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JAPAN INTERNATIONAL COOPERATION AGENCY
ROAD DEVELOPMENT AUTHORITY
MINISTRY OF HEALTH, HIGHWAYS
AND SOCIAL SERVICES

MASTER PLAN STUDY ON BRIDGE DEVELOPMENT IN THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

FINAL REPORT

VOLUME II

MAIN TEXT

JULY 1996

JAPAN BRIDGE & STRUCTURE INSTITUTE, INC., TOKYO
PACIFIC CONSULTANTS INTERNATIONAL, TOKYO

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CURRENCY EQUIVALENT

(As of 13 th October, 1995)

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PREFACE

In response to a request from the Government of the Democratic Socialist Republic of Sri Lanka, the Government of Japan decided to conduct the Master Plan Study on Bridge Development in Sri Lanka and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Sri Lanka a study team headed by Mr. Hiroshi Namba from Japan Bridge & Structure Institute, Inc., three times between March 1995 and May 1996.

The team held discussions with officials concerned of the Government of Sri Lanka, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

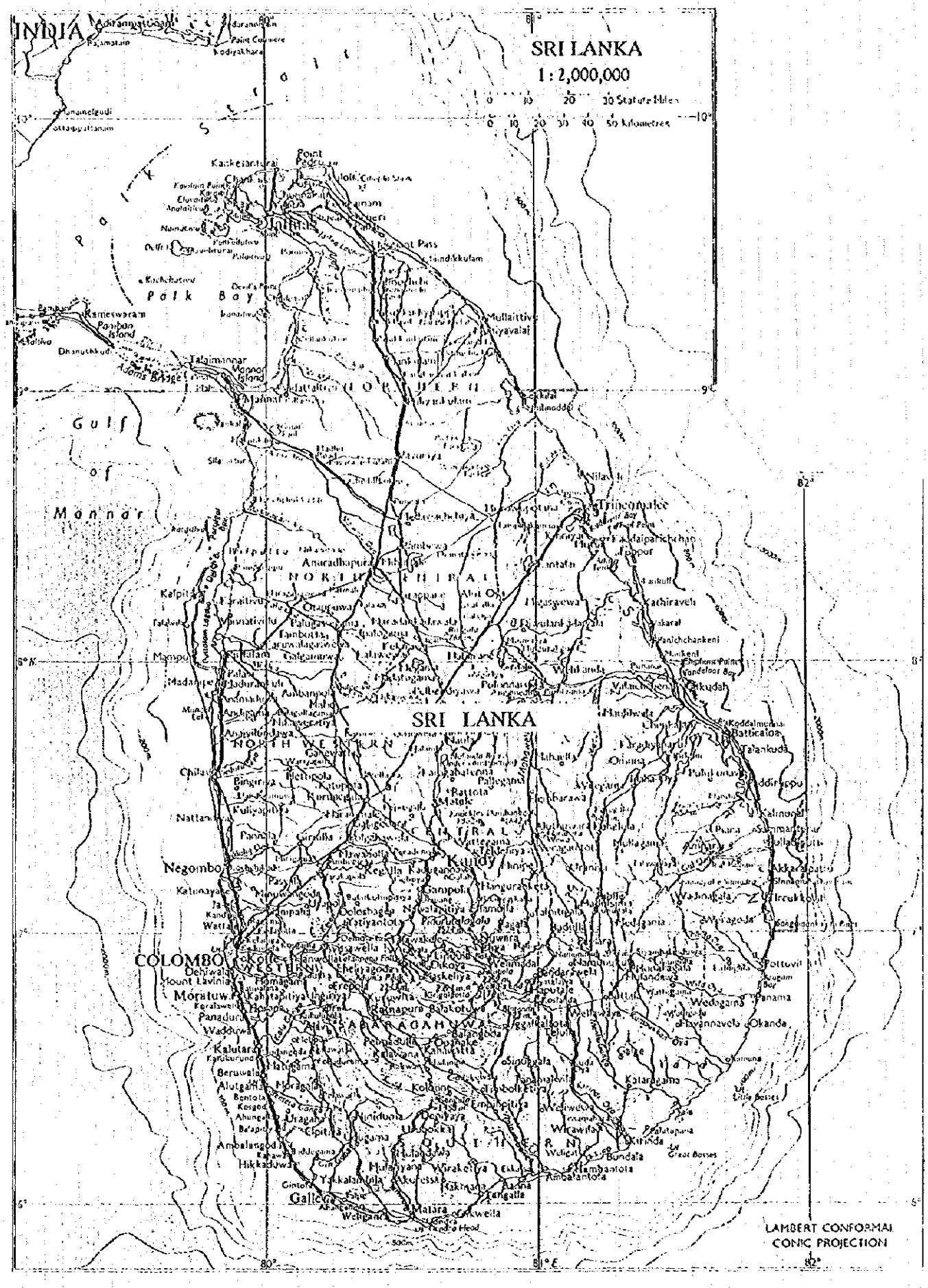
I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

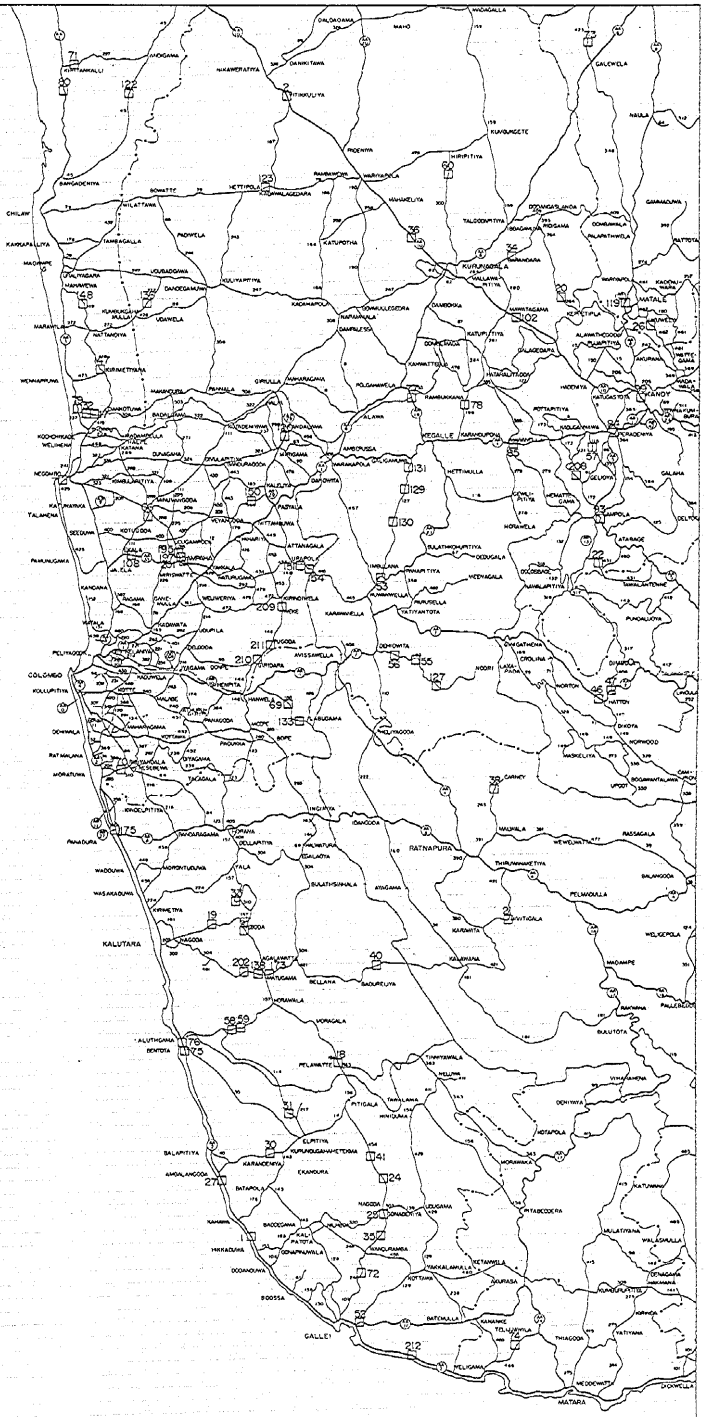
I wish to express my sincere appreciation to the officials concerned of the Government of Sri Lanka for their close cooperation extended to the team.

July 1996

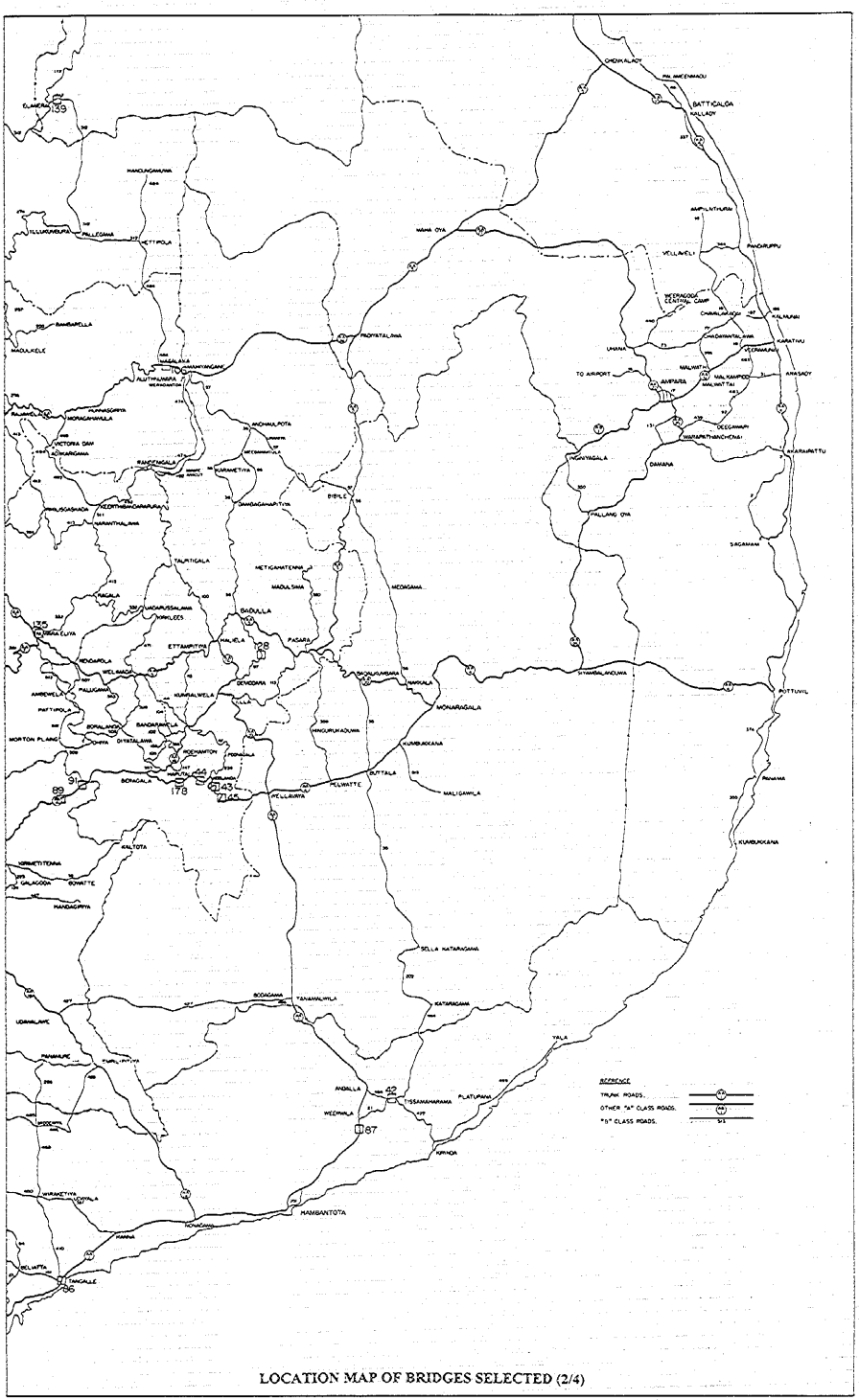
Kimio Fujita
President
Japan International Cooperation Agency

LOCATION MAP





LOCATION MAP OF BRIDGES SELECTED (1/4)



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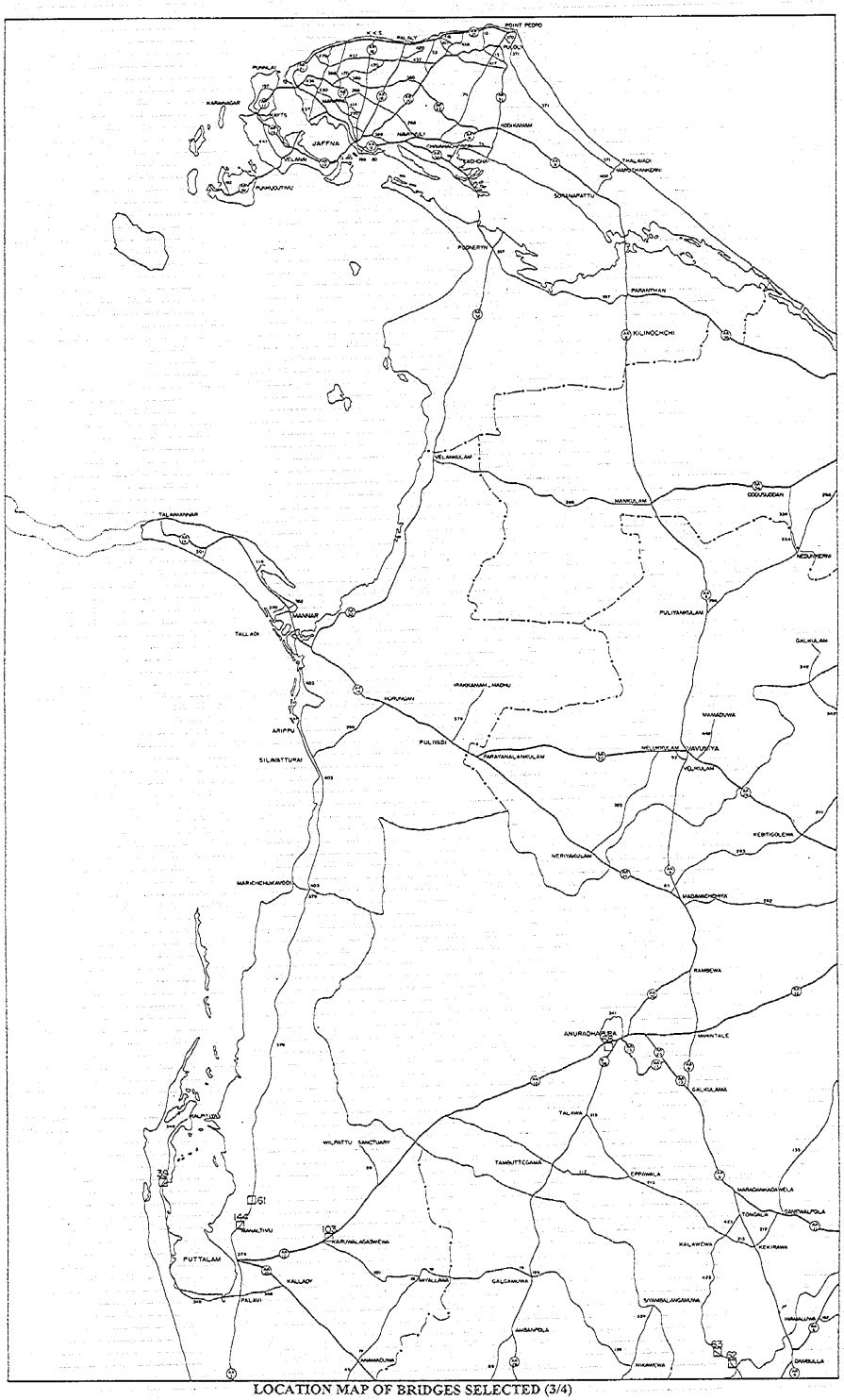
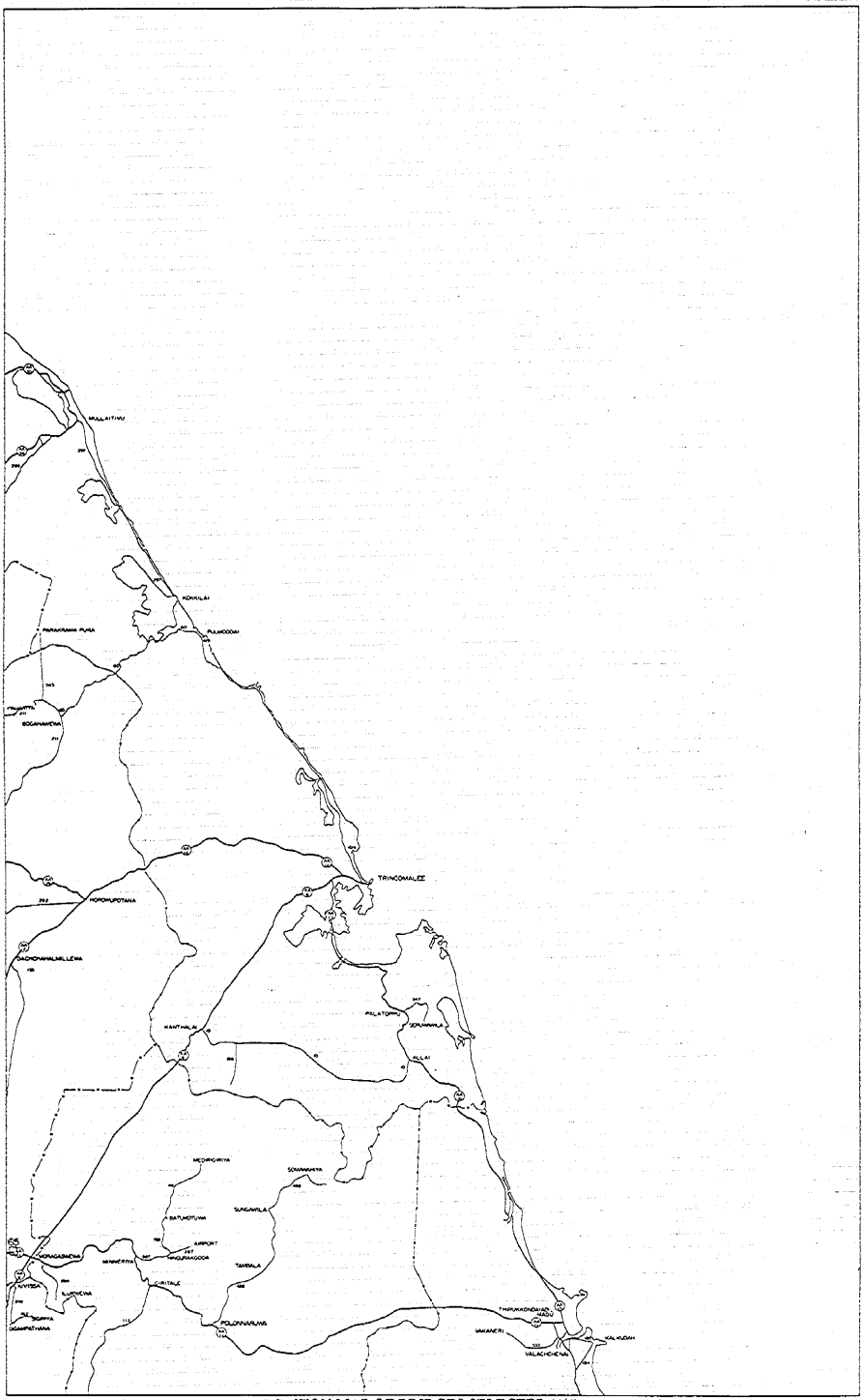


LOCATION MAP OF BRIDGES SELECTED (3/4)



LOCATION MAP OF BRIDGES SELECTED (4/4)

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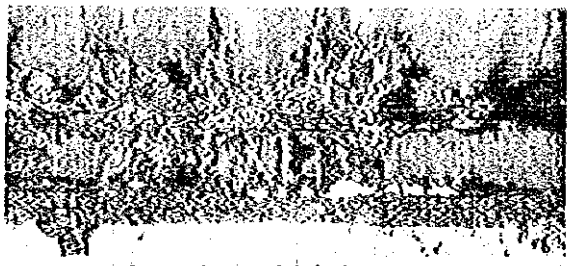
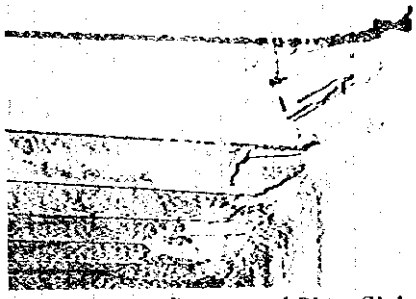
1. Steel Bridge

Free Lime from Buckle Plate Slab (BUC)



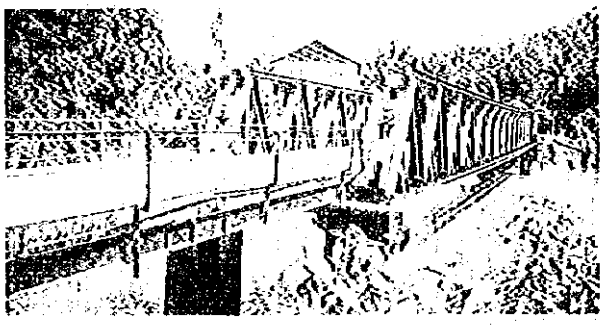
Corrosion on Main beam

Rust on Main beam

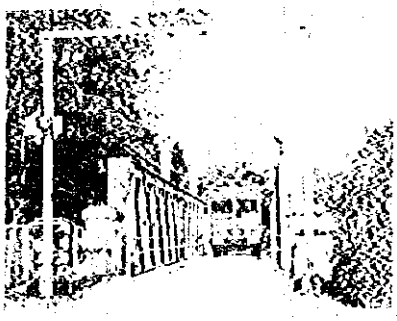


Corrosion on Corrugated Plate Slab (COR)

Crack and Reinforcement exposure on Reinforced Concrete Slab (RCS)



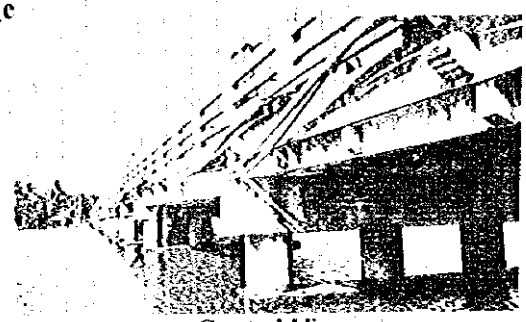
Remarkable Deflection of Main Chord of Pony Truss



Narrow Width

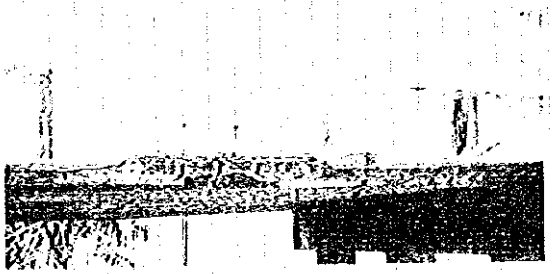
Water Stagnation

2. Concrete Bridge



General View

Damage on Reinforced Concrete Beam (RCB)



Flaking of Cover Concrete on RCB

Flaking of Cover Concrete on Prestressed Pretensioned Concrete Beam (PSC/PRE)

Crack on Reinforced Concrete Box Culvert (RC/BOX)

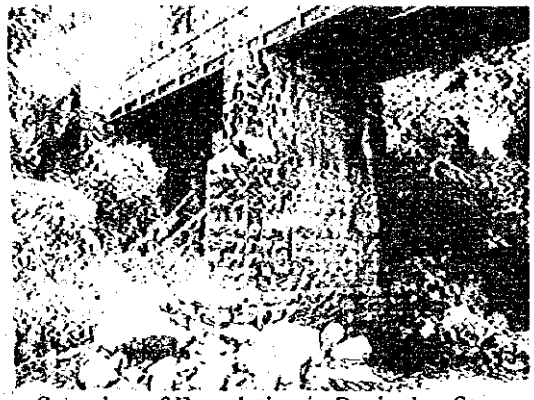
3. Arch Bridge

General View

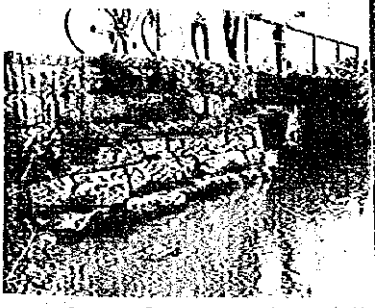
Scouring of Foundation on Stone Arch Bridge (ARCH/ST)

Vegetating on Brick Arch Bridge (ARCH/BR)

4. **Substructure**

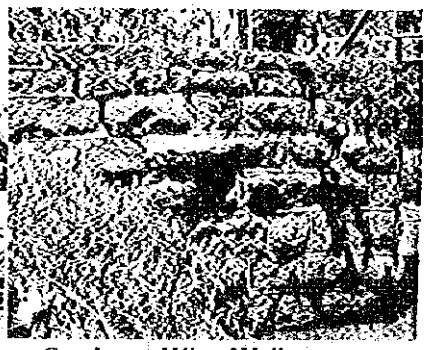


Scouring of Foundation in Beginning Stage

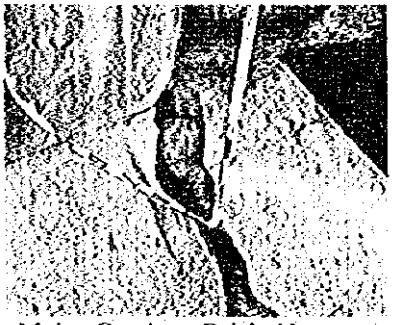


Loose Stone on Wing Wall

Cracks on Abutment

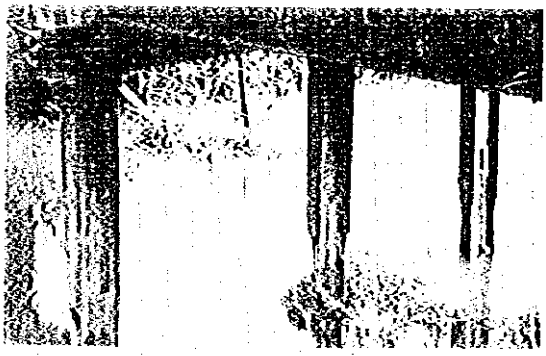


Cracks on Wing Wall



Major Crack on Brick Abutment

Scouring of Foundation



Corrosion on Additional Rolled Steel Joist (RSJ) Pier constructed later

Cracks on Concrete Pile

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Abbreviation

A.D.	: Anno Domini
AASHOTO	: American Association of State Highway and Transportation Officials
ADB	: Asia Development Bank
Admin.	: Administration
ADT	: Average Daily Traffic
ALINE	: Alignment
ARCH / BR	: Brick Arch Bridge
ARCH / CO	: Concrete Arch Bridge
ARCH / S	: Steel Arch Bridge
ARCH / ST	: Stone Arch Bridge
B/C	: Benefit / Cost Ratio
BAILEY	: Bailey Bridge
Br.	: Bridge
BS	: British Standard
CARR	: Carriageway
CAUSEWAY	: Causeway Bridge
CKE	: Colombo - Katunayake Expressway
CL	: Center line
Con.	: Concrete
Const.	: Construction
CORRD	: Corroded
Cov	: Cover
D.P	: Design in Progress
DAM	: Damaged
DD	: Detailed Design
Dept.	: Department
DF/R	: Draft Final Report
Diff	: Difference
DOH	: Department of Highway
E.E.	: Executive Engineer
EIA	: Environmental Impact Assessment
Expendi	: Expenditure
EXST	: Existing
EXT	: Extension of Bridge
F/S	: Feasibility Study
GDE	: Goods Domestic Expenditures
GDP	: Gross Domestic Product
GNP	: Gross National Product
gr pa	: Growth Ratio per Annum
IC/R	: Inception Report
ID	: Identification
IEE	: Initial Environmental Examination
IMF	: International Monetary Fund
Inspect.	: Inspection
IT/R	: Interim Report

JICA	: Japan International Cooperation Agency
JIS	: Japanese Industrial Standard
JS	: Japanese Design Standard
KU	: Kuwait
L	: Length
M/M	: Minutes of Meeting
MB	: Main Beam
MC	: Motorcycle
MMC	: Maintenance Management & Construction Division
Mt.	: Mountain
N.A.	: Not applicable
NHDA	: National Housing Development Authority
NKB	: New Kelani Bridge
No.	: Number
Nos.	: Numbers
NPV	: Net Present Value
O.W.L.	: Ordinary Water Level
OCH	: Outer Circular Highway
ODA	: Official Development Assistance
OECF, OECFJ	: Overseas Economic Cooperation Fund, Japan
OVRAL	: Overall
PC	: Per Capita
PIPCF	: Public Investment Programme under Consolidation Fund
Pop.	: Population
PROP	: Proposed
PSC/ POS	: Prestressed Posttentioned Concrete Beam
PSC/ PRE	: Prestressed Pretensioned Concrete Beam
R	: Ratio
R/f	: Reinforced
RCB	: Reinforced Concrete Beam (Bridge)
RCC	: Reinforced Concrete
RCDC	: Road Construction and Development Corporation
RCS	: Reinforced Concrete Slab (Bridge)
Rd.	: Road
RDA	: Road development Authority
RECONST	: Reconstruction
RED, Red	: Re-decking
REP, Rep	: Repair
REPL	: Replacement
RESUPER, Resuper	: Replacement of Superstructure
RC / BOX	: Reinforced Concrete Box Culvert
Rs.	: Rupees
RSJ / BUC	: Buckle Plate over Rolled Steel Joist
RSJ / COR	: Corrugated Plate over Rolled Steel Joist
RSJ / DEC	: Deck Plate over Rolled Steel Joist
RSJ / RCS	: Reinforced Concrete Slab over Rolled Steel Joist
RSJ / T	: Timber Deck over Rolled Steel Joist

RST / BUC	: Buckle Plate Over Steel Girder
S/W	: Scope of Work
Sch.	: Scheduled
SER. Ser.	: Serial
SETT	: Settlement
SLJFB (II)	: Sri Lanka Japan Friendship Bridge Widening Project
SPT	: Standard Penetration Test
ST. TR / D	: Steel Deck Truss
ST. TR / T	: Steel Through Truss
Stl. Grd (SG)	: Steel Girder
Stl. Trs	: Steel Truss
STONE	: Stone Bridge
T.C	: Tender Dcument Completed
TIMBER	: Timber Bridge
UK	: United Kingdom
Veh.	: Vehicle
VOC	: Vehicle Operation Cost
vpd	: Vehicle per Day
W	: Width
WB	: World Bank
WDN, Wdn	: Widening of Bridge

CHAPTER 1 INTRODUCTION

1.1 General

Sri Lanka has a total area of 65,610 sq. km and is composed of eight provinces.

Sri Lanka built up their economy based on the exportation of tea, coconut, rubber, etc. to Western countries and the Middle East during the British Dominion Era. Further, transportation of those goods between plantation and port had stimulated the development of a domestic transportation network.

Of the national transportation system in Sri Lanka, roads are the most dominant transportation mode for both passenger and freight. Traffic surveys show that road transports carry as high as 82% of the total passengers and 90% of the total freight in the country, and it is expected that also in the next decade the role of roads will increase.

Since independence from Britain, Sri Lanka was given various assistance from developed countries including Japan for their infrastructure improvement. Road maintenance, therefore, had been implemented nationwide. On the other hand, there are a lot of bridges which need to be repaired urgently. However, only 20% have been repaired, and others remain untouched due to budget limitations and inexperienced engineering. These decrepit bridges are a serious hindrance to providing a larger and better road network. Without repairing these bridges, further economic growth in Sri Lanka not can be expected.

Under these circumstances, the Government of Sri Lanka (herein after called "GOS") asked the Government of Japan (herein after called "GOJ") for their assistance in January, 1990, and GOJ carried out the Project Formation Study in February, 1993 to investigate and analyze the needs of these bridge projects. As a result, GOJ decided to conduct the Master Plan Study on Bridge Development in the Democratic Socialist Republic of Sri Lanka and entrusted the Study to the Japan International Cooperation Agency (herein after called "JICA"), the official agency responsible for the implementation of technical cooperation program of GOJ.

JICA dispatched a Preparatory Study Team to Sri Lanka from 28th November to 11th December, 1994. Accordingly, JICA and RDA concluded and signed the Scope of Work (S/W) and the Minutes of Meeting (M/M) on 8th December 1994. Subsequently JICA organized an Advisory Committee and selected a Study Team organized by the consultants of Japan Bridge & Structure Institute, Inc. (JBSI) and Pacific Consultants International (PCI) in March 1995, which has conducted the Study.

The Study Team was dispatched to Sri Lanka on 30th March, 1995.

1.2 Objectives of the Study

The principle objectives of the Study are two fold:-

(1) To formulate a master plan for bridge rehabilitation on all A routes and some selected B routes of those bridges which need to be repaired urgently, by the year 2010.

(2) To prepare guidelines for the implementation of maintenance and rehabilitation by Sri Lankan authorities.

In addition to the above, the Study includes providing practical training to RDA counterparts in field inspection techniques, bridge loading teat and assessment techniques on the required maintenance and rehabilitation method for various types of defective bridge members.

1.3 Scope of the Study

The Study covers the entirely country of Sri Lanka except for the eastern and northern provinces. In order to achieve the objectives mentioned above, the Study covers the following items;

1) Collection and review of data and related information
   1) Socio-economic data and information
   2) Existing plans related to road development
   3) Traffic data/information
   4) Engineering data/information
      a. Topographic map
      b. Bridge inventory
      c. Soil and geological data
      d. Hydrological data
      e. Meteorological data
   5) Other data necessary for the Study

2) Review of trunk road development plans

3) Traffic demand projection and analysis

4) Identification of the bridges requiring rehabilitation, and rating of their priority

5) Selection of bridges for preliminary inspection (approximately 100 bridges)

6) Preliminary Inspection of the selected bridges (Visual inspection, Measurement of dimensions, taking photos, etc.)

7) Preparation of bridge inventory

8) Setting up of bridge rehabilitation policy

9) Selection of bridges for detailed inspection (approximately 10 bridges)

10) Detailed survey of the selected bridges

11) Preliminary rehabilitation design of the selected bridges

12) Maintenance and management Plan

13) Initial Environmental Examination

14) Preliminary Cost Estimate

15) Economic and financial analysis

16) Implementation program of rehabilitation of the 100 bridges to which preliminary inspection was made

17) Preparation of bridge inspection, maintenance and rehabilitation guideline

18) Conclusion and recommendations

1.4 Work Flow and Major Work Items

The Study was principally divided into three main phases: Phase I - Preliminary Inspection of Bridges and Selection of 10 Representative Bridges, Phase II - Detailed Survey and Preparation of Implementation Program and Phase III - Submission of the Draft Final Report and completion of Final Report. Each main phase was further subdivided into two stages which involve work in Sri Lanka and Japan, which is indicated y the suffix (A) and (B) respectively.

Main work items during each phase are summarized as follows:

- Phase I (A) Study: Selection of 100 bridges, Preliminary Visual Inspection and Preparation of Bridge Inventory
- Phase I (B) Study: Setting of Evaluation Criteria and Selection of 10 Bridges
- Phase II(A) Study: Detailed Survey, Preliminary Design, and Planning of Maintenance & Rehabilitation Work
- Phase II(B) Study: Cost Estimate, Economic Evaluation, Implementation Programming

■ Phase III(A) Study: Preparation of Draft Manual & Draft Final Report

■ Phase III(B) Study: Completion and submission of Final Report and Manual

The flow chart of the work program and the interrelations of the above main work items are shown in Figure 1.1.

1.5 Study Organization

For smooth implementation of the Study, GOS established a Steering Committee chaired by the General Manager of RDA and a Technical Committee led by the Director of the Engineering Services, RDA.

For the Study, RDA acted as the counterpart agency to the Study Team and also as the coordination body between the government agencies concerned. A counterpart team comprising 6 members from the Engineering Services was formed and headed by the Director, Engineering Services.

On the other hand, JICA organized an Advisory Committee consisting of 3 members who provided advice and guidance to ensure proper execution of the Study, and the Study Team comprising of 8 specialists headed by Mr. H. Namba.

The interrelationships between the above mentioned Committees and Teams are shown in Figure 1.2.

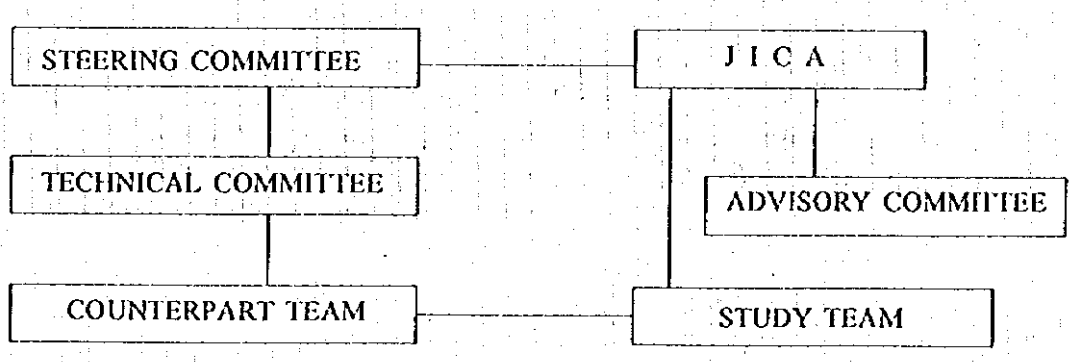

Figure 1.2 Study Organization

Member of the Steering Committee, Technical Committee, Counterpart Team, JICA, Advisory Committee, and Study Team are listed in Appendix- A.

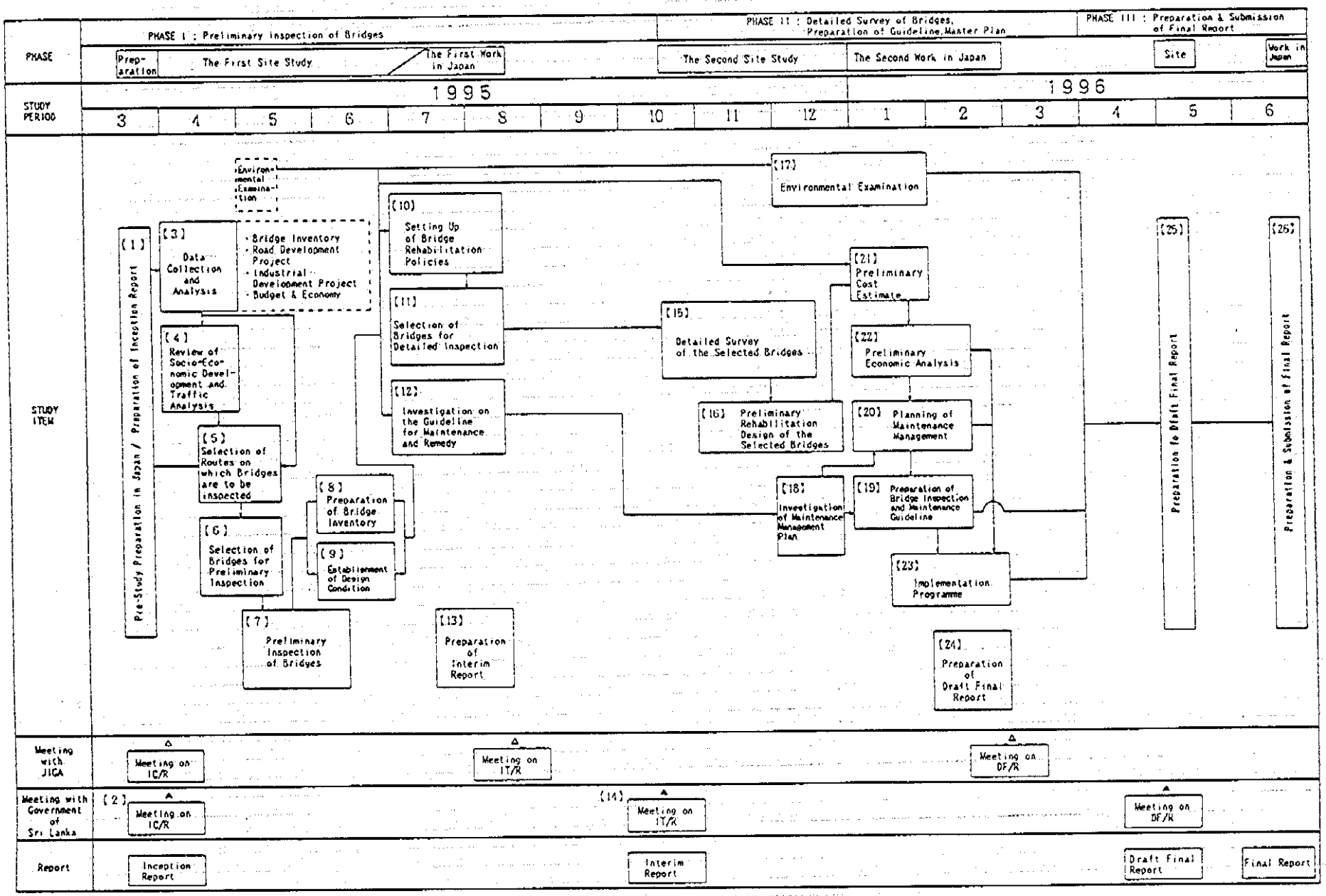

Figure 1.1 Flow Chart of the Study

1.6 Composition of Final Report

The final Report contains summarized findings and recommendation, followed by the results of all the works carried out including field survey, all the structural assessment, cost estimates, and economic evaluation.

The final Report consists of four volumes as listed below:

Volume I	Summary
Volume II	Main Text
Volume III	Appendixes
Volume IV	Drawings

In addition to the above, a bridge inventory, guideline for maintenance and rehabilitation was prepared as a separate booklet and submitted to GOS.

1.7 Major Meetings Held

During the whole study period, the following major meetings were held in Sri Lanka and the minutes of each meeting is attached in Appendix - .

CHAPTER 2 SOCIO-ECONOMIC FRAMEWORK AND TRAFFIC DEMAND ANALYSIS

2.1 General

This chapter discusses macroscopic changes in the socio-economic conditions of the country in such aspects as population, GDP, motorization and others. Growth prospects of those economic indices are estimated. Based on those growth prospects, an over-all traffic growth rate up to 2010 is proposed.

2.2 Existing Social and Economic Conditions

2.2.1 Demography and Population Distribution

(1) Demography

Sri Lanka has a population of around 18 million population in 1995 with the land area of 64,454 square kilometers (excluding large inland waters), resulting a population density of 280 people per sq. km. According to the census in 1946 the population was nearly 7 million and 85% of them inhabited in rural area. The latest population census in 1981 prevailed that the population has increased to about 15 million, that is an average growth rate of 2.2% per annum, and the percentage population of rural area has decreased to 78%.

The population growth during 1981-1995 has slowed down to be 1.3% per annum with a declining birth rate. Despite a significant slowing down of the population growth, the population share in urban sector has increased from 21.5% in 1981 to 24.0% in 1995(estimated in this study), and which indicates the urban population growth in the same period to be 2.2% per annum as shown in Table 2.1. Although the rural-urban drift has been modest, in recent years there has been a considerable increase of the population in the western part of the country, in areas surrounding the metropolis, where there is a concentration of industries and the economic and social infrastructure is much better developed than in other parts of the country.

Table 2.1 Population Growth in Sri Lanka

Year	Population (*1,000)	Average Annual Growth Rate (%)
1891	3,007.9 *	-
1901	3,566.1 *	1.72
1911	4,106.2 *	1.42
1921	4,497.8 *	0.92
1946	6,660.4 *	1.58
1953	8,097.9 *	2.83
1963	10,582.2 *	2.71
1971	12,689.8 *	2.30
1981	14,846.8 *	1.58
1991	17,259.2 **	1.52
1995	17,940.0 **	0.97

Notes : * Census data
** Estimates by Department of Census and Statistics
Source : Statistical Abstract 1994, Department of Census and Statistics

(2) Regional Distribution of Population

Sri Lanka consists of 9 Provinces which are divided into 25 Districts in 1995. The 1981 census population, when the total district was 24 in number, i.e. Kilinochchi District was part of Jaffna District, the largest population holder was Western Province which accounts for about 26% of the total population. Colombo District lies in Western Province and which has the largest population among the districts, i.e. about 11% of the total Sri Lankan population in 1981. The regional population growth during 1971-1981 is presented in Table 2.2, and the population distribution and density in 1981 are diagrammed in Figure 2.1. and Figure 2.2.

Table 2.2 Distribution and Growth of District Population

District	Land Area*	1971	1981	1993	1993 Population		Average Annual Growth	
					% Distri-bution	Den-sity**	1971-1981	1981-1993
Colombo	656.7	2672.3	1699.3	2026.0	11.5%	3,085	-4.43%	1.48%
Gampaha	1597.6	n.a.	1390.8	1555.0	8.8%	973	Note (1)	0.93%
Kalutara	1377.6	729.5	829.7	961.0	5.5%	698	1.30%	1.23%
Kandy	1906.3	1187.9	1048.3	1269.0	7.2%	666	-1.24%	1.60%
Matale	1993.3	314.9	357.3	429.0	2.4%	215	1.27%	1.54%
Nuwara-Eliya	1720.5	450.3	603.6	535.0	3.0%	311	2.97%	-1.00%
Galle	1635.6	735.1	814.6	971.0	5.5%	594	1.03%	1.47%
Matara	1282.5	586.4	643.8	797.0	4.5%	621	0.94%	1.79%
Hambantota	2579.3	340.3	424.3	531.0	3.0%	206	2.23%	1.89%
Jaffna	983.6	701.6	830.6	879.0	5.0%	894	1.70%	0.47%
Kilinochchi	1235.0			107.0	0.6%	87	Note (2)	0.47%
Mannar	1985.2	77.8	106.2	137.0	0.8%	69	3.16%	2.14%
Vavuniya	1966.9	95.2	95.4	117.0	0.7%	59	0.02%	1.72%
Mullaitivu	2516.9	0.0	77.2	96.0	0.5%	38	Note (3)	1.83%
Batticaloa	2686.3	256.7	330.3	433.0	2.5%	161	2.55%	2.28%
Amparai	4318.2	272.6	389.0	501.0	2.8%	116	3.62%	2.13%
Trincomalee	2630.8	188.2	255.9	323.0	1.8%	123	3.12%	1.96%
Kurunegara	4812.8	1025.6	1211.8	1462.0	8.3%	304	1.68%	1.58%
Puttalam	3013.4	378.4	492.5	617.0	3.5%	205	2.67%	1.90%
Anuradhapura	7034.3	388.7	587.9	741.0	4.2%	105	4.22%	1.95%
Polonnaruwa	3224.2	163.7	261.6	329.0	1.9%	102	4.80%	1.93%
Badulla	2802.8	615.4	641.0	724.0	4.1%	258	0.41%	1.02%
Moneragala	5545.6	193.0	273.6	36.1	2.0%	65	3.55%	2.34%
Ratnapura	3255.4	661.4	797.1	960.0	5.4%	295	1.88%	1.56%
Kegalle	1692.8	654.8	685.0	758.0	4.3%	448	0.45%	0.85%
Total	64453.6	12689.8	14846.8	17619.0	100.0%	273	1.58%	1.44%

Note : * sq. kilometers, ** persons per sq. kilometers
Note (1) : Gampaha District was separated from Colombo District in 1978
Note (2) : Kilinochchi District was separated from Jaffna in 1984
Note (3) : Mullative District was separated from Vavuniya District in 1978
Sources : Statistical Abstract 1994, Department of Census and Statistics

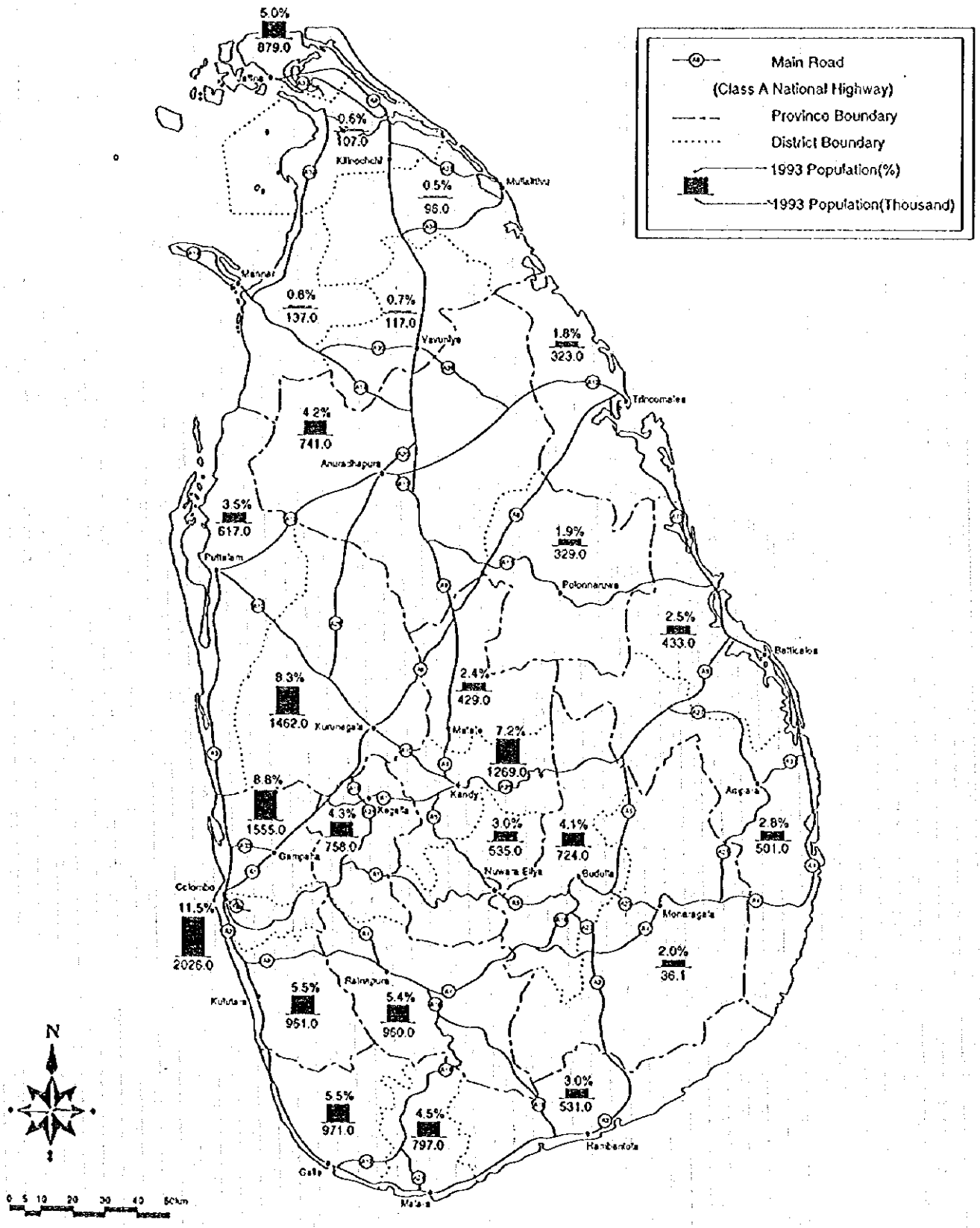

Figure 2.1 Regional Population Distribution in 1983

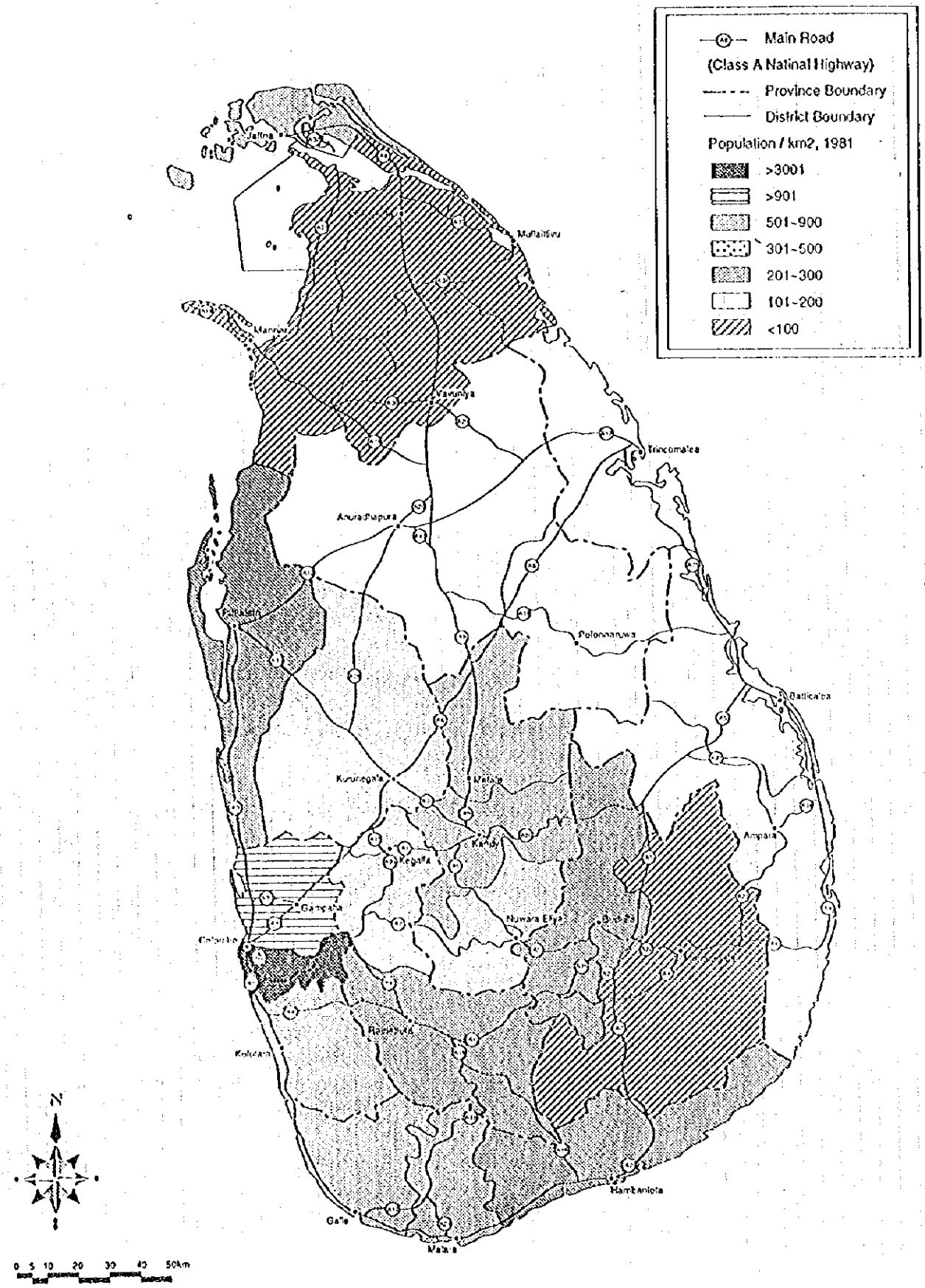

Figure 2.2 Population Density by District in 1981.

2.2.2 Economic Policies and Development

(1) Economic Policy Changes

From 1970 to 1977, the Government relied on State control and State ownership of many sectors, discouraged private enterprise, adopted an import substitution strategy for both agriculture and industry, and placed only limited reliance on the private sector and export markets. These policies were executed through stringent important export controls.

The Government which took office in 1977 introduced the package of economic reforms that consist of liberalized trade, relaxed exchange controls and announced a strategy to stimulate private investment. The policy reforms relied in large-scale support from international agencies, notably the IMF and the World Bank, and other donor countries.

The objectives of the 1977 reforms were to increase the rate of economic growth, to expand the production of rice and other food crops, to reduce the high rate of unemployment, and to develop a competitive economic system that would be capable of producing industrial goods fro the export market.

While prior to 1977 the Government had extensive welfare programmes including free health, free education and food subsidies, the new economic policies curtailed some of these programmes and attempted to target subsidies to a smaller section of the population which required such assistance.

The new economic policies have been basically succeeded by the new Government of the People's Alliance, which took office in August 1994. It confirmed officially that market oriented economic policies would continue to hold its way, ending uncertainty about the future direction of economic policy.

(2) Growth of Economy and Structural Changes

In the period 1970 to 1977, when the country pursued policies of State controlled economic development, the economy grew at an average annual rate of 2.8 per cent. In 1978, consequent to the policy reforms, the economy attained a growth rate of 8.2 per cent. Between 1978 and 1984 the economy grew at an average rate of 5.9 per cent per annum. Due mainly to civil conflicts, the rate of growth since 1985 declined sharply from 5 per cent in 1985 to 1.5 per cent in 1987. The economy stagnated till 1989 with an average growth rate of 2.7 per cent per annum during the period 1986 to 1989. In 1990, there were signs of renewed growth in the economy, when the GDP grew at 6.2 per cent, and the GNP at 6.6 per cent.

Since 1990, Sri Lankan economy showed a steady growth of the economy with an averaged rate of 5.4 per cent during 1990-1994, and it marked a 6.9 per cent

growth in 1993, which is the highest since 1979 as shown in Table 2.3.

Table 2.3 Economic Development by Industrial Sector
(Rs. Million at 1982 Constant Price)

	1989	1990	1991	1992	1993	1994
1. Agriculture, Forestry & Fishing	27,666	30,011	30,570	30,090	31,554	32,593
2. Mining & Quarrying	3,576	3,901	3,511	3,300	3,693	3,915
3. Manufacturing	20,488	22,427	23,949	26,059	28,806	31,418
4. Construction	8,514	8,761	9,033	9,765	10,400	11,024
5. Services	61,485	64,144	68,141	71,776	76,330	80,319
6. GDP	121,729	129,244	135,204	140,990	150,783	159,269

		1989-90	1990-91	1991-92	1992-93	1993-94
1. Agriculture, Forestry & Fishing	--	8.48 %	1.86 %	-1.57 %	4.87 %	3.29 %
2. Mining & Quarrying	--	9.09 %	-10.00 %	-6.01 %	11.91 %	6.01 %
3. Manufacturing	--	9.46 %	6.79 %	8.81 %	10.54 %	9.07 %
4. Construction	--	2.90 %	3.10 %	8.10 %	6.50 %	6.00 %
5. Services	--	4.32 %	6.23 %	5.33 %	6.34 %	5.23 %
6. GDP	--	6.17 %	4.61 %	4.28 %	6.95 %	5.63 %

Source: Statistical Abstract of Sri Lanka, 1994

Table 2.4 Structural Changes in the Economy in Percentage

	1989	1990	1991	1992	1993	1994
1. Agriculture, Forestry & Fishing	22.7 %	23.2 %	22.6 %	21.3 %	20.9 %	20.5 %
2. Mining & Quarrying	2.9 %	3.0 %	2.6 %	2.3 %	2.4 %	2.5 %
3. Manufacturing	16.8 %	17.4 %	17.7 %	18.5 %	19.1 %	19.7 %
4. Construction	7.0 %	6.8 %	6.7 %	6.9 %	6.9 %	6.9 %
5. Services	50.5 %	49.6 %	50.4 %	50.9 %	50.6 %	50.4 %
6. GDP	100.0 %	100.0%	100.0 %	100.0 %	100.0 %	100.0 %

Source: Statistical Abstract of Sri Lanka, 1994

(3) Structural Changes in the Economy

There have been structural changes in the economy during the last four decades. Agriculture, which accounted for about 40 per cent of the GDP in 1950, declined to about 30 per cent in 1960, 26 per cent in 1970, 25 per cent in 1980, and 23 per cent in 1990, and a little decreased to 21 per cent in 1994 as shown in Table 2.4. It should be noted that the importance of the agricultural sector is higher than these figures as the crop processing and service sectors depend to a considerable extent on agricultural production.

A major change in the structure of the economy in recent years has been the increased share of manufacturing. Manufacturing industry increased its share from about 9 per cent of the GDP in 1950 to about 17 per cent in 1990, and 20 per cent in 1994. Most of this increase has occurred after 1978. During the period 1978 to 1985, manufacturing output increased by an annual average of 5 per cent. From 1985 to 1989, manufacturing increased by over 6 per cent, and further the GDP of manufacturing industry grew at 8.9 per cent per annum from 1989 to 1994.

The services sector has always been the primary job creating sector covering various activities in the economy. Even in 1950, it accounted for 58 per cent of the GDP, and is currently responsible for about 51 per cent in 1994.

2.2.3 Motorization

A total number of motorized vehicles in Sri Lanka is about 1 million in 1994, of which the motorcycle and the car account for about 60 per cent (606,924 motorcycles) and 20 per cent (210,013 cars), respectively.

The increase in motorcycle ownership is drastic to show the average growth of over 15 per cent per annum during 1986 to 1994, while the car ownership increased at nearly 4 per cent per annum during the same period. The motor vehicle ownership except for motorcycles grew at 5.6% per annum as shown in Table 2.5.

Table 2.5 Motorization Growth in Sri Lanka

Year	Vehicles by Type					
	Motor Car	Buses	Trucks	Motor Cycle	Total	Total w/o MC
1986	155,224	40,214	106,067	187,717	489,222	301,505
1987	147,837	37,064	106,624	213,441	504,966	291,525
1988	155,194	37,977	111,658	240,869	545,698	304,829
1989	163,779	38,609	117,025	307,392	626,805	319,413
1990	173,519	39,147	124,959	391,732	729,357	337,625
1991	180,135	43,259	136,608	450,372	810,374	360,002
1992	189,477	46,162	151,583	516,205	903,427	387,222
1993	197,300	47,692	165,418	570,136	962546	392410
1994	210,013	51,512	180,396	606,924	1,048,845	441,921

Year	Vehicles per Pop. and GDP				
				Ownership Ratio /GDP per capita ***	
	Population*	GDP**	GDP/Population	w/o M. Cycle Ownership Ratio	Total M. Vehicle Ownership Ratio
1986	16,127	114,263	7,085	18.70	30.34
1987	16,361	115,922	7,085	17.82	30.86
1988	16,589	119,050	7,176	18.38	32.90
1989	16,806	121,729	7,243	19.01	37.30
1990	16,993	129,244	7,606	19.87	42.92
1991	17,247	135,204	7,839	20.87	46.99
1992	17,405	140,990	8,101	22.25	51.91
1993	17,619	150,783	8,558	22.27	54.63
1994	17,865	159,269	8,915	24.74	58.71

Note* : Thousand persons
Note** : Million Rupees at 1982 constant prices
Note*** : Rupees at 1982 constant prices
Source: Statistical Abstract 1994 & Department of Motor Traffic.

A motorization rate (to be defined as the number of 4-wheeled motor vehicles per 1000 inhabitants) in Sri Lanka has increased from 19 in 1986 to 25 in 1994, and its level is almost equal to such countries in 1992 as Peru(29), Guatemala(27), Ecuador(27), El Salvador(22), Honduras(28) and Paraguay(24). Compared to such South Asian countries as Bangladesh(1), India(4) and Pakistan(6), the motorization level in Sri Lanka is ranked high, and even higher than that of Indonesia(16) and the Philippines(10), but lower than that of Thailand(52). They are in Table 2.9 and Figure 2.3.

2.3 Future Socio-Economic Framework

2.3.1 National Development Policy and Economic Growth

(1) National Development Policy

The Government of Sri Lanka delivered in September 1994 the Economic Policy Statement as follows:

oThe Government stands committed to build a strong national economy within a market framework.

oThe maintenance of a stable macro-economic and financial framework is conducive to the reduction of inflation, the pursuit of rapid economic growth, the creation of productive employment opportunities, and the equitable distribution of the fruits of development.

oThe principal engine of growth is expected to be the private sector, both domestic and foreign.

oThe medium term goal by the year 2000 is to attain 8 percent GDP growth annually with continuing emphasis on export led growth and encouragement of the private sector.

oAn important new pole of growth in the economy would be the development of an export-oriented services sector by exploiting the unique geographical opportunity conferred on Sri Lanka by its location at the hub of a potentially dynamic South Asian region. The vision is for Sri Lanka to become the principal regional financial services and trans-shipment center, with preferential access to the regional market being obtained either through an acceleration of the SAARC process of regional cooperation, or by suitable bilateral preferential arrangements, as for example with India.

(2) Projection of Future GDP

According to the Draft Public Investment Programme 1995-1999, which was

prepared in April 1995, the GDP and Per Capita GDP of the five years period are stated that the Gross Domestic Product (GDP) is expected to increase at an average rate of 6.9 per cent per annum. This implies an average per capita income growth of about 5.7 per cent per annum.

After the Draft Programme was issued civil conflicts occurred again in Trincomalee in the middle of April 1995, and the armed struggles escalated in Northern and Eastern regions of the country. But, it is said the conflict was quiet after the re-control of Jaffna by the government in late 1995. Review of the Draft Programme begun already but it is not finalized yet in January 1996.

The expected GDP growth in the Draft Programme is based largely on rise in overall levels of investment by creating a policy environment conductive to investment, and by ushering in an era of peace and stability in the country. It is, therefore, assumed that the future growth of GDP should be expected to grow conservatively rather than challenging as being stated in the Draft Programme 1995-1999. Consequently, a historical trend of the per capita GDP growth during 1990-1994, that is 4 per cent per annum is adopted to derive the future economic framework in 2010.

2.3.2 Future Population Projection

(1) Total Population

(a) National Total

The Department of Census and Statistics made a set of projections, i.e. standard, high and low levels, in a time horizon from 1991 to 2031. The best estimate made by the Department is 17.3 million population in 1991, and which is assumed to grow continuously to 19 million when stepping in to the next century and then to over 23 million by 2031. Depending on the extent to which future progress of fertility, mortality and migration will favor or arrest growth, the final population is estimated as high as 25 million or as low as 20 million. The standard population projection was adopted as an imperative socio-economic framework that will significantly effect the growth of a future traffic demand, and it is presented in Table 2.6.

Table 2.6 Future Population Projection in Sri Lanka

Year	Population (in thousand)	Annual Average (growth rate in %)
1995	17,940	-
2000	18,830	0.97
2005	19,780	0.99
2010	20,690	0.90

(b) Provincial Population

Provincial distribution of the projected national population was based on the study result of "Sectoral Consultancy Study for National Economic Development in Sri Lanka", conducted recently by PCI in 1994.

A basic structure of the national economic development is proposed in the above study to constitute three trunk corridors and three sub-corridors as described below:

Trunk Corridors:

o Northern Bound Corridor (Colombo-Puttalam);
o North-Eastern Bound Corridor (Colombo-Trincomalee); and
o Southern Bound Corridor (Colombo-Galle-Matara)

Sub-Corridors

o Jaffna Sub-Corridor (Jaffna-Dambulla)
o Kandy Sub-Corridor (Kandy-Ambepussa)
o Ratnapura Sub-Corridor (Colombo South-Ratnapura)

These corridor development are proposed where economic activities are significantly vital and be capable of accommodating further investment for new business and social services because of the higher accessibility and market integration. The corridor development approach implies not only highway development but also provision of basic infrastructure such as power, water, telecommunication cum alongside industrial development.

As the consequence, a higher increase in population was assumed to take place in western, southern and north-western provinces.

(c) District Population

A future district population was based on the past trend of population growth in the respective districts, and a provincial total of its member districts' population was adjusted to agree with the previously determined framework of the provincial population. The estimated future District population is presented in Appendix D-4

(2) Urban Population

(a) National Total

Among the limited data available for regional characteristics, the urban population is one of important statistics to describe socio-economic situation of the regions. According to the census results, the urban population grew at about 1.5 times faster than the total population as shown in Table 2.7.

Table 2.7 Comparison of Total and Urban Population Growth

Year	(a) Growth Rate of Urban Pop (%)	(b) Growth Rate of Total Pop (%)	Comparison (a)/(b)
1891-1981	2.58	1.79	1.441
1946-1981	3.30	2.32	1.422
1953-1981	3.44	2.19	1.571

Applying the above relationship, the 1995 urban population was estimated at 4,306,000 persons which implies an urbanization rate (percentage urban population over the total population) increased from 21.5% in 1981 to 24.0% in 1995.

As envisaged in the past census data, a recent urbanization is likely to proceed at a higher speed than ever experienced in Sri Lanka. Although liberalization of market economy and industrialization process will encourage the urbanization speed it is aware that the excessive urban concentration of the development brings about enormous defects in the social and economic systems of the urban area. Therefore, it was assumed not to apply more than the highest rate of urban growth experienced in Sri Lanka, that is 3.44% per annum; and which will result in the urbanization rate to be about 35% in 2010. Eventually, the 35% urbanization rate in 2010 was adopted and those to be applied to the intermediate years of 2000 and 2005 were estimated by the interpolation between 1995 and 2010, as presented in Table 2.8.

Table 2.8 Estimated Future Urban Population in Sri Lanka

Year	Urban Pop. (in thousand)	Urbanization Rate (%)
1995	4,306.0	24.0%
2000	5,209.9	27.7%
2005	6,197.9	31.3%
2010	7,241.5	35.0%

(b) Provincial Urban Population

Annual average growth rates of the respective provincial urban population during 1891-1981 are found most stable, though lowest in rates of increase compared to other time duration. Therefore, these rates were adopted as basic potential of the urban population growth of the provinces.

A balance derived from the totaled basic potential of the provincial urban growth and the previously determined national total of the urban population was distributed taking into account such regional development strategies as:

o Western, Southern and North-Western provinces will be given relatively higher priority for infrastructure development in the early stage;

o Northern and Easter provinces will commence the substantial recovery of economy with the assurance of social and political stability in the medium term of development. The urban growth in Western province will gradually slow down; and

o Western province will continue to reduce the urban population growth towards the target planning year of 2010.

The derived future urban population by Province is presented in Appendix D-4.

(c) District Urban Population

A relationship found between the total population growth and the urban population growth of the respective districts was employed to estimate the future district urban population, of which totals were adjusted to comply with the previously determined provincial totals of urban population. The estimated future urban population by District is summarized in Appendix E.

2.3.3 Future Motorization Estimate

A future motorization was estimated by the regression analysis of per capita GDP and registered motor vehicles during the years of 1986-94 shown in Table 2.5. The regression equation is derived eventually as follows:

$$\ln Y = 1.252 \ln X - 8.197 \qquad R^2=0.958$$
$$(t=12.587) \quad (t=-9.204)$$

where,
Y: Motor Vehicles per 1000 population
X: Per Capita GDP at 1982 constant prices

A future per capita GDP has been assumed to grow at 4.0% on average, and it will, therefore, reach Rs. 16,698 (at 1982 constant price) in 2010 from Rs. 8,915 in 1994. This will result in the motorization rate of 52.2 motor vehicles per 1000 population, which is more than double (or 5.7 % annual average increase in vehicle ownership) as much as the motorization in 1994 (24.7 motor vehicles per 1000 population).

The overall growth rate, which takes into account the growth rate of population, is estimated at 5.7 % per annum. The growth of ADTs in total is:-

1995 - 2000 (5 years)	1.32
1995 - 2010 (15 years)	2.30

This motorization level was compared with the experience in other countries corresponding to their levels of per capita GNPs as shown in Table 2.9 and Figure 2.3, and as the consequence, the future motorization level estimated above was considered acceptable.

The derived motorization growth will be utilized to control a future growth of vehicle-kilometers, which are aggregated by observed/estimated traffic counts in 1995 and a road length of the pertaining road sections.

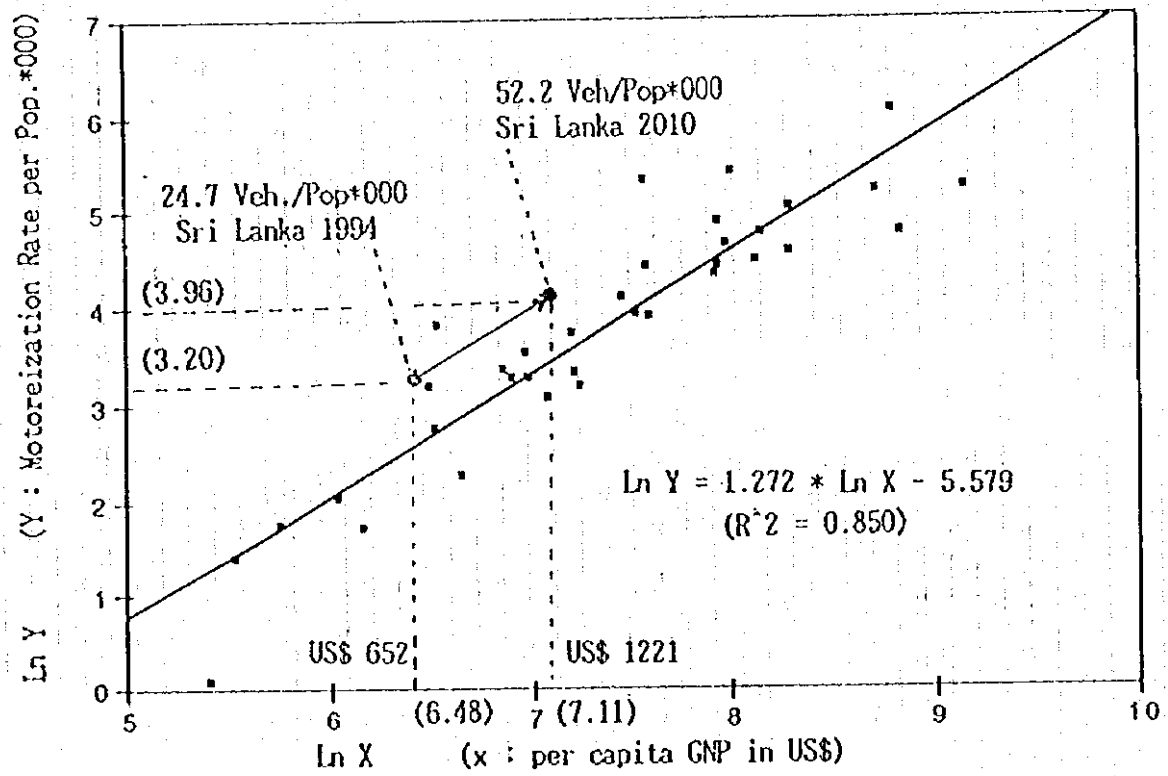

Figure 2.3 Relationship Between Motorization Rate and Per Capita GNP

Table 2.9 Comparison of Motorization Rates of Selected Countries

1992				
Country	Motorized Veh.	Population (in 000)	Per Capita GNP	M.Veh./ 1,000 Pop
Bangladesh	130,000	119,412	220	1.09
Lao PDR	18,000	4,440	250	4.05
India	5,203,271	886,362	310	5.87
Pakistan	944,500	121,665	420	7.76
China	6,556,600	1,169,620	470	5.61
Sri Lanka *	441,921	17,865	652	24.74
Indonesia	3,088,651	195,684	670	15.78
Bolivia	335,000	7,323	680	45.75
Philippines	656,138	67,114	770	9.78
Peru	671,485	22,768	950	29.49
Guatemala	260,000	9,784	980	26.57
Dominican R.	260,000	7,515	1,050	34.60
Ecuador	295,600	10,933	1,070	27.04
El Salvador	123,000	5,574	1,170	22.07
Colombia	1,470,000	34,296	1,330	42.86
Honduras	140,000	4,949	1,340	28.29
Paraguay	120,000	4,929	1,380	24.35
Tunisia	525,000	8,445	1,720	62.17
Thailand	3,016,453	57,624	1,840	52.35
Poland	7,889,869	38,386	1,910	205.54
Costa Rica	267,700	3,187	1,960	84.00
Turkey	2,997,632	59,640	1,980	50.26
Chile	1,045,700	13,529	2,730	77.29
Brazil	13,298,800	158,202	2,770	84.06
Malaysia	2,492,800	18,411	2,790	135.40
Venezuela	2,225,000	20,676	2,910	107.61
Hungary	2,347,248	10,333	2,970	227.16
Uruguay	281,300	3,142	3,340	89.53
Mexico	10,900,000	92,380	3,470	117.99
Panama	244,300	2,530	3,940	96.56
Trinidad & Tobago	203,626	1,299	3,940	156.76
Argentina	5,970,775	32,901	6,050	181.48
Puerto Rico	1,595,328	3,777	6,590	422.38
Korea, Rep.	5,230,894	44,149	6,790	118.48
Taiwan	3,967,600	20,879	9,329	190.03

Source: Statistics of the World, 1994 (Bureau of Statistics Japan, 1994 in Japanese)

* Sri Lanka for 1994

2.4 Traffic Demand Analysis

2.4.1 1995 Traffic Volumes

Traffic count data are available for most of Class A and B road sections other than those in Northern and Eastern Provinces.. However, the count survey is carried out not annually but some years regular/irregular intervals or in ad hoc at selective fixed stations. Accordingly, 1995 traffic volumes are not necessarily available for all the sections of Class A and B roads.

Stratified growth rates of traffic volumes were analyzed from the past traffic count data of each province. The stratification of the traffic volume data, which include motorcycles, was made for such daily traffic bands as 0-5000, 5001-15000, 15001-30000 and 30001-over, and the aggregated growth rates of the traffic bands are derived as shown in Table 2.10.

Table 2.10 Annual Average Growth by Traffic Bands and Province

Province	0-5000	5001-15000	15001-30000	30001-Over
Western	8.5%	8.7%	7.4%	4.9%
Central	8.5%	7.6%	6.3%	n.a.
Southern	6.9%	8.6%	n.a.	n.a.
North Western	5.3%	7.0%	n.a.	n.a.
North Central	9.0%	7.0%	n.a.	n.a.
Uva	8.0%	n.a.	n.a.	n.a.
Sabaragamuwa	3.8%	5.3%	n.a.	n.a.

Western Province followed by Central Province has a wide variety of stratified traffic volumes, but Uva Province has only road sections confined to small traffic volume less than 5000 vehicles per day. Southern, North Western and North Central Provinces hold a road network with traffic volumes up to 15000 vehicles per day. Likewise, a road network in Sabaragamuwa Province shows the traffic volume up to 15000 but their growth rates are relatively lower than other Provinces.

Adopting the above growth factors traffic volumes were estimated for road sections where 1995 traffic data are not available. The 1995 traffic volumes are diagrammed in Figure 2.4.

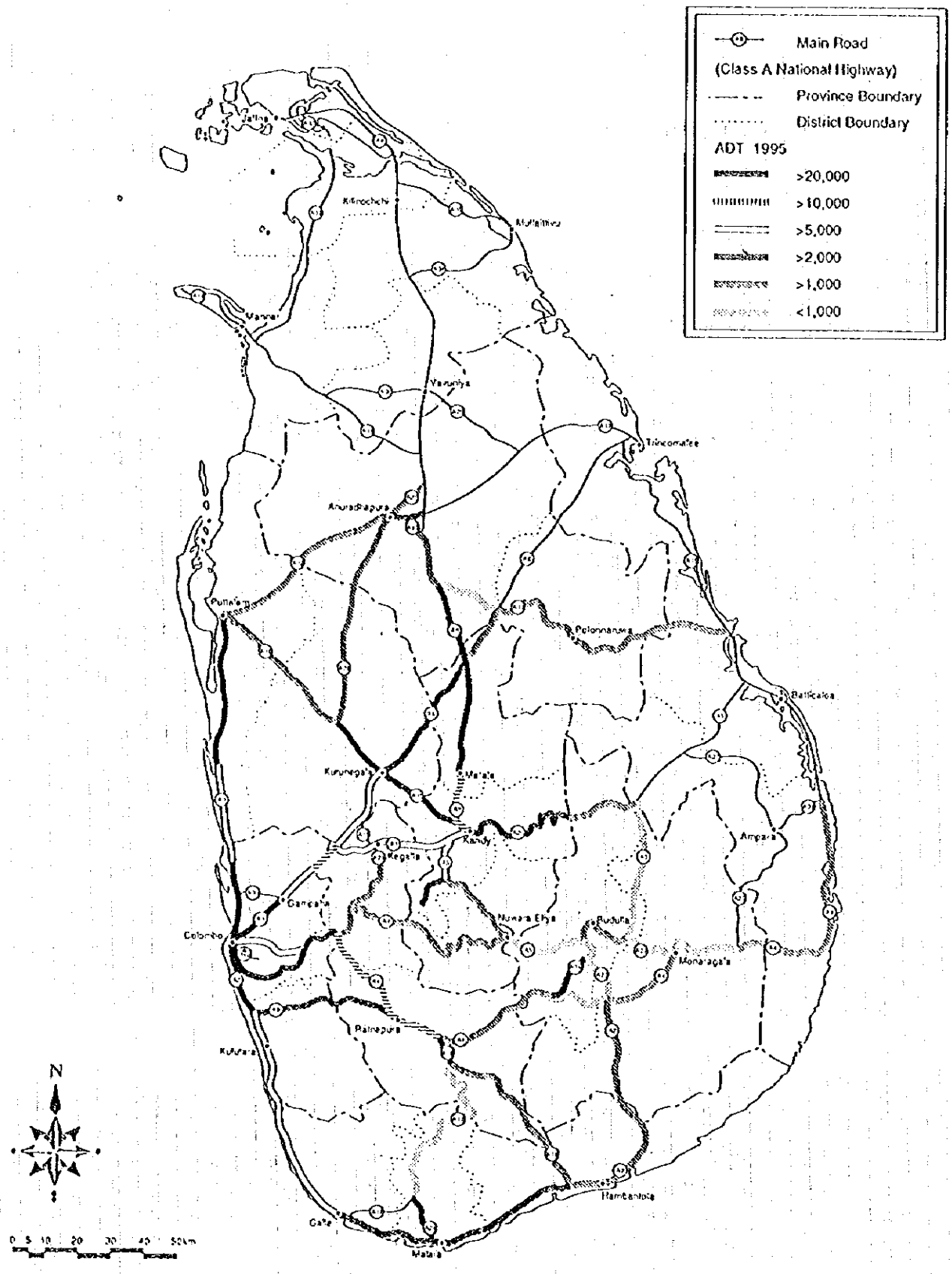

Figure 2.4 Estimated 1995 Traffic Volumes on Class A Roads

2.4.2 Traffic Growth by Road Section

A nation wide origin-destination table of vehicle trips is not available in Sri Lanka, so that it was considered imperative to derive elements that represent not only the trip production/attraction power but also the strength of linkage between origin and destination of the trip. As the consequence, the following method was employed to estimate an indicative strength of linkage between one zone (district) and another. That is, the linkage strength between the two zones will be defined by the size of urban population and distance.

The future urban population by district has been estimated previously in the section 2.3.2 "Future Population Projection". Road distance is available from the RDA data source. Therefor, a minimum route path is searched by the computer to determine the road distance for different combinations of zone pairs. The indicative linkage strength is expressed in the following form:

$$ILSij=(Pi \times Pj)^{(1/2)}/Dij$$

where, ILSij: Indicative Linkage Strength between Zone (i) and (j)
Pi, Pj: Urban Population in Zone (i) and (j)
Dij: Kilometer distance between Zone (i) and (j)

The above calculation filled out the origin/destination zone table, which is comprised of 25 zones(districts). This ILS zone table will be assigned to the road network to find a compound ILS accumulated as the assignment result. This process is repeated for the planing years 1995, 2000, 2005 and 2010.

The derived compound ILSs on respective road sections are compared among the planning years, and a rate of ILS increase on one road section is estimated between the two planning years. Accordingly, preliminary growth factors of the 1995 traffic volumes will result for the respective road sections.

In the case of Route A and AB, multiplying the above growth factor to the relevant 1995 traffic volume and distance of the road section, and aggregated those vehicle-kilometers for the years 2000, 2005 and 2010. The resulting increase in the aggregated vehicle-kilometers during 1995-2000, 2000-2005 or 2005-2010 will not coincide with the previously determined increase of the national total traffic demand in terms of vehicle-kilometers. Therefore, the vehicle-kilometers of the respective road sections were finally adjusted to conform with growth rate of the national control total for every planning year as presented in Appendix D-1. In the case of Route B, the estimated growth ratio is estimated similar way and shown in Appendix D-2. It is found the general trend of increase is 5.7% per annum in the future years in those tables.