CHAPTER 1 INTRODUCTION

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1-1 Study Background

The Burmese economy is administrated through the Four Year Plan, based on the Twenty Year Plan established in 1974.

The objectives of the Twenty Year Plan are as follows:

- To double the standard of living of all nationalities of the Union and to fulfil, to the maximum extent, food, clothing, shelter and social needs of all the people.
- To transform smoothly and by planning the Burmese economic structure from an agricultural country to an agriculture-based industrial country.

Up to the end of the Third Four Year Plan, the economic growth rate has been high enough compared with the guideline of the Twenty Year Plan. In the Fourth Four Year Plan period, the growth rate fell down due to the repercussion of the recession of world economy. According to the Fifth Four Year Plan, this severe tendency will continue for at least several more years.

Period of Four Year Plan	Second '74/75 - '77/78	Third '78/79 - '81/82	Fourth '82/83 - '85/86	Fifth '86/87 - '89/90	Sixth '90/91 - '93/94
Growth Rate Target of Twenty Year Plan	4.0	5.0	6.0	7.0	7.6
Actual	4.7	6.5	5.4	(4.5) 1/	

Note: 1/ Target of Fifth Four Year Plan

In order to realize the expected economic growth under such conditions, it is necessary to carry out many measures such as diversification of export goods and improvement of quality of goods. And also, it is very important to improve transportation conditions. The present transport capacity of the public sector is relatively small in meeting the increasing traffic demand, and this causes production inefficiency and high production cost due to the usage of private means of transportation.

The Burma Railways Corporation (hereinafter referred to as BRC) has some plans to introduce more diesel locomotives, wagons, and carriages in order to increase its transport capacity.

However, if the investment is made only for rolling stock, and ground facilities are left in a deteriorated condition as they are, smooth, safe, and efficient train operation cannot be achieved. Consequently, much cannot be expected from the effect of such investment only.

Accordingly, it is necessary to improve track, telecommunication and signalling facilities in order to restore the inherent functions of the railways.

The feasibility study to improve track, telecommunication and signalling on the Mandalay line has been conducted as a step of a short-term improvement project based on the long-term modernization programme.

1-2 Objective of the Study

The feasibility study is carried out to establish a short-term improvement project for track, telecommunication and signalling on the Mandalay line whose selection is based on the first priority given in the long-term modernization programme.

This report covers traffic demand forecast, transport and rolling stock plan, facility improvement plan, maintenance management and training plan, estimated project cost, economic and financial analysis, and overall evaluation and execution plan.

Aims of the facility improvement and the main subject of technology transfer are as follows:

(1) Aims of the Facility Improvement

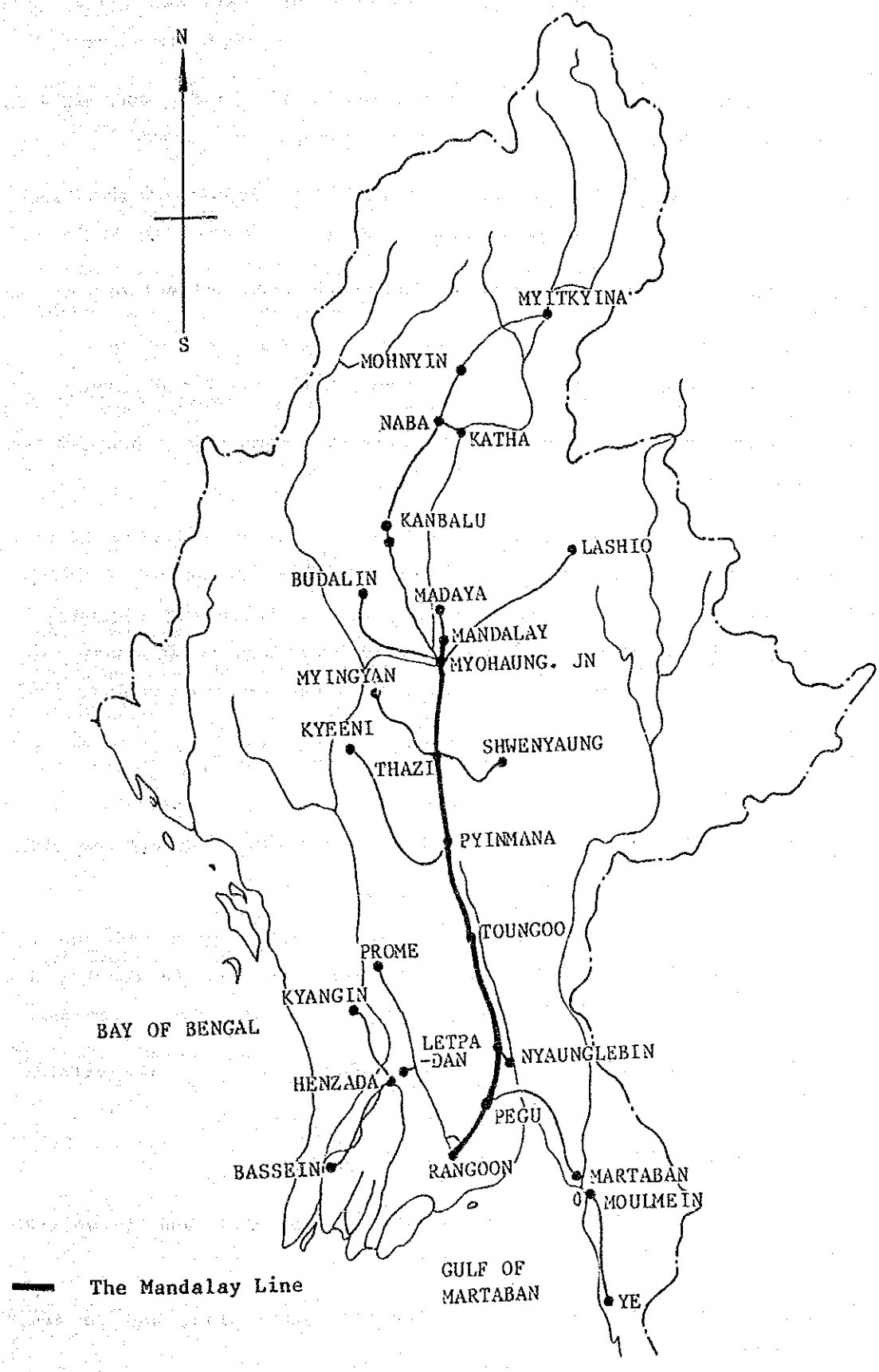
1) To increase train speed
2) To enhance safety
3) To improve punctuality
4) To increase track capacity

(2) Technology Transfer

1) Prestressed concrete sleeper (hereinafter referred to as PC sleeper) production

2) Rail welding

Key Map of Burma Railways



1-3 Study Schedule

The Study was carried out through the following phases.

(1) Phase I Field work

The field work was conducted for a month and a half, from July 23 to September 5, 1986 mainly through the following phases:

1) Presentation, and explanation of the Draft Report of the long-term modernization programme and discussion on it

2) Discussion with authorities concerned and collection of their opinions

3) Collection of related data and information, and field survey

4) Discussion on premises of the short-term improvement project and on the facility standards

(2) Phase II Work in Japan

The work in Japan was carried out from the beginning of September, 1986 to the beginning of February 1987 in the following sequence. The Interim Report and Draft Final Report were presented in November 1986 and January 1987, respectively. The report was completed in February 1987.

1) To forecast the transport demand up to the year 2015/16 on the Mandalay line.

2) To sum up and grasp the transport, the facility and maintenance problem.

3) To establish the transport and rolling stock plan and the ground facility improvement plans on the Mandalay line, and to roughly design the related facility standards.

4) To prepare maintenance management and training plans suitable for the improved ground facilities.

5) To conduct an economic and financial analyses.

6) To make an overall evaluation of the project and establish its implementation schedule up to 1995/96.

7) To duly consider the coordination with each plan, and to complete the Report.

1-4 Outline of the Short-term Improvement Project

The short-term improvement project has been established on the basis of the following concepts.

(1) On the basis of the social and economic structure in Burma as well as the transport demand, the social role of the Mandalay line is defined.

(2) The ground facility improvement plan along with the transport and rolling stock plan is drawn up to improve transport on the Mandalay line by restoring the inherent function of railway transport such as higher train speed, greater punctuality, higher degree of safety, and capability for mass transport, based on the traffic demand forecast of the line.

(3) Technology transfer plan is drawn up on the following items required for the facility improvement.

1) PC sleeper production

Pretension and post-tension methods of PC sleeper production are studied and a proposal made.

2) Rail welding

Rail welding method and training of workers are studied and a proposal made.

(4) Regarding maintenance and training of workers, the optimum maintenance method and staff training plan required for the improved facilities are studied and a proposal made.

1-5 Study Organization

1-5-1 Members of Advisory Committee

Mr. Masatoshi MATSUNAMI - Leader
Director, Engineering and Planning Division
Land Transport Engineering Dept.
Regional Transport Bureau, Ministry of Transport

Mr. Masao WADA - Demand Forecast
Senior Officer for International Cooperation
International Cooperation Division
International Transport and Tourism Bureau
Ministry of Transport

Mr. Toshiro KOTAKE	- Demand Forecast Senior Officer for International Cooperation International Cooperation Division International Transport and Tourism Bureau Ministry of Transport
Mr. Yoshifumi SUZUKI	- Track Chief, Railway Facilities Division Land Transport Engineering Dept. Regional Transport Bureau, Ministry of Transport
Mr. Hiroshi KATO	- Telecommunication and Signalling Director, Technology Division Railways Dept. Kinki District Transport Bureau Ministry of Transport

1-5-2 Study Team Member

Tatsuya ISHIHARA	Team Leader
Nobuhisa OSADA	Co-leader Facility Management and Execution Plan
Takeshi HASHINO	Co-leader Facility Management and Execution Plan
Masahide SHINMYO	Related Development Plan
Osamu OHTSU	Traffic Demand Forecast
Shiro KONDO	Transport and Rolling Stock Plan
Haruki OKUNO	Train Operation Control Plan
Keiji ITOH	Track Plan
Kiyoshi HOSOBUCHI	Telecommunication and Signalling Plan
Tomio WATANABE	Track Design
Sadajiro SANO	Telecommunication and Signalling Design
Hiroyuki ENDO	Cost Estimation and Construction Plan
Yasuo HARA	Economic and Financial Analysis

1-5-3 Counterparts in BRC

Mechanical and Electrical Department

U Maung Maung Aye	- Deputy Chief Electrical Engineer
U Kyaw Myint	- Deputy Chief Electrical Engineer
U Win Aung	- Deputy Chief Mechanical Engineer (Operating)
U Tin Hlaing	- Divisional Electrical Engineer
Daw Win Kyi	- Assistant Foreman
U Tin Han	- Locomotive Running Superintendent

Civil Engineering Department

U Htun Thein	- Chief Engineer
U Kyi Nyunt	- Deputy Chief Engineer (Signal and Telecommunication)
U Thin Tu	- Deputy Chief Engineer (Planning and Administration)
U Than Myint	- Staff Engineer
U Soe Lwin	- Divisional Engineer (Signal and Telegraph Workshop)
U George Bu Mu	- Divisional Engineer (Signal and Telegraph)
Daw Myint Myint San	- Deputy Staff Engineer

Traffic Department

U Kenneth Shein	- Chief Traffic Manager
U Tin Shwe	- Deputy Chief Traffic Manager (Operating)
U Chan Htun Aung	- Deputy Chief Traffic Manager (Passenger)
U Joe Ba Maung	- Deputy Chief Traffic Manager (Goods)
U Tin Yee	- Divisional Traffic Manager

Accounts Department

U Kan Tun	- Controller of Railway Accounts
U Maung Maung	- Deputy Controller of Railway Accounts
U Nyan Win	- Senior Accounts Officer
U Maung Maung Lwin	- Accounts Officer

1-5-4 Related Organizations

Timber Corporation (T.C.), Ministry of Agriculture and Forest

U Ohn	- Project Director (Forest Project II)
U Maung Maung Lay	- Deputy Manager (East Pegu Yoma Forestry Project)
U Thet Tin	- Deputy Manager (Marketing and Milling)

Mining Corporation-1, Ministry of Mines

U Khin Maung Win	- Chief Procurement Officer

Mining Corporation-2, Ministry of Mines

U Than Htoon	- Mining Engineer

Mining Corporation-3, Ministry of Mines

U Htun Aung	- General Manager (Iron and Steel Plant-1)
U Lu Pe Myint	- Mining Engineer

Foodstuff Industry Corporation, Ministry of Industry-1

U Ne Win Myint	- Deputy Assistant Director

Textile Industry Corporation, Ministry of Industry-1

Daw Khin Than Nwe	- Assistant Director

Petroleum Products Supply Corporation, Ministry of Energy

U Tin Mya	- Director (Planning)
U Thein Tun	- Director (Finance)
U Mya Thin	- Deputy Director (Sales)
U Myint Tun	- Manager (Installation)

Department of Co-operative, Ministry of Co-operative

U Ko Ko Aung	- Deputy Director
U Kyaw Hlaing	- Deputy Director

Pegu Township Transport Committee (P.T.T.C.)

U Saw Myint	- Member of P.T.T.C.

Toungoo Township Transport Committee (T.T.T.C.)

U Yan Aung	- Secretary of T.T.T.C.

Pyinmana Township Transport Committee (P.T.T.C.)

U Khin Maung Htay	- Secretary of P.T.T.C.
U Tin Maung	- Member of P.T.T.C.

CHAPTER 2. SOCIO-ECONOMIC SITUATION AND PRESENT TRANSPORT CONDITIONS OF THE AREA SERVED BY THE MANDALAY LINE

CHAPTER 2 SOCIO-ECONOMIC SITUATION AND PRESENT TRANSPORT CONDITIONS OF THE AREA SERVED BY THE MANDALAY LINE

2-1 Socio-economic Situation

2-1-1 Scope of Affected Area

The affected area is classified into two, namely, the directly affected area and the indirectly affected area. The former consists of those areas being directly served by the Mandalay Line, while the latter includes those which are indirectly served by means of other railway branch lines connected with the Mandalay Line.

The classification of the affected area is shown in Table 2.1.1.

This paper deals mainly with the present socio-economic situation of the directly affected area, inasmuch as a comprehensive study on the BRC-served area is already prepared in the Report on the Long-term Modernization Programme (hereinafter referred to as LTMP).

Table 2.1.1 Classification of the Area Served by the Mandalay Line

	Name of Region	Administrative Scope of Region
Directly Affected Area	Rangoon	Rangoon Division
	Pegu (East)	14 townships of Pegu Division located in the east side of the Pegu Mountains
	Mandalay (Main)	Mandalay Division except 4 townships of Kyaukpadaung, Taungtha, Nyaung-U and Myingyan
Indirectly Affected Area	West Region	8 townships of Magwe Division located in the east side of the Irrawaddy River and 4 townships of Mandalay Division of Kyaukpadaung, Taungtha, Nyaung-U and Myingyan
	North Region	Sagaing Division and Kachin State
	East Region	Shan State
	South-east Region	Karen State and Mon State

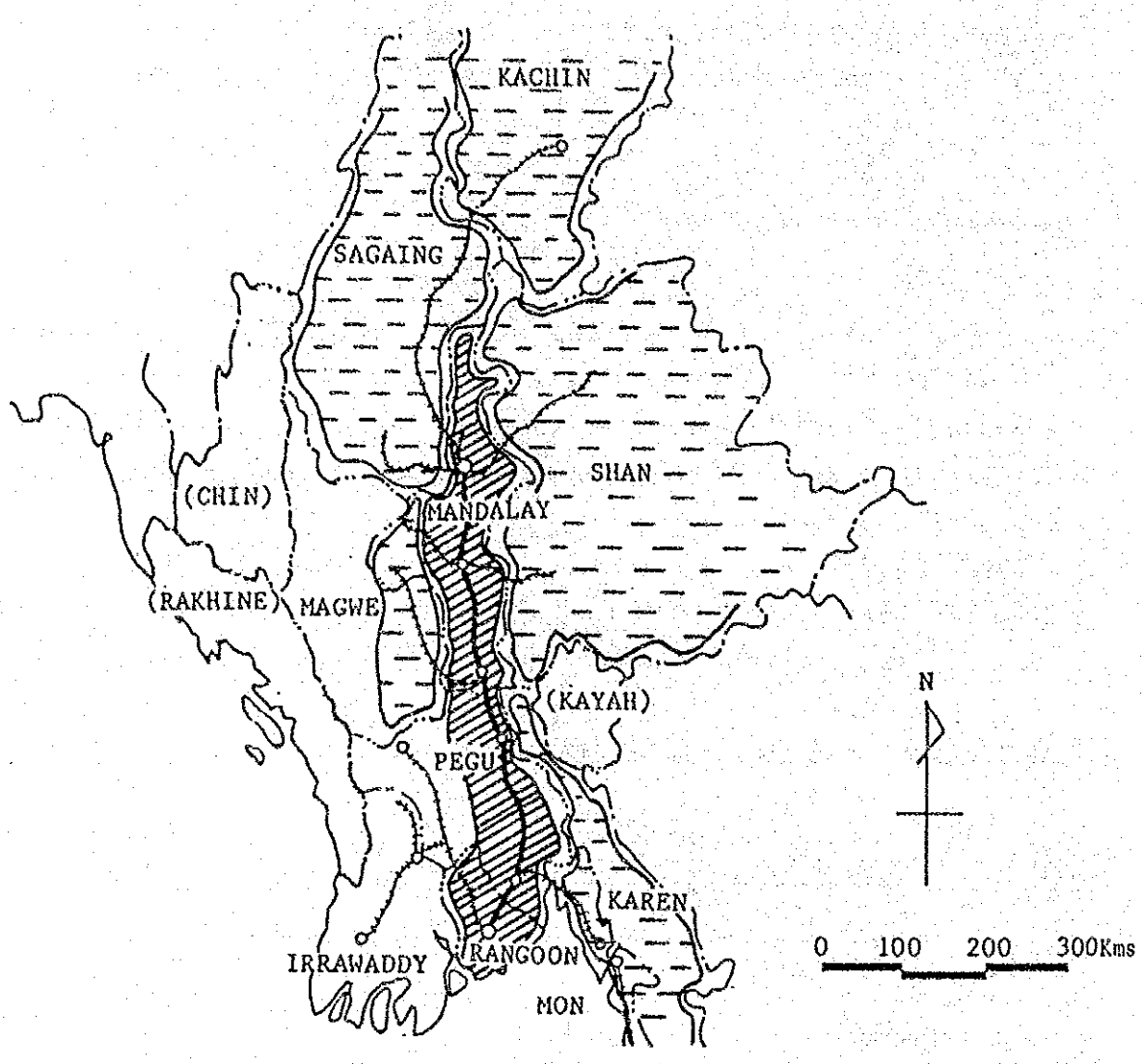


Fig. 2.1.1 The Area Served by the Mandalay Line

2-1-2 Population and Land Use

The present population in each region together with their forecasting is shown in Table 2.1.2.

The directly affected area has a population of 10,278 thousand in 1985/1986, of which Rangoon has 4,197 thousand, Pegu (East) 2,209 thousand, and Mandalay (Main) 3,872 thousand, according to an estimate based on two recent censuses. The present annual increase rate is estimated at 2.14 percent, of which Rangoon is 2.16 percent, Pegu (East) 1.94 percent, and Mandalay (Main) 2.22 percent.

Table 2.1.2 Population Forecasting

(Population Forecasted: in thousand)

Year	Directly Affected Area			Indirectly Affected Area			
	Rangoon	Pegu (East)	Mandalay (Main)	Western Region	Northern Region	Eastern Region	South-eastern Region
1985/86	4,197	2,209	3,872	2,349	5,010	3,873	2,903
1993/94	4,980	2,576	4,615	2,767	5,873	4,470	3,390
1997/98	5,422	2,780	5,031	3,002	6,351	4,798	3,659
2005/06	6,414	3,235	5,957	3,526	7,396	5,509	4,239

(Annual Increasing Rates: percent)

Year	Rangoon	Pegu (East)	Mandalay (Main)	Western Region	Northern Region	Eastern Region	South-eastern Region
1986/87 - 1993/94	2.16	1.94	2.22	2.07	2.01	1.81	1.96
1994/95 - 1997/98	2.15	1.92	2.18	2.06	1.98	1.78	1.93
1998/99 - 2005/06	2.12	1.91	2.13	2.03	1.92	1.74	1.86
(Ref. 1974 - 83)	2.22	1.99	2.31	2.13	2.13	1.58	2.35

Source: Study Team

Relative estimates on Pegu (East) and Mandalay (Main) are likewise presented in Table 2.1.3. A noticeable characteristic is that Thazi zone in Mandalay (Main) and Nyaunglebin zone in Pegu (East) have relatively moderate increase rates.

Table 2.1.3 Estimation of Population in 1985/86 and Present Annual Increasing Rates by Traffic Zone in Pegu (East) and Mandalay (Main)

	Population in 1985/86	Present annual increasing rate
Pegu zone	805 (thousand)	2.0 (%)
Nyaunglebin zone	575	1.7
Toungoo zone	829	2.0 - 2.1
Pegu (East)	2,209	1.94
Pyinmana zone	800	2.2 - 2.3
Thazi zone	1,012	1.9
Mandalay zone	2,060	2.3 - 2.4
Mandalay (main)	3,872	2.22

Note: 1. Pegu zone: 4 townships around Pegu township
Nyaunglebin zone: 4 townships around Nyaunglebin township
Toungoo zone: 6 townships around Toungoo township
Pyinmana zone: 4 townships around Pyinmana township
Thazi zone: 5 townships around Meiktila township
Mandalay zone: 16 townships except Mandalay (West), Pyinmana zone and Thazi zone

2. Those figures are based on a rough estimation, so figures have to be understood with some ranges.

Population density of Mandalay (Main), comprising 25 townships, is 117 persons per square kilometre, of which 21 townships have densities of approximately 105. Pegu (East) has 86, which is lower than that of Pegu (West), the area served by the Prome Line. These figures are in conformity with the land use pattern in each region.

Table 2.1.4 shows land use pattern and population density by region.

Table 2.1.4 Population Density and Land Use by Region

	Population Density (Persons per Km^2)	Percentage Distribution of Land Utilization (%)					Net Area sown per 1,000 Polulation (Km^2)
		Net Area Sown	Other Cultivable Land	Reserved Forest	Other Lands	Total	
Rangoon	391	53.8	12.7	11.9	21.5	100.0	1.3
Pegu (East)	86	22.9	8.5	32.4	36.2	100.0	2.5
Mandalay (Main)	117	25.3	11.7	30.8	32.1	100.0	2.0
West Region	130	32.3	15.7	10.4	41.6	100.0	2.8
North Region	26	7.6	15.3	15.6	61.5	100.0	2.8*
East Region	24	3.7	18.8	5.6	71.8	100.0	1.5
South-east Region	64	13.2	8.4	14.4	64.0	100.0	1.9
(Ref. Pegu (West))	(119)	(30.2)	(12.5)	(36.8)	(20.5)	(100.0)	(2.5)

Note: Population density for 1983
Land use for 1984/85
* 3.0 for Sagaing Division and 1.7 for Kachin State

Source: Documents provided by the Planning Department

Rangoon has a high net area sown ratio, while the reserved forest ratio is relatively low. Conversely, the net area sown ratios of Pegu (East) and Mandalay (Main) are less than half that of Rangoon, and their reserved forest ratios are 2.6 - 2.7 times as high. The ratios of Pegu (East) and Mandalay (Main) are less than those of Pegu (West) in both net area sown and reserved forest, and ratios of other lands, that is, economically under-used areas except those of the urban area, are more than those of Pegu (West).

Considering population, population density, and net area sown per population, the directly affected area may be aptly described as follows: It has two urban area (Rangoon and Mandalay), and all the remaining ones are predominantly agricultural areas.

2-1-3 Present Economic Conditions

The overall economic situation of BRC-served area has been taken up in Section 3, Chapter 2 of the LTMP, so only the present characteristics of the directly affected area will be discussed here.

Gross regional product (GRP)* of the directly affected area accounts for 34.8 percent of the GDP in 1985/86. Table 2.1.5 shows a detailed percentage distribution of the GRP of the area by region and by sector.

Per capita GRP of the area is higher than the average of the whole country. This phenomenon is attributed to active service and trade activities in the area in which Rangoon plays a major role. Similarly, Pegu (East) and Mandalay (Main) also have higher per capita GRP than the national average.

Present economic situation by region is as follows:

(1) Rangoon

Per capita GRP is estimated at 156 in 1985/86 (national average = 100). The region specializes in service and trade activities accounting for shares of 27.9 percent and 33.0 percent, respectively, in the whole country.

Rangoon is the capital of the Union of Burma and is the national business center. For this reason, the national administrative functions, as well as the national distribution functions, concentrate in the region. Moreover, high population density and per capita GRP encourage service and trade activities. To meet consumption demands, processing and manufacturing establishments have developed, centring on consumer goods production.

(2) Pegu (East)

Per capita GRP is estimated at 107 as against 116 in Pegu (West).

Pegu (East) specializes in goods production, specially agriculture, livestock, and forestry. The share of agriculture in the whole country is 8.4 percent in 1985/86, as against the 6.4 percent share of the GRP. The main crop is paddy and vegetable oil seeds, such as groundnut, sesame, and sunflower, rank next. Sugar cane is also mentioned. Livestock and forestry are other spheres of active economic activities.

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* Gross regional product is defined as the gross value added originating from the territorial sphere of the region defined.

Table 2.1.5 Gross Regional Product in 1985/86 (at 1985/86 prices)

(1) Percentage Distribution by Region (percent)

	Directly Affected Area				Indirectly Affected Area				
	Rangoon	Pegu (East)	Mandalay (Main)	Sub-total	West Region	North Region	East Region	South-east Region	Sub-total
Agriculture	5.5	8.4	11.8	25.7	8.8	16.5	7.3	5.3	37.9
Livestock, Fishery and Forestry	12.9	7.3	9.2	29.4	7.1	12.5	5.1	4.7	29.5
Mining, Processing and Manufacturing	18.2	6.7	9.8	34.7	7.2	11.3	8.0	5.1	31.6
Other Goods	18.8	5.9	11.0	35.8	6.5	12.5	7.9	6.1	33.0
Transportation	22.9	6.0	9.8	38.7	6.2	11.8	7.0	5.3	30.4
Other Services	27.9	3.9	9.5	41.3	4.6	10.9	8.4	6.3	30.3
Trade	33.0	3.9	10.8	47.7	3.7	9.5	7.5	6.2	27.0
Gross Divisional Product	17.7	6.4	10.8	34.8	6.6	13.0	7.4	5.6	32.6

(2) Percentage Distribution by Sector (percent)

Agriculture	12.2	50.9	42.6	28.7	51.6	49.4	38.5	36.7	45.2
Livestock, Fishery and Forestry	6.6	10.2	7.6	7.6	9.6	8.6	6.2	7.6	8.1
Mining, Processing and Manufacturing	11.4	11.7	10.1	11.0	12.0	9.6	12.0	10.2	10.7
Other Goods	2.4	2.1	2.3	2.3	2.2	2.1	2.4	2.4	2.3
Transportation	4.5	3.3	3.1	3.8	3.2	3.1	3.3	3.3	3.2
Other Services	17.7	6.8	9.9	13.3	7.8	9.4	12.8	12.7	10.4
Trade	45.3	14.9	24.4	33.3	13.5	17.8	24.8	27.1	20.1
Gross Divisional Product	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

(3) Differential by Region (Average of the whole country = 100)

Per Capita GRP	156	107	103	126	105	96	71	71	86

Note: 1. Refer to Table 2.1.1 on the definition of the regions.
2. Gross regional product means the gross value added originated from the territorial sphere of region defined.
3. Totals may not be consistent as the amounts of each component are rounded off.

In processing and manufacturing, agriculture-based industrial establishments, such as rice mills, sugar mills, canning and alcohol factories are operating. On the other hand, service and trade activities are relatively under-developed.

Reflecting the economic situation, 50.9 percent of GRP comes from agriculture, and another 10.2 percent from livestock, fishery, and forestry. These figures are confirmed to be in accordance with a low ratio of labour forces engaging in non-primary industries.

(3) Mandalay (Main)

Per capita GRP is estimated to be 103 compared with the national average of 100 in 1985/86.

The region has a relatively large share in agriculture due to the predominantly agricultural zones of Thazi and Pyinmana. Main crops are vegetable oil seeds such as sesame and groundnut; commercial crops such as sugar cane, tobacco, and cotton; and pulses.

In processing and manufacturing, the region has several foods processing factories, as well as beverage, textile, marble, brick and steel billet producing factories and establishments. Various non-metallic minerals and gem stones are also produced in the region.

The trade share in the whole country concurs with the GRP share. This is so because a high level of activity in Mandalay zone on the one hand, and underdevelopment in Thazi and Pyinmana zones on the other, cancel out.

(4) Conclusion

Present economic situation is better in the area directly affected by the Mandalay Line according to the population and land use pattern.

2-1-4 Forecasting Regional Economy

(1) Forecast method

Gross regional product by region is forecasted to divide the GRP (each division) by sector using indicators estimated by several statistical data. Those data is as follows: ① population and its increasing rate by township in 1983 census, ② land utilization pattern by township group for 1984/85, ③ classified labour force excluding agriculture, forestry and fishery by township group in 1984, and ④ existing regional development projects by location.

Data ① and ② above mentioned are mainly utilized for the primary industries, while data ①, ③ and ④ for the secondary industries and data ① and ③ for services except transportation. Trade is forecasted as a function of the primary and secondary industries by region. Transportation is forecasted as functions, which are adjusted with co-efficients by economic sector, of all other economic activities.

(2) Forecast results

Table 2.1.6 and 2.1.7 show the summarised results.

1) Growth rates

The growth rates of the directly affected area are higher for Mandalay (Main) and lower for Pegu (East) through all forecast periods. But their differentials have reductive trends in course of the forecast period. The differential between Mandalay (Main) and Pegu (East) is, for example, forecasted by 0.8 percentage points for 1986/87 - 1993/94 period, while it will reduce by 0.5 percentage points for 1998/99 - 2005/06 period.

In the indirectly affected area, the growth rates are higher in West Region and North Region.

2) Economic structure

In almost all regions, the shares of agriculture will decline and ones of the other sectors will increase.

Relatively important changes will be found in mining, processing and manufacturing in Mandalay (Main) and West Region.

The shares of the primary industries in 2005/06 will be at around 58 percent for Pegu (East), 48 percent for Mandalay (Main) and 17 percent for Rangoon, as against 61 percent, 50 percent and 19 percent in 1985/86, respectively.

3) Per Capita Gross Regional Product

Per capita gross regional product in 2005/06 will account at Kyat 3,906 for Rangoon, Kyat 2,706 for Mandalay (Main) and Kyat 2,600 for Pegu (East) as against Kyat 2,592 for the whole country.

Their relative level (national average = 100) will decline by 5 points for Rangoon and by 7 points for Pegu (East) and will increase by 1 point for Mandalay (Main) in 2005/06, compared with ones in 1985/86. In the indirectly affected area, the relative level will increase in the West Region and North Region and will decline in East Region and South-East Region in 2005/06 compared with 1985/86.

Table 2.1.6 Gross Regional Product at 1985/86 Prices (1)

(Kyat in Million)

(1) 1985/86

	Directly Affected Area			Indirectly Affected Area			
	Rangoon	Pegu (East)	Mandalay (Main)	West Region	North Region	East Region	South-east Region
Agriculture	1,244.6	1,869.0	2,650.0	1,976.6	3,711.4	1,637.5	1,181.8
Livestock, Fishery and Forestry	667.9	374.1	475.1	368.2	643.7	263.9	245.0
Mining, Processing and Manufacturing	1,161.4	430.9	624.6	459.6	724.3	509.5	329.0
Other Goods	242.0	76.1	141.7	83.5	160.7	101.1	78.2
Transportation	454.7	119.8	194.5	123.0	235.4	139.3	105.4
Other Services	1,803.5	251.1	613.8	299.9	704.4	544.6	408.1
Trade	4,615.8	548.4	1,514.7	516.9	1,334.0	1,055.3	873.3
Gross Regional Product	10,189.9	3,669.4	6,214.4	3,827.7	7,513.9	4,251.2	3,220.8

(2) 1993/94

	Directly Affected Area			Indirectly Affected Area			
	Rangoon	Pegu (East)	Mandalay (Main)	West Region	North Region	East Region	South-east Region
Agriculture	1,491.2	2,447.4	3,775.4	2,786.6	5,368.0	2,168.7	1,468.3
Livestock, Fishery and Forestry	1,002.7	590.0	766.1	598.0	991.5	414.9	349.4
Mining, Processing and Manufacturing	1,635.9	639.3	1,039.7	730.6	1,148.5	828.7	502.4
Other Goods	367.5	106.8	203.3	119.4	227.2	144.6	109.0
Transportation	650.7	171.9	297.8	187.2	354.3	197.3	147.7
Other Services	2,561.6	350.1	876.6	422.9	985.7	749.0	567.8
Trade	6,729.4	788.5	2,211.7	749.4	1,927.3	1,500.8	1,255.4
Gross Regional Product	14,439.0	5,094.0	9,170.6	5,594.1	11,002.5	6,004.0	4,400.0

Table 2.1.6 Gross Regional Product at 1985/86 Prices (2)

(Kyat in Million)

(3) 1997/98

	Directly Affected Area			Indirectly Affected Area			
	Rangoon	Pegu (East)	Mandalay (Main)	West Region	North Region	East Region	South-east Region
Agriculture	1,630.9	2,799.7	4,458.0	3,275.8	6,411.1	2,490.1	1,573.2
Livestock, Fishery and Forestry	1,230.9	727.3	954.9	745.4	1,178.3	511.8	434.5
Mining, Processing and Manufacturing	1,949.2	763.6	1,311.0	899.6	1,430.4	1,031.4	621.5
Other Goods	467.2	131.1	253.4	148.2	281.6	179.2	134.6
Transportation	777.6	202.7	361.2	226.1	426.9	233.8	174.2
Other Services	3,036.9	410.4	1,040.6	499.0	1,158.8	872.0	664.5
Trade	8,080.7	931.6	2,632.9	890.1	2,281.3	1,761.5	1,480.9
Gross Regional Product	17,173.4	5,966.4	11,012.0	6,684.2	13,168.4	7,079.8	5,083.4

(4) 2005/06

	Directly Affected Area			Indirectly Affected Area			
	Rangoon	Pegu (East)	Mandalay (Main)	West Region	North Region	East Region	South-east Region
Agriculture	2,026.3	3,719.6	6,229.6	4,539.1	9,133.6	3,346.6	1,999.1
Livestock, Fishery and Forestry	1,896.7	1,144.8	1,488.6	1,184.0	1,821.0	784.2	675.5
Mining, Processing and Manufacturing	2,873.1	1,130.9	2,110.4	1,399.6	2,257.5	1,602.3	996.3
Other Goods	809.6	216.6	434.3	249.5	473.8	298.8	225.9
Transportation	1,137.1	289.5	534.8	331.6	624.0	332.0	250.9
Other Services	4,330.9	571.7	1,486.0	703.6	1,621.2	1,192.2	918.1
Trade	11,976.8	1,336.6	3,838.6	1,287.2	3,287.5	2,486.9	2,114.0
Gross Regional Product	25,050.5	8,409.7	16,122.3	9,694.6	19,218.6	10,043.0	7,179.8

Note: Refer to Table 2.1.1 on the definition of the Regions.
Gross Regional Product means the gross value added originated from the territorial sphere of region defined.
Totals may not be consistent as the amounts of each component are rounded off.

Table 2.1.7 Gross Regional Product at 1985/86 Prices (1)

Annual Growth Rates (percent)

(1) 1986/87 - 1993/94

	Directly Affected Area			Indirectly Affected Area			
	Rangoon	Pegu (East)	Mandalay (Main)	West Region	North Region	East Region	South-east Region
Agriculture	2.3	3.4	4.5	4.4	4.7	3.6	2.8
Livestock, Fishery and Forestry	5.2	5.9	6.2	6.2	5.6	5.8	4.5
Mining, Processing and Manufacturing	4.4	5.1	6.6	6.0	5.9	6.3	5.4
Other Goods	5.4	4.3	4.6	4.6	4.4	4.6	4.2
Transportation	4.6	4.6	5.5	5.4	5.2	4.4	4.3
Other Services	4.5	4.2	4.6	4.4	4.3	4.1	4.2
Trade	4.8	4.6	4.8	4.8	4.7	4.5	4.6
Gross Regional Product	4.5	4.2	5.0	4.9	4.9	4.4	4.0

(2) 1994/95 - 1997/98

	Directly Affected Area			Indirectly Affected Area			
	Rangoon	Pegu (East)	Mandalay (Main)	West Region	North Region	East Region	South-east Region
Agriculture	2.3	3.4	4.2	4.1	4.5	3.5	1.7
Livestock, Fishery and Forestry	5.3	5.4	5.7	5.7	4.4	5.4	5.6
Mining, Processing and Manufacturing	4.5	4.5	6.0	5.3	5.6	5.6	5.5
Other Goods	6.2	5.3	5.7	5.6	5.5	5.5	5.4
Transportation	4.6	4.2	4.9	4.8	4.8	4.3	4.2
Other Services	4.3	4.1	4.4	4.2	4.1	3.9	4.0
Trade	4.7	4.3	4.5	4.4	4.3	4.1	4.2
Gross Regional Product	4.4	4.0	4.7	4.6	4.6	4.2	3.7

Table 2.1.7 Gross Regional Product at 1985/86 Prices (2)

Annual Growth Rates (percent)

(3) 1998/99 - 2005/06

	Directly Affected Area			Indirectly Affected Area			
	Rangoon	Pegu (East)	Mandalay (Main)	West Region	North Region	East Region	South-east Region
Agriculture	2.8	3.6	4.3	4.2	4.5	3.8	3.0
Livestock, Fishery and Forestry	5.6	5.8	5.7	6.0	5.6	5.5	5.7
Mining, Processing and Manufacturing	5.0	5.0	6.1	5.7	5.9	5.7	6.1
Other Goods	7.1	6.5	7.0	6.7	6.7	6.6	6.7
Transportation	4.9	4.6	5.0	4.9	4.9	4.5	4.7
Other Services	4.5	4.2	4.6	4.4	4.3	4.0	4.1
Trade	5.0	4.6	4.8	4.7	4.7	4.4	4.5
Gross Regional Product	4.8	4.4	4.9	4.8	4.8	4.5	4.4

Table 2.1.8 Per Capita GRP at 1985/86 Prices

(Kyat)

	Directly Affected Area			Indirectly Affected Area			
Year	Rangoon	Pegu (East)	Mandalay (Main)	West Region	North Region	East Region	South-east Region
1985/86	2428	1661	1605	1630	1500	1098	1109
1993/94	2899	1977	1987	2022	1873	1343	1298
1997/98	3167	2146	2189	2227	2073	1476	1389
2005/06	3906	2600	2706	2749	2599	1823	1694

Note: Refer to Table 2.1.1 on the definition of the Regions.
Gross Regional Product means the gross value added originated from the territorial sphere of region defined.
Totals may not be consistent as the amounts of each component are rounded off.

2-2 Present Transportation Conditions

2-2-1 Railway Service

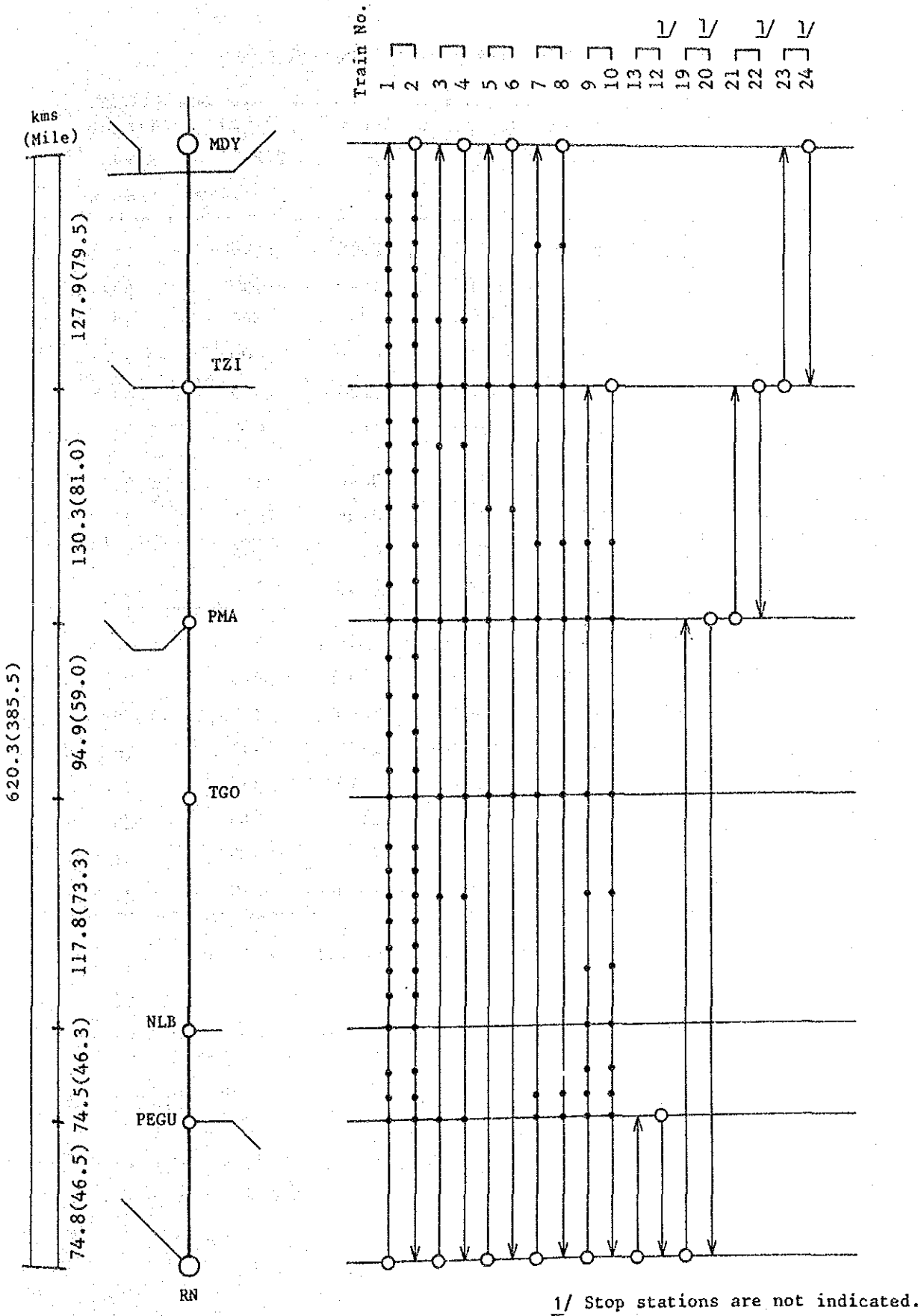
On the Mandalay line there were 18 passenger trains and 10 freight trains per day in 1984/85.

The 18 passenger trains consist of 6 express, 4 mail/ordinary and 8 mixed/local trains, and their characteristics are summarized as following:

Table 2.2.1 Train Formation and Capacity

Train No.	from/to	No. of coaches						Seating Capacity
		Upper	Ordn.	Mail	L/V	B/V	Total	
Express.								
. 3UP/4DN	RN - MDY	2	11	-	-	1	14	800
. 5UP/6DN	RN - MDY	3	12	-	-	1	16	880
. 7UP/8DN	RN - MDY	3	10	-	-	1	14	760
Mail/Ordinary								
. 1UP/2DN	RN - MDY	3	8	1	3	1	16	600
. 9UP/10DN	RN - TZI	3	9	-	3	1	16	660
Mixed/Local								
. 13UP/12DN	RN - PEGU	-	4	-	4	1	9	260
. 19UP/20DN	RN - PMA	-	4	1	2	1	8	260
. 21UP/22DN	PMA - TZI	-	4	1	2	1	8	260
. 23UP/24DN	TZI - MDY	-	4	-	1	1	6	260

Source: BRC



1/ Stop stations are not indicated.

Fig. 2.2.1 Present Train Service

Source: BRC

Table 2.2.2 Scheduled Travel Time and Speed

Train No.	from/to	Distance (kms)	Departure Time	Arrival Time	Travel Time (hrs/min)	Travel Speed (kms/hr)
3UP	RN - MDY	620	0600	2000	1400	44
4DN	MDY - RN	620	0600	1945	1345	45
5UP	RN - MDY	620	1815	0835	1420	43
6DN	MDY - RN	620	1815	0815	1400	44
7UP	RN - MDY	620	2100	1125	1425	43
8DN	MDY - RN	620	2100	1110	1410	44
1UP	RN - MDY	620	1145	0640	2855	21
2DN	MDY - RN	620	1110	0705	2955	21
9UP	RN - TZI	492	1535	0430	1255	38
10DN	TZI - RN	492	2140	1030	1250	38
13UP	RN - PEGU	75	1700	1930	230	30
12DN	PEGU - RN	75	0545	0855	310	23
19UP	RN - PMA	362	0620	2000	1340	26
20DN	PMA - RN	362	0430	1825	1355	26
21UP	PMA - TZI	130	1335	1710	335	37
22DN	TZI - PMA	130	0545	1100	515	25
23UP	TZI - MDY	128	0445	1040	555	21
24DN	MDY - TZI	128	1205	1755	550	21

Schedule of freight trains is summarized in the table below.

Source: BRC

Table 2.2.3 Freight Train Schedule

Train No.	from/to	Travel Time	Average loads (ton) 1/
901/902	MLG - TZI	23 hrs 40 min.	120
903/904	MLG - MOH	37 hrs 50 min.	580
905/906	TZI - MOH	6 hrs 00 min.	25
907/908	MLG - PEGU	2 hrs 30 min.	120
501/502	MLG - PMA	19 hrs 20 min.	280

1/ Including wagon's tare

Source: BRC

There are some special trains (unit trains) for carrying such as lime stone, ballast and sugar cane, in addition to the above scheduled services.

2-2-2 Passenger Transport by BRC

The Mandalay line, between Rangoon and Mandalay, transported 6,252 thousand passengers and 718 million passenger-kms in 1984/85. This means approximately 17,000 passengers per day and 22 percent of the total amount of the main lines (excluding the suburban line).

Table 2.2.4 No. of Passengers

(1000)

Year	Mandalay line	Main line total	Share
1982/83	6,239	30,323	21 percent
1983/84	6,676	29,563	23 percent
1984/85	6,252	28,800	22 percent

Source: BRC

There are about 90 stations between Rangoon and Mandalay, and the number of passengers boarding at major stations is summarized in the table below.

Table 2.2.5 No. of Passengers and Average Trip Length by Major Stations 1/, 1980/81

Station	No. of Passengers Boarding (per day)	Average Travel Length (kms.)
Mandalay 2/	4,180	370
Thazi 2/	1,190	171
Pyawbwe	320	139
Tatkon	310	79
Pyinmana 2/	1,700	130
Toungoo	580	210
Nyaunglebin 2/	430	72
Pegu 2/	1,810	157
Kyauktan	380	29
Rangoon 3/	15,790	169

1/ Above 300 passengers excluding suburban line
2/ Including branch line
3/ Including other main line and suburban line

Source: BRC

The monthly fluctuation of boarding passengers by major stations shows significant features. At Mandalay, for instance, the demand in August is nearly double of the average because of a big festival.

Table 2.2.6 Monthly Fluctuation of Boarding Passengers, 1980/81

St. / Month	MDY	TZI	PMA	TGO	NLB	PEGU	RN
April, 1980	108	106	100	127	111	121	111
May	113	119	100	118	123	108	88
June	89	99	88	105	128	104	97
July	88	108	97	100	101	109	103
August	175	104	93	102	116	77	107
September	61	93	91	97	100	89	96
October	88	106	109	109	127	96	103
November	94	99	101	89	93	108	81
December	91	93	97	92	84	98	104
January, 1981	91	84	90	86	66	92	105
February	85	85	93	70	70	87	94
March	117	104	138	105	79	112	111
Average per month	100 (110,520)	100 (35,445)	100 (38,154)	100 (17,229)	100 (16,685)	100 (50,078)	100 (441,344)

Note: Figures in table indicate the quantum indexes to the average, and figures in parentheses show the number of passenger per month.

Source: BRC

The present passenger flow along the Mandalay line is estimated by the data from BRC statistics and the interview survey carried out by study team in August, 1986. This is summarized in the form of Origin-Destination table with 7 zones.

Table 2.2.7 Present Passenger OD (1985/86)

(1,000 pass.)

O \ D	1 MDY	2 TZI	3 PMA	4 TGO	5 NLB	6 PEGU	7 RN	Total
1 MDY	244	122	110	48	18	53	530	1,126
2 TZI	141	340	134	39	14	44	247	959
3 PMA	87	86	585	72	17	30	137	1,014
4 TGO	40	36	80	77	37	34	106	410
5 NLB	18	24	33	55	160	56	82	428
6 PEGU	39	43	31	39	42	202	1,375	1,770
7 RN	579	265	178	110	79	1,315	258	2,785
Total	1,149	918	1,151	439	367	1,734	2,736	8,494

Note: 1. MDY : Mandalay to Myittha, and branch lines
2. TZI : Kume road to Nyaungyan, and branch lines
3. PMA : Shanywa to Myohla, and branch line
4. TGO : Thagaya to Pyu
5. NLB : Nyaungbintha to Kadok, and branch line
6. PEGU: Pyinbongyi to Kyauktan, and branch line
7. RN : Tongyi to Rangoon, and branch lines

Source: Study team

The passenger traffic volume by major sections is also derived based on the estimated O-D table.

Table 2.2.8 Passenger Traffic by Section, 1985/86

Section	Zone - Zone 1/ (Direction)	Dist. (kms)	Passenger (1,000 pass.)
1) MDY-TZI	1 - 2	128	882
	2 - 1	128	905
	Both	128	1,787
2) TZI-PMA	2 - 3	130	1,238
	3 - 2	130	1,219
	Both	130	2,457
3) PMA-TGO	3 - 4	95	1,250
	4 - 3	95	1,368
	Both	95	2,618
4) TGO-NLB	4 - 5	118	1,269
	5 - 4	118	1,416
	Both	118	2,685
5) NLB-PEGU	5 - 6	75	1,321
	6 - 5	75	1,407
	Both	75	2,728
6) PEGU-RN	6 - 7	75	2,478
	7 - 6	75	2,528
	Both	75	5,006

1/ Refer to Table 2.2.7 on the Zone No.

Source: Study Team

2-2-3 Freight Transport by BRC

Mandalay line had 926 thousand tons of freight transport in 1984/85 and the demand had decreased from 1,001 thousand in 1982/83.

Table 2.2.9 Tonnage of Freight

(1000 ton)

Year	Mandalay line	Main line total	Share
1982/83	1,001	2,257	44 percent
1983/84	980	2,208	44 percent
1984/85	926	2,087	44 percent

Source: BRC

The major commodities of goods traffic are shown in the following table. Rice and rice products account for a large share both in ton and ton-kms, while for sugar cane only the tonnage is large.

Table 2.2.10 Freight Transport by Commodities, 1984/85

Type of Commodities	Ton (1000)	Ton-kms (1000)	Average kms (Per ton)
1. Rice and rice products	225	85,076	378
2. Sugar cane	250	14,079	56
3. Forest products	120	46,339	386
4. Coke	12	10,561	880
5. Oil products	70	20,273	290
6. Lime stone	17	6,154	362
7. Lead-Zinc	19	16,722	880
8. Other metal and ore	10	5,632	563
9. Stone	6	2,317	386
10. Salt	15	8,447	563
11. Molasses	6	869	145
12. All other industrial	36	18,187	505
13. Military	20	9,654	483
14. BRC freight	120	15,446	129
Total	926	259,757	281

Source: BRC

The freight flow in the form of O-D table is estimated in the same manner as the passenger flow by tabulating the original data collected by BRC.

Table 2.2.11 Present Freight OD (1985/86)

(100 ton)

O \ D	1 MOH	2 TZI	3 PMA	4 TGO	5 NLB	6 PEGU	7 MLG	Total
1 MOH	28	63	16	14	67	46	864	1,097
2 TZI	35	42	-	-	33	83	503	697
3 PMA	160	14	1,252	500	7	136	1,307	3,375
4 TGO	299	108	97	810	12	64	189	1,580
5 NLB	236	260	73	76	-	187	700	1,532
6 PEGU	140	79	76	6	-	-	438	740
7 MLG	595	468	106	104	20	727	11	2,030
Total	1,495	1,033	1,620	1,510	140	1,243	4,012	11,053

Note: 1. MOH: Mandalay to Myittha, and branch lines
2. TZI: Kume road to Nyaungyan, and branch lines
3. PMA: Shanywa to Myohla, and branch line
4. TGO: Thagaya to Pyu
5. NLB: Nyaungbintha to Kadok, and branch line
6. PEGU: Pyinbongyi to Kyauktan, and branch line
7. MLG: Tongyi to Rangoon, and branch lines

Source: Study Team

Table 2.2.12 Freight Traffic by Section, 1985/86

Section	Zone - Zone 1/ (Direction)	Dist. (kms)	Freight (100 ton)
1) MOH-TZI	1 - 2	124	1,069
	2 - 1	124	1,466
	Both	124	2,535
2) TZI-PMA	2 - 3	130	1,626
	3 - 2	130	2,359
	Both	130	3,986
3) PMA-TGO	3 - 4	95	3,560
	4 - 3	95	2,538
	Both	95	6,098
4) TGO-NLB	4 - 5	118	3,312
	5 - 4	118	2,220
	Both	118	5,532
5) NLB-PEGU	5 - 6	75	4,079
	6 - 5	75	1,594
	Both	75	5,673
6) PEGU-MLG	6 - 7	71	4,001
	7 - 6	71	2,020
	Both	71	6,021

1/ Refer to Table 2.2.11 on the zone No.

Source: Study Team

CHAPTER 3 TRANSPORT DEMAND FORECAST

CHAPTER 3 TRANSPORT DEMAND FORECAST

3-1 Methodology

3-1-1 General

Traffic demands both in passenger and freight on the Mandalay line were forecasted based on the present OD tables analyzed in 2.2 of Chapter 2.

The general procedure of the forecasting are summarized in the following flow-chart.

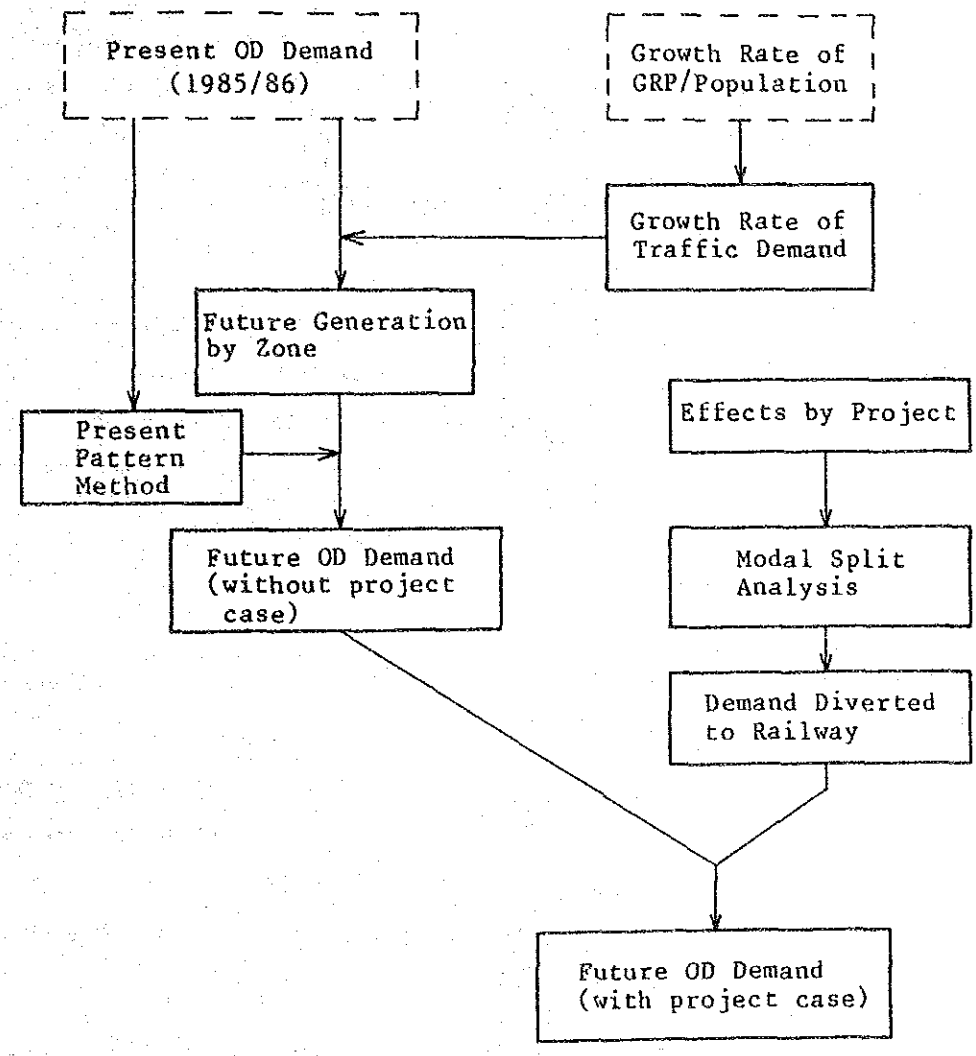


Fig. 3.1.1 Outline of Demand Forecast Procedure

3-1-2 Major Premises for the Forecasting

(1) Study area and zoning

Since the forecasting aimed at estimating the traffic demand along the Mandalay line by major sections, the line was divided into 6 sections (by 7 Origin-Destination Nodes) and the related branch lines were merged into the terminated zones as shown in Fig. 3.1.2.

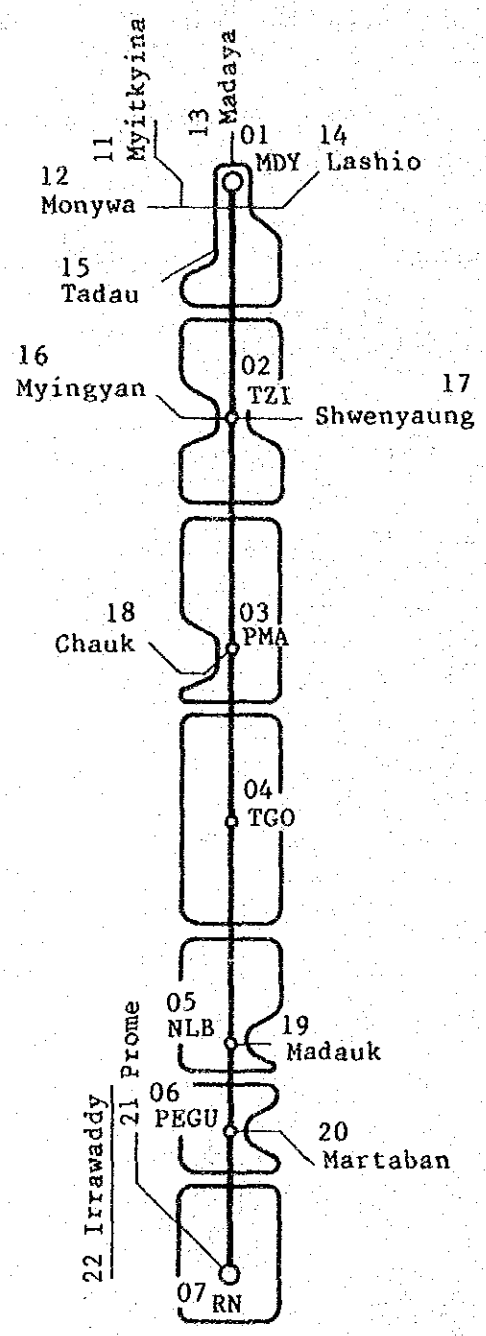


Fig. 3.1.2 Zoning Map

(2) Target years

Taking 1985/86 as the basis year, 1993/94, 1996/97 and 2005/06 are target years in accordance with the stage planning of the project and forecasting regional economy. Moreover, in order to provide the data for economic and financial evaluation, 2016/17 is the final target year, being the 30th year since the commencement of the project implementation.

(3) Transport conditions of other modes

Regarding the competitive transport modes such as road and water, future improvement/change in terms of travel time and fare is not considered except in the case of authorized programmes.

(4) Passengers by express or local trains

Travel time reduction by the project depends on the train service: express or local. The ratio of the two types are estimated by OD pair based on the actual survey results and this is assumed to be the same even in the future.

3-1-3 Growth Rate of Traffic Demand

The relationship between socio-economic indicators and transport demand was analyzed based on the statistical data from 1975/76 to 1985/86, and finally the followings were obtained.

Table 3.1.1 Results of Traffic Generation Analysis

Items	Factor	Correlation coefficient	Elasticity to the growth rate
Passengers 1/			
- Railway	GDP (Transport Service)	0.87	0.55
- Railway and road 2/	- do -	-	0.80
Freight			
- Railway	GDP (Total Net Output)	0.79	0.66
- Railway and road	GDP (Total Goods Products)	0.80	0.96

1/ Data from 1975/76 to 1982/83

2/ Based on the estimated passenger data by road

The results obtained above were applied for future generation forecast by zone in accordance with economic growth rate by region. Table 3.1.2 shows the results of without project case.

Table 3.1.2 Growth of Future Demand (without project case)

	Rangoon	Pegu (East)	Mandalay (Main)
Passenger			
1985/86	1.000	1.000	1.000
	(2.5)	(2.5)	(3.0)
1993/94	1.221	1.221	1.269
	(2.5)	(2.3)	(2.7)
1997/98	1.349	1.338	1.411
	(2.7)	(2.7)	(2.8)
2005/06	1.669	1.655	1.753
	(2.6)2/	(2.6)2/	(2.8)2/
Freight			
1985/86	1.000	1.000	1.000
	(3.0)	(2.8)	(3.3)
1993/94	1.266	1.246	1.299
	(2.9)	(2.7)	(3.1)
1997/98	1.421	1.384	1.469
	(3.2)	(2.9)	(3.3)
2005/06	1.826	1.743	1.898
	(3.1)2/	(2.8)2/	(3.3)2/

1/ Figures in parentheses indicate annual growth rate in percent.

2/ Assumed from the average 1985/86 to 2005/06

3-1-4 Origin-Destination Distribution Pattern

Since the growth of future demand by zone were balanced within some extent, the present pattern method was adopted in order to estimate O-D pattern in future.

3-1-5 Effects of the Project

The significant effects of railway improvement by the project are:

- increase in train speeds
- punctuality of train operation
- increase in frequency
- improvement in safety

and they bring about an adequate modal split condition between railway and road transport.

Therefore, the effects on the future demand by railway are considered from two aspects; the growth of demand and the diverted demand by reduction of travel time.

For the former the growth rate of Railway and Road estimated in Table 3.1.1 was applicable. The modal split model was analyzed for the latter. Modal split between railway and road transport was explained by the following formula:

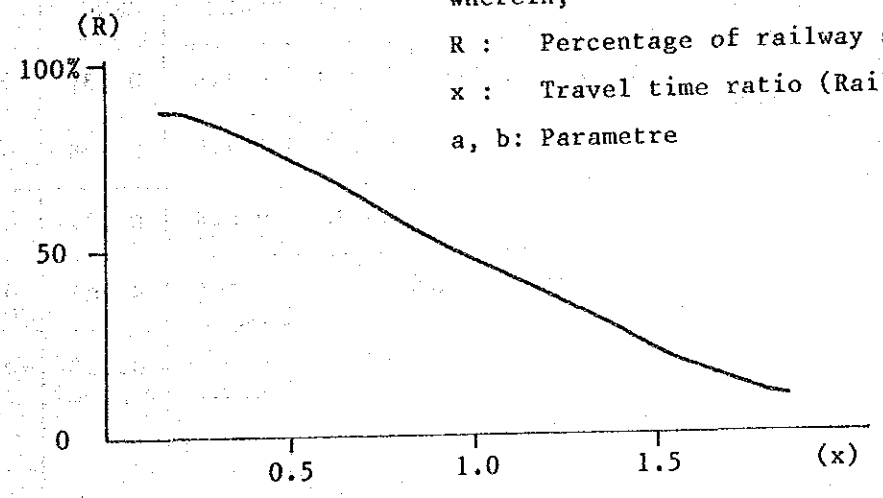
$$R = \frac{1}{1 + a \cdot \exp^{bx}}$$

wherein,

R : Percentage of railway share

x : Travel time ratio (Railway/Road)

a, b: Parametre



while, the reductions of travel time by railway are estimated by project phase, that is, phase 1 - Rangoon to Toungoo (effective from 1993/94) and phase 2 - whole line (from 1996/97). Travel times differ by train types such as express, local and freight train.

Table 3.1.3 shows the travel time reduction rate by express train, as an example.

Table 3.1.3 Travel Time Reduction Rate [1/] (Express)

Year 1993/94 (Phase 1)

	1 MDY	2 TZI	3 PMA	4 TGO	5 NLB	6 PEGU	7 RN
1	-	1.000	1.000	1.000	0.912	0.890	0.865
2		-	1.000	1.000	0.880	0.858	0.832
3			-	1.000	0.809	0.795	0.774
4				-	0.669	0.700	0.699
5					-	0.753	0.724
6						-	0.698
7							-

[1/] Rate = Travel Time (Future) / Travel Time (Present)

Year 1996/97 (Phase 2)

	1 MDY	2 TZI	3 PMA	4 TGO	5 NLB	6 PEGU	7 RN
1	-	0.755	0.754	0.750	0.728	0.732	0.727
2		-	0.754	0.747	0.719	0.725	0.721
3			-	0.738	0.698	0.712	0.709
4				-	0.669	0.700	0.699
5					-	0.753	0.724
6						-	0.698
7							-

The diverted traffic demand was calculated by applying these reduction rates to the modal split model examined before. As the result, the approximately 5 to 25 percent of diverted traffic adding to the basic volume are estimated in accordance with the travel time reduction by OD pairs.

3-1-6 Forms of Results Tabulation

These results of demand forecasting are tabulated mainly in two forms; Origin-Destination tables (7 zones x 7 zones) and traffic volume by section.

Table 3.1.4 List of Basic Results

O-D Table Number

		1985/86	1993/94	1996/97	2005/06	2016/17
<Passenger>						
	Express	1	4	7	10	13
Without	Local	2	5	8	11	14
	Total	3	6	9	12	15
	Express	-	16	19	22	25
With	Local	-	17	20	23	26
	Total	-	18	21	24	27
<Freight>						
Without		1	2	4	6	8
With		-	3	5	7	9

Traffic Volume Table

	1985/86	1993/94	1996/97	2005/06	2016/17
Without	1	2	4	6	8
With	-	3	5	7	9

Note: Figures in table indicate serial number of outputs.

3-2 Passenger Traffic

Passenger demands forecasted in accordance with the procedure mentioned hereinbefore are summarized as follows:

3-2-1 Total Demand

Total passenger demands on the Mandalay line are forecasted as 10,523 thousand in 1993/94 and 14,442 thousand in 2005/06 in case of without project, and the annual increase rate is 2.7 percent against 8,494 thousand in 1985/86. On the other hand, in case of with project 11,906 thousand in 1993/94 and 19,388 thousand in 2005/06 are estimated, with the diverted demand from road transport added.

Both number of passengers and passenger-kilometers are summarized in Table 3.2.1.

Table 3.2.1 Total Passenger Demand

(1000)

Year	Without project		With project	
	No. of Pass.	Pass.-Kms[1/]	No. of Pass.	Pass.-Kms[1/]
1985/86	8,494	1,693,725	-	-
1993/94	10,523	2,104,052	11,906	2,346,812
1996/97	11,341	2,273,267	13,783	2,733,255
2005/06	14,442	2,891,010	19,388	3,848,215
2016/17	19,313	3,870,928	29,353	5,839,473

1/ Excluding intra-zonal trips

Source: Study Team

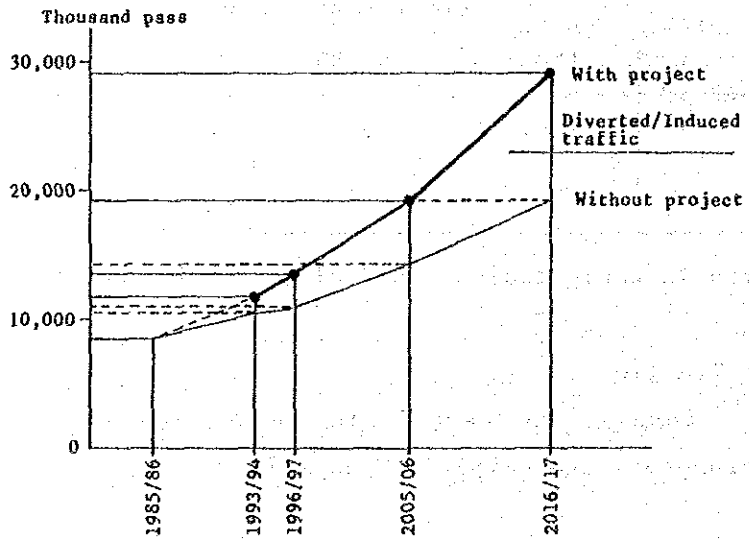


Fig. 3.2.1 Total Passenger Demand

3-2-2 O-D Distribution

Passenger flow is also estimated in each case based on the present OD Tables. Details are attached in Annex and some examples are shown in Table 3.2.2.

Table 3.2.2 Future Passenger OD Tables

PASSENGER OD (1985/86) (1000)

O \ D	1 MDY	2 TZI	3 PMA	4 TGO	5 NLB	6 PEGU	7 RN	TOTAL
1 MDY	244	122	110	48	18	53	530	1,126
2 TZI	141	340	134	39	14	44	247	959
3 PMA	87	86	585	72	17	30	137	1,014
4 TGO	40	36	60	77	37	34	106	410
5 NLB	18	24	33	55	160	56	82	428
6 PEGU	39	43	31	39	42	202	1,375	1,770
7 RN	579	265	178	110	79	1,315	258	2,785
TOTAL	1,149	918	1,151	439	367	1,734	2,736	8,494

Without project

PASSENGER OD (1993/94) (1000)

O \ D	1 MDY	2 TZI	3 PMA	4 TGO	5 NLB	6 PEGU	7 RN	TOTAL
1 MDY	317	158	142	60	23	67	661	1,429
2 TZI	182	437	172	48	17	56	306	1,218
3 PMA	112	111	748	89	21	38	170	1,288
4 TGO	50	44	99	93	45	42	128	501
5 NLB	23	31	41	66	195	68	99	523
6 PEGU	50	55	39	47	51	249	1,670	2,161
7 RN	723	329	221	132	96	1,595	308	3,404
TOTAL	1,457	1,164	1,461	536	448	2,115	3,342	10,523

With project

PASSENGER OD (1993/94) (1000)

O \ D	1 MDY	2 TZI	3 PMA	4 TGO	5 NLB	6 PEGU	7 RN	TOTAL
1 MDY	317	158	142	60	25	73	724	1,498
2 TZI	182	437	172	48	19	61	342	1,261
3 PMA	112	111	748	89	24	44	197	1,324
4 TGO	50	44	99	103	56	51	156	560
5 NLB	25	33	47	82	242	83	119	631
6 PEGU	54	60	45	58	62	308	2,030	2,618
7 RN	791	368	256	162	115	1,939	382	4,013
TOTAL	1,531	1,212	1,508	602	543	2,560	3,950	11,906

PASSENGER OD (1996/97) (1000)

O \ D	1 MDY	2 TZI	3 PMA	4 TGO	5 NLB	6 PEGU	7 RN	TOTAL
1 MDY	343	172	154	65	25	72	717	1,567
2 TZI	197	473	186	52	19	60	332	1,318
3 PMA	121	120	810	95	22	41	184	1,394
4 TGO	54	48	106	99	48	44	137	537
5 NLB	25	33	44	72	209	73	106	560
6 PEGU	53	59	42	50	54	264	1,792	2,315
7 RN	283	356	239	142	103	1,712	333	3,669
TOTAL	1,377	1,261	1,581	574	480	2,266	3,601	12,361

PASSENGER OD (1996/97) (1000)

O \ D	1 MDY	2 TZI	3 PMA	4 TGO	5 NLB	6 PEGU	7 RN	TOTAL
1 MDY	426	204	183	77	30	86	854	1,859
2 TZI	234	587	226	63	23	73	402	1,608
3 PMA	144	146	1,005	114	27	50	223	1,709
4 TGO	65	58	128	123	60	55	167	655
5 NLB	30	40	54	88	259	88	128	687
6 PEGU	64	72	51	62	66	328	2,178	2,820
7 RN	932	432	289	174	125	2,081	413	4,446
TOTAL	1,895	1,538	1,935	700	590	2,760	4,366	15,783

Source: Study Team

3-2-3 Traffic Volume by Section

Future traffic volume by section is derived from estimated OD table, and the summary is tabulated in Table 3.2.3.

Table 3.2.3 Passenger Traffic Volume by Section

(1000)

Section	Without project			With project	
	1985/86	1993/94	1996/97	1993/94	1996/97
1) MDY-TZI	1,787	2,252	2,437	2,395	2,902
2) TZI-PMA	2,457	3,079	3,332	3,313	3,998
3) PMA-TGO	2,618	3,260	3,525	3,579	4,234
4) TGO-NLB	2,685	3,330	3,598	3,754	4,336
5) NLB-PEGU	2,728	3,376	3,648	3,822	4,392
6) PEGU-RN 1/	5,006	6,130	6,603	7,199	7,983
	(2,689)	(3,303)	(3,562)	(3,764)	(4,287)

1/ Figures in parentheses indicate the demand excluding the Martaban line.

Fig. 3.2.2 Forecasted Passenger Demand by Section by Direction
(thousand per year)

3-3 Freight Traffic

Almost the same procedure as for passenger is applied also to freight traffic forecasting, and the results are summarized in the following:

3-3-1 Total Demand

Table 3.3.1 Total Freight Demand

(1000)

	Without project		With project	
Year	Ton	Ton-kms[1/]	Ton	Ton-kms[1/]
1985/86	1,105	291,751	-	-
1993/94	1,408	374,412	1,522	405,835
1996/97	1,536	409,583	1,802	482,586
2005/06	2,026	541,850	2,674	718,767
2016/17	2,826	755,573	4,274	1,150,857

1/ Excluding intra-zonal trips

Source: Study Team

As shown in the table above, in 2005/06 2 million tons in the without case and 2.7 million tons in the with case are forecasted, respectively.

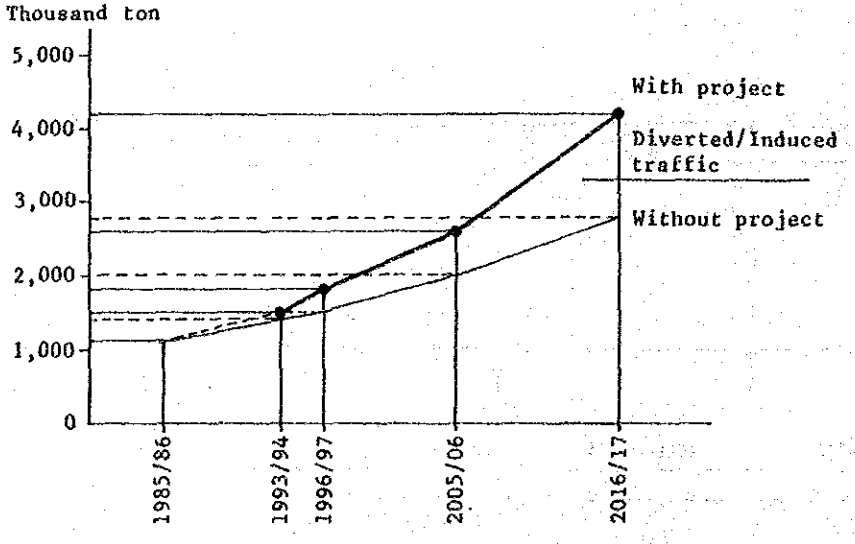


Fig. 3.3.1 Total Freight Demand

3-3-2 Traffic Volume by Section

Freight flow is also estimated from future OD tables (attached in Supporting paper) same as that of passengers.

Table 3.3.2 Freight Traffic Volume by Section

(1000 tons)

Section	Without project			With project	
	1985/86	1993/94	1996/97	1993/94	1996/97
1) MOH-TZI	254	329	361	346	428
2) TZI-PMA	399	516	565	548	670
3) PMA-TGO	610	785	859	843	1,014
4) TGO-NLB	553	709	776	777	915
5) NLB-PEGU	567	723	790	799	925
6) PEGU-MLG 1/	602	763	832	847	969
	(492)	(623)	(680)	(688)	(795)

1/ Figures in parentheses indicate the demand excluding the Martaban line.

Fig. 3.3.2 Forecasted Freight Demand by Section by Direction
(thousand tons per year)

CHAPTER 4 TRANSPORT AND ROLLING STOCK PLAN

CHAPTER 4 TRANSPORT AND ROLLING STOCK PLAN

4-1 Transport Improvement Plan

4-1-1 Short-term Improvement Project

The deterioration of the ground facilities and rolling stock of BRC has progressed, and their present condition is such that it is difficult to perform satisfactorily the railway's inherent functions, such as providing high-speed, safe, punctual, and mass transport for the nation. This makes it necessary to take action to improve transport on the Mandalay Line, the main trunk line, by carrying out the short-term improvement project on track, signalling, and telecommunication. The following four points are the main guidelines for this project.

(a) Reduction in scheduled time by increasing train speed

- Maximum speed
  - Passenger train : 80 km/h (50 mph)
  - Freight train (with bogie make-up) : 56 km/h (35 mph)
- Maximum permissible speed through turnouts
  - Straight side : 72 km/h (45 mph)
  - Turnout side : 32 km/h (20 mph)

(b) Improvement of punctuality, by decrease of delays in train operation

(c) Enhancement of safety, by the improvement of facilities

(d) Increase in track capacity to meet the increased transport demands

To satisfy the four points mentioned above, the present short-term improvement project includes improvement of tracks, using long-welded rails, improvement of the block system and of interlocking in the station yards, improvement of the main communication network, and also improvement of the train control system, etc. Stable transport on the Mandalay Line will be achieved by these measures.

4-1-2 Execution Plan for Transport Improvement

The short-term improvement project will require nine years, for completion, in two separate phases, considering the scale of investment, effects of investment, and capability for construction work, etc. Fig. 4.1.1 shows the schedule of the improvement.

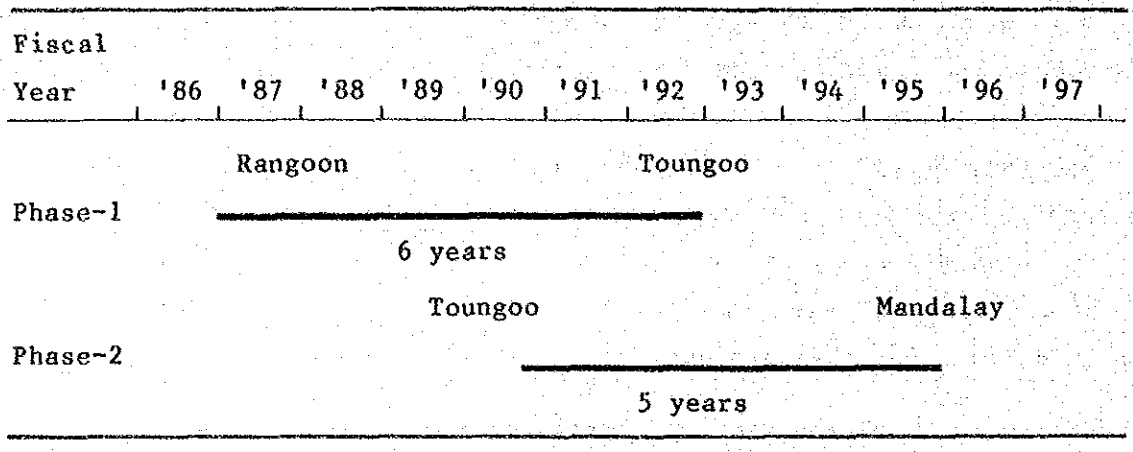


Fig. 4.1.1 Implementation Schedule

Source: Study Team

The scheduled time of express passenger trains will be shortened from 13 hours and 45 minutes in the present operation, to 10 hours, at the time of completion of Phase-2. (Hereinafter, "phase" will be abbreviated to "Ph."in Tables). However, at the time of completion of Phase-1, timetable revision will be made, including the additional operation of passenger trains and freight trains, for the purpose of meeting the increased transport demand, and of increasing the effects of investment. Table 4.1.1 shows the scheduled time for each phase, for each type of train.

4-1-3 Improvement of Rolling Stock

The improvement of rolling stock is essential for achievement of the targets of improved transport. For this purpose, the Rolling Stock Modernization Plan, presently being promoted by BRC, must be carried out steadily. What is considered basic to achieving the targets of transport improvement is improvement of the performance of rolling stock, such as the tractive force, and the braking distance (improved braking rate), along with the increase in running speed.

Table 4.1.1 Scheduled Time for the Section between Rangoon and Mandalay

Type of train	At present (A)	At the time of completion of Ph.-1	At the time of completion of Ph.-2 (B)	Reduction rate (%) (A-B)/A
Express passenger trains	13 hrs : 45 min	12 hrs : 00 min	10 hrs : 00 min	27
Ordinary passenger trains	19 : 05	16 : 10	14 : 00	27
Freight trains	37 : 10	32 : 00	25 : 00	33

Source: Study Team

The braking rate attained at the time of the completion of the modernization of rolling stock, is as shown below.

(a) The braking rate for passenger trains will be increased from the present 41 percent, to 82 percent.

(b) The braking rate for important freight trains will be increased to 50 percent. (Most wagons are not equipped with brake equipment at present.)

(c) Normal braking distance, based on the above:
Passenger trains: 2200 ft. (Max. speed : 50 mph)
Freight trains : 1/2 mile (Max. speed : 35 mph)
Each of the above distances does not include any margin.

4-2 Effect of Transport Improvement

4-2-1 Speed Increase

The increase in train speed is one of the important targets of transport improvement. As shown in Table 4.1.1, the scheduled time of all types of trains will be greatly shortened when the facility improvement is completed in Phase-2.

This will improve passenger and freight service, increase working efficiency of rolling stock by 16 percent, increase track capacity and cause diversion of passenger and cargo traffic from other means of transport.

4-2-2 Improvement of Punctuality

At present, the speed restriction at turnouts and some bridges due to repair works, defective communication network and signal failures hinder smooth train operation to cause delays in train operation.

Table 4.2.1 shows the trends of the delay on passenger trains for the past three years, and the average delay time per type of trains is shown in Fig. 4.2.1. The figures show accelerated tendency of the delay. The freight trains between Malagon and Myohaung are planned to take 37 hours and 10 minutes, however, actually take 50 to 60 hours.

Introduction of train radio, and control telephone system, and improvement of turnouts, can greatly contribute to reducing the delays in future train operation. The effect on the delay of the improvement is shown in Table 4.2.2.

Table 4.2.1 Number of Passenger Train Delays for the Past Three Years on the Mandalay Line [Percent]

Type of Train	Year	On-time	1-30 min	30 min-1 h	1-3 hr	3 hr and over
Express	'83/84	51	26	10	4	5
	'84/85	34	34	18	12	2
	'85/86	11	32	24	27	6
Ordinary	'83/84	16	17	18	39	10
	'84/85	6	14	14	42	22
	'85/86	2	12	17	45	23
Local	'83/84	24	21	24	25	6
	'84/85	10	17	21	33	18
	'85/86	5	6	10	19	17

Source: BRC

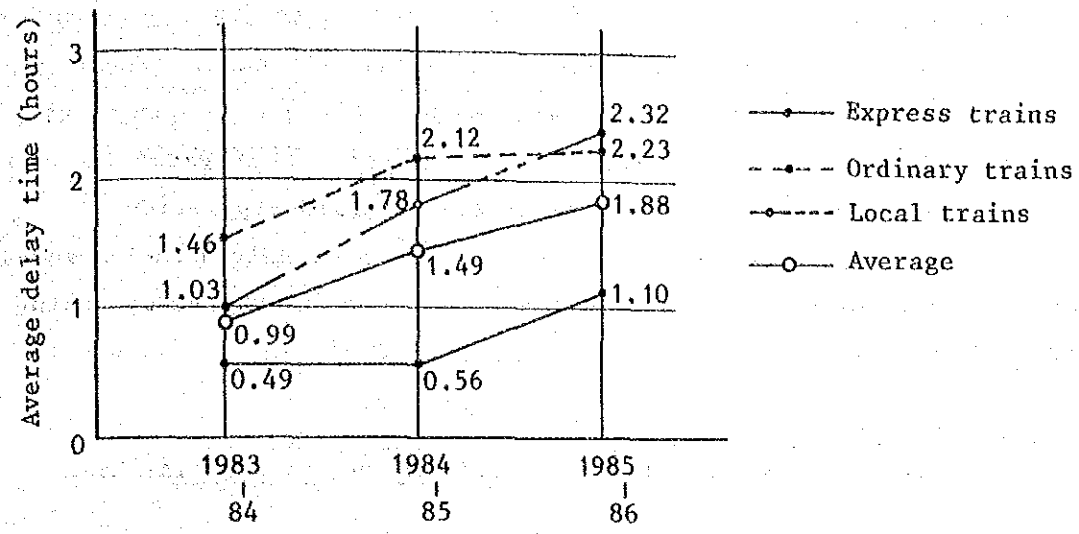


Fig. 4.2.1 Punctuality of Train Operation

Source: Study Team

Table 4.2.2 Reduction Rate of Delay Time

Phase	Alternative plan A	Alternative plan B
1	43%	41%
2	90%	85%

Note: 1. Difference in plans A and B is mainly due to introduction of train radio in plan A.

2. For alternative plans A and B, refer to Chapter 5-4.

Source: Study Team

4-2-3 Improvement of Safety

Table 4.2.3 shows the number of train accidents on the Mandalay line for the past three years, of which serious accidents, i.e., train collisions, train derailments and train fires, amount 80. Rolling stock collisions and derailments in station yards, train accidents at level crossings, and train separation amount as high as 119.

When train accidents are grouped by cause, the number of train accidents from human errors such as by a driver or station staff is 38, the number from defective track or signal failure among those is 6, and that from level crossing failure is 31.

The facility improvement plan will eliminate most of the train accidents caused by facility failure and human mistakes, except for the accidents caused by rolling stock failure, when Phase-2 is completed.

Among the facility improvements, train separation detection will be provided to prevent train collisions caused by train separation.

Table 4.2.4 shows the decrease in train accidents under alternative plans A and B for signals, as compared with the accidents based on the data for the past three years.

Table 4.2.3 Number of Train Accidents on the Mandalay Line

Classification	1983/84	1984/85	1985/86	Total
Train collision	-	1	3	4
Train derailment	23	31	21	75
Train fire			1	
Total	23	32	25	80
Rolling stock collision (at station)	1	2	2	5
Rolling stock derailment (at station)	23	24	22	69
Level crossing accidents	2	6	6	14
Train separation	1	11	19	31
Total	27	43	49	119
Grand total	50	75	74	199

Source: BRC

Table 4.2.4 Decrease in Train Accidents

Phase	Alternative plan A	Alternative plan B
1	35%	28%
2	75%	60%

Note: 1. Difference in plans A and B is mainly due to introduction of ATS in plan A.
2. For alternative plans A and B, refer to Chapter 5-4.

Source: Study Team

4-2-4 Increase in Track Capacity

On the Mandalay line, the sections where the track capacity has to be checked are 1) from TGL to YTG (9.3 km) where the suburban trains and trains for Martaban line are jointly using the same tracks, 2) from PEGU to PAG (17.3 km) the longest block section, 3) from TNGD to TGO (6.8 km) where a single track bridge locates in the double track sections, and 4) from SMN to TAB (11.7 km) the longest block section in the single track sections.

The approximate present and future track capacity is calculated based on the assumption that the train operation diagram of the concerned section is made on the aforementioned premise, taking into account the average running time between stations and handling time for blocking.

As Table 4.2.5 shows, the track capacity of all sections will be greatly increased over that at present, as a consequence of increase in train speed and decrease in block handling time.

Therefore, the track will have sufficient capacity for the planned train diagram (number of trains) in 1996/97, when Phase-2 is to be completed, and further increase in future.