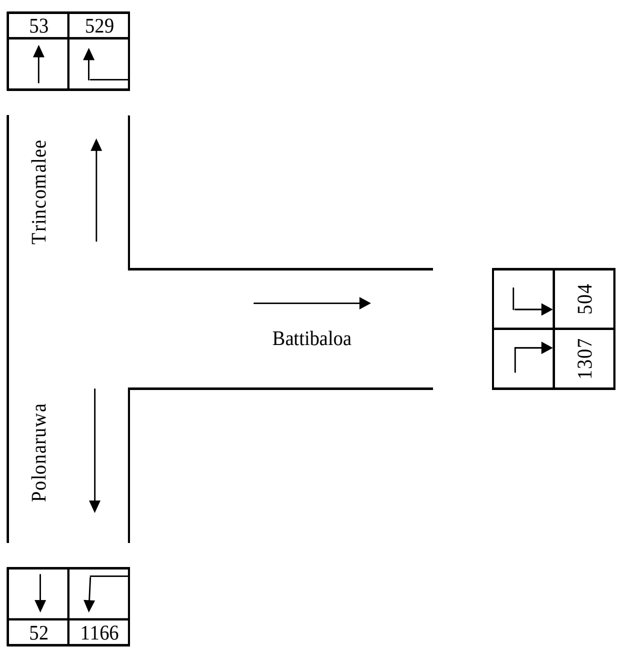


Figure 11.3.13. Trikkandimadu Jct. Traffic Flows (6 am - 6 pm)

11.3.6. Rail Travel

A rough sketch of the rail network is as shown in Figure 11.3.14. However, the number of people using the train in the Project area is quite low. As Table 7.3.8 indicates, only 265 passengers on average ride the train from Batticaloa Rail Terminal. Moreover, most of these trips (87%) are to locations outside of the Project area, with about 78% of these trips being to the capital Colombo. Given this, it can be said that rail transport at present does not have a significant impact in the Project area on the use of other modes of transport.

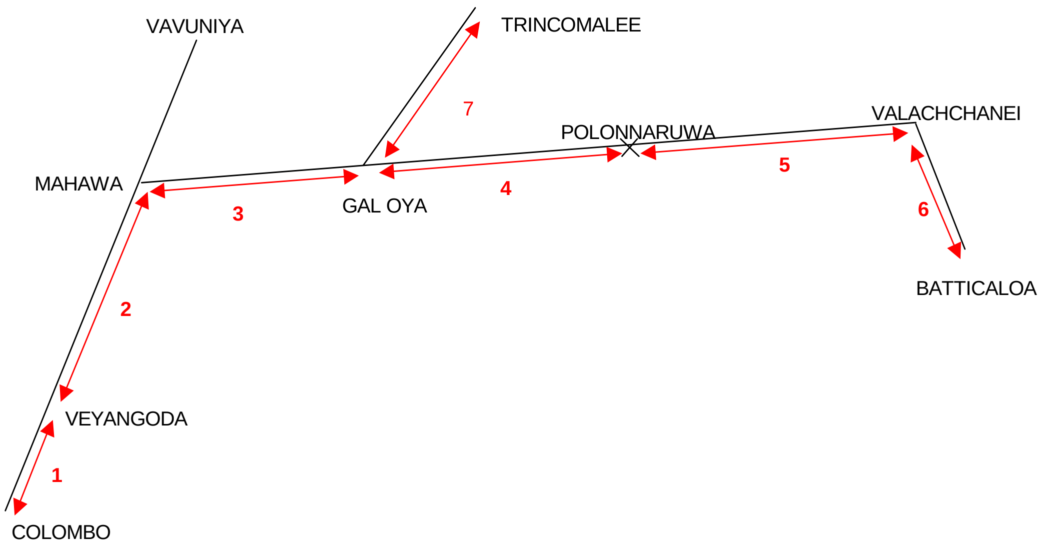


Figure 11.3.14. Sketch of Rail Network

Table 11.3.8. Average No. of Daily Trips from Batticaloa Rail Station

Origin	Destination	Daily Trips
Batticaloa	Valachchenai	30
Batticaloa	Trincomalee	5
Batticaloa	Other	230
Total Trips	-	265

Note: The row shaded in gray represents trips within the Project area.

11.4 Traffic Demand Model

11.4.1 Outline of Model

The model for calculating traffic demand for the Project road is as shown in Figure 7.4.1, with the final output consisting of daily traffic by road link and daily vehicle-hours for work/non-work trips as well as daily vehicle-kilometers for the entire Project area.

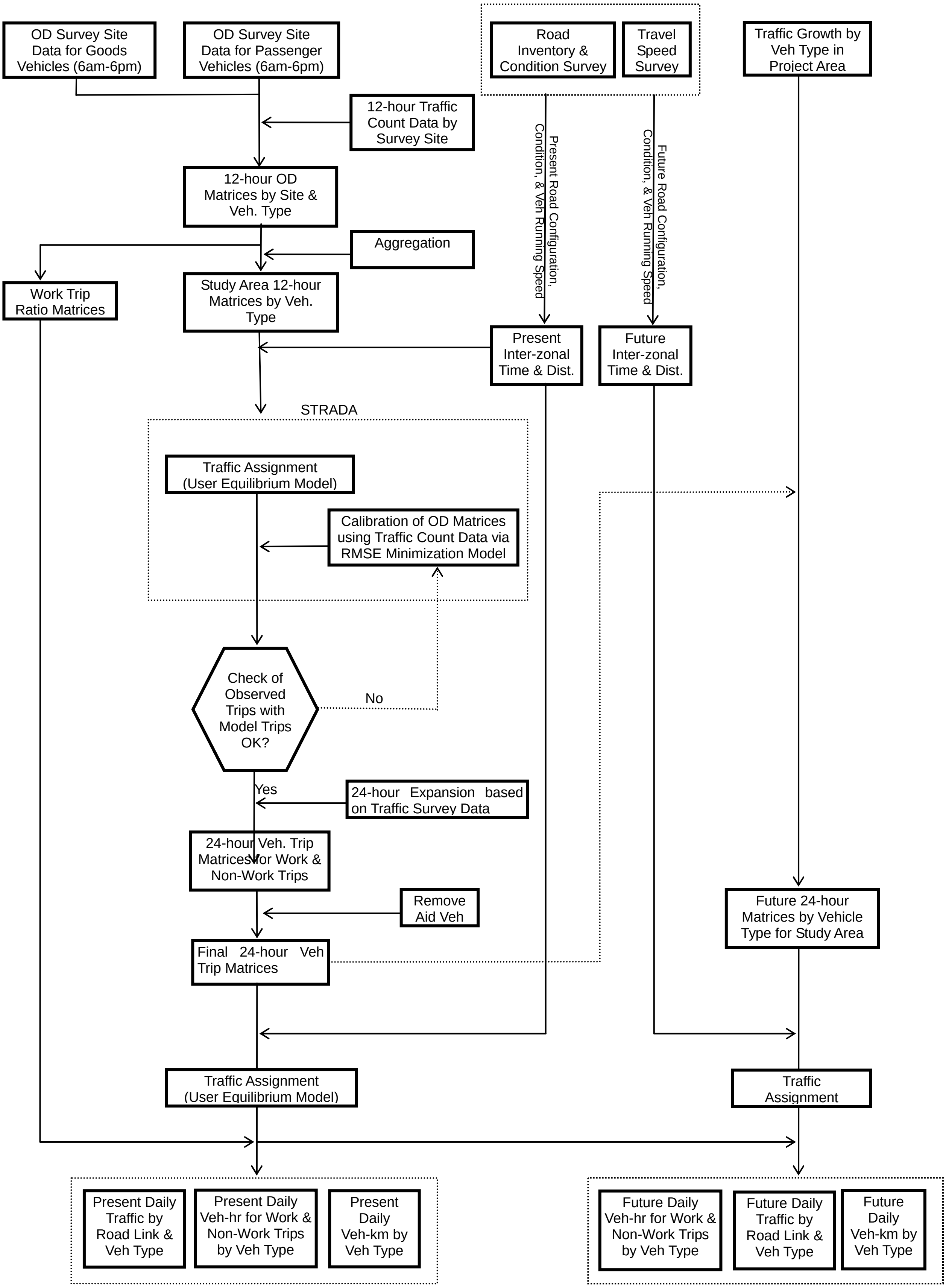


Figure 11.4.1. Process for Determining Future Traffic Demand

As the preceding figure indicates, present traffic demand is modeled by first inputting vehicle-trip OD matrices into a user-equilibrium traffic assignment model, and the OD matrices calibrated so that the discrepancy between traffic counts and model estimates for road links minimized via the minimization of the root mean square error between calculated link flows and generated trips.

The general concept for deriving an OD matrix from traffic counts is as described in Equation (1).

$$V_a = \sum_{ij} T_{ij} p_{ij}^a \qquad 0 \le p_{ij} \le 1 \qquad \text{Equation (1)}$$

Where,

V_a: Observed vehicle trips on link a

$\sum_{ij} T_{ij}$: Summation of all trips moving from zone i to zone j

P_{ij}^a: Proportion of total trips traveling from zone i to zone j via link a, and is derived using a traffic assignment model

After obtaining calibrated 12-hour trip matrices for each vehicle type, the matrices are expanded into 24-hour matrices using the expansion factors described in 11.3.2. The 24-hour matrices are then reloaded onto the road network of the traffic assignment model, and daily flows, vehicle-hours, and vehicle-kilometers obtained for present travel, taking into account the proportion of work and non-work trip making. As for future vehicle trip making, present daily OD matrices are factored up applying vehicle traffic growth rates derived from existing information regarding past traffic growth trends (see 11.4.3). These factored up matrices are then loaded onto the future road network and the final traffic outputs calculated.

11.4.2 Zoning

The Project road is located in the districts of Ampara and Batticaloa of Eastern Province, and it was therefore decided that the Project area would consist of these two districts in analyzing traffic demand. As shown in Table 11.4.1, the zoning for traffic analysis is based on the existing administrative zoning for these districts, and there are a total of 26 traffic analysis zones (TAZ) that comprise the Project area (see Figure 11.4.1). Note that five additional zones for processing trips from/to the outside of the Project area are included in the traffic model (i.e., trips to north and northwestern provinces, to Western Province, to southern provinces, and to Trincomalee District).

Table 11.4.1. Project TAZ Code

Administrative Zone No.	Zone Name	TAZ Code
5113	Koralai Pattu Central DSD	1
5114	Koralai Pattu South DSD	2
5105	Eravur Town DSD	3
5106	Manmunai North DSD	4
5107	Manmunai West DSD	
5108	Kattankudy DSD	5
5109	Manmunai Pattu DSD	6
5110	Manmunai South-West DSD	
5111	Porativu Pattu DSD	7
5112	Manmunai South & East DSD	
5208	Kalmunai DSD	8
5206	Navithanveli DSD	9
5209	Sainthamarathu DSD	
5210	Karaitivu DSD	10
5211	Ninthavur DSD	11
5212	Addalachchenai DSD	12
5214	Akkaraipattu DSD	13
5215	Aliyadiwembu DSD	
5217	Tirukkovil DSD	14
5102	Koralai Pattu West DSD	15
5103	Koralai Pattu DSD	
5104	Eravur Pattu DSD	16
5219	Lahugala DSD	17
5213	Eragama DSD	18
5205	Ampara DSD	19
5216	Damana DSD	20
5207	Samanthurai DSD	21
5203	Mahaoya DSD	22
5201	Dehiattakandiya DSD	23
5202	Padiyatalawa DSD	
5101	Koralai Pattu North DSD	24
5218	Pottuvil DSD	25
5204	Uhana DSD	26

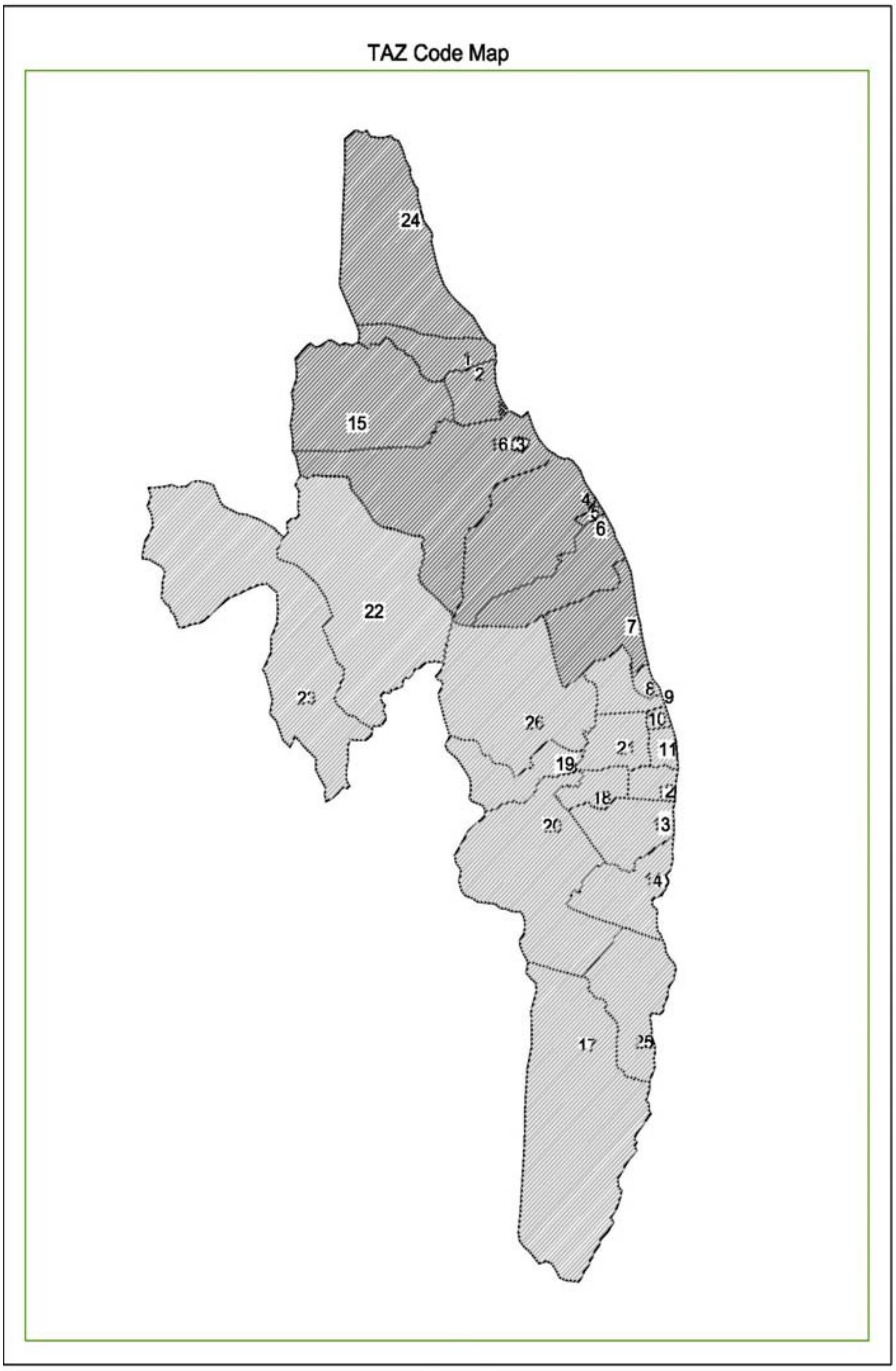


Figure 11.4.1. TAZ Map for Project Area

11.4.3 Socioeconomic Considerations &Future Trip-Making Assumptions

1) Socioeconomic Considerations

In forecasting trips, usually three types of traffic should be considered: normal (or existing) traffic, diverted traffic, and generated traffic. In the case of normal traffic, it is common practice to make future forecasts for trip making by linking it with changes in various socioeconomic indices such as population, GDP, income, employment, and vehicle ownership. Unfortunately, due to the past troubles of the Eastern Province, the necessary time-series data is either insufficient or nonexistent for constructing reliable trip generation models. Given this, it was decided to estimate future trip making by applying a range of likely traffic growth rate bands by vehicle type for low, medium, and high growth cases, based on a close examination and extrapolation of growth rates from recent studies carried out in Sri Lanka.

As a point of reference, an ADB study for Sri Lanka suggesting that traffic increase at a rate of 1.10 times GDP is considered.[3] Examination of literature on the relationship between GDP and vehicle kilometers (or road traffic intensity) corroborates that overall traffic growth is usually about 1.00 times GDP or slightly higher, although, there can be large variations from country to country.[4] To err on the side of safety, a value 20% greater than 1.10, or 1.32, can serve as an upper threshold. As for annual GDP growth, the value of 4.64% can serve as the low case, which is the growth from 1997 to 2001 in Eastern Province prior to the Ceasefire Agreement of 2002 between the Sri Lankan Government and the LTTE.[5] As for the high growth case, given that the future of the province is still unclear, it is suggested that the value of 6.50% be applied, which is the GDP high growth case for the whole of Sri Lanka from a joint study by the World Bank and United Nations Development Programme.[6] As for the medium growth case, the median of the low and high growth cases, or 5.57% is applied.

Based on the preceding, the overall traffic growth for the low, medium, and high growth cases should fall in the range of 5.10 to 6.12%, 6.13 to 7.35%, and 7.15 to 8.58%, respectively.

2) Future Trip Making Assumptions

With the ranges for overall traffic growth rates established above, the growth rates for individual vehicle types are determined in this section via a review of extant information. As indicated in Table 11.4.2, motorcycles have the highest rates of growth varying from a

[3] *Road Sector Development Project*, Report and Recommendation to the President (RRP: SRI31280), ADB, November 2002.
[4] *Transport and the economy*, Standing Advisory Committee for Trunk Road Development, Department of Transport, UK, June 1999.
[5] Based on statistics provided on the official website of the Sri Lankan Government's Secretariat for Coordinating the Peace Process: http://www.peaceinsrilanka.org/peace2005/Insidepage/printV/SCOPPpv/18July2005PV.htm.
[6] *Sustainable Transport Options for Sri Lanka*, Joint UNDP and World Bank Energy Sector Management Assistance Programme, February 2003.

low of 6% to a high of 10%, while passenger cars have a much lower per annum growth ranging from 3% to 5%, and 3 wheelers grow at rates somewhere between 4% to 8%.[7] On the other hand, buses and trucks grow at rates of 3% to 5% and 3% to 6%, respectively, which are in line with existing information and RDA recommendations.[8]

Table 11.4.2. Growth Rate Bands by Vehicle Type

Vehicle Type	Range of Growth (%)
Car	3-5
Motorcycle	6-10
3 Wheeler	4-8
Bus	3-5
Truck	3-6
Tractor	3-5

The above growth rate bands are applied to construct three traffic growth scenarios (low, medium, and high) for the different vehicle types for the period of 2006 to 2025, which is divided into 3 sub-periods as shown in Table 11.4.3 to 11.4.5. The assumptions underlying these scenarios are as follows:

- Given the relatively low levels of household income[9], the growth rate for passenger car traffic would be the same for the 2006 to 2010 period (3% per annum) for all traffic growth scenarios and then would increase slowly after that by 0.5% to 1% reaching a maximum of 5% growth per annum in the high growth scenario.
- Motorcycle traffic, which already accounts for a large proportion of current traffic flows, would grow at a high pace of 8% to 10% per annum for the low, medium, and high growth scenarios, respectively, in the initial sub-period of 2006 to 2010. These rates would then decrease by 1%, respectively, for each of the sub-periods afterwards based on the assumption that the motorcycle market would be reaching saturation and that people would also start switching to 4-wheeled vehicles.
- Three wheelers have been growing at a very fast pace in Sri Lanka, especially, in the Colombo area. However, in the Project area, it seems that motorcycle traffic is more

[7] In a recent May 2005 ADB report for a study (*Tsunami Emergency Recovery Programme*) carried out by BCEOM & RDC on roads near the southern coast of the country, traffic growth rates of 5.5% were adopted for passenger cars, 3 wheelers, and motorcycles, while growth rates of 3.5% to 3.8% were adopted for all trucks. On the other hand, in an earlier November 1998 ADB RRP (*SRI 28331*), traffic growth rates for roads outside of Colombo and the southern coastal area were 7.5% to 9.6% for motorcycles, 3.3% to 4.2% for cars, an average of 5.0% to 6.4% for trucks, and an average 4.5% to 5.7% for buses.
[8] The RDA April 1999 *Guide to the Structural Design of Roads Under Sri Lankan Conditions* recommends growth rates of 4% to 7% for trucks and 3% to 5% for buses in cases where existing traffic data is insufficient. Note, however, it was decided that the growth rates for trucks be reduced by 1% due to the small amount of industrial activity in the Project area, while bus growth rates were applied as is.
[9] According to the Department of Census and Statistics of Sri Lanka, the mean household income for Eastern Province for the year 2002 was the lowest in the country.

prevalent and it was decided that its growth would be lower than that of motorcycles but higher than that of private cars (or 4% to 8%). On the other hand, it is assumed that over time that as people's income levels rise that the use and therefore the traffic growth of 3 wheelers would decline, as people would prefer to purchase their own motorcycles or cars. Given this, traffic growth rates decline over time in the case of 3 wheelers.

- In the initial sub-period of 2006 to 2010, the bus traffic growth rate is inverse to that of motorcycles. That is, the lower the growth rate of motorcycle traffic the higher the growth rate for buses and vice versa. The assumption here is that people would switch from bus use to motorcycles. Afterwards, there would also be some minor shifting to car use as incomes rise. It is assumed in all traffic growth scenarios that bus traffic will decrease over time as a result of this trend.
- It is assumed that truck traffic growth will steadily increase over time as the Project area continues to develop and more economic linkages are established with the rest of the country.
- Tractor traffic growth is assumed to be constant, as most farmers already own their vehicles. The differences in traffic growth for the different growth scenarios is based on the assumption that this would be due to increases in the intensity of agricultural production.

Table 11.4.3. Low Traffic Growth Scenario

Veh. Type	2006-2010 Annual Growth	2011-2020 Annual Growth	2021-2025 Annual Growth
Passenger Car	3.0%	3.5%	4.0%
Motorcycle	8.0%	7.0%	6.0%
3 Wheeler	6.0%	5.0%	4.0%
Bus	5.0%	4.5%	4.0%
Truck	3.0%	3.5%	4.0%
Tractor	3.0%	3.0%	3.0%

Table 11.4.4. Medium Traffic Growth Scenario

Veh. Type	2006-2010 Annual Growth	2011-2020 Annual Growth	2021-2025 Annual Growth
Passenger Car	3.0%	4.0%	4.5%
Motorcycle	9.0%	8.0%	7.0%
3 Wheeler	7.0%	6.0%	5.0%
Bus	4.5%	4.0%	3.5%
Truck	3.5%	4.5%	5.5%
Tractor	4.0%	4.0%	4.0%

Table 11.4.5. High Traffic Growth Scenario

Veh. Type	2006-2010 Annual Growth	2011-2020 Annual Growth	2021-2025 Annual Growth
Passenger Car	3.0%	4.5%	5.0%
Motorcycle	10.0%	9.0%	8.0%
3 Wheeler	8.0%	6.0%	5.0%
Bus	4.0%	3.5%	3.0%
Truck	4.0%	5.0%	6.0%
Tractor	5.0%	5.0%	5.0%

As for diverted traffic, which is traffic that changes from another road or mode to the Project road, the possibility of the former type of diversion is considered in the traffic assignment model and the latter in the setting of the growth rates described previously.

Finally, generated traffic, which is traffic that occurs as a response to the provision or large improvement of a road, is not considered in the case of the Project road being rehabilitated, as it is considered that the level of change would be insufficient to trigger significant numbers of such trips. On the other hand, the economic impact of generated trips that would arise from the realization of the Trikkandimadu to Trincomalee link via Mutur and Kinniyai is considered in Chapter 15.

Based on the above assumptions and logic, the total vehicle trips that would be made within the Project area for each of the growth scenarios for the period of 2006 to 2025 is as shown in Table 11.4.6.

Table 11.4.6. Future Daily Trips within the Project Area by Growth Scenario

Scenario	2005	2010	2025	Average Annual Growth
Low Growth	20,530	28,030	64,720	5.9%
Medium Growth	20,530	29,030	76,150	6.8%
High Growth	20,530	30,060	88,300	7.6%

Note: Vehicle trips rounded off to the nearest ten.

As the above table shows, overall traffic growth for trips made within the Project area is predicted to grow from a low of 5.9% to a high of 7.6% over the period of 2005 to 2025 and is considered to be a realistic range by the Study Team.[10] Note, however, that the

[10] According to the March 2005 Draft Final Report for the JICA *Detailed Design on the Outer Circular Highway to the City of Colombo Study* carried out by Oriental Consultants and Pacific Consultants International, traffic growth on major arterials in the suburbs of Colombo is about 7.4% per annum. Given this, it seems that the upper range for traffic growth as represented by the high growth scenario for the Project area is sufficient, as it seems unlikely that it would be greater than that of the economically more dynamic capital area.

Medium Growth Scenario is considered as the most likely case (i.e., base case) for the Project road.

11.4.4 Traffic Network & Assignment

Based on the preceding in 11.4.3, future OD matrices for the Project area were constructed by expanding the current calibrated 2005 matrices for each vehicle type using the above growth rates. The matrix for all vehicle trips for 2005, together with the matrices for all vehicle trips for 2010 and 2025 for the medium growth scenario, are as shown in Tables 11.4.8 to 11.4.10. As for the statistical validity of the calibrated matrices, this was checked via the comparison of vehicle trips assigned to a network using the equilibrium model in STRADA[11] with actual observed trips. Table 11.4.7 indicates the correlation (i.e., R) between observed and assigned traffic flows. Excluding the farm vehicle mode (tractors), which mostly makes trips within a zone and is probably the reason for its R being so low, the statistical validity of the calibrated OD tables for each vehicle type was satisfactory.[12]

Table 11.4.7. Fit between Observed & Assigned Traffic Flows

Function of Vehicle	Type of Vehicle	Model Fit (R)
Passenger Transport	1. Passenger Vehicle	0.946
	2. 3 Wheeler	0.919
	3. Motorcycle	0.957
	4. Minibus	0.966
	5. Bus	0.813
Goods/Agricultural Transport	6. Small Truck	0.711
	7. Medium Truck	0.823
	8. Heavy Truck	0.867
	9. Tractor	0.394

The road network that was constructed for comparing the cases of rehabilitation and no rehabilitation is essentially the same, except for the increases in capacity and travel speed on the Project road in the case of its improvement. Note that the modeled network is simple, consisting of a total of 39 links and 36 nodes. That is, only major Class A and Class B roads are considered, as the Project road and most of the traffic that uses it is linear in nature.

The current Project road, which has free flow speeds varying on average between 60 to 70

[11] STRADA (System for Traffic Demand Analysis) is JICA transportation planning software. For the analysis of this Project, version 3 of STRADA was used.
[12] A perfect statistical fit would have an R equal to 1, and a value greater than 0.70 is generally considered quite good.

km/h with daily link capacities equal to 11,400 to 17,700 vpd, is assumed with its improvement to have free flow speeds that will vary between 80 to 90 km/h and to have a uniform link capacity of 18,000 vpd. The equation that was applied to calculate daily link capacities for the road network, and the equation applied in the user equilibrium assignment model (which is based on Wardrop's equal travel time principle) to determine link travel times are as follows:

$$ADT = (3200 \times (v/c) \times F_d \times F_w \times F_g \times F_{hv}) \times PHF/K \qquad \text{Equation (2)}$$

Where, 3200: basic link capacity

ADT: average daily traffic

v/c: flow capacity ratio for selected level of service

F_d: peak-hour directional distribution factor

F_w: lane and useable shoulder width factor

F_g: factor for effect of grade on cars

F_{hv}: heavy vehicle adjustment factor

PHF: peak hour factor for level of service

K: proportion of ADT expected to occur in the design hour

$$t_a(x_a) = t_{a0}\left\{1 + \alpha\left(\frac{x_a}{C_a}\right)^{\beta}\right\} + F_a + D_a \qquad \text{Equation (3)}$$

Where, t_{a0} : Travel time without restraint at the link a

x_a : Link flow at the link a

C_a : Capacity of the link a

F_a : Fare resistance independent of the link flow

D_a : Delay independent of the link flow

α, β : Parameters

Table 11.4.8. Vehicle Trip Matrix for 2005 (All Vehicle & Trip Types)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Total
1	46	32	3	141	13	0	0	7	0	0	0	0	2	0	2	0	0	0	0	0	0	0	0	60	0	0	306
2	26	235	50	354	16	37	5	37	0	0	0	0	5	0	17	17	0	0	0	0	0	0	0	84	0	0	883
3	42	50	173	298	43	30	29	41	0	0	1	0	1	0	16	11	0	0	1	0	0	0	2	44	0	0	782
4	180	281	171	117	27	437	307	327	4	17	27	32	93	12	81	111	0	1	87	0	1	2	0	122	3	0	2440
5	16	14	24	64	73	125	55	76	1	0	4	12	12	0	11	0	0	0	8	0	28	0	0	42	4	0	569
6	2	5	7	149	103	81	56	9	0	0	2	0	0	0	1	3	0	0	2	0	0	0	0	5	0	0	425
7	3	6	18	162	46	41	383	36	0	0	25	0	6	6	7	10	0	0	30	0	16	0	0	6	0	0	801
8	1	1	2	134	3	2	17	2	3	15	99	56	121	7	0	1	0	3	138	0	149	0	0	1	10	1	766
9	0	0	0	9	7	0	0	361	156	74	479	161	245	12	0	0	0	20	133	0	569	0	0	0	0	0	2226
10	0	0	6	39	4	0	13	256	110	252	192	24	52	2	0	0	0	16	120	0	128	0	0	1	0	0	1215
11	0	0	1	11	12	0	0	676	304	187	71	0	0	0	0	0	0	0	129	0	245	0	0	1	0	0	1637
12	0	0	10	92	19	0	0	156	15	20	0	31	0	0	0	0	0	0	58	0	61	0	0	0	0	3	465
13	1	12	10	243	13	3	35	440	21	108	3	0	2	42	0	2	0	2	30	0	20	0	0	13	33	1	1034
14	0	0	0	115	0	0	0	34	0	0	65	0	0	20	0	0	0	0	2	0	7	0	0	10	0	0	253
15	24	29	62	151	11	11	56	13	0	0	0	0	1	0	39	15	0	0	1	0	4	0	0	106	0	0	523
16	36	42	84	242	8	15	4	13	0	0	0	0	0	0	13	172	0	0	6	0	0	0	0	5	0	0	640
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	270	0	0	0	0	0	0	0	0	0	270
18	0	0	0	0	0	0	0	110	0	0	3	0	0	0	0	0	0	252	0	0	0	0	0	0	0	0	365
19	4	6	4	173	212	6	58	1100	376	160	353	131	109	11	0	0	0	0	312	0	25	0	0	28	0	0	3068
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	324	0	0	0	0	0	0	324
21	0	0	3	18	11	0	10	111	47	1	44	8	1	12	0	3	0	0	2	0	35	0	0	4	0	0	310
22	1	0	0	0	0	0	0	24	0	0	11	0	0	0	0	0	0	0	3	0	0	229	0	0	0	0	268
23	0	0	1	9	2	1	0	26	4	0	0	44	41	0	0	0	0	0	4	0	0	0	95	0	0	0	227
24	5	23	5	34	5	0	2	5	0	0	0	0	1	0	7	4	0	0	2	0	1	0	0	69	0	0	163
25	0	7	0	2	0	0	0	89	0	0	0	0	0	0	1	0	0	0	0	0	11	0	0	0	172	0	282
26	0	0	0	30	0	0	0	0	0	0	6	0	0	0	0	0	0	0	6	0	0	0	0	0	0	242	284
Total	388	745	637	2591	633	795	1037	3957	1050	844	1396	511	705	138	210	365	287	312	1093	344	1321	253	120	625	247	273	20526

Table 11.4.9. Vehicle Trip Matrix for 2010 (All Vehicle & Trip Types) for Medium Traffic Growth Scenario

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Total
1	56	42	3	198	19	0	0	10	0	0	0	0	2	0	2	0	0	0	0	0	0	0	0	83	0	0	415
2	32	298	69	487	23	48	7	46	0	0	0	0	8	0	21	26	0	0	0	0	0	0	0	108	0	0	1173
3	59	72	253	442	63	44	42	60	0	0	1	0	1	0	23	14	0	0	1	0	0	0	3	63	0	0	1141
4	261	382	248	161	36	639	451	448	4	25	42	40	135	16	117	163	0	1	124	0	1	2	0	165	4	0	3465
5	22	20	36	93	100	181	80	110	1	0	5	15	17	0	16	0	0	0	10	0	40	0	0	59	6	0	811
6	3	7	10	222	145	114	84	12	0	0	3	0	0	0	2	4	0	0	3	0	0	0	0	8	0	0	617
7	4	9	27	240	67	61	564	51	0	0	35	0	9	8	10	14	0	0	39	0	22	0	0	9	0	0	1169
8	2	1	3	174	4	3	23	2	4	23	145	83	157	10	0	2	0	5	183	0	222	0	0	2	14	1	1063
9	0	0	0	10	9	0	0	537	226	109	700	230	350	14	0	0	0	31	188	0	827	0	0	0	0	0	3231
10	0	0	9	58	6	0	17	380	160	367	276	34	77	2	0	0	0	25	181	0	188	0	0	1	0	0	1781
11	0	0	1	15	18	0	0	981	445	276	100	0	0	0	0	0	0	0	183	0	365	0	0	1	0	0	2385
12	0	0	12	130	28	0	0	217	21	30	0	39	0	0	0	0	0	0	75	0	80	0	0	0	0	4	636
13	1	15	12	357	18	4	51	603	32	162	3	0	2	52	0	2	0	3	38	0	27	0	0	16	42	1	1441
14	0	0	0	149	0	0	0	41	0	0	100	0	0	24	0	0	0	0	2	0	8	0	0	12	0	0	336
15	36	41	89	219	13	16	83	19	0	0	0	0	1	0	51	21	0	0	1	0	4	0	0	146	0	0	740
16	50	60	123	356	11	23	6	19	0	0	0	0	0	0	16	248	0	0	9	0	0	0	0	7	0	0	928
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	374	0	0	0	0	0	0	0	0	0	374
18	0	0	0	0	0	0	0	141	0	0	4	0	0	0	0	0	0	372	0	0	0	0	0	0	0	0	517
19	5	7	4	219	318	7	83	1549	542	230	522	185	160	13	0	0	0	0	387	0	33	0	0	33	0	0	4297
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	458	0	0	0	0	0	0	458
21	0	0	4	22	13	0	11	135	58	2	53	10	2	14	0	4	0	0	2	0	44	0	0	5	0	0	379
22	1	0	0	0	0	0	0	29	0	0	13	0	0	0	0	0	0	0	4	0	0	325	0	0	0	0	372
23	0	0	1	11	2	1	0	32	5	0	0	67	63	0	0	0	0	0	5	0	0	0	124	0	0	0	311
24	7	29	6	42	5	0	2	5	0	0	0	0	1	0	8	5	0	0	2	0	1	0	0	86	0	0	199
25	0	8	0	2	0	0	0	117	0	0	0	0	0	0	1	0	0	0	0	0	13	0	0	0	258	0	399
26	0	0	0	37	0	0	0	0	0	0	7	0	0	0	0	0	0	0	7	0	0	0	0	0	0	340	391
Total	540	993	913	3648	903	1147	1511	5552	1507	1234	2020	715	998	167	282	519	391	455	1463	478	1896	349	150	828	349	372	29029

Table 11.4.10. Vehicle Trip Matrix for 2025 (All Vehicle & Trip Types) for Medium Traffic Growth Scenario

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Total
1	106	90	7	495	58	0	0	26	0	0	0	0	4	0	5	0	0	0	0	0	0	0	0	201	0	0	992
2	63	577	170	1211	66	107	18	94	0	0	0	0	23	0	37	79	0	0	0	0	0	0	0	248	0	0	2693
3	152	188	689	1232	170	121	124	177	0	0	2	0	2	0	64	30	0	0	2	0	0	0	9	166	0	0	3128
4	728	905	674	393	87	1768	1272	1076	9	71	126	85	360	37	331	461	0	2	336	0	2	5	0	409	7	0	9144
5	58	60	101	256	230	476	231	299	3	0	8	37	49	0	50	0	0	0	21	0	106	0	0	152	17	0	2154
6	7	19	27	626	364	281	240	27	0	0	9	0	0	0	5	11	0	0	9	0	0	0	0	23	0	0	1648
7	12	26	82	691	191	179	1549	144	0	0	95	0	28	18	30	42	0	0	96	0	58	0	0	25	0	0	3266
8	5	2	9	357	12	9	56	4	7	68	405	242	332	28	0	5	0	14	419	0	640	0	0	5	38	2	2659
9	0	0	0	19	16	0	0	1553	608	303	1908	618	954	26	0	0	0	93	508	0	2251	0	0	0	0	0	8857
10	0	0	28	163	19	0	38	1090	432	1004	746	89	225	5	0	0	0	75	531	0	524	0	0	2	0	0	4971
11	0	0	2	40	49	0	0	2690	1228	775	246	0	0	0	0	0	0	0	498	0	1055	0	0	2	0	0	6585
12	0	0	24	352	83	0	0	555	44	87	0	71	0	0	0	0	0	0	180	0	194	0	0	0	0	7	1597
13	2	37	24	1018	53	8	144	1485	98	473	7	0	4	92	0	5	0	4	66	0	70	0	0	38	72	2	3702
14	0	0	0	313	0	0	0	73	0	0	303	0	0	48	0	0	0	0	5	0	17	0	0	24	0	0	783
15	97	109	235	610	36	49	240	58	0	0	0	0	2	0	101	63	0	0	2	0	10	0	0	370	0	0	1982
16	120	154	342	994	26	70	16	58	0	0	0	0	0	0	34	659	0	0	28	0	0	0	0	21	0	0	2522
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	940	0	0	0	0	0	0	0	0	0	940
18	0	0	0	0	0	0	0	289	0	0	7	0	0	0	0	0	0	1056	0	0	0	0	0	0	0	0	1352
19	9	14	9	481	929	14	208	4086	1477	639	1499	504	452	24	0	0	0	0	686	0	71	0	0	66	0	0	11168
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1192	0	0	0	0	0	0	1192
21	0	0	7	41	27	0	22	272	113	5	101	20	5	26	0	7	0	0	5	0	78	0	0	9	0	0	738
22	2	0	0	0	0	0	0	59	0	0	24	0	0	0	0	0	0	0	7	0	0	844	0	0	0	0	936
23	0	0	2	19	5	2	0	64	10	0	0	198	191	0	0	0	0	0	10	0	0	0	248	0	0	0	749
24	14	56	11	90	10	0	4	10	0	0	0	0	2	0	16	9	0	0	4	0	2	0	0	162	0	0	390
25	0	15	0	4	0	0	0	237	0	0	0	0	0	0	2	0	0	0	0	0	27	0	0	0	745	0	1030
26	0	0	0	70	0	0	0	0	0	0	15	0	0	0	0	0	0	0	14	0	0	0	0	0	0	872	971
Total	1376	2254	2446	9479	2436	3090	4169	14434	4038	3435	5512	1876	2646	318	690	1387	957	1262	3446	1212	5126	871	280	1947	904	909	76149

11.5 Future Traffic Demand & Traffic Evaluation Criteria

In Tables 11.5.1 to 11.5.2, the traffic evaluation criteria of daily vehicle-kilometers (Veh-km), vehicle-hours (Veh-hr), and average area speed are used to assess the impact of the rehabilitation of the Project road.

Table 11.5.1. Traffic Impact With & Without Rehabilitation for 2010 by Scenario

Scenario		Traffic Evaluation Criteria		
		Daily Veh-km	Daily Veh-hr	Daily Av. Speed
Low Growth Scenario	With Rehabilitation	525,591	12,144	70.7
	Without Rehabilitation		14,226	59.4
	Ratio of With to Without	-	0.854	1.190
Medium Growth Scenario	With Rehabilitation	537,832	12,466	70.7
	Without Rehabilitation		14,598	59.4
	Ratio of With to Without	-	0.854	1.190
High Growth Scenario	With Rehabilitation	549,554	12,746	70.7
	Without Rehabilitation		14,929	59.3
	Ratio of With to Without	-	0.854	1.192

Note: Veh-km are for the Project road only and Veh-hr are for the Project area.

Table 11.5.2. Traffic Impact With & Without Rehabilitation for 2025 by Scenario

Scenario		Traffic Evaluation Criteria		
		Daily Veh-km	Daily Veh-hr	Daily Av. Speed
Low Growth Scenario	With Rehabilitation	1,007,892	24,983	67.7
	Without Rehabilitation		30,066	56.3
	Ratio of With to Without	-	0.831	1.202
Medium Growth Scenario	With Rehabilitation	1,209,525	30,088	65.3
	Without Rehabilitation		36,644	54.9
	Ratio of With to Without	-	0.821	1.189
High Growth Scenario	With Rehabilitation	1,359,126	35,581	63.5
	Without Rehabilitation		43,835	53.0
	Ratio of With to Without	-	0.812	1.198

Note: Veh-km are for the Project road only and Veh-hr are for the Project area.

The conclusions that can be drawn from the above are as follows:

- With Project road rehabilitation, travel speed increases in the Project area from about 59 km/h to 71 km/h (or approx. 19%) in 2010. In 2025, travel speeds without rehabilitation range from a low of 53 km/h to a high of about 56 km/h, while with rehabilitation speeds would be in the range of 64 km/h to 68 km/h, indicating that improvement of the Project road would have a significant impact on vehicle operation speeds in the Project area.
- As a result of the preceding, there would be a significant decline in daily travel time

(Veh-hr), ranging from about 15% in 2010 to 17%-19% in 2025 depending on the growth scenario. Note that with increases in traffic over time, the impact of Project road rehabilitation on travel time saving becomes larger.

- Travel distance (Veh-km) for with and without rehabilitation is the essentially the same for the Project road, since there is no other viable alternative. Savings regarding the distance traveled on the road therefore comes from a decrease in vehicle operating cost, as a result of a reduction in the IRI of the Project road due to its rehabilitation. Note that the Veh-km for the Project road increases over the time period of 2010 to 2025 from a low of about 1.92 times to a high of 2.47 times.

Below, in Figure 11.5.1 and 11.5.2, the vpd and pcu for links of the Project road are given for the medium traffic growth scenario or base case. The Kalmunai area (Karativu Jct.) has the largest predicted traffic volumes, with 11,200 vpd in 2010 and 29,200 vpd in 2025 north of the junction. Immediately south of the junction predicted traffic volumes vary from 8100 in 2010 to 20,200 in 2025, and have the second largest traffic flows on the Project road. Excluding the tail end of the Project road above Eravur (i.e., north of Jct. AA005), traffic volumes north of the Kalmunai area range from 5,500 to 6,000 vpd in 2010 to 14,000 to 15,500 in 2025. After Eravur, traffic flows decrease and range approximately from 3,600 to 4,400 vpd in 2010 to 8,500 to 10,600 in 2025.

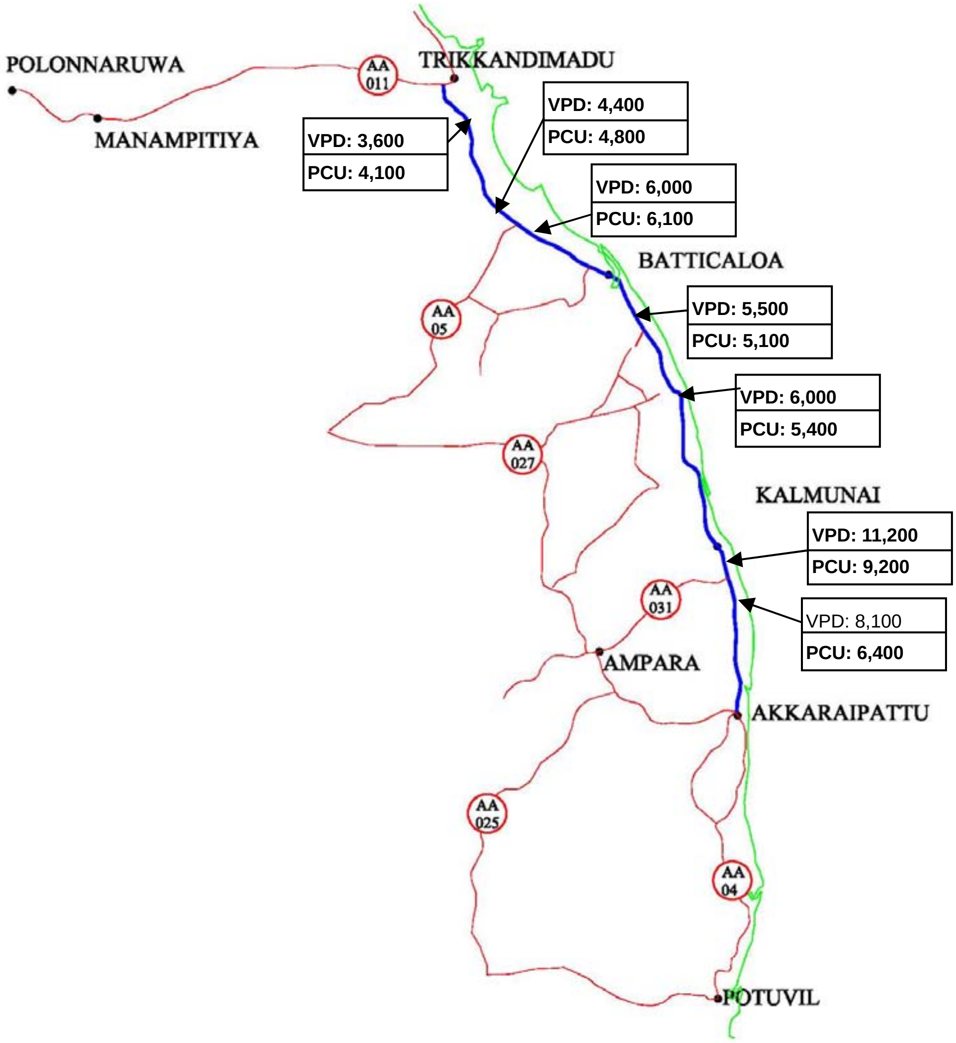


Figure 11.5.1. Traffic Volume for Project Road Links for 2010 (With Rehabilitation)

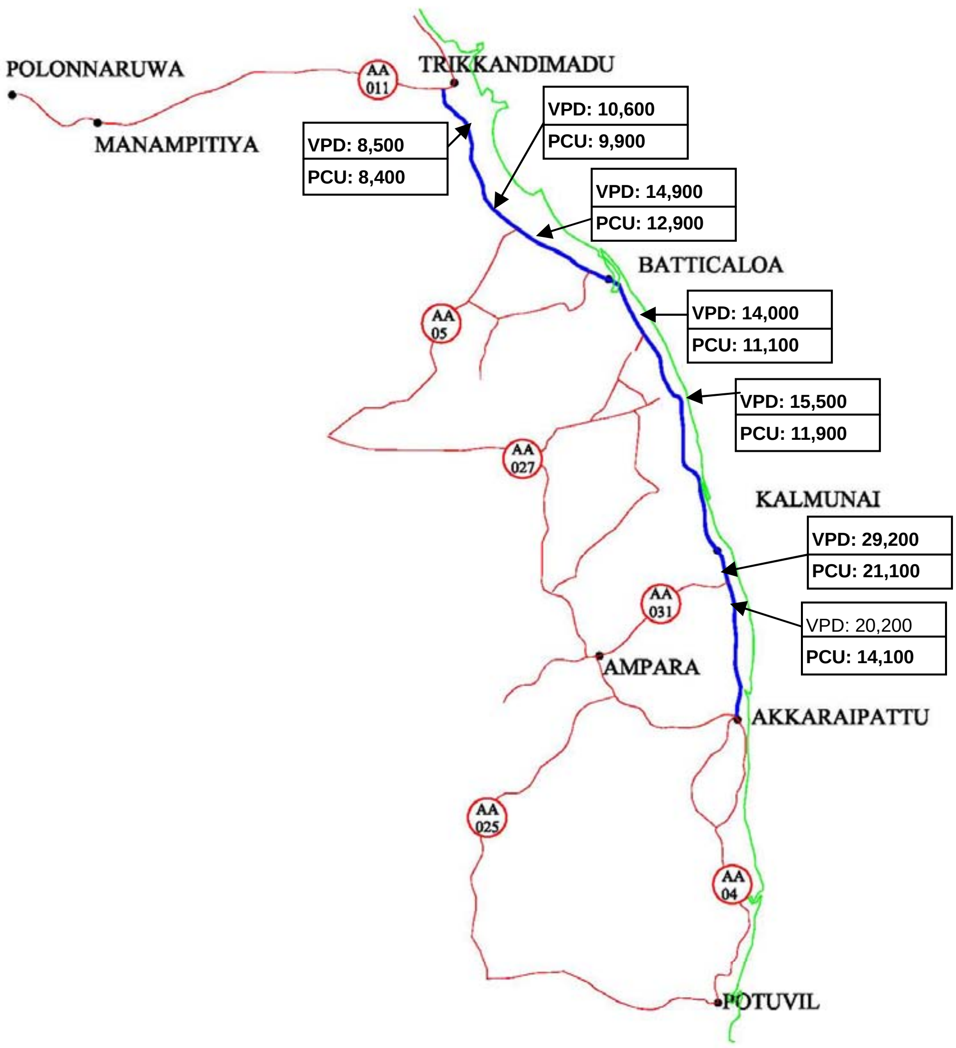


Figure 11.5.2. Traffic Volume for Project Road Links for 2025 (With Rehabilitation)