NATURAL RESOURCES, ENERGY
AND SCIENCE AUTHORITY OF SRI LANKA

ACCESS - MOBILITY IN INDUSTRIAL LOCATION

Dr. Nagananda Jayawardene

URBAN DEVELOPMENT AUTHORITY
OF SRI LANKA

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The book is printed and published by the Urban Development Authority of Sri Lanka

Dr.Nagananda Jayawardene

With his B.Sc. Eng. degree from the University of London he joined the the Public Works Department in 1951 as an Asst. Engineer. In 1969 he was appointed to the Dept. of Highways. From 1971 to 1975 he worked at Senior Management Level in the Ministry of Highways.

He obtained his training in the U.K., Thailand, Australia and India. In 1976 he took the initiative in establishing the Centre for Transportation Research in Sri Lanka. For some time he worked in the USA with transportation consultants. He worked with the Colombo Master Plan from 1978 and thereafter with the Urban Development Authority.

In 1990 he was awarded the Ph.D. for his research by the University of Colombo and was given an Award of Merit in the Physical and Engineering Sciences by the Natural Resources, Energy & Science Authority of Sri Lanka

He has many papers to his credit and has presented several papers at International forums. As a consultant and team member he has worked in Sri Lanka on many of the World Bank, Asian Development Bank, U.N assissted transportation projects.

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ACCESS - MOBILITY
IN
INDUSTRIAL LOCATION

Dr. Nagananda Jayawardene
B.Sc. Eng. (Lon.); Dip. Eng.; Ph.D.;
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URBAN DEVELOPMENT AUTHORITY
OF SRI LANKA

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May this effort contribute to the

Welfare of the Many.

Dedicated to

My Loving Parents

FORWARD

One of the functions of the Natural Resources, Energy & Science Authority of Sri Lanka (NARESA) is to award grants annually for scientific research in different disciplines with the aim of enhancing research capabilities and knowledge among scientists. In this connection every effort is made to provide researches with the facilities and funds they need to carry out the work planned. The progress of projects are monitered by the respective working committees and once the projects are completed the results are published and made available to other scientists.

Industry, infrastructure and energy play major roles in fostering economic growth in developing countries. Dr. Nagananda Jayawardene who chose this sphere of work for his research has made a valuable original contribution regarding the inter-relationships in these sectors. Besides the applicability of the information and the results of the research among other scientists he has shown how the analysis could be used in planning and policy formulation. Further, based on the research findings he has formulated a major programme for the development of the Colombo Metropolitan and the Southern Regions in the country.

The research work carried out resulted in his being awarded the Degree of the Doctor of Philosophy by the University of Colombo. The working committee on Physical and Engineeering Sciences of NARESA was of the view that a monograph should be prepared to enable the work to be widely circulated locally and abroad. This would give the author the recognition he deserves.

I thank the Urban Development Authority of Sri Lanka for undertaking to print and publish this important work.

47/5, Maitland Place,
Colombo 7.
Sri Lanka.
April 1992.

Dr. R. P. Jayawardene
Director General
Natural Resources, Energy & Science,
Authority of Sri Lanka

PREFACE

Access-Mobility in the Location of Industry is a well documented comprehensive study of the inter-relationships between such factors as industrial location, transport infrastructure, mobility, demographics, land pricing and income and travel characteristics of urban workers. Several valuable statistical and network analysis techniques have been applied in an original manner in dealing with the complex problem of industrial location and access-mobility. The research findings are well illustrated with several graphical, tabular and other methods. It is a valuable resource for other analysists.

Dr. Nagananda Jayawardene has shown detailed understanding of the theories of industrial location, network analysis and transportation systems. This is highlighted by his detailed methods of analysis. Penetrating deeper into the subject his analysis has confirmed and illustrated certain hypotheses regarding the inter-relationships between the sectors. I am confident that the author was able to produce this high quality of research due to his long years of expertize in transportationsector in this country and abroad and his twelve years of experience with the Colombo Master Plan and the Urban Development Authority.

This work is a significant contribution for development planning of the Colombo Metropolitan Region in relation to industrial location. The study helps to fill the vacuum that exists in the transport and industrial sector planning in the Colombo Metropolitan Region. In decision making this work will be very useful to planners and policy makers.

The author has been able to deduce successful conclusions regarding industrial development policies and these have lead him to formulate a major spatial and transport development strategy for the region.

Dr. Nagananda Jayawardene has been given an Award of Merit for this research work in the Physical and Engineering Sciences by the Natural Resources, Energy & Science Authority of Sri Lanka(NARESA).

I am therefore, very glad to introduce this work as the first independent research study in an important area of the economy which will be very useful to planners and policy makers. It should be stated that the Government has also laid great emphasis on a break through in the National Economy by accelerating industrialization. This research work is thus timely. The Urban Development Authority therefore, takes great pleasure in publishing this valuable document.

27, D.R.Wijewardene Mawatha,
Colombo 10,
Sri Lanka.
April 1992.

S. W. P. Bulankulame
Chairman,
Urban Development
Authority of Sri Lanka

ACKNOWLEDGEMENT

This research work was made possible due to the generous grant from the Natural Resources, Energy and Science Authority of Sri Lanka and the computer and reproduction facilities I availed at the Urban Development Authority. I acknowledge this gratefully. I thank the staff of these two organizations for the assistance they rendered me during the course of this project and the invaluable encouragement I recieved.

I wish to thank and acknowledge the assistance of the Department of Census and Statistics and it's Industrial and Trades Division, the Central Bank of Sri Lanka, the Sri Lanka Ports Authority, the Department of Highways, the Road Development Authority, the North and South Regional Transport Boards, the Commissioner of Motor Traffic, the Survey Department, the Valuation Department,, the Universities of Moratuwa and Colomboand the Transport Center.

.I wish to thank my colleaguesand other officers in the various institutions and the students who were involved in the project for their cooperation and unstinted assistance they rendered me to make this research project a success.

My special thanks are due to the Urban Development Authority for sponsoring and publishing this research work for the benefit of the many.

Finally, a word of gratitude to my wife Nalini and my children for sacrificing their leisure and the encouragement I had during this work.

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ABSTRACT

In developing countries such as ours infrastructure and energy are crucial factors in development. Work on infrastructure is costly and energy usage involves the high levels of foreign exchange. Therefore, to optimally locate economic activity such as manufacturing industry the aim should be to maximize the use of infrastructure and the savings in energy.

The Colombo Urban Area and the Area of Authority of the Greater Colombo Economic Commission which lies within the Colombo Metropolitan Region forms the most developed part of the country. It is high in resources and therefore has high potential for further industrial development.

The research study is structured on the basis that the demand for travel is due to the interaction of socio-economic factors, infrastructure parameters and vehicle operating performance. The data sources were obtained from government departments and other organizations. A sample survey was also done to supplement the data.

The survey revealed that approximately one fourth of ali industries, a little over one third of employment with output and value added of nearly two thirds is concentrated in the Colombo Metropolitan Region. Analysis of population, employment and industry show remarkably close parallel growth in four stages indicating definite threshold levels. Further analysis of industry highlighted that there are five stages in the industrial growth pattern. Locational analysis emphasized the clustering of industry around the City of

Colombo and the very dominating role of the Colombo Municipal Area and the AGA division of Nugegoda. There is also

a sharp disparity in location with most of industry in the north and northwest coastline and very low intensity in the east, south and south east. These show almost parallel relationships to traffic flow patterns.

The role of access is shown by the very close relationship to network factors such as the densities of intersections, links and mileage and affinity to the shape and beta functions.

The influence of mobility is illustrated in two ways. The density of vehicular traffic and it's close relationship to industry in the study zones shows the effect on both vehicles and persons and the magnitudes of traffic at intersections. On the other hand, the relationship of transport. particularly to density of seat kilometers used by 80 to 87% of the workers shows the influence of location on the Public Bus Transport system.

The study has revealed the close affinity between access-mobility and industrial location. This understanding enabled a comprehensive multi-sectoral programme involving industry, transport and urban sector development to be formulated for the Colombo Metropolitan and the Southern Region as detailed in the study. It has also emphasized the importance of a clear, cogent and enlightened policy formulation if the goals are ecconomic advancement and substaintial increase in employment. Relevant areas where further research could be carried out with advantage have also been outlined.

ABBREVIATIONS

CUA	Colombo Urban Area
CMA	Colombo Municipal Area
CSA	Colombo Sub-Urban Area
GCEC	Greater Colombo Economic Commission
AGA	Assistant Government Agent
ISIC	International Standard Industrial Classification
UN	United Nations
SLTB	Sri Lanka Transport Board
GS	Gramasevaka Division
MC	Municipal Council
UC	Urban Council
TC	Town Council
DOH	Department of Highways
RDA	Road Development Authority
RTB	Regional Transport Board
SLCTB	Sri Lanka Central Transport Board

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1

INTRODUCTION

1.1 Introduction

The development of modern society entails two important functions, namely;

The need to go for regular work

The urge to produce and consume goods

The journey to work demands safe, economical and swift movement from the home to the place of work and back. The demand for consumption goods require the movement of raw materials to factories and the produce to wholesalers and retailers. The solution of the problems created are approached in two ways-the classical and the alternative. **The classical approach strives to make movement smoother and faster**. The **emphasis** is on the **transport function.**

The solution lies in the improvement or the construction of better roads and in the betterment of the means of movement using such vehicles as modern buses, electric trains etc. But this action generates more traffic, increases congestion and complicates the whole problem.

On the other hand, an attempt could be made to **minimize the need to move**. In this case the **greater attention** is on the **spatial relationship**. The focus is on where **journeys begin** and where **journeys end.**

The prime concern is on the reduction of passenger miles—which is an index to movement—for a given number of journeys. Perhaps the better solution lies in a mix of the strategies.

Transport thus forms the single most significant factor in creating the urban form and structure. It is most effective in the choice of links to form growing towns, in structuring a metropolitan area or an economic zone and in creating a balance between urbanization and the spread of industries. **This study is an attempt to explore this sphere of activity.**

1.2 Research Objectives

Energy and infrastructure are crucial factors for development. In the developing world it is in these areas that constraints are high. A large proportion of energy in the form of fossil fuel is imported at very high costs and consume a substantial amount of foreign exchange earnings. In the development of infrastructure the increased expenditure is involved in land acquisition, construction and maintenance costs.

All forms of transport necessitate the use of a road system at the origin and destination of every journey. Furthermore, all other infrastructure development patterns follow the road network. The **optimum location of economic activities** therefore, would aim at **substantial savings in energy usage with a maximum use of infrastructure capacity.**

The access to land is determined to a great extent by the road network. The mobility on the other hand, is mainly controlled by the type and variety of vehicles used. The degree of access and level of mobility have been considered at various stages independently of each other in the location of industry. **The present task is to examine access -mobility as a conjoint function in the location of industry.**

1.3 The Research Proposal.

The Colombo Urban Area and the Area of Authority of the Greater Colombo Economic Commission have a fairly developed road network. A very considerable proportion of vehicles in the country are registered in this area. These areas also contain a high concentration of industries. **These two areas are likely to**

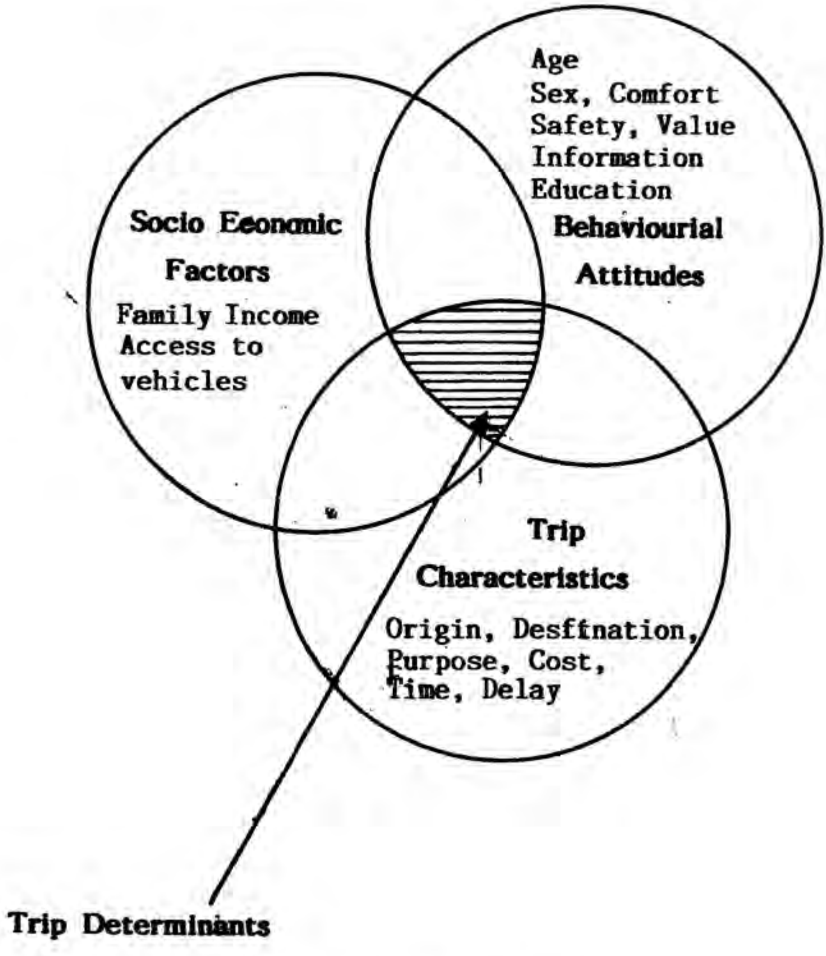


Figure 1.1

Characteristic Determinants of Trips

Source : Author

become the base for future industrial expansion in the island. Hence the **aim of this study** is to **analyse the functioning of these two** areas with respect to the **conjoint phenomena of access-mobility** and to find out how it affects industrial location. In doing so, the research would probe and examine;

> The **location of industries**, the **distribution** of the **working population** and their **travel characteristics.**
>
> The **network hierarchy, extent of the road** infrastructure
>
> **Growth of vehicle populations of various kinds and their distribution and use on the present network.**
>
> **Distribution of the working population**, and the **levels and use** of the **public transport systems;**

In the light of the analysis an attempt would be made to ascertain to what extent accessibility and mobility have acted as factors in determining the location of industries. It may be possible to deduce indices of access-mobility for possible *optimal location of industry in the future*.

1.4 The Conceptual Model

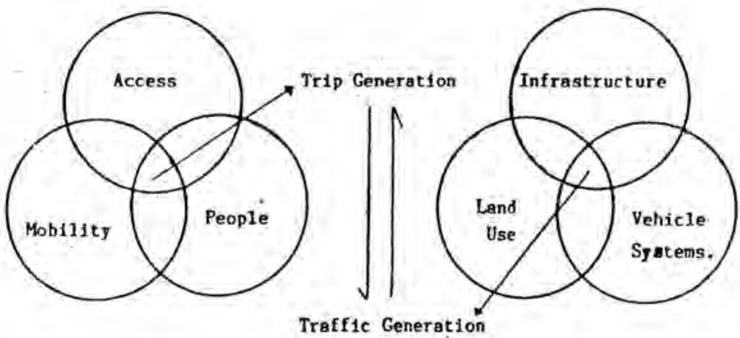
1.4.1 Access-Mobility Function

The movement of goods, people and services are related to personal characteristics such as age, sex, income, education, employment etc. It is also associated with the spatial dimension such as the location of infrastructure, cost of travel and the availability of travel modes as illustrated in figure 1.1

Performance of Infrastructure

Cul-de-sac

access roads.
distributor.
arterial.
express way.
rail stations.
bus stations.
air ports.
harbours.



Performance of vehicles systems.

bicycles.
cars.
coaches.
trucks.
ships.
aircraft.

Figure 1.2

Access - Mobility - Interaction.

Source : Author

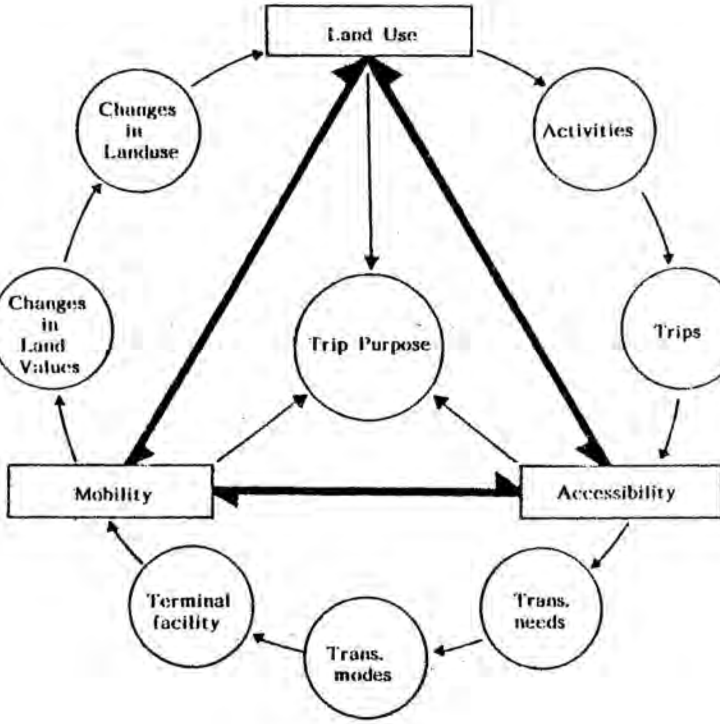


FIGURE : 1.3

LAND PRICE LINKS TO ACCESS - MOBILITY

To achieve these objectives two very important interlinking factors are necessary. They are ;

A means of access to land

A mode of movement.

These bring out the notions of **accessibility** and **mobility.**

1.4.2 Access and Mobility

Access and accessibility have a wide range of connotations in various transport literature. But in this conceptual formulation it has a specific and limited meaning.

Access is defined as the ability or the degree of opportunity to penetrate a parcel of land which is exploited for a specific purpose. Mobility is defined as the opportunity to use a mechanical device to get from one place to another.

Access to a parcel of land generates varied activities which in turn condition the ownership and use of different types of vehicles and vehicular systems. **Thus a means of access and a mode of movement become predominant factors in the location of activities.** The degree to which the land resource is exploited is therefore, greatly influenced by the level and standards of accessibility and mobility. As illustrated in figure 1.2 this interaction between people, access and mobility determine the kind and intensity of **trips** generated. The consequent interaction of land use functions, infrastructure and vehicle systems result in the generation of **traffic,** figure 1.2. Thus **land use, infrastructure and vehicle systems form a dynamic system.** All three factors keep on changing both in time and space. The figure 1.3. illustrates the dynamics of the transportation process.

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2

METHODOLOGY AND DATA ANALYSIS

2.0 Methodology and Data Analysis

2.1 Basis of the Study

The general **structure of the study** is based on the premise that the **present demand for travel** is due to the **interaction of socio-economic factors, infra-structure functions and vehicle operating system performance.** These travel patterns are repetitive and predictable.

An attempt is therefore, made to understand ;

1. **The inter-relationships if any, between the type, size and location of manufacturing industry and the role of transportation as it affects the work force, their residential location, their travel patterns, and the related expenditure on travel.**

2. **The inter-relationships between type, size and location of manufacturing industry and the role of the network performance on transport efficiency.**

Through this understanding it may be possible to isolate the more important **factors** which have **influences on industry** and the **work force** so that they may be manipulated to bring about **greater efficiency** and **cost reduction in transport in future.**

It may be possible to bring about any necessary **policy changes** in the provision of **infrastructure, vehicle operations and location of industry** needed for **accelerated development**

The conceptual model showed how trips and traffic are inter-related. It also demonstrated the associated factors with each of them, such as people, access and mobility for trips and land-use, and infrastructure and vehicle systems for traffic. They are all related to an **origin** and a **destination.** The accompanying

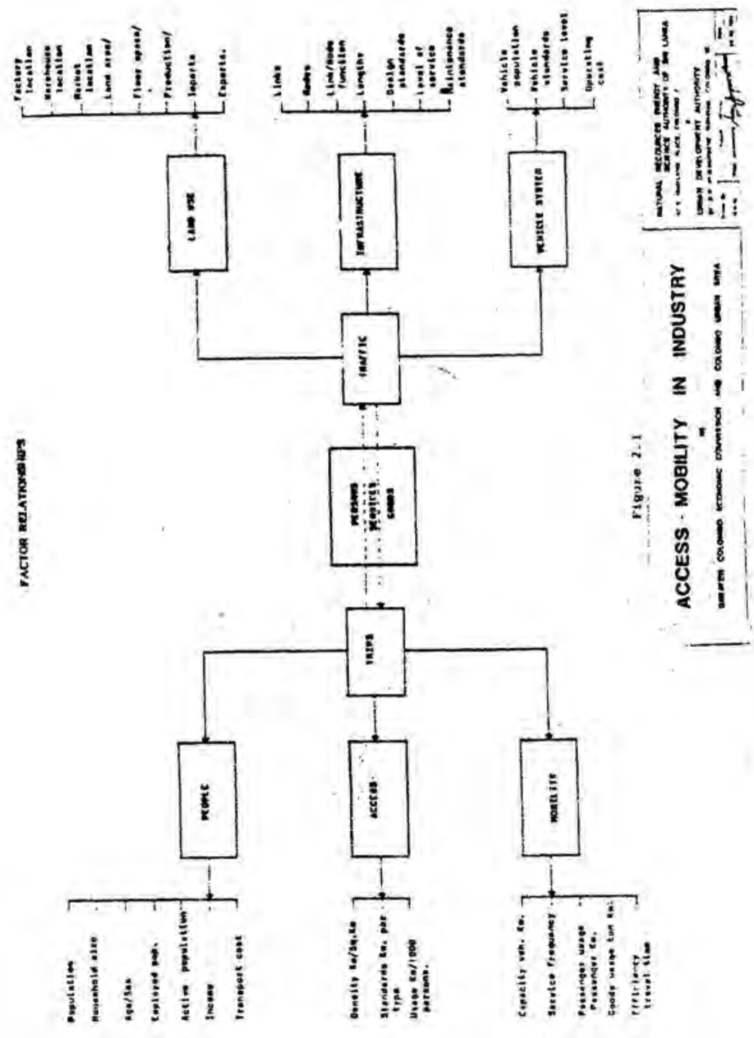

FACTOR RELATIONSHIPS
LAND USE
INFRASTRUCTURE
VEHICLE SYSTEM
TRAFFIC
PERSONS
VEHICLES
GOODS
TRIPS
PEOPLE
ACCESS
MOBILITY
ACCESS - MOBILITY IN INDUSTRY

Figure 2.1

diagram 2.1 shows the **factor relationships** of the **parameters** involved and some of the **units of measurement.**

2.2 The Methodology

The methodology is a direct sequence of the development of the conceptual model. The flow diagram 2.2 illustrates the methodology adopted.

The conceptual model suggests **six factors of interaction, namely people, access, and mobility on the one hand and land-use, infrastructure, and vehicle system** on the other. Consideration of these factors enable the formulation and identification of the problems within the stated objectives.

The first stage then was the analysis of the national situation with respect to industry, transport infrastructure and vehicle operating systems. This analysis produced the guidelines for limiting the above factors to **manufacturing industry, highway infrastructure and public transport system** and the criteria for the choice and limitation of the area of study to the **Colombo Metropolitan Region(CMR).** Further analysis of the size and location of the industries showed that the more dominant areas are the **Area of Authority of the Greater Colombo Economic Commission (GCEC) and the Colombo Urban Area(CUA).** Since the **Colombo Municipality (CMA)** enjoys a unique position as the Capital and the largest City it is given special consideration.

After the project was defined a search was made for relevant literature, an assessment of the data sources available, and of those data that may be required for the study.

The primary sources of data were the relevant inputs from the Department of Census and Statistics and its special Industrial

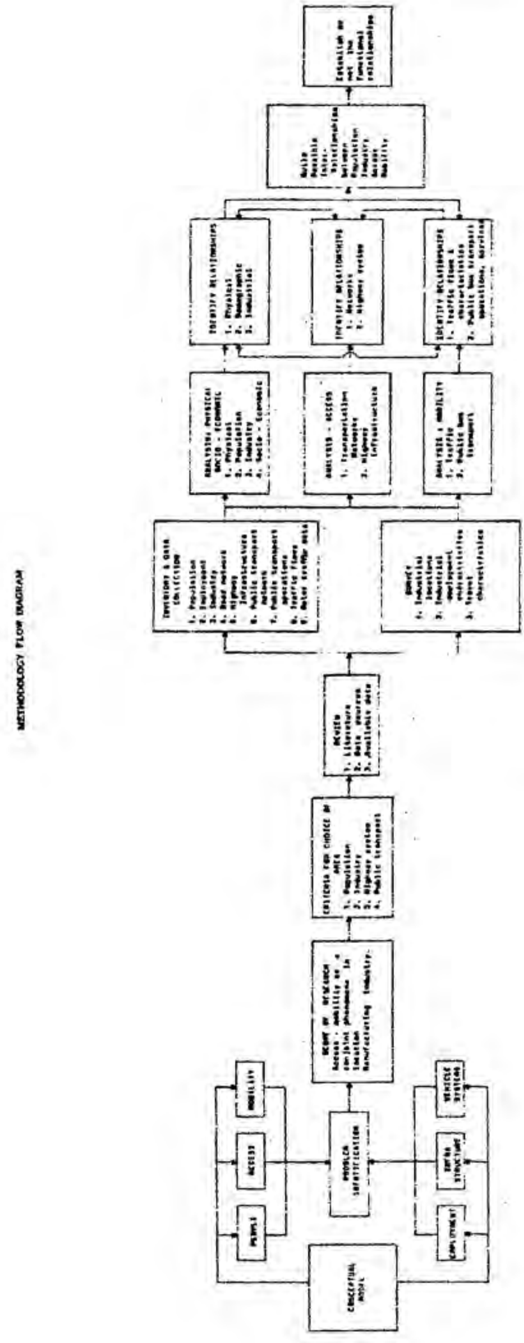


Figure 2.2

ACCESS - MOBILITY IN INDUSTRY

IN

GREATER COLOMBO ECONOMIC COMMISSION AND COLOMBO URBAN AREA and Trades division, the Central Bank, the Department of Highways, the Sri Lanka Transport Board, the North and South Regional Transport Boards, the Commissioner of Motor Traffic, the Survey Department, the Valuation Department, the Universities of Moratuwa and Colombo, and the Urban Development Authority.

No data was available relating to the personal travel patterns and characteristics of industrial workers. Hence, manufacturing industrial sites were surveyed employing standard sampling techniques and administering a questionnaire to obtain the location, type of industries and particulars of industrial workers. The manufacturing industrial data, the highway infrastructure and public transport data were analysed to study the location, structure and development patterns. The inter-relations between the varied factors were examined and mathematical relationships were developed.

2.3. The Data Base

A simplified data base was adopted for data collection, analysis, interpretation and presentation. The scope and form of the data to be collected were related to:

1. **The use of such data.**
2. **The time frame available for the study.**
3. **The budget provision.**

The data base was formed in relation to socio-economic factors, industry, highway system and the public transport system. The study area was divided up into zones on the basis of suitability for data collection and a network corresponding to the zonal system. In this study the optimal size of the standard zone is taken as the area of an Assistant Government Agent's Division (AGA division figure 2.3).

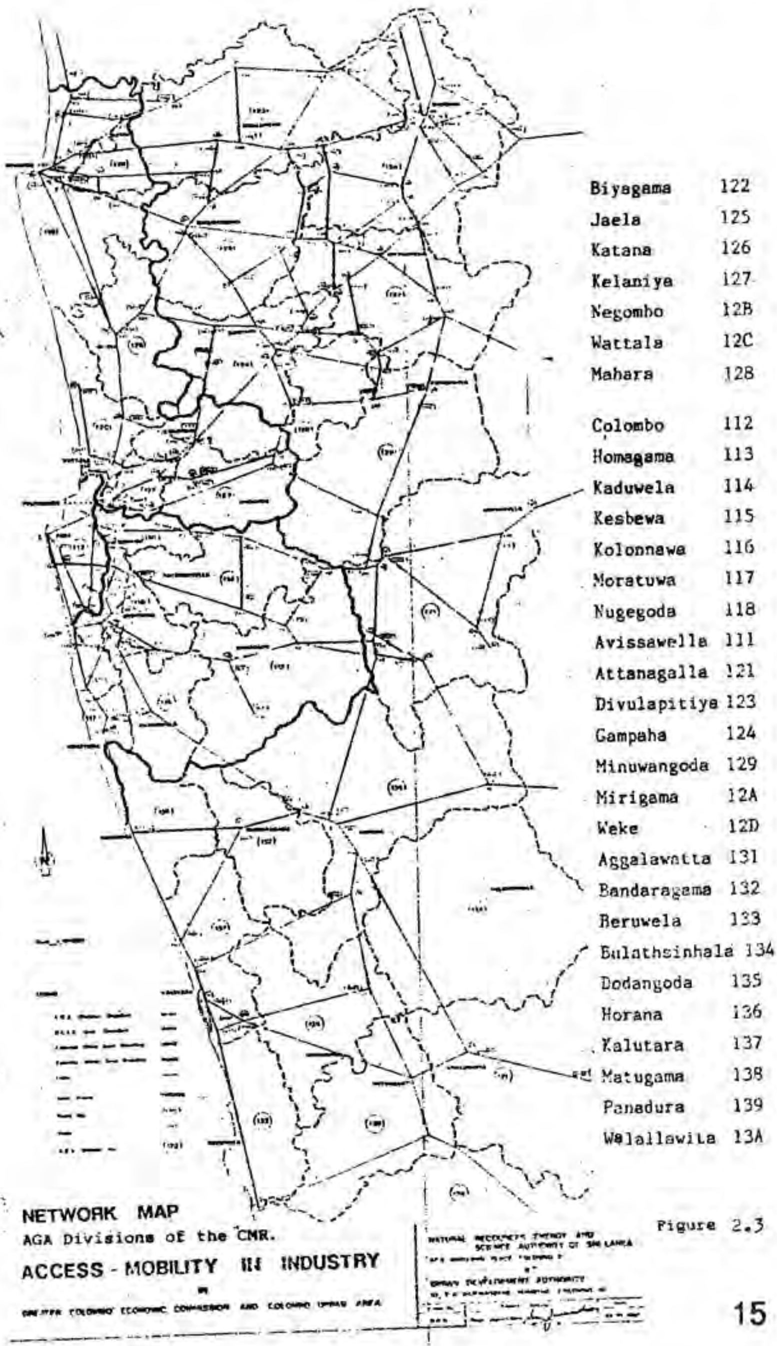

Biyagama 122
Jaela 125
Katana 126
Kelaniya 127
Negombo 12B
Wattala 12C
Mahara 128
Colombo 112
Homagama 113
Kaduwela 114
Kesbewa 115
Kolonnawa 116
Moratuwa 117
Nugegoda 118
Avissawella 111
Attanagalla 121
Divulapitiya 123
Gampaha 124
Minuwangoda 129
Mirigama 12A
Weke 12D
Aggalawatta 131
Bandaragama 132
Beruwela 133
Bulathsinhala 134
Dodangoda 135
Horana 136
Kalutara 137
Matugama 138
Panadura 139
Walallawita 13A
NETWORK MAP
AGA Divisions of the CMR.
ACCESS - MOBILITY IN INDUSTRY

Figure 2.3

The criteria considered in the choice of zones are;

1. The size of the statistical units used in the official Census. The basic unit has been the "Gramasevaka Vasama" or the area of the Village Council. But most data are aggregated to the level of the AGA division.

2. The availability of other data at this basic level of the AGA units.

3. The composition of the Colombo Urban Area(CUA) and the Greater Colombo Economic Commission(GCEC) by aggregation of the AGA units.

4. The zones are to be of areas which have a manageable size for data processing.

5. Each zone to contain a network of a size which could be built up later to a higher level with road links of a lower order.

6. The flexibility in regrouping zones to form larger areas such as the economic zones (GCEC, CUA, CSA, and CMU) as well as administrative or political divisions such as districts and electorates.

7. The possibility of forming data bases of socio- economic variables which could be formed without considerable use of time or labour.

8. Development policies and activities are more and more being oriented on the basis of AGA and electoral units. Therefore, the possibility exists of using the study as well as data bases in relation to the emerging new political system of provincial government.

9. The possibility of extending the data systems for future studies.

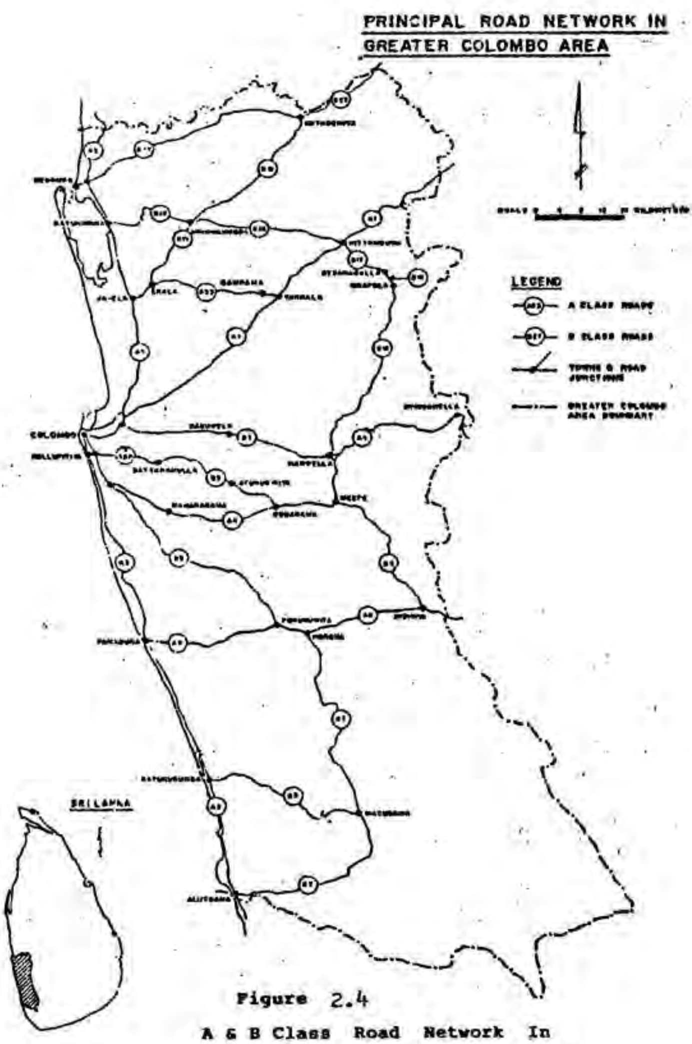


Figure 2.4

A & B Class Road Network In

the Colombo Metropolitan Area

Source: Sri Lanka Transport Sector Planning Study.

10 As an aid to the development of efficient urban data banks. Data required for spatial planning could be stored in a systematic and easily retrievable manner in relation to the locational references of the nodes or intersections, links or sections and regions or cells.

The data may then be aggregated into units such as the Colombo Municipal Area (CMA), the Colombo Urban Area(CUA) or the Area of Authority of the Greater Colombo Economic Commission (GCEC). The next unit in the hierarchy is the district administered by the Government Agent followed by the provincial administration.

2.4 Maps and Zoning System.

A basic network system was formulated and designed using;

1. **A map of 1:100,000 on the metric scale for the whole of the Colombo Metropolitan Region.**

2. **A map of 1:12,500 on the metric scale for use of the Colombo Municipal Area.**

2.4.1 Identification of Areal Units

The whole of the study region is divided into zones or cells, the basic unit being the AGA division, the next in higher order the district and finally it is followed by the provincial unit. The road network in the CMR is shown in figure 2.4 and the mileage of **A** and **B** roads in the AGA units is given in table 2.1.

The first digit:- The numbers 1 to 9 are allocated for identifying the nine provinces to which the country is divided.

The second digit:- This number identifies the district as related to a particular province.

The third digit:- This digit identifies the AGA division as related to each district.

2.4.2. Coding System

The whole system is modelled as a set of links and nodes corresponding to actual sections of roads and junctions. The coding of the network consists in principle of the numbering of nodes and links in the network. In order to compile the network data base a unique numbering system is used. Each node and each link has a separate identifying number. The system is applicable to different levels of aggregation; for local as well as regional studies.

2.5 Industrial Data

Chief landuse categories are;

1. **Residential**
2. **Government and Institutional**
3. **Commercial**
4. **Light Industrial**
5. **Heavy Industrial**
6. **Retail Trade**
7. **Transportation and Utilities**

Road Mileage of A and B Routes
Colombo Metropolitan Area

Zone	Code Number	Total sq. km.	A Route km.	B Route km.	A & B Routes km.
Biyagama	122	61.90		26.04	26.04
Jaela	125	79.20	12.45	5.84	18.29
Katana	126	22.60		20.43	20.43
Kelaniya	127	22.20	6.86	12.65	19.51
Negombo	12B	127.90	18.85	42.51	61.36
Wattala	12C	46.20	8.97	19.56	28.53
Mahara	128	47.90	6.73	30.62	37.35
Greater Col.Eco.Comm.	**GCEC**	**407.90**	**53.86**	**157.65**	**211.51**
Colombo Municipality	**112**	**41.08**	**14.83**	**57.10**	**71.93**
Homagama	113	157.94	15.49	28.75	44.24
Kaduwela	114	90.81		34.32	34.32
Kesbewa	115	63.47		19.86	19.86
Kolonnawa	116	26.32	7.79	10.63	18.42
Moratuwa	117	19.22	4.70	4.32	9.02
Nugegoda	118	58.53	17.65	29.00	46.65
Colombo Suburban Area	**CSA**	**416.29**	**45.63**	**126.88**	**172.51**
Colombo Urban Area	**CUA**	**457.37**	**60.46**	**183.98**	
Avissawella	111	237.21	20.02	15.28	35.30
Attanagalla	121	153.90	29.64	32.52	62.16
Divulapitiya	123	198.40	4.19	78.47	82.66
Gampaha	124	94.50	25.91	21.21	47.12
Minuwangoda	129	132.80	2.25	54.94	57.19
Mirigama	12A	187.40	32.72	64.61	97.33
Weke	12D	175.90	3.35	32.65	36.00
Aggalawatta	131	361.30		20.43	20.43
Bandaragama	132	84.80	8.13	2.79	10.92
Beruwala	133	73.00	14.35	3.94	18.29
Bulathsinhala	134	235.30		30.61	30.61
Dodangoda	135	107.00		27.81	27.81
Horana	136	255.60	20.28	49.50	69.78
Kalutara	137	77.90	13.08	27.05	40.13
Matugama	138	134.10		35.77	35.77
Panadura	139	57.50	20.97	20.97	
Rest.Col.Metro.Area	**R.CMR**	**2,566.61**	**194.89**	**497.58**	**692.47**
Tot. Col.Metro.Area	**CMR**	**3,431.88**	**309.21**	**839.21**	**1,148.42**

Author's Computation **Table 2.1**
Source : Road Development Authority

8. **Open Space**

9. **Vacant Space.**

In this particular study it is the **manufacturing industry** that is under consideration. Thus, the nature and character of the industry and the number of employed personnel by the industry may be considered.

The data collected by the Trade and Industry Division of the Department of Census and Statistics in a survey of Manufacturing Industry in 1983 formed the initial base. The **survey** covers the **activities of nine industrial divisions.** These nine industrial divisions include the references 31 to 39 of the major groups of the International Standard Industrial Classification (I.S.I.C.) of the United Nations (1968) as shown below.

Code No.	Description of Item
31.	**Food, Beverages and Tobacco.**
32.	**Textiles, Wearing Apparel and Leather Industries.**
33.	**Wood, and Wood Products including Furniture.**
34.	**Paper and Paper Products, Printing and Publishing**
35.	**Chemicals, Petroleum, Rubber and Plastic Products.**
36.	**Non-Metallic Mineral Products including Petroleum and Coal.**
37.	**Basic Metal Industries.**

38. **Fabricated Metal Products, Machinery and Transport Equipment.**

39. **Other Manufacturing Industries.**

2.5.1 The Sample Survey of Industries

The sample selection for the survey was designed to reveal the travel characteristics of the employed population in the manufacturing industry. It was influenced by the fact that the Department of Census and Statistics had carried out a survey of industrial establishments. The following data was obtained from the survey;

1. **The address of the firm**
2. **The type of manufacturing industry**
3. **The employee size category**

The study area was divided into four sub areas namely;

1. **The Colombo Municipal Area (CMA)**
2. **The Colombo Sub-Urban Area (CSA)**
3. **The Area of Authority of the Greater Colombo Economic Commission (GCEC)**
4. **The rest of the Colombo Metropolitan Area (CMR).**

The employee size had been categorised into three main classes.

1. **"A" Category, 100 persons and over.**
2. **"B" Category, 50 to 99 persons .**

Distribution of Industries in the Colombo Metropolitan Region

Indust Class	Colombo Municip.Area					Colombo Urban Area					Greater Colombo Eco.Com.					Total	Rest of Col. Metro. Region					Gr. Total
	Employment Classes in Each Region																					
		25	50	100	200		25	50	100	200		25	50	100	200				25	50	100	200
	Number of Industries in Each Group																					
31	08	07	02	01	18	08	00	04	00	12	19	06	07	03	35	65	19	17	09	05	50	115
32	07	03	05	09	24	14	17	08	26	65	23	09	03	06	41	130	62	09	13	01	85	215
33	03	00	01	00	04	08	03	02	02	15	05	00	00	00	05	24	10	04	03	00	17	41
34	15	05	02	05	27	03	01	03	01	08	07	04	00	00	11	46	00	01	00	00	01	47
35	01	02	02	02	07	11	09	04	04	28	08	02	03	04	17	52	38	12	03	08	61	113
36	03	00	02	02	07	06	01	00	02	09	08	03	00	00	11	27	06	04	01	01	12	39
37	00	00	00	00	00	03	00	00	00	03	00	01	00	00	01	04	02	01	00	00	03	07
38	16	04	02	05	27	17	05	04	03	29	09	05	03	03	20	76	13	03	00	02	18	94
39	02	02	00	01	05	03	02	02	00	07	01	00	02	00	03	15	01	03	00	00	04	19
Total	35	23	16	25	119	73	38	27	38	116	80	30	18	16	144	439	151	54	29	19	251	690

Source: Department of Census and Statistics - Industrial Division

Table 2.2

3. "C" Category, 25 to 49 persons .

The total distribution of industries in the study area as obtained from the records of the Industrial Division of the Department of Census and Statistics is shown in table 2.2. Because of the **heterogeneity** of the **size and nature** of the **industries** and **locational differences** a **cluster stratified random sampling technique** was used.

Since some of the cells in the matrix were low in value a number of them were combined and a summarized table showing the regional distribution of industries was prepared table 2.3. As the study is concerned with the functioning of industries in the CUA and the GCEC the rest of the CMR is not taken into account. A 20 % sample was selected and the sampling distribution is given in table 2.4. A total of 88 firms were selected, written to and were visited. Some of the firms had closed down and a few were reluctant to furnish data. The overall response is as stated in table 2.5.

Table 2.3

Regional Distribution of Industries

Group	CMA	CUA	GCEC	Total
25- 49	55	73	80	208
50- 99	23	38	30	92
100-199	16	27	18	62
200	25	38	16	81
Total	**119**	**176**	**144**	**439**

Source: Department of Census and Statistics

T able 2.4

Size of the Samples

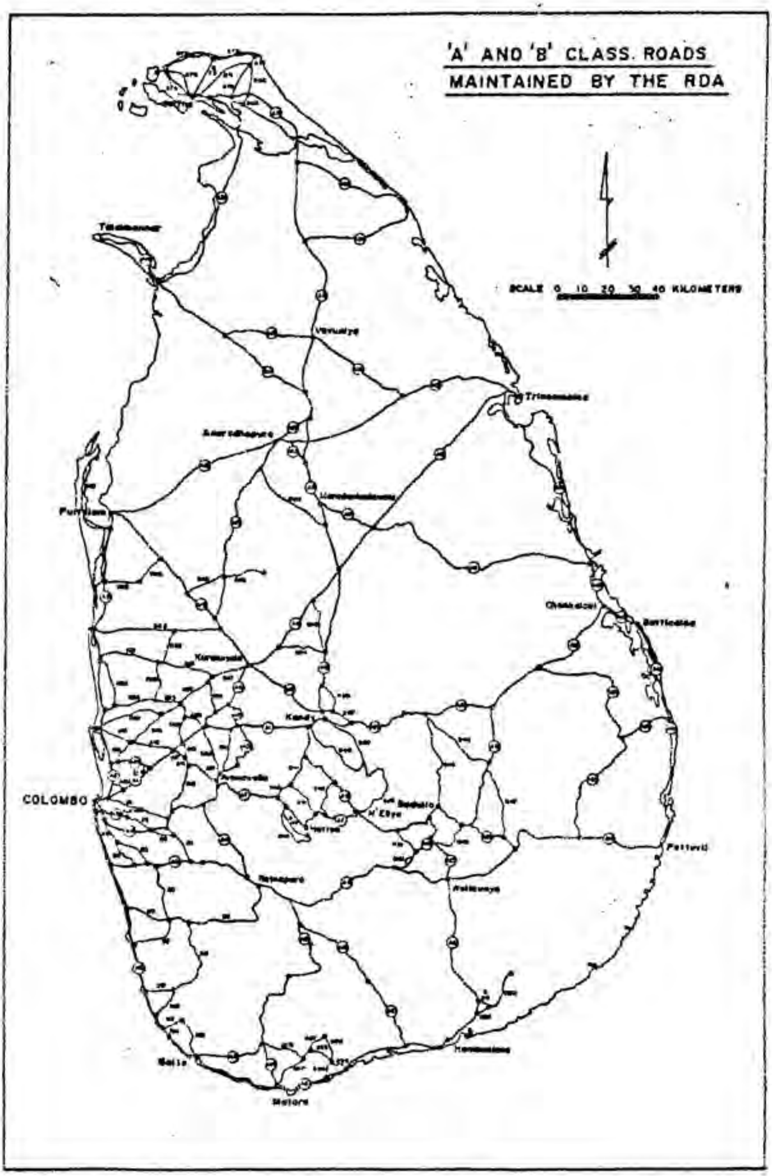
Sample %	Group Size	CMA	CUA	GCEC	Total
10	25 - 49	6	7	8	21
20	50 - 99	5	7	6	18
30	100 - 199	5	8	5	18
40	200	10	15	6	31
100	**Total**	**26**	**37**	**25**	**88**

Author's Computation

Table 2.5 **Response to the Survey**

	CMA	CSA	GCEC	Total
1. The number of firms approached by letter	28	41	19	88
2. The number of firms visited	16	31	12	59
3. The number of firms closed or not located	6	3	2	11
4. The number of firms with no response	6	11	4	21

Author's Computation



Source : Road Development Authority

Figure 2.5

2.6 Infrastructure Network Data.

The next stage dealt with the transportation system. The transportation network had to be coded for data collection and analysis. The existing road network was coded as a graph of links and nodes. The entire highway network was not coded as the magnitude of the work involved was very large and such detail was not considered necessary at the level of analysis undertaken.

For the highway network a simplified network was taken for coding. This includes the major inter-city roads classified as **A** routes and the secondary system of roads defined as **B** routes.

2.6.1 The Road System

The network data on infrastructure was primarily obtained from the former Department of Highways presently the Road Development Authority. The data were recorded in the departmental maps, records and files kept in the Traffic and Planning Division. The information on names of roads, their mileage, widths, surface conditions and traffic flows were recorded accordingly.

The Department of Highways maintain five types of roads. The distribution of **A** and **B** class roads island wide is shown in figure 2.5

'**A**' class road

'**C**' class road

'**D**' class road

'**E**' class road.

The **A** class roads are the National Highways linking the main centres of the country, the district centres with the national capital or those connecting one district centre with another.

The **B** class roads are primarily provincial roads which serve each province only and connect towns or population centres in the district or in the vicinity. The **C** class roads are distributary in nature as they help to distribute the traffic on the provincial roads within the area. All roads other than **A** or **B** class roads which have at least one terminal point on a **A** or **B** class road are classified as **C** class roads. The **D** and **E** class roads are essentially access roads, the **E** class roads being to a great extent earth roads.

The bus or transit transport system has also to be represented by a network. This may or may not be identical to the highway network. As already said only the major routes are considered for the highway network but there may be important bus routes on roads not identified in the former. The island wide bus network is shown in figure 2.6

The transit or bus network could identify the type of service provided, the capacity of the services, their frequency, the route mileage, the travel time and the number of stops etc. on a particular route.

2.6.2 The Traffic Measures

The data relating to traffic was collected from the basic surveys carried out by the former Department of Highways (DOH) and the Colombo Municipal Council (CMC). The type of data collected and the frequency of such collection was determined by the importance of the route and the purpose for which the traffic was used

The mileages of A and B routes on the network and the total travel in vehicle kilometres on A and B routes in the whole of the CMR have been computed and summarized in table 2.1 by AGA divisions.

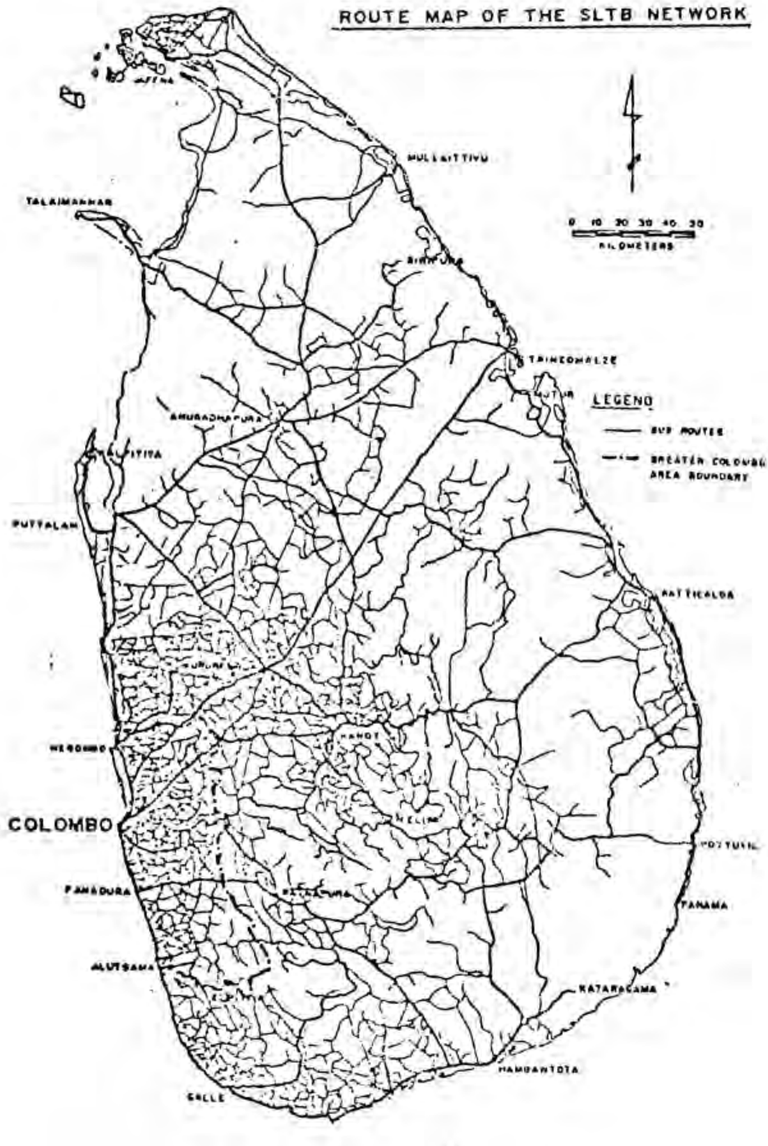


Figure 2.6

Island-wide Bus Route Network.

Source: Sri Lanka Transport Board.

2.7 The Vehicle System Operations

The greater proportion of travel by workers is by public transport. The primary transit service had been provided by the Sri Lanka Transport Board (SLTB).

However, from 1979 the private sector had been given the right to operate public service vehicles on certain routes. But little or no information was available on the services they provide. It was estimated that still the SLTB provides about 70 % of the transit service.

The SLTB however maintains very good vehicle operations records. The operations records are computerised and processed as monthly returns for every bus depot in the island by every operational route. These data sheets such as table 2.6 for the Avissawella depot form the basis of assessments of vehicle operations such as the total vehicle miles operated, the passenger miles run, the seat kilometres provided, the load factors, average occupancies, the average journey lengths, revenue per route, the frequency of operations and travel times on the transit networks.

2.8 Travel Survey

The data relating to travel characteristics of workers in the manufacturing industrial sector was not available. A basic survey was designed to generate and supplement the data required in addition to the data collected from various organizations. A sample survey was carried out for this purpose within the CMA, CSA and the GCEC areas.

The questionnaire related to the sample survey is available as an appendix. Though not required for this study, fairly extensive data was collected, with a view of further research in this field and as it was economical to do so at the same time.

SRI LANKA CENTRAL TRANSPORT BOARD *** OPERATIONS DIVISION

REGION - CENTR

106 AVISSAWELLA DEPOT.

SUMMARY OF OPERATIONAL STATISTICS FOR THE MONTH OF SEPTEMBER 1984

ROUTE	AV.C	SCH.KM	OP.KM	T.KM	FGS	NCV	T/UR	R/KM	FG.KM	ST.KM	L.F.	AV.HJ
LX	60	12,242	12,242		21,725	41,914	15.00	3.42	279,427	734,520	38.0	12.9
0-1-1	60	9,349	5,899		4,547	19,029	11.04	3.53	161,140	324,940	49.7	34.1
003-T	60	23,320	9,174		7,562	35,027	14.07	3.82	248,940	550,440	45.2	32.0
014-2	60	3,616	3,377		3,733	20,331	15.34	6.00	133,080	202,620	66.0	35.9
021	60	34,349	17,507		18,106	85,330	15.59	4.85	547,330	1,055,220	51.9	30.2
023-1	60	60,094	54,265		60,230	262,266	19.05	4.83	1,376,724	3,255,900	42.2	23.9
049-1	60	10,644	9,665		6,065	50,435	12.83	5.22	393,102	579,900	67.7	64.6
049-4	60	10,482	7,000		11,703	30,501	11.29	5.49	332,192	420,480	79.0	20.4
122	60	105,054	55,771		47,435	154,176	10.38	2.76	1,485,318	3,346,260	44.3	31.3
164	50	5,620	4,161		7,322	17,974	14.18	4.32	126,756	208,050	60.9	17.3
164-1	40	21,399	16,568		22,249	53,648	15.39	3.24	348,590	662,720	52.5	15.7
231-5	30	5,598	4,388		8,921	16,565	31.25	4.22	59,216	131,640	44.9	6.6
232	30	6,400	5,493		14,546	32,395	23.41	5.90	130,301	164,790	83.9	9.5
239-1	30	2,748	2,311		4,227	9,454	30.36	4.09	31,140	69,330	44.9	7.4
301	30	5,476	4,727		6,491	17,427	35.91	2.08	37,948	141,810	26.7	5.0
301-1	30	6,407	4,576		6,371	14,237	63.59	3.11	22,779	137,280	16.5	3.6
470-2	40	71,697	36,001		46,367	99,379	12.35	2.76	804,203	2,160,060	37.2	17.3
600	30	7,104	6,546		13,257	27,954	13.16	4.27	212,416	196,300	108.1	16.0
600-1	30	5,181	4,727		10,040	18,884	17.39	3.99	100,591	141,810	70.5	10.8
601	30	9,054	6,313		17,406	32,997	42.03	3.97	100,509	249,390	40.3	5.8
601-1	30	2,661	2,594		3,540	5,920	32.00	2.28	18,500	77,820	23.7	5.2
602	30	4,239	4,057		7,896	13,073	33.78	3.42	41,069	121,710	33.7	5.2
603	30	4,548	4,118		9,180	16,056	16.91	3.90	94,950	123,540	76.8	10.3
603-1	30	2,703	1,854		3,092	5,298	18.76	2.86	20,225	55,620	50.7	9.1
604	30	1,704	1,373		1,424	1,990	20.19	1.48	9,801	41,190	23.8	6.9
605	30	5,852	4,189		6,236	10,542	34.30	2.61	31,827	125,670	25.3	5.1
606	30	5,054	4,908		8,431	17,494	34.25	3.56	51,077	147,240	34.6	5.9
607	30	4,440	3,549		6,909	14,524	20.83	4.09	69,726	106,470	65.4	10.1
608	30	11,346	9,662		19,831	46,016	30.48	4.76	149,987	289,890	51.7	7.4
609	30	6,904	4,977		11,090	21,197	30.93	4.26	60,532	149,310	45.8	4.7
610	60	19,902	12,611		37,573	55,301	27.78	4.39	199,058	756,660	26.3	7.2
611	30	12,646	10,174		10,067	39,507	21.53	3.08	183,497	305,220	60.1	10.2
612	30	7,326	7,088		9,606	24,314	27.42	3.43	88,673	212,640	41.7	9.2
613-1	30	4,542	4,362		10,163	20,135	27.00	4.62	74,574	130,860	56.9	7.3
613	30	6,837	5,740		8,973	24,044	32.77	4.32	75,359	172,440	43.7	8.4
614	30	2,595	2,011		3,279	8,798	25.69	4.37	34,247	60,330	56.7	10.5
671-2	40	3,198	705		72[illegible]	1,528	15.60	2.24	10,089	28,200	35.7	13.9
671-3	40	6,999	3,151		6,073	12,041	30.00	3.10	40,137	109,060	31.2	6.6
675-3	60	74,503	50,856		80,790	197,102	12.47	3.88	1,580,609	3,051,360	51.8	19.6
677	50	11,250	7,939		11,442	38,545	13.14	4.86	293,341	396,950	73.8	25.6
677-1	50	14,505	9,572		13,852	46,906	12.45	4.90	376,755	478,600	78.7	27.2
677-4	60	74,460	69,179		35,362	85,397	14.12	1.23	604,795	4,162,740	14.5	17.1
685	30	8,829	4,916		9,305	22,505	17.79	4.58	126,504	147,480	85.7	13.6
685-1	30	26,505	16,621		28,003	67,180	20.73	3.74	299,952	498,630	60.1	10.7
686	30	20,046	15,407		25,257	59,390	20.34	3.86	292,026	462,210	63.1	11.6
686-1	30	9,744	5,038		10,199	20,080	23.18	3.99	86,661	151,140	57.3	8.5
688	30	9,222	7,337		17,640	32,302	23.59	4.40	136,931	220,110	62.2	7.8
690	50	9,696	8,467		13,632	35,105	17.10	4.36	204,002	423,350	48.3	15.0
690-1	50	23,269	11,038		14,790	43,562	19.65	3.95	221,890	551,900	40.1	13.2
692	30	10,443	9,515		12,706	29,466	28.24	3.10	104,341	285,450	36.5	8.2
692-1	30	5,037	4,302		11,900	21,558	29.60	5.49	84,279	129,060	65.2	7.0

Table 2.6

NA - 9 - 33

3

ANALYSIS OF THE STUDY REGION

3.0 Analysis of the Study Region

3.1. Choice of the Study Region

The study area consists of the **Colombo Urban Area (CUA)** which includes the Colombo Sub-Urban Area(CSA) and the Colombo Municipal Area(CMA) and the **Area of Authority of the Greater Colombo Economic Commission (GCEC)** figure 3.1. These areas constitute the core of the **Colombo Metropolitan Area (CMR).**

The factors which are considered to play a significant role in this study are **population, population density, urban/rural distribution, industries and their distribution, infrastructure and vehicular use.** The main features are examined in an overview to illustrate the reasons for the choice of the study region.

3.2. Colombo Metropolitan Region

The boundaries of the CMR were identified considering the population, employment, urbanization and the communication systems. The CMR approximates in its boundaries to the Western Province of the country and consists of the three districts of Colombo, Gampaha and Kalutara ,figure 3.2. A small part of the Kegalle district inclusive of Avissawella was included but a part of the south-eastern district of Kalutara was omitted.

The CMR comprising of an area of 2,905 sq. km is formed following the U.N. Study,*Figure 3.3.

1. **A Central sub-region with the Colombo Urban Area (CUA) surrounded by urban centres.**

2. **Six outer sub-regions with centres at Negombo, Veyangoda, Avissawella, Horana and Kalutara .**

United Nations Technical Report . Vol.2;1978

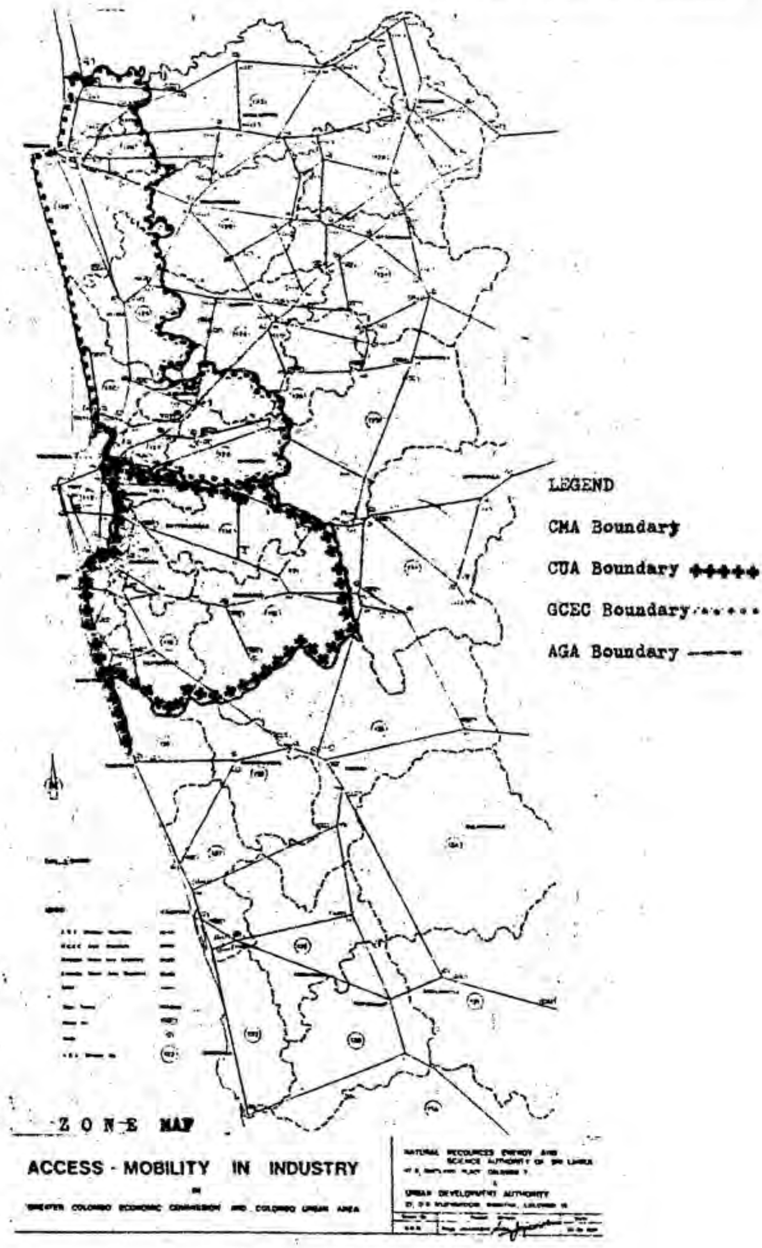

LEGEND
CMA Boundary
CUA Boundary
GCEC Boundary
AGA Boundary
ZONE MAP
ACCESS - MOBILITY IN INDUSTRY
NATURAL RESOURCES ENERGY AND SCIENCE AUTHORITY OF SRI LANKA
URBAN DEVELOPMENT AUTHORITY

Figure 3.1

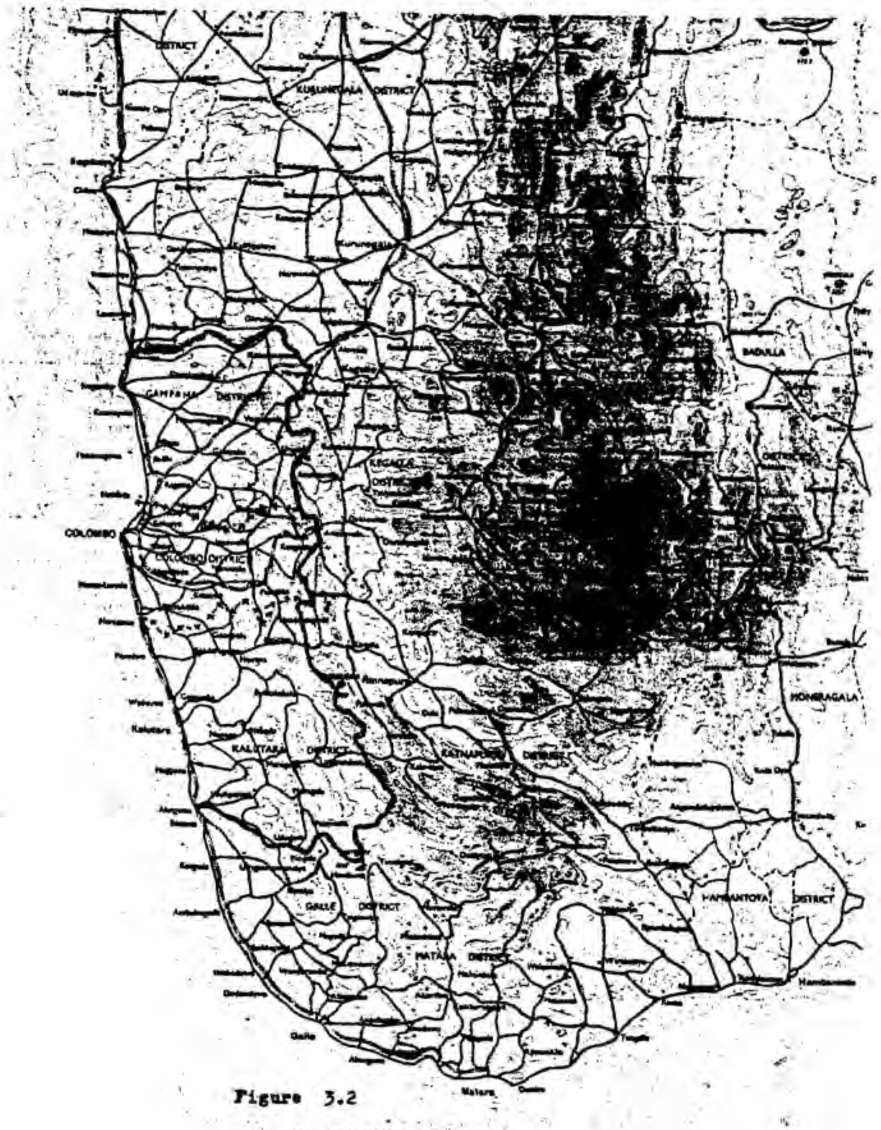


Figure 3.2

Scale 1/1,000,000

Source: Survey Department

Further changes have taken place since then in the creation of economic zones to the north of the Central sub-region and to the north of the Kelani river. The sub-region to the north forms the area of Authority of the Greater Colombo Economic Commission (GCEC). The Capital City of Sri Jayawardenepura -Kotte and the CMA are included in the Colombo Urban Area(CUA).

The CMR may now be depicted as in figure 3.4 to consist of the of the following areas;

1. **Colombo Municipal Area (CMA).**
2. **Colombo Sub-urban Area (CSA) with the Capital City of Sri JayawardenepuraKotte.**
3. **Greater Colombo Economic Commission Area(GCEC)**
4. **Rest of the Colombo Metropolitan Region**

3.3. Colombo Urban Area.

The Colombo Urban Area (CUA) forms the most important sector of the Colombo Metropolitan Region. **The CUA area is about 200 sq.km of which 60% is residential and 40% used as non-residential land.** It consists of the Colombo Municipal Area (CMA) and the surrounding Colombo Sub-urban Area (CSA). **The CMA is treated as a separate economic area.**

Urbanization shows that the built up area of the Colombo M.C. is surrounded by groups of smaller towns which are generally extensions of the municipal limits. This sub-urban area extends approximately 15 km. from Fort to the north and east and 20 km. to the south. The majority of the people live in local authorities with urban status figure 3.5 and table 3.1.

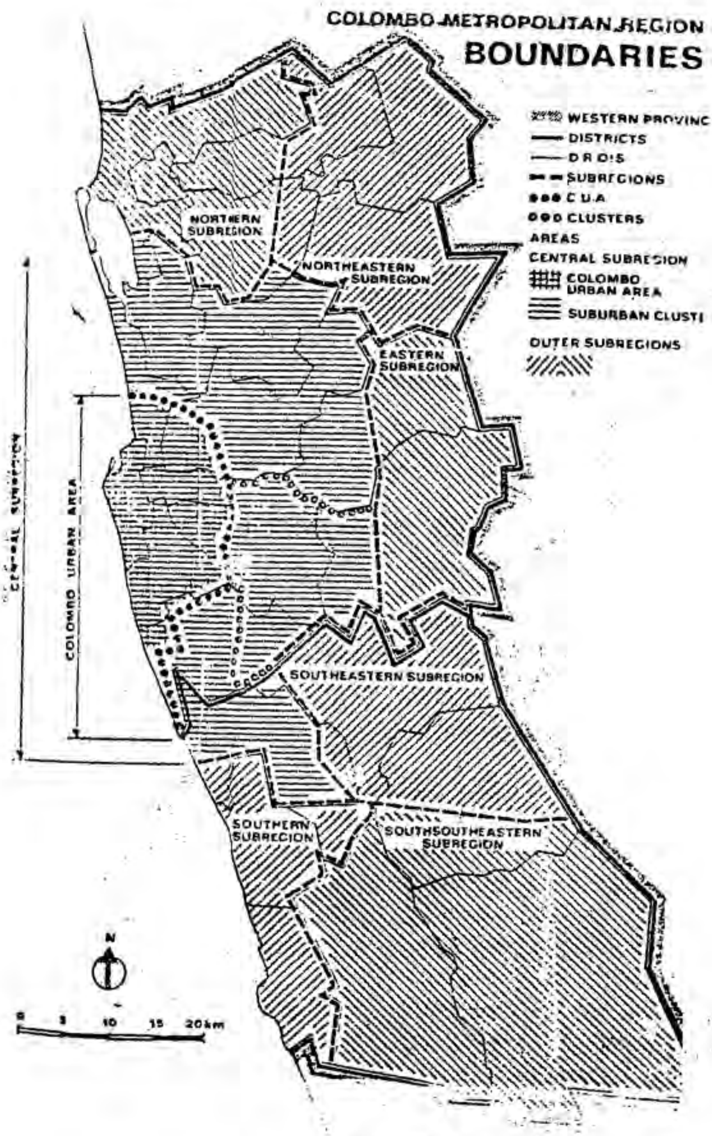


Figure 3.3

The Colombo Metropolitan Region.

Source : The Colombo Master Plan
UNDP Technical Report : Vol.2,
April, 1978.

Figure 3.4

Administrative Areas of the C.M.R.

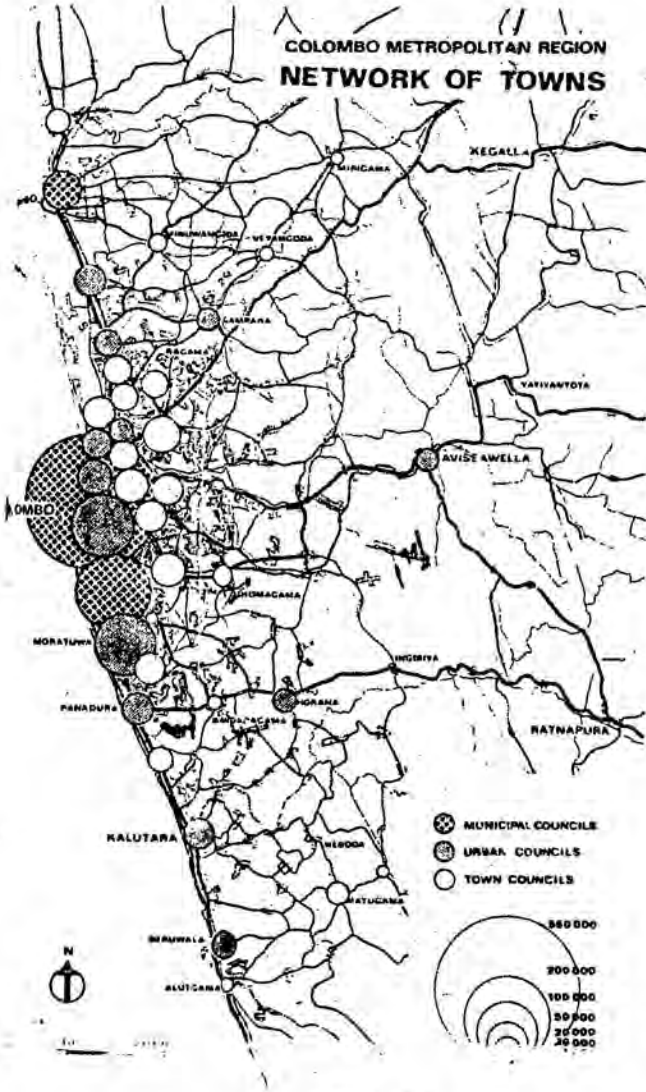


Figure 3.5

Source : Colombo Master Plan Project
UNDP Technical Reports, Vol.2, April 1978.

Local Authorities and their Populations

Town	District	Code	Division AGA	Status Local	Population 1971	Population 1981	Net Increase	Percent Change	Rank by %
Colombo	Colombo	112	Colombo	M.C.	562420.00	587647.00	25227.00	4.48	33.00
Deh.Mt.Lavinia	Colombo	118	Nugegoda	M.C.	154194.00	173529.00	19335.00	12.54	19.00
Moratuwa	Colombo	117	Moratuwa	M.C.	96267.00	134826.00	38559.00	40.05	1.00
Kotte	Colombo	114	Kaduwela	U.C.	93680.00	101039.00	7359.00	7.86	30.00
Negombo	Gampaha	12B	Negombo	M.C.	56795.00	60762.00	3967.00	6.98	31.00
Battaramulla	Colombo	114	Kaduwela	T.C.	44212.00	56535.00	12323.00	27.87	6.00
Maharagama	Colombo	118	Nugegoda	T.C.	41756.00	49765.00	8009.00	19.19	10.00
Kotikawatta	Colombo	116	Kolonnawa	T.C.	41795.00	48262.00	4467.00	10.20	25.00
Dalugama	Gampaha	127	Kelaniya	T.C.	42564.00	47723.00	5159.00	12.12	22.00
Kolonnawa	Colombo	116	Kolonnawa	U.C	37429.00	41005.00	3576.00	9.55	27.00
Hendala	Gampaha	12C	Wattala	T.C.	29660.00	36927.00	7267.00	24.50	8.00
Kelaniya	Gampaha	127	Kelaniya	T.C.	32667.00	36738.00	4071.00	12.46	20.00
Keselwatta	Kalutara	139	Panadura	T.C.	28955.00	33879.00	4924.00	17.01	12.00
Kalutara	Kalutara	137	Kalutara	U.C.	28634.00	31503.00	2869.00	10.02	26.00
Seeduwa Katun	Gampaha	126	Katana	U.C.	23411.00	31491.00	8080.00	34.57	3.00
Panadura	Kalutara	139	Panadura	U.C	27720.00	31090.00	3370.00	12.16	21.00
Welisara	Gampaha	12C	Wattala	T.C.	20800.00	26700.00	5970.00	28.70	5.00
Beruwala	Kalutara	133	Beruwala	U.C.	19769.00	26320.00	6552.00	33.14	4.00
Peliyagoda	Gampaha	12C	Wattala	U.C.	24403.00	25466.00	1063.00	4.36	34.00
Mulleriyawa	Colombo	116	Kolonnawa	T.C.	23018.00	25071.00	2053.00	8.92	29.00
Jaela	Gampaha	125	Jaela	U.C.	21717.00	24485.00	2768.00	12.75	18.00
Ragama	Gampaha	125	Jaela	T.C.	17421.00	22238.00	4817.00	26.67	7.00
Kandana	Gampaha	125	Jaela	T.C.	18980.00	21662.00	2682.00	14.13	16.00
Wattala	Gampaha	12C	Wattala	U.C.	18037.00	19957.00	1920.00	10.64	24.00
Wadduwa	Kalutara	139	Panadura	T.C.	13426.00	15507.00	2081.00	15.50	14.00
Avissawella	Colombo	111	Avissawella	U.C.	15590.00	14147.00	1443.00	(9.26)	36.00
Matugama	Kalutara	138	Matugama	T.C.	10201.00	11971.00	1770.00	17.35	11.00
Gampaha	Gampaha	124	Gampaha	U.C.	9964.00	10656.00	692.00	6.95	30.00
Dharaga Town	Kalutara	133	Beruwela	T.C.	8707.00	9968.00	1261.00	14.48	15.00
Kochchikade	Gampaha	12B	Negombo	T.C.	8642.00	9642.00	1000.00	11.57	23.00
Homagama	Colombo	113	Homagama	T.C.		8923.00			
Horana	Kalutara	136	Horana	U.C.	7576.00	8812.00	1236.00	16.31	13.00
Piliyandala	Kalutara	115	Keshewa	T.C.	5754.00	6547.00	793.00	13.78	17.00
Aluthgama	Kalutara	133	Beruwala	T.C.	5430.00	6513.00	1083.00	19.94	9.00
Minuwangoda	Gampaha	129	Minuwangoda	T.C.		6400.00			
Veyanguda	Gampaha	121	Attanagalla	T.C.	3823.00	3903.00	80.00	2.09	34.00
Mirigama	Gampaha	12A	Mirigama	T.C.	2597.00	3522.00	925.00	35.62	2.00
Aggalawatta	Kalutara	131	Aggalawatta	T.C.	2475.00	2508.00	33.00	1.33	36.00

Source: Dept. of Census and Statistics   Author's Compoistion   Table 3.1

The annual population growth in the CUA is less than that in other parts of the region. **Colombo itself and the surrounding urban clusters have the infrastructure developed to a high standard and therefore presents very suitable conditions for industry as well as for residential purposes.**

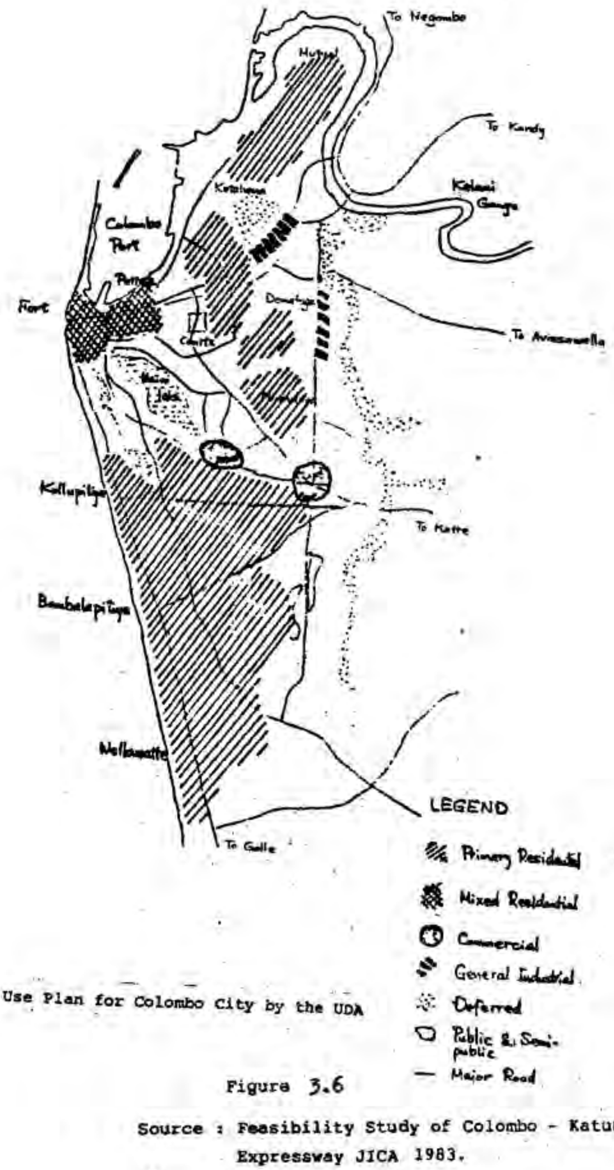
3.4. The Colombo Municipal Area.

The City of Colombo developed to become the Capital City of Sri Lanka around the Port of Colombo as it is strategically located on the East-West trade route. It evolved over centuries through the hands of the Portuguese, the Dutch and the British. Each period made its own contribution to the development of specific areas. The highly urbanized central area of the Fort, the contrasting commercial, wholesale and retail trade centre in Pettah, the elegantly built mansions in Cinnamon Gardens presents picturesque city development over the years.

The Colombo Municipal Area has a land mass of 3635 hectares and 98 hectares covered by lakes, channels and other water bodies, figure 3.6. The analysis of land uses as made by the Colombo Metropolitan Area Master Plan Project (1977) shows that for an area of 3733 hectares of land 87.2% has been developed, 2.6% occupies water bodies and only 10.2% is left open for development. Of the total area 45.2% is occupied by residential premises and 12.5 % by public and semi-public uses.

The second largest use is for transport facilities amounting to 16.3% and small industry occupies only 151 hectares (4%). The table 3.2 shows the analysis of land uses as at 1979 as well as for the year 2000.

The Central Area of Colombo is divided into two main parts, namely Fort and Pettah. These two areas are distinct from each other in terms of landuse functions and characteristics. Fort occupies 120 acres of land and was the chief administrative center until Sri Jayawardenepura-Kotte was constructed.



Land Use Plan for Colombo City by the UDA

Figure 3.6

Source : Feasibility Study of Colombo - Katunayake Expressway JICA 1983.

Table.3.2

Land Uses
Colombo Municipal Area

Land Use.		1977 Hectares	1977 Area in %	2000 Hectares	2000 Area in %
1.	Primary Residential.	1687	45.2	1035	27.7
2.	Residential.	680	18.2		
3	Commercial	201	6.2	320	8.6
4.	General Industrial	151	4.0	185	5.0
5.	Special Industrial.				
6.	Public & Semi-Public	465	12.5	530	14.2
7.	Transport.	10	6.3	700	18.8
8	Parks,Playgrounds Open spaces	142	3.8	165	4.4
9	Agricultural.	-	-	-	-
10.	Deferred.	-	-	-20	0.5
11.	Undeveloped.	379	10.2	-	-
12.	Water Bodies.	98	2.6	98	2.6
	TOTAL	**3733**	**100.0**	**3733**	**100.0**

Source: Urban Development Authority: "City of Colombo Development Plan ". Vol. 1. November 1985.

It is still the financial and commercial capital. In 1979 the Fort had 5,125 million sq.ft of floor space in use, where half was dominated by commercial activities, one third by institutional functions and the balance 20 % used for residential, utilities and other purposes. Pettah continues to be the wholesale and retail distribution centre for the whole country.

Kollupitiya and Cinnamon Gardens and parts of Bambalapitiya form the high income residential area. Borella, Bambalapitiya, Wellawatte contain mostly middle income groups. Kochchikade, Dematagoda, Mattakkuliya, sections of Maradana and Narahenpitiya are occupied by the majority of low income groups, and are studded with slums and shanties.

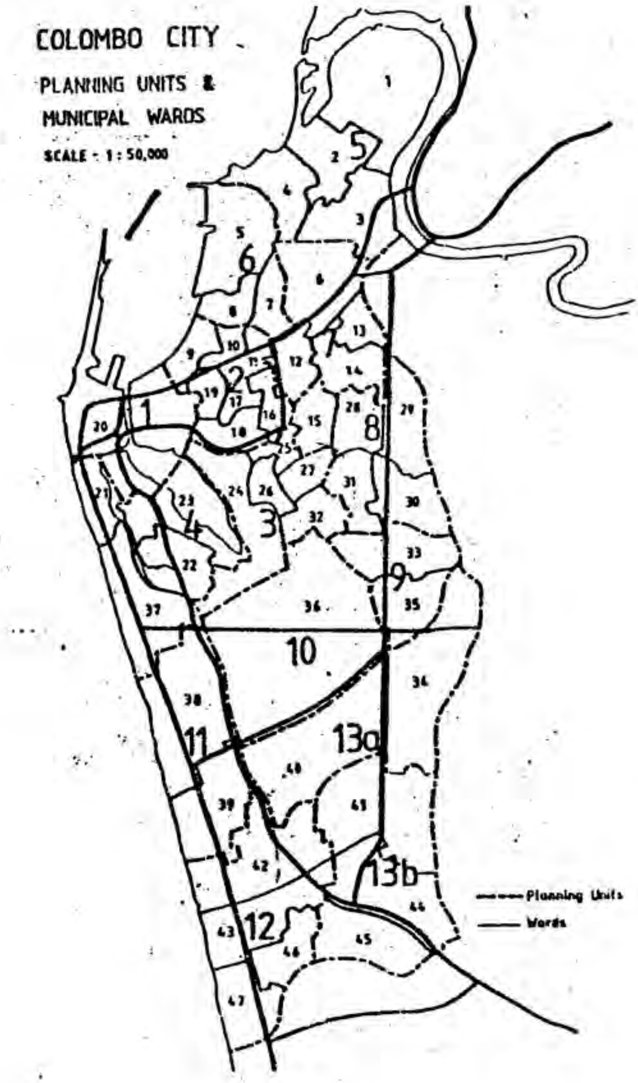


Figure 3.7

Scource: City of Colombo Development Plan, Vol. 1, UDA. 1985

Table.3.3

Population of the City by Planning Units

Planning Unit		Population in 000'		
		1971	**1986**	**2001**
1.	Fort	17	17	17
2.	Kochchikade	76	76	76
3.	Maradana	46	47	47
4.	Kollupitiya	45	46	46
5.	Mattakkuliya	56	55	55
6.	Kotahena	33	33	33
7.	Grandpass	51	51	51
8.	Dematagoda	57	63	66
9.	Borella	26	29	32
10.	Cinnamon Gardens	17	23	34
11.	Bambalapitiya	25	34	41
12.	Wellawatte	46	52	64
13a.	Narahenpitiya	68	84	104
13b.	Kirillapona			
	Total	**562**	**610**	**666**

Source: Urban Development Authority: " City of Colombo Development Plan." Vol. 1. November 1985.

Maradana and Kotahena are old residential areas. Borella, Kollupitiya, Bambalapitiya stretching along Galle Road to Dehiwela is a major shopping area. -figure 3.7 and table 3.3.

3.5 Area of Authority of the Greater Colombo Economic Commission

With the change of Government in 1977 there was a major shift in economic policies. The Greater Colombo Economic Commission (GCEC) was set up under the GCEC Law No.4 of 1978 with the objectives of promoting export-oriented foreign investment, creating employment opportunities and increasing export earnings and for the general economic development of the area.

The area of the GCEC, figure 3.8 spreads from the Kelani river in the south to Maha Oya in the north. It is situated entirely within the Gampaha district. It encompasses the AGA divisions of Negombo, Katana, Ja-ela, Wattala, Kelaniya, Biyagama and a part of Mahara, figure 3.9 and table 3.4. The area extends approximately 32.2 km. (20 miles) in length and about 18 km. (11 miles) at the widest section in the south. The total area covered is about 415 sq. km. (155 sq. Miles) with a total population of 701,483 at the 1981 census and with 50 % living in urban areas.

The GCEC area has close association with the Colombo Municipal Area and the Colombo Urban Area; all these areas being within the Colombo Metropolitan Region, figure 3.4. The Katunayaka and Biyagama industrial zones, the Ekala industrial zone and the International Airport are within the GCEC figure 3.10, while the Port of Colombo and the commercial centre is in the City of Colombo.

Area of Authority of the G.C.E.C.

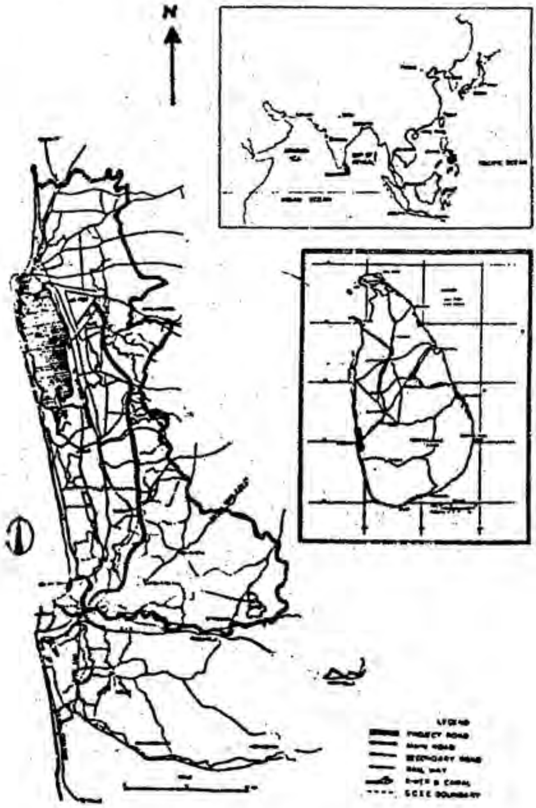


Figure 3.8

Source : Feasibility Study for Katunayake Expressway
JICA 1983.

Figure 3.9

Source : Feasibility Study of the Katunayake Expressway
JICA 1983.

Table 3.4

Composition of the GCEC.

Region	AGA. Division	Code Num.	Area In Sq.km.	Percentage
	Negombo	12B	127.90	31.3
North	Katana	126	22.60	5.5
			150.50	36.9
	Ja-ela	125	79.20	19.4
Center	Wattala	12C	46.20	11.3
			125.40	30.7
	Kelaniya	127	22.20	5.4
South	Biyagama	122	61.90	15.1
	Manara(part.)	128	48.59	11.9
			132.69	32.5
GCEC.		408.59	100.0	

Source: GCEC unpublished report 1982

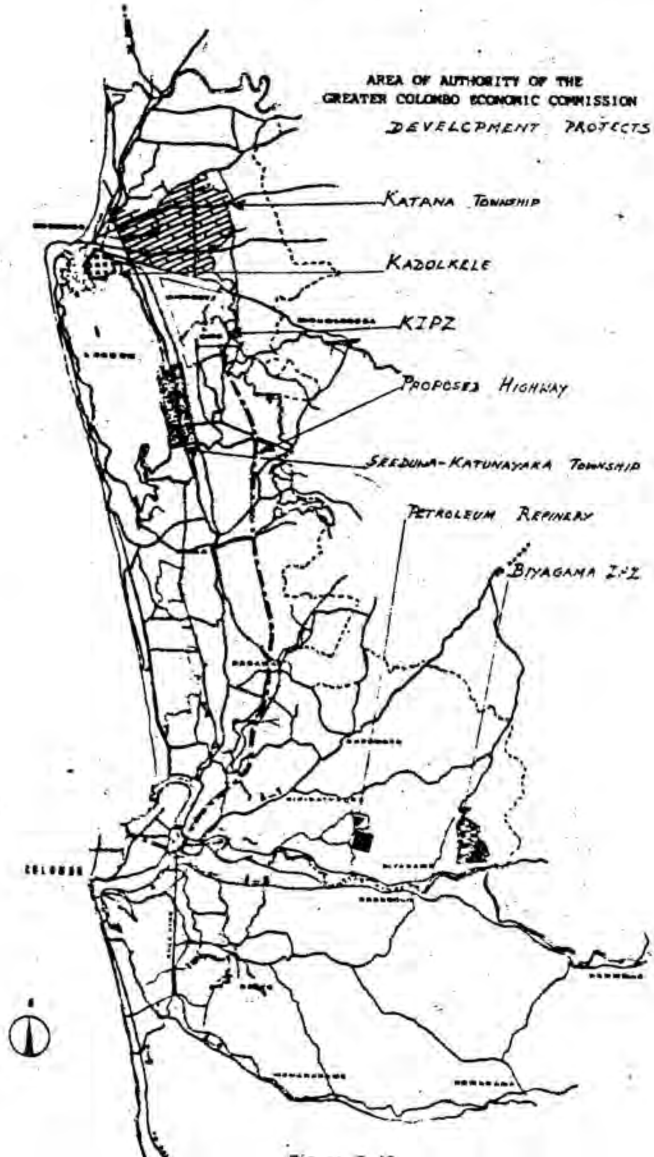


Figure 3.10

Source : Unpublished Report G.C.E.C. 1980.

3.6 Population Growth

The total population recorded at the 1981 census was 14,846,750 with a density of 230 persons per square kilometre. The demographic features of the country during the last decade 1971-1981 is shown in the table 3.5 and clearly indicates the steady decline in growth. Though there is a decreasing growth rate the projected population of the country is expected to attain 21.8 million by the year 2001 as per the medium value estimate of the Department of Census and Statistics table 3.6.

3.6.1 Population Distribution

The distribution of population among the 24 districts, the urban-rural distribution, the average density and it's increase during the period 1971 to 1981 is given in table 3.7. The population growth during the decade has varied from negative growth of 0.4% for Nuwara Eliya to 4.8% for Vavuniya and Polonnaruwa. However, for the project area the growth is below the average. Thepopulation of the three districts of the Colombo Metropolitan Region consists of 26.5% of the total population of the country, 57.3% of the total urban population in the island and exhibits a very wide range of population densities. The dispersal of the population in the island is also clearly illustrated in the dot map where each dot represents 5000 persons as in figure 3.11.

It is very evident that the population is heavily concentrated in the wet zone of the island especially clustering in and around the Capital City of Colombo with a tapering effect along the south -west coastline.

Table 3.5

Demographic Features

1971-1981

Year	Population in 000'	Birth Rate crude/000'	Death Rate crude/000'	Growth %
1971	12,608	32.7	8.1	2.2
1972	12,861	30.0	8.1	2.0
1973	13,091	28.0	8.7	1.7
1974	13,284	27.5	9.0	1.7
1975	13,496	27.8	8.5	1.7
1976	13,717	27.8	7.8	1.6
1977	13,942	27.9	7.4	1.7
1978	14,190	28.5	6.6	1.9
1979	14,471	28.7	6.5	1.9
1980	14,738	27.6	6.1	1.8
1981	14,988	27.0	6.0	1.7

Source: Central Bank of Ceylon "Review of the Economy, 1981"

The estimated growth for high, medium, and low rates based on fertility and family size are given in table 3.6

Table 3.7

Population Distribution)

Areas / Districts	Population 1981 Total	Urban	Rural	Density per sq. km.	Population 1971 Total	Urban	Rural	Density per sq km.	Average Increase pop. %	Increase in density %
Sri Lanka	14846.8	3192.5	11654.2	230	12689.9	2848.1	9841.8	196	1.7	17.3
Colombo	1699.2	1264.3	435.0	2605	2672.3	1476.2	1196.1	2247	1.3	13.4
Gampaha	1390.9	388.3	1002.5	994 -	- -					
Kalutara	829.7	178.1	651.6	516	729.5	159.5	570.0	444	1.3	13.7
Kandy	1048.3	145.1	903.2	554	1187.9	147.3	1040.6	548	0.3	09.1
Matale	373.3	38.1	319.2	180	314.8	37.6	277.3	158	1.3	13.9
N'eliya	603.6	37.3	566.3	364	450.3	27.6	422.7	377	-0.4	-3.4
Galle	814.5	166.4	648.2	487	735.2	154.9	580.2	439	1.0	10.9
Matara	643.8	71.2	572.6	516	586.4	66.1	520.3	470	0.9	09.8
Hambantota	424.3	41.4	382.9	164	340.3	33.3	307.0	131	2.2	25.2
Jaffna	830.6	270.6	560.0	401	701.6	233.9	467.7	336	1.8	19.3
Mannar	106.2	13.9	92.3	53	77.8	11.1	66.7	37	3.8	43.2
Vavuniya	95.4	18.5	76.9	36	95.2	20.6	74.6	23	4.8	56.5
Mullaitivu	77.2	7.2	70..0	39						
Batticaloa	330.3	79.4	250.9	134	256.7	69.5	487.2	104	2.6	28.8
Ampara	255.9	82.7	173.2	86	188.2	72.2	240.6	60	3.6	43.3
Trincomalee	389.0	53.3	336.0	98	272.6	37.0	116.0	72	3.2	36.1
Kurunegala	1211.8	43.5	1168.3	254	1025.6	42.2	983.4	215	1.7	18.1
Puttalam	492.5	61.7	430.8	165	318.4	52.4	326.0	127	2.7	29.9
Anuradhapura	587.9	41.4	546.5	82	388.8	38.8	349.9	55	4.2	49.1
Polonnaruwa	261.6	20.5	241.1	77	163.7	16.3	147.4	48	4.8	60.4
Badulla	641.0	51.6	589.4	227	615.4	55.4	560.0	218	0.4	04.1
Moneragala	273.6	6.0	267.6	49	193.0	5.1	187.9	35	3.8	40.0
Ratnapura	797.1	59.2	737.9	246	661.3	50.0	611.4	208	1.7	18.3
Kegalle	684.9	52.8	632.2	412	654.8	46.1	608.7	384	0.6	07.3
Study Region;	3919.8	1830.7	2089.1	1371.6	3401.8	1635.7	1766.1	1375.5	1.5	
C.M.R. %	26.4	57.3	17.9	-	26.8	57.4	17.9			

Source: Department of Census and Statistics. 1982.

POPULATION DISTRIBUTION BY DISTRICT IN SRI LANKA, 1981

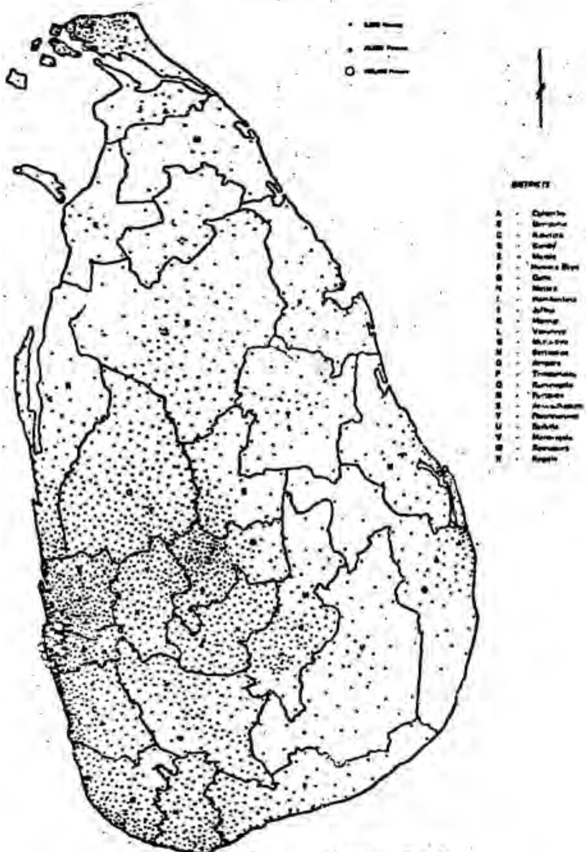


Figure 3.11

Source: Census of Population & Housin 1981
General Report Volume 3 Department of Census
& Statistics.

Table 3.8

Population and Employment.
Sri Lanka
Western Province(CMR)
1971-1981

	Sri Lanka				Western Province(CMR)			
	1971	1981	Increase	%	1971	1981	Increase.	%
Area (sq.km.)	64,652					3,658		
Population in thousands	12,689.9	14,846.8	2156.9	17.0	3401.8	3919.8	518.0	15.2
Population per hectare	1.96	2.3	0.34	17.3	9.30	10.7	1.4	15.1
Total Employment (000')	3,648.9	4,119.3	470.0	12.9	1110.0	1062.3	52.3	5.2
Agricultral A Sector	1,829.0	1876.0	47.0	2.6	157.0	140.6	-16.4	-10.4
Manufacturing M Sector	456.1	576.5	121.0	26.5	171.4	258.1	86.7	50.4.
Services S Sector	1050.0	1298.0	248.0	23.6	553.7	556.4	2.7	0.5
Unspecified	314.0	369.0	55.0	17.5	127.9	107.2	-20.7	-16.2
Manufacturing only	339.4	408.7	69.3	20.4	135.3	205.5	70.2	51.9

Source: Census of Population and Housing - 1981 -

General Report Vol.3. 1986.

Table 3.6 **Estimates of Population in millions**

Value \ Year	1981	1986	1991	1996	2001
High		16,525	18,039	19,669	21,309
Medium	15,046	16,484	17,879	19,319	20,673
Low		16,445	17,707	18,934	20,000

Source: Census of Housing and Population, General Report, Vol. 3. 1981, Dept. of Census and Statistics.

3.6.2 Population Growth in CMR.

The characteristics with respect to population and employment for Sri Lanka and the CMR for 1971 and 1981 are given in table 3.8. The study region (CMR) has some of the highest population densities in the country figure 3.12 but populationpopulation in the relevant districts have growth rates of (1.3%) for Colombo , Gampaha (1.8%) and Kalutara (1.4%) table 3.9. But the Colombo M.C. which has the highest population of 586,000 for any town (1981) has recorded a growth rate of 0.4% per annum.

The higher densities in the sub region are associated with increased industrial activity and denser traffic flows. After a peak period of growth of 2.8% between 1946/1953 the population declined to 1.7% between 1971/1981 table 3.9 due mainly to a declining birth rate.

The table 3.10 shows the sectoral growth in population. The population in the urban sector increased from 2.8% during 1946/1953 to 4.9% in the period 1963/1971 and then decreased to 1.2% during the interval 1971/1981.

Table 3.9 **Population Growth by Districts**

Years	46/53	53/63	63/71	71/81
Districts				
Colombo	2.7	2.5	2.3	1.3
Gampaha				1.8
Kalutara	2.0	1.8	1.7	1.4
Average	2.8	2.7	2.2	1.7

Source: Dept. of Census and Statistics.

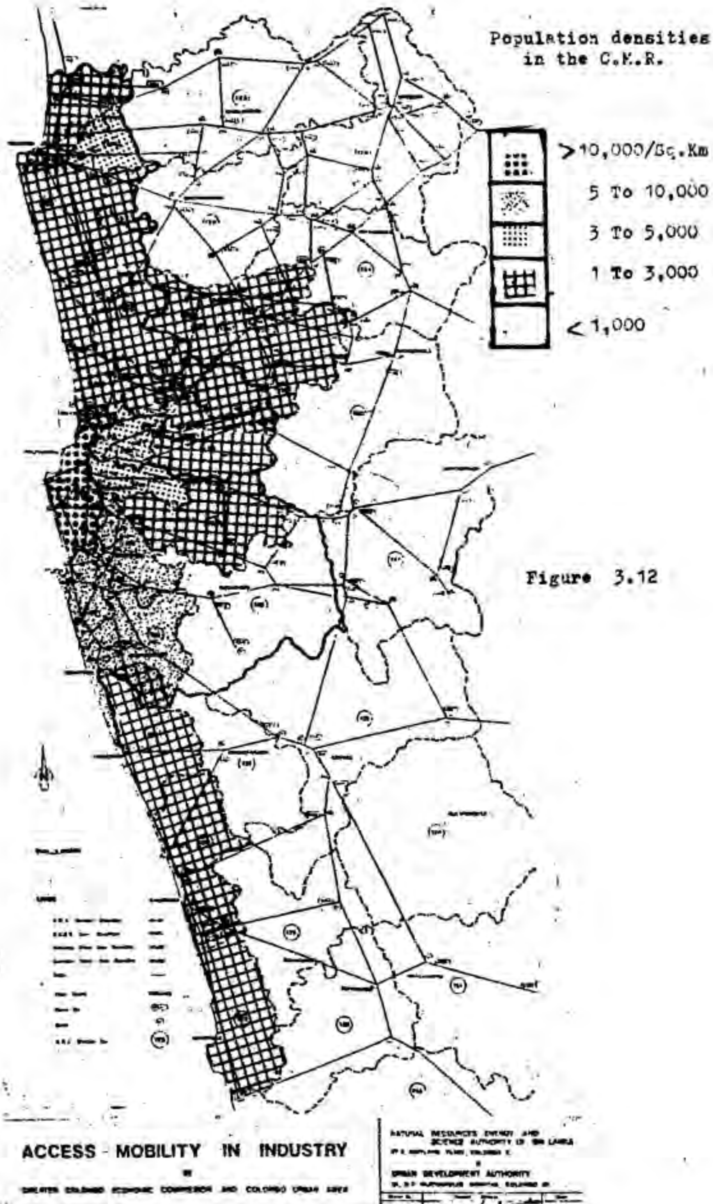
Table 3.10

Population Growth by Sector

Annual Rate 1946/1981

Years	46/53	53/63	63/71	71/81
Urban	2.8%	4.8%	4.9%	1.2%
Rural	2.8%	2.2%	1.9%	1.8%
Total	2.8%	2.7%	2.2%	1.7%

Source: Statistical Pocket Book Dept. of Census and Statistics.



Population densities
in the C.M.R.
>10,000/Sq.Km
5 To 10,000
3 To 5,000
1 To 3,000
< 1,000
ACCESS - MOBILITY IN INDUSTRY
URBAN DEVELOPMENT AUTHORITY

Figure 3.12

Table 3.11

Population Projections
for
Colombo Metroplitan Region

in thousands

	Colombo Metropolitan Region			Central Sub-Region			Outer Sub-Region		
Years	Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural
1971	3250	1623	1627	2224	1423	801	1026	200	826
1986	4070	2350	1720	2860	2050	810	1210	300	910
2001	4800	3000	1800	3340	2570	830	1460	490	970

Source: Colombo Metropolitan Study. UNDP. 1978

However, in the rural sector the population growth continued to decrease steadily from 2.8% in 1946/1953 period to 1.8% in the interval 1971/1981. These were due to decreasing fertility rates.

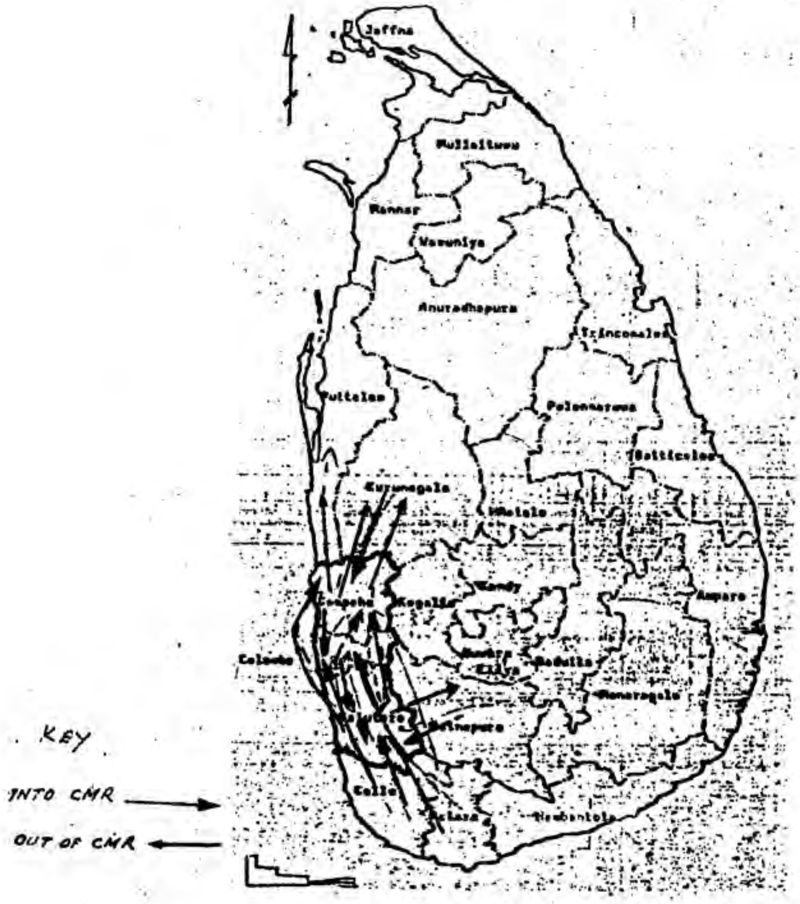
The population projections for the CMR, the Central sub-region which includes the CUA and the Outer sub-regions are shown in table 3.11. The **highest increase (76.95%) by 2001 is** in the **urban area of the Central sub-region**. Also in the **outer sub-region** there is likely to be a considerable **change in the urban population**, a change **from 19.49 % to 33.56 %.**

3.6.3 Migration

Migration to the CMR increased due to rapid urbanization and increasing employment opportunities in the Western Province. Population movements have been confined mainly to the Colombo and Gampaha districts. Colombo district received about 330,000 persons with over 35,000 each coming in from Galle, Matara, Kalutara and Kandy districts. Gampaha district ranks second in in-migration of 209,000 the greater part being from Colombo figure 3.13.

3.6.4 Urban Growth Pattern

The level of urbanization in the project area is shown in figure 3.14 and changes in the urban population growth in the CMR, CUA and the CMA are shown in the figure 3.15. Population densities in the CMR and their variation is shown in figure 3.12. It clearly illustrates the high densities in the City, CUA and the coastal belt. The distribution of the increase in urban population is shown in figure 3.16.



Inter District Movements in CMR.

Figure 3.13

Author's Compilation.

Source : Census of Population & Housing
General Report, Vol. 3 1981.

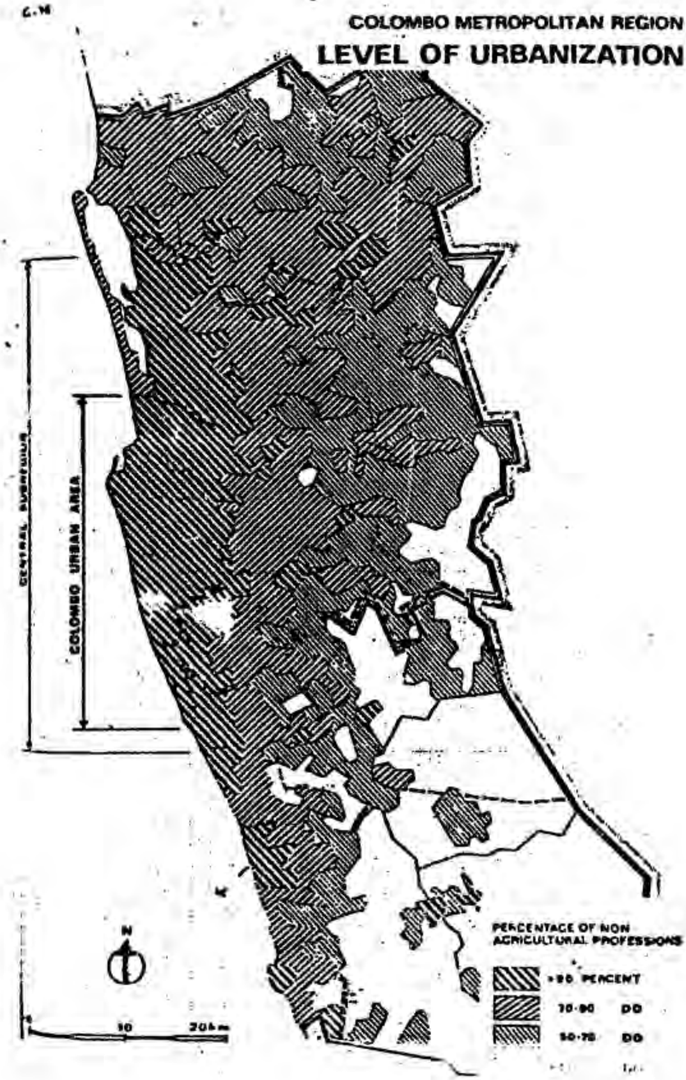


Figure 3.14

Source : Colombo Master Plan Project.
UNDP Technical Report, Vol. 2 April 1978.

COLOMBO METROPOLITAN REGION

INCREASE OF URBAN POPULATION

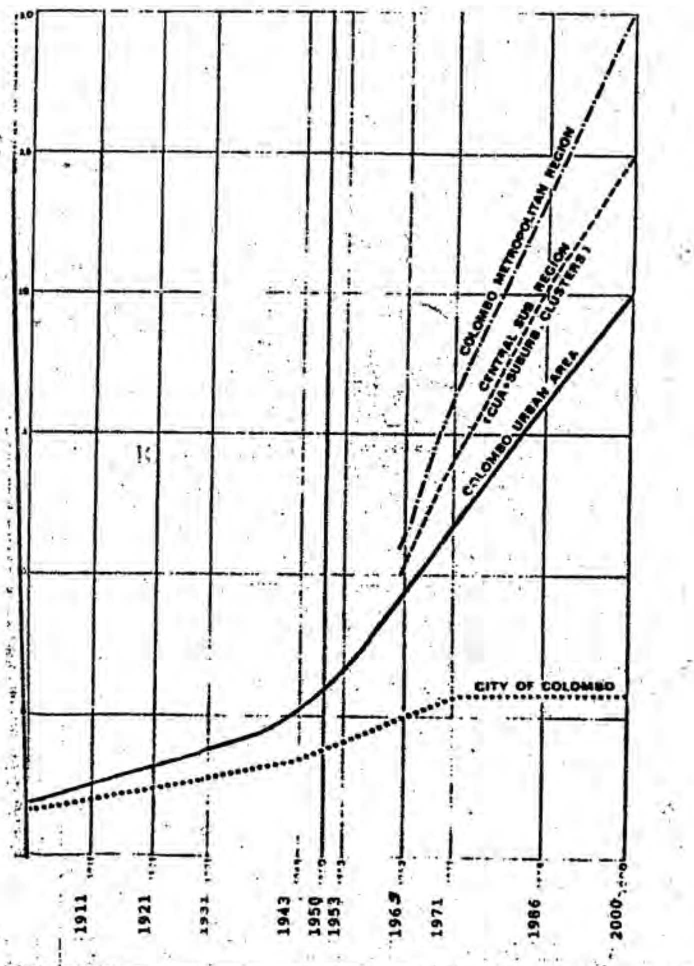


Figure 3.15

Source : Colombo Master Plan Project.
UNDP Technical Report, Vol.2, April 1978.

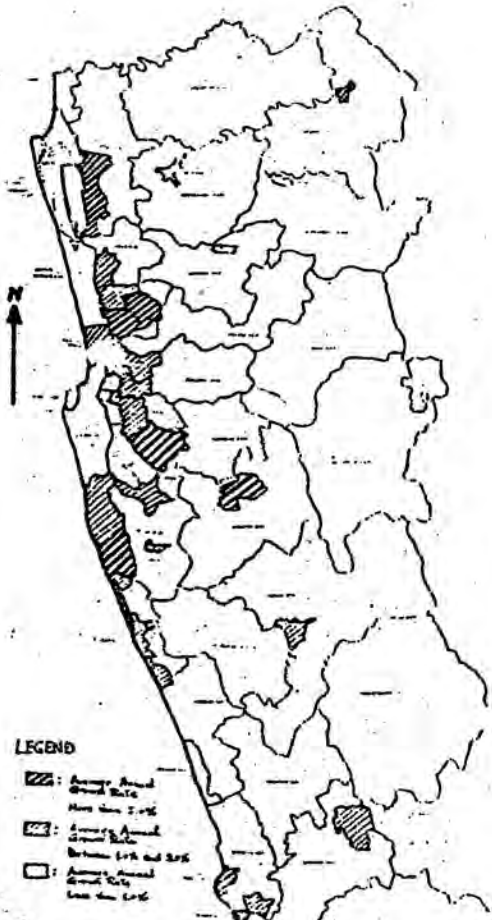


Figure 3.16

Population Increase in Urban Areas of the Study Region, 1971-1981

Source : Report on the Regional Economy; The Feasibility Study on Katunayake Expressway, JICA 1983.

3.6.5 Towns in Sri Lanka

The distribution of towns by population and degree of urbanization are shown in figure 3.5 and table 3.1 Considering the location and distribution of the towns it may be noted that of 9 towns of a population of over 50,000 five are located in the vicinity of Colombo. Of the 30 towns of populations 20,000 to 49,999 sixteen are situated within the Colombo district. Five of the most important towns in the country as per table 3.12 are located within this area

The towns with populations between 10,000 and 50,000 have increased. As seen from the table the largest growth is in Moratuwa with a 4.01% per annum and the least growth in Aggalawatta with a 0.13%. The towns of Moratuwa, Mirigama, Seeduwa, Beruwela, Welisara, Battaramulla, Ragama and Hendala all show more than 2.5% growth per annum. Avissawella is the only town showing a negative growth of 0.93%.

The location of the strategic towns and their linkage to the GCEC and the Sri Jayawardenepura, Kotte is illustrated in figure 3.17. The regional structure plan that had been developed for the CMR by the Colombo Master Plan study clearly emphasizes the role of the urban areas figure 3.18 and their linkages to growth centres in the region .

Table 3.12 **Major Towns in Project Area.**

Population in 000'

Town	**1971**	**1981**
Colombo	562.2	587.7
Dehiwala-Mt.Lavinia	154.2	173.5
Moratuwa	96.3	134.8
Kotte	93.7	101.0
Negombo	56.8	60.8
Kalutara	28.6	31.5

Source: Department of Census and Statistics

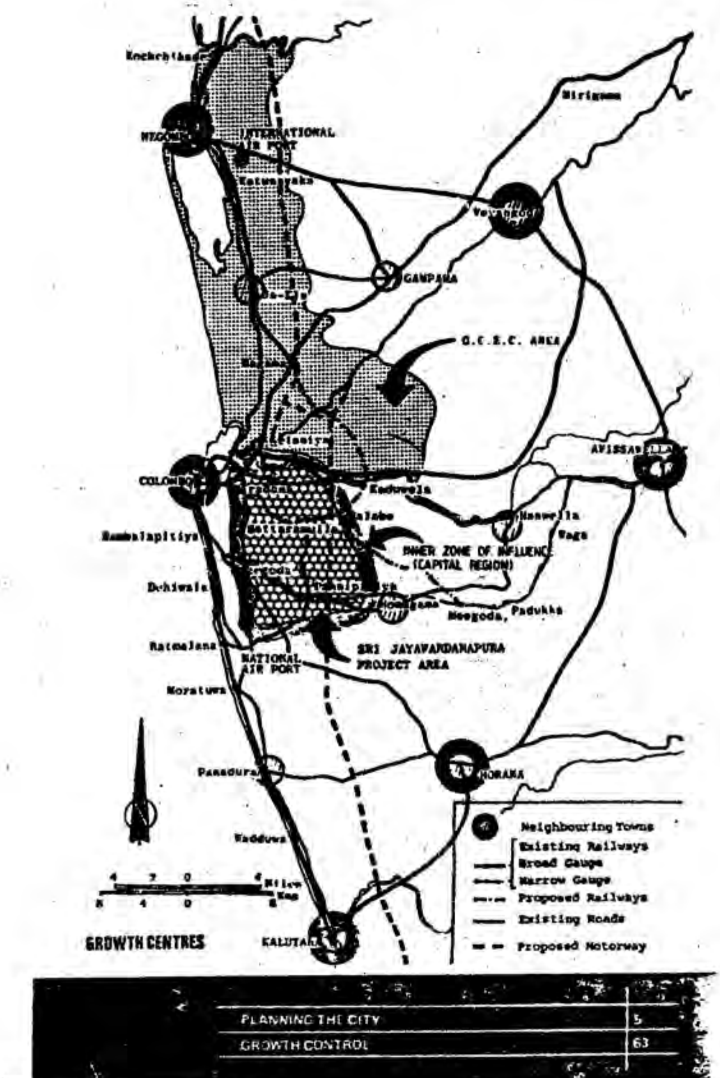


Figure 3.17

Growth Centres of the CMR

Source : Colombo Master Plan.
UNDP Technical Report, Vol.2, April 1978.

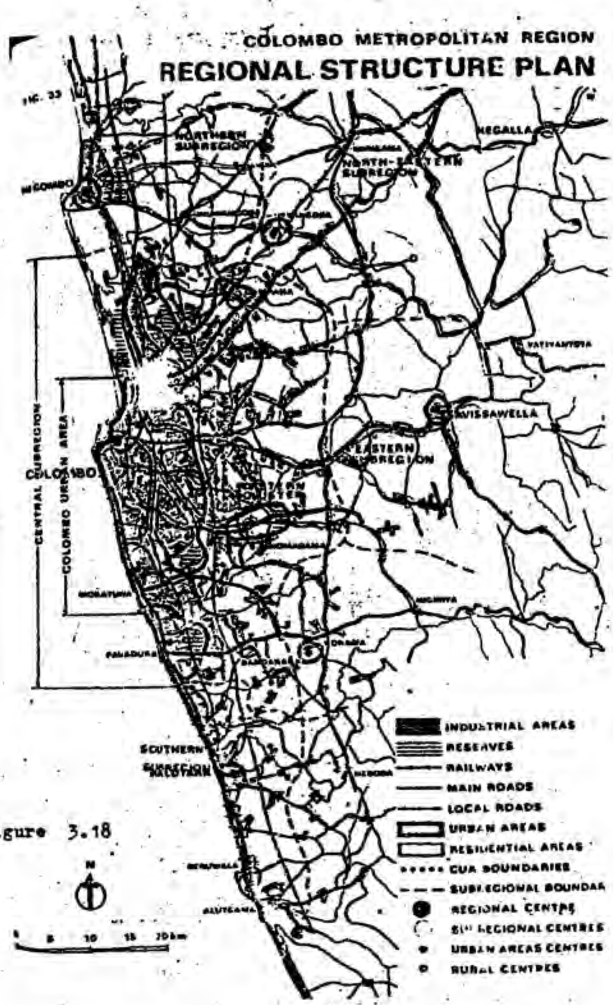


Figure 3.18

3.7 Industry

The basis of the analysis of industry is the census of Industry carried out by the Department of Census and Statistics in 1983. This was the major census done after the last industrial census of 1963. The 1983 census is important due to the high priority given by the present government to the development of trade and industry in relation to the liberalization policy of the economy. The census covered primarily the activities of Mining and Quarrying, Manufacture and Production and distribution of Electricity, Gas and Water corresponding to the major divisions 2, 3 and 4 respectively of the U.N. International Standard Classification of All-Economic Activities (I.S.I.C.). It covered all industrial establishments engaging 5 or more persons.

3.7.1 Distribution of Industry

The employed population has been divided into three broad categories based on three major economic sectors.

1. **Agricultural:** agriculture, forestry hunting and fishing.
2. **Manufacturing:** minining quarrying construction.
3. **Services:** electricity, gas and water, transport, finance, social and community services.

3.7.2 Manufacturing

The employment in the economic sector as revealed by the censuses of 1971 and 1981 are given in table 3.13. Compared to agriculture which employed 45.5 % of the population, manufacturing employment contributed only 9.9 % in 1981 and formed only a marginal increase over the 1971 percentage of 9.3 percent.

Manufacturing is classified into nine divisions according to the I.S.I.C division of industries. The largest sub-group in manufacturing is the textiles, wearing apparel and leather industries which represented 30.6 % and absorbed 124,925 workers. The second largest group is the food, beverages and tobacco which represented 20.0 % of the workers and provided employment to 81,840 persons. Chemicals, petroleum and rubber, non-metallic products and fabricated metals showed a high increase in labour content (39,463).

3.7.3 Dominance of the Manufacturing Sector.

The manufacturing industrial sector dominates all of industry. Of 102,721 industrial units 99,689 or 97 % of the total number of establishments employing 600,804 persons (94 %) is in manufacturing. The contribution of the manufacturing sector in the value of output amounted to Rs. 47,625.5 million or 93.7 % of the total industrial sector output (.table 3.14).

Table 3.13 **Distribution of Industrial Sector**

1971 and 1981 in 000'

Economic	**Employees**		**Percentage**		**Increase**	
Sector	**1971**	**1981**	**1971**	**1981**	**1971**	**1981**
Agriculture	1,829	1,876	50.1	45.5	47	2..6
Manufacturing	456	577	12.5	14.0	121	26.5
Services	1,050	1,298	28.8	31.5	24.8	23.6
Unspecified	314	369	8.6	9.0	55	17.5
All Sectors	3,649	4,119	100	100	47	12..9

Source: Census of Population and Housing 1981. Vol.3

Table 3.14

Indicators of the Industrial Sector

	Establish. Numbers	%	Persons Engaged	%	Value Output Rs. Mill.	%	Value Added Rs. Mill.	%
Manufacturing	99,689	97.1	600,804	94.0	47,625.5	93.7	18,116.3	90.3
Others	102,721	100.0	639,256	100.0	50,844.5	100.0	20,091.3	100.0

Source: Sri Lanka Census of Industry 1983. Department of Census and Statistics.

Table 3.35

Distribution of Industries by Districts

Code	District	No. of Establish.	% of Total	Total No. of Persons in 000'	% of Total	Value of output in Rs. Mill.	% of Total	Value Added in Rs. Mill.	% of Total
01	Colombo	7411	7.3	112.5	17.9	13236.6	27.5	7832.3	42.2
02	Gampaha	9851	9.6	86.2	13.7	17123.2	35.6	3282.2	17.7
03	Kalutara	6677	6.5	24.9	4.0	839.8	1.7	483.7	2.6
04	Kandy	6566	6.4	46.2	7.4	1,259.0	2.6	648.3	3.5
05	Matale	2052	2.0	14.2	2.3	322.9	0.7	183.4	1.0
06	Nawalapitiya	2065	2.0	37.8	6.0	1,803.6	3.7	897.1	4.8
07	Galle	10570	10.3	37.5	6.0	1,318.3	2.7	749.8	4.0
08	Matara	8723	8.5	28.9	4.6	858.9	1.8	366.4	2.0
09	Hambantota	3019	3.0	8.9	1.4	199.9	0.4	95.6	0.5
10	Jaffna	3121	3.0	18.5	3.0	1,143.8	2.4	457.9	2.5
11	Mannar	563	0.6	1.8	0.3	59.3	00.1	27.0	0.2
12	Vavuniya	176	0.2	1.0	0.2	81.3	0.2	13.8	0.1
13	Mullaitivu	91	0.1	0.5	0.1	12.8	0.0	7.6	0.0
14	Batticaloa	2733	2.7	10.3	1.7	439.6	0.9	136.2	0.7
15	Amparai	2049	2.0	13.4	2.2	464.0	1.0	186.8	1.0
16	Trincomalee	938	0.9	4.6	0.7	2,670.7	5.6	643.5	3.5
17	Kurunegala	11122	10.8	42.9	6.8	1,295.8	2.7	371.4	2.0
18	Puttalam	3894	3.8	35.8	5.7	1,090.0	2.0	419.6	2.2
19	Anuradhapura	2144	2.1	7.1	1.2	426.3	0.9	267.9	1.4
20	Polonnaruwa	1003	1.0	4.7	0.8	315.7	0.7	162.7	0.9
21	Badulla	2066	2.0	15.7	2.5	896.4	1.9	297.9	1.6
22	Moneragala	935	0.4	3.5	0.6	130.1	0.3	55.8	0.3
23	Ratnapura	5685	5.5	29.6	4.7	1,178.9	2.5	445.3	2.4
24	Kegalle	9151	8.9	39.5	6.3	973.9	2.0	536.5	2.9
	% in Study		23.4		35.6		64.8		62.5
	Total	102,605	100.0	625.1	100.0	48,142.0	100	18,569.9	100.0

Source: Census of Industry, 1983; Dept. of Census and Statistics

The relevant figures in the table 3.14 illustrates the very striking and dominant function of the manufacturing sector in all of industry. The table 3.15 shows the districts in the country, the number of industrial units in each, the number of persons employed, the value of output and the value added both by numers and percentage. The major industrial districts when classified according to establishments range as follows; Kurunegala(10.5%), Galle (10.3%), Gampha(9.6%), Kegalle(8.9%), Matara(8.5%), Colombo(7.3%), Kalutara(6.5%),Kandy(6.4%) and Ratnapura(5.5%).

But in terms of employment Colombo and Gampaha districts outstrip the others contributing 31.6% to job opportunities. In terms of value of output Gampaha district even overruns the Colombo district and both these districts make a contribution of 63.1% So is the case with value added with both areas making up 59.9 % of the total. The contributions of these three districts to employment in industry is 35.6% , to the economy 64.8% and to value added 62.5% as shown in the table.

3.8 Transportation

The other aspect that is examined is the role of transportation in the choice of the study area. It is looked at from several angles namely;

1. **The highway system.**
2. **Vehicle registration and growth.**
3. **Traffic flows.**
4. **Public transport operations.**

POSTED HIGHWAYS, RAILWAYS AND MAJOR BUS ROUTES—1962

CEYLON TRAFFIC AND PLANNING STUDY

MINISTRY OF TRANSPORT—WILBUR SMITH AND ASSOCIATES

UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

Figure 3.19

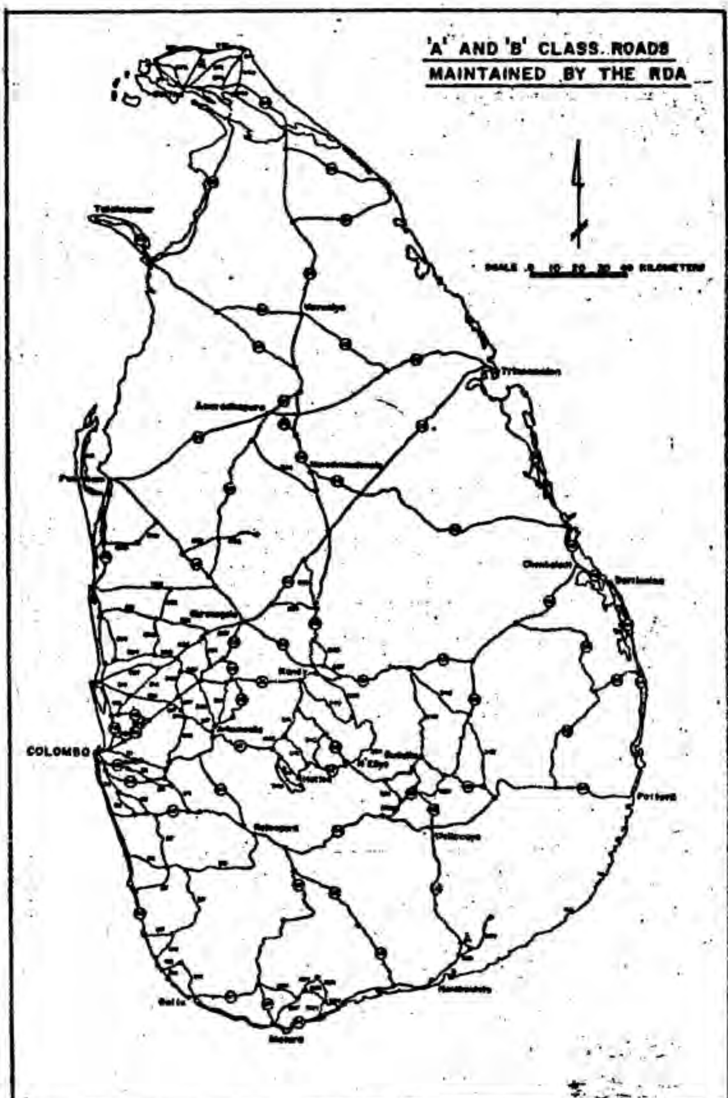


Figure 3.20

Table 3.16

Roads Maintained by RDA

Region and Class-1986

C.EE. Region	'A' Class	'B' Class		'C' Class		'D'Class		'E' Class		Total	
	Paved	Paved	Unpaved	Paved	Unpaved	Paved	Unpaved	Paved	Unpaved	Paved	Unpaved
1. Colombo	99.5	169.70		310.10	1.21	120.98	1.37			700.28	2.58
2. Gampaha	161.35	472.74		447.53		430.54	20.95		4.99	1512.16	25.94
3. Kalutara	80.22	258.81		476.79	1.66	188.09	5.71			1003.91	7.37
4. Kandy	135.06	431.95		1000.27	14.75	69.52	17.12	3.35	8.05	1660.15	39.92
5. Matale	105.18	184.70		293.98	39.52	77.15	82.46	21.88	27.87	682.89	149.85
6. Nuwara Eliya	122.72	341.46		514.94	28.61	14.53	62.99	8.45	227.63	1002.10	319.23
7. Galle	97.13	235.81		457.02	2.25	248.67	28.70		88.40	1038.63	119.35
8. Matara	256.02	266.87		567.99	34.19	350.57	172.76			1441.45	206.95
9. Jaffna	380.08	266.06		468.06	105.53	115.33	100.24			1229.73	205.77
10. Vavuniya	353.19	101.14		286.21	212.61	140.16	425.42			880.70	638.03
11. Batticaloa	448.09	147.50	10.30	353.75	66.42	83.73	182.12		13.68	1033.07	272.52
12. Trincomalee	140.58	124.73		164.92	41.22	55.28	38.29			485.51	77.42
13. Kurunegala	196.81	417.20	4.26	570.50	213.27	405.64	371.81		10.73	1590.15	600.07
14. Puttalam	156.07	195.80		400.80	85.08	49.35	123.80		16.25	802.02	225.13
15 Anuradhapura	349.30	200.77		574.89	224.57	99.89	600.41			1224.85	824.98
16. Polonnaruwa	122.85	61.95		276.78	45.45	8.61	43.44			470.19	88.89
17. Badulla	264.95	359.59		684.03	62.94	241.54	93.13		91.34	1550.11	245.43
18. Moneragala	185.76	0.45		155.33	92.76	65.32	36.94		35.80	406.86	165.50
19. Ratnapura	272.89	246.08		506.77	10.73	19.32	6.99		8.85	1045.06	26.57
20. Kegalle	143.89	246.87		412.22	43.25	202.80	61.79			1005.78	105.04
All Island	4091.64	4730.18	14.56	8922.88	1326.02	2987.22	2472.37	33.68	533.59	20765.60	4346.54
CMR	341.07	901.25	0	1234.42	2.87	739.61	28,03	0	4.99	3216.35	35.9
% of Total	8.34	19.05	0	13.83	.02	24.76	1.13	0	.09	15.49	.08

Source: The Road Development Authority

Table 3.17
Roads Maintained by Local Authorities

District	Metalled	Gravel	Other	Total
Colombo	1753	2288	298	4339
Gampaha	-	-	-	-
Kalutara	324	1530	109	1963
Kandy	338	72	264	674
Matale	91	426	306	823
Nuwara Eliya	74	83	27	184
Galle	228	1425	412	2065
Matara	173	1204	162	1539
Hambantota	91	1409	179	1679
Jaffna	689	832	184	1705
Mannar	64	127	107	298
Vavuniya	3	766	324	1093
Mullaitivu	-	-	-	-
Kilinochchi	-	-	-	-
Batticaloa	106	777	56	939
Amparai	59	1019	397	1475
Trincomalee	64	298	138	7849
Kurunegala	152	4795	2902	7849
Puttalam	271	1022	237	530
Anuradhapura	24	2151	1356	3531
Polonnaruwa	22	681	862	1565
Badulla	1000	676	348	2024
Moneragala	24	293	631	948
Ratnapura	173	2479	199	2851
Kegalle	272	548	199	1019
All Island	5995	24901	9697	40593
CMR	2077	818	407	4502
% of Total	34.65	15.3	4.20	15.52

Source: The Department of Local Government.

3.8.1 Highway System.

Roads in Sri Lanka are built and maintained by the Road Development Authority(RDA) (the successor to the Department of Highways), Local Authorities, other Government and State Sector organizations.

The roads built by the RDA are classified into **five levels A,B,C,D, and E.** All **A** class roads are paved and bitumen surfaced while some mileages of the other classes are unpaved. These roads are maintained by Chief Engineers' regions which are generally similar to the Government Agents districts. The **A** and **B** roads which are posted and maintained by the RDA are shown in figure 3.19and figure 3.20 shows all **A and B** class roads maintained by the RDA The table 3.16 shows the distribution of the mileage by class and district. The study region or CMR has 15.50% of all paved roads and 27.4% of A and B class roads. The roads maintained by the Local Authorities are shown in table 3.17. The above table illustrates the distribution of other roads in the island. The CMR contains 34.6% of all other metalled roads.

3.8.2 Vehicle Licensing and Revenues.

The growth and distribution of the motor vehicle population and the dominating position of the CMR in attracting the larger proportion of registered vehicles in the island is shown by the table 3.18. This table shows that the three districts Colombo, Gampaha and Kalutara contain 63.88% of all licenced vehicles in the island. This yeilds a density of 39.5 vehicles per sq. kilometer and 36.9 vehicles per 1000 of the population whereas all other districts including Kandy and Jaffna are far below in all three respects. The all island average for vehicle density is 3.5 veh/per sq. km. and the vehicle ownership is 15.2 per 1000 of the population.

Table 3.3B

Vehicles Licenced

1983.

No.	District	Pass.Veh.	Percent	Goods Veh.	Percent.	Total	Percent.	Veh./sq.Km.	Veh./1000Pop
01	Colombo	101097	58.89	36516	66.85	137613	60.81	710.93	44.6
02	Gampaha								
03	Kalutara	5562	3.24	1385	2.54	6947	3.07	4.32	8.4
04	Kandy	8150	4.75	3920	7.18	12070	5.33	6.38	11.5
05	Matale	1549	0.90	591	1.08	2140	0.95	1.08	5.7
06	Nuwera Eliya	1468	0.86	1000	1.83	2468	1.09	1.72	4.1
07	Galle	5022	2.93	1115	2.04	6137	2.71	3.67	7.5
08	Matara	2918	1.70	1025	1.88	3943	1.74	3.16	6.1
09	Hambantota	1112	0.65	328	0.60	1440	0.64	0.56	3.4
10	Jaffna	9728	5.67	1240	2.27	10980	4.85	5.29	13.2
11	Mannar	437	0.26	108	0.20	545	0.24	0.27	5.1
12	Vavuniya	495	0.29	229	0.42	724	0.32	0.27	7.6
13	Mullaitivu	125	0.07	37	0.07	162	0.07	0.08	2.1
14	Batticaloa	1853	1.08	288	0.53	2141	0.95	0.87	6.5
15	Amparai	1722	1.00	421	0.77	2143	0.95	0.47	8.4
16	Trincomalee	1036	0.60	226	0.41	1262	0.56	0.48	3.2
17	Kurunegala	11374	6.63	1684	3.08	13058	5.77	2.76	10.8
18	Puttalam	4526	2.64	978	1.79	5504	2.43	1.85	11.2
19	Anuradhapura	3251	1.89	606	1.11	3857	1.70	0.54	6.6
20	Polonnaruwa	838	0.49	244	0.45	1082	0.48	0.32	4.1
21	Badulla	1997	1.16	936	1.17	2933	1.30	1.04	4.6
22	Moneragala	470	0.27	152	0.28	622	0.28	0.11	2.3
23	Ratnapura	4505	2.62	944	1.73	5449	2.41	1.68	6.8
24	Kegalle	2443	1.42	649	1.19	3094	1.37	1.86	4.5
	All Island	171680	100	54622	100.00	226301	100.00	3.50	15.2
	CMR	106659	62.13	37901	69.39	144560	63.88	39.50	36.90

Source: The Registrar of Motor Traffic.

The second highest value of vehicle density is 6.38 per sq.km. in the Kandy district while the second highest vehicle ownership per 1000 persons is 13.2 in the Jaffna district. These figures illustrate the high intensity of vehicle ownership and movements in the project area.

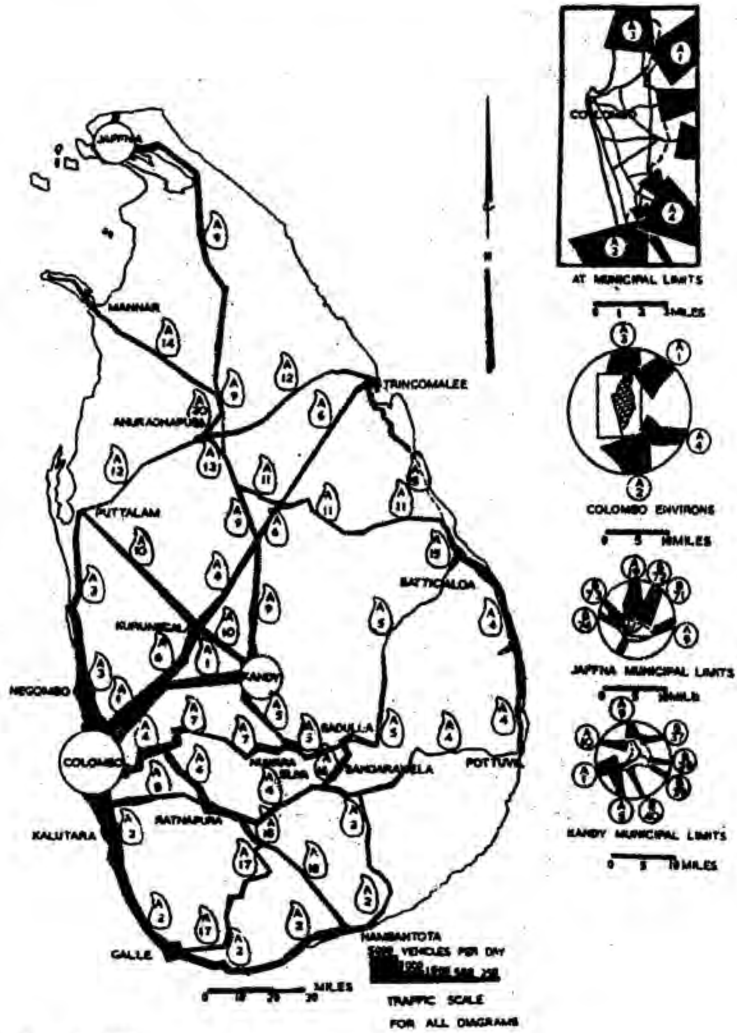
3.8.3.Traffic Flows.

The figure 3.21 was prepared for the 1961 Traffic and Planning study undertaken by Wilbur Smith & Associates with the former Department of Public Works. The figure 3.22 is the product of the RDA from recent traffic counts carried out by them for the year 1986. Both these figures illustrate the density of traffic flows on the island's road network and in particular the continuning importance of the CMR and the relative growth of traffic throughout the country.

There are six main routes namely, Colombo-Kandy, Colombo-Galle, Colombo-Negombo, Colombo-Aviissawella Low Level, Colombo-Ratnapura High-Level and the Colombo-Horana which traverse the CMR and enter the City of Colombo.

The results of traffic counts carried out at the main entries to the City are illustrated in the figure 3.23. These figures show the relative importance of the CMR and the City of Colombo in the growth of traffic in the project area.

PRELIMINARY TRAFFIC FLOW ON MAIN ROADS



December 1961

Figure 3.21

CEYLON TRAFFIC AND PLANNING STUDY

PUBLIC WORKS DEPARTMENT—WILBUR SMITH AND ASSOCIATES

UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

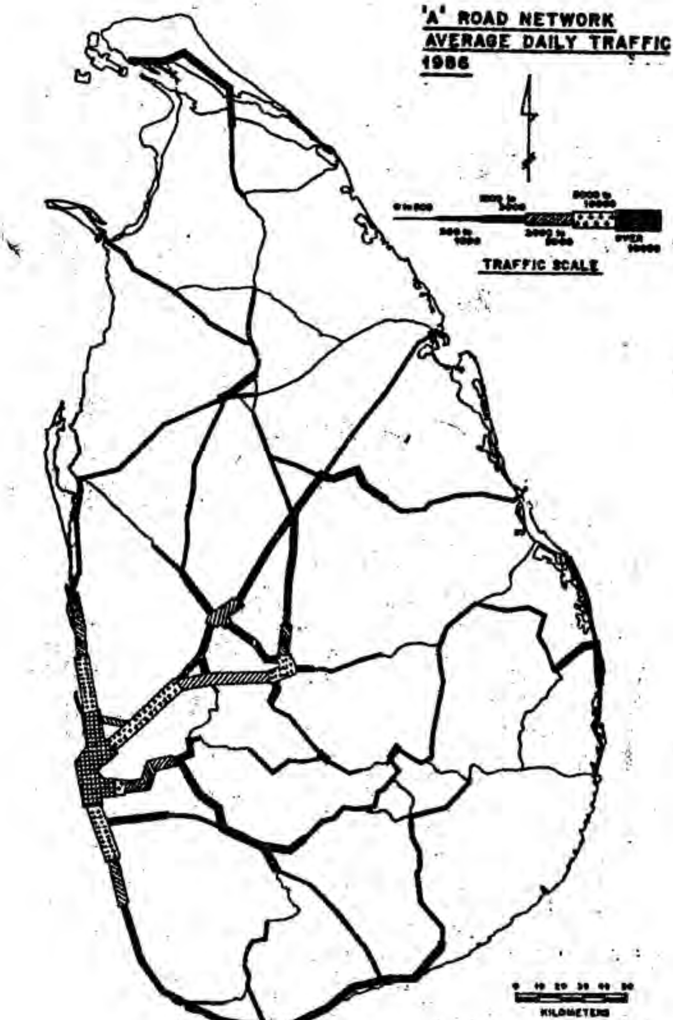

'A' ROAD NETWORK
AVERAGE DAILY TRAFFIC
1986
TRAFFIC SCALE
KILOMETERS

Figure 3.22

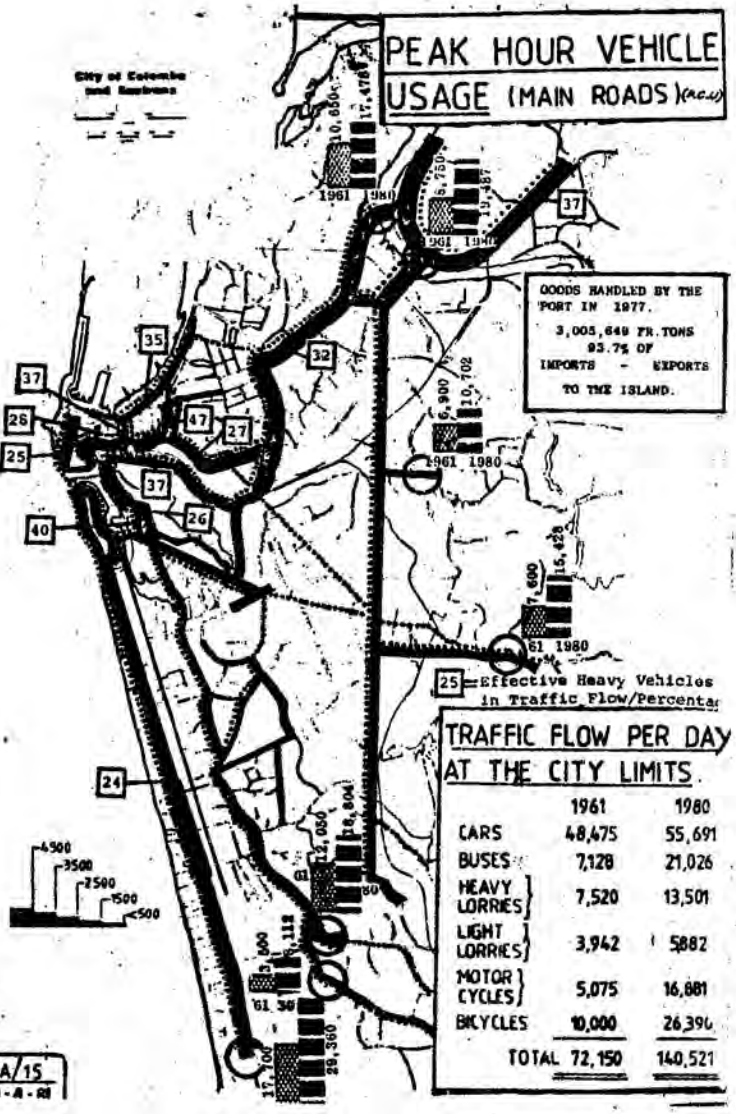

PEAK HOUR VEHICLE USAGE (MAIN ROADS)
City of Colombo and Environs
GOODS HANDLED BY THE PORT IN 1977.
3,005,649 FR.TONS
93.7% OF
IMPORTS - EXPORTS
TO THE ISLAND.
25 = Effective Heavy Vehicles in Traffic Flow/Percentag
TRAFFIC FLOW PER DAY AT THE CITY LIMITS.
	1961	1980
CARS	48,475	55,691
BUSES	7,128	21,026
HEAVY LORRIES	7,520	13,501
LIGHT LORRIES	3,942	5882
MOTOR CYCLES	5,075	16,881
BICYCLES	10,000	26,390
TOTAL	72,150	140,521
CA/15
10,650
17,478
6,750
19,487
6,900
10,702
7,600
15,428
12,050
16,804
3,600
17,700
29,360
1961
1980
37
35
32
37
26
25
47
27
37
26
40
24
4500
3500
2500
1500
500

Figure 3.23

3.8.4 Public Transport.

The Public Transport operations are another pointer to the prime importance of economic activity in the CMR. This may be examined in four ways, such as;

1. **The distribution of passenger kilometres by provinces.**
2. **The distribution of bus operations by districts.**
3. **The operation of inter-city services.**
4. **The operation of coordinated services between the Regional Transport Boards and the Private Bus Operators.**

The distribution of passenger kilometres throughout the highway system in the various regions both by the state services and the private sector is shown in the table 3.19 and table 3.20 respectively. This shows the usage of the services by the people.

The distribution of bus operations by districts and the number of routes operated in each district is an indication of the extent the people have of access to the public transport facilities and the state of the mobility of the population. The table 3.19 shows that **37.12 percent of all passenger traffic is concentrated within the CMR** and the dominating position of private passenger services with 51.14 percent, and the SLCTB with only 23.53 percent of the travel share in the CMR.

The table 3.20 shows the position of the private bus operations in the country as in April 1986. The private bus operations had increased considerably by the year 1985. Of the registered bus strength of 11,001 vehicles nearly 80% or 8000 were in effective operation and 58.1% of these were in service in the project area. Moreover 35.3% of the routes and 58.1% of the vehicle mileage operated on by the private sector is concentrated in this area. These factors thus emphasize the importance of the area in relation to public pasenger road traffic.

The table 3.21 shows the SLCTB operations on inter-city and other services. With 31.2% of all long distance bus services originating in the CMR it emphasizes the controlling influence of the CMR in attracting people to the area,

Table 3.19 **Passenger Kilometres by Region** 1985

Estimated Passenger Kilometres in Millions

Region	**Public**	**Private**	**Total**	**Percentage**
Colombo(N&S)	3410	7190	10600	37.12
Central	2630	1585	4215	14.76
North West	2550	1840	4390	14.37
Southern	1880	1405	3700	12.96
Uva	1880	895	2775	9.72
Eastern	450	345	795	2.78
North Central	960	410	1370	4.80
Northern	320	390	710	2.49
All Island	14495	14060	28555	100
CMR	%	23.53	51.14	37.12

Source: The Sri Lanka Transport Board

Table 3.20

Private Bus Operations -1986

District	Registered Buses	Operated Buses	Operational Routes	Performance Veh.Km./day
Colombo	3,954	3,163	313	648,415
Gampaha	1,555	1,244	208	255,020
Kalutara	884	707	121	144,935
Kandy	873	699	180	143,295
Matale	144	115	44	23,575
Nuwara Eliya	141	113	59	23,165
Galle	399	319	93	65,395
Matara	385	308	70	63,140
Hambantota	59	47	26	9,635
Jaffna	170	136	28	27,880
Mannar	8	6	3	1,230
Vavuniya	38	30	11	6,150
Mullaitivu	1	1	1	205
Batticaloa	23	18	12	3,690
Amparai	146	117	41	23,985
Trincomalee	69	55	25	11,275
Kurunegala	748	599	159	122,795
Puttalam	231	185	28	37,925
Anuradhapura	128	103	49	21,115
Polonnaruwa	191	153	66	31,365
Badulla	210	168	69	34,440
Moneragala	66	52	39	10,660
Ratnapura	344	275	89	56,375
Kegalle	234	187	85	38,335
Sri Lanka	11,001	8,800	1,818	1,804,000
CMR	6,393	5,114	642	1,048,370
CMR%	58.1	58.1	35.3	58.1

Source: The Dept. of Private Omnibus Services

Table 3.21

Inter-City and Other Services

Region	**Buses Long Dist.Service**	**Buses on Other Service**	**Total Buses**
Colombo South	36	1236	1272
Southern	39	548	587
North Central	49	257	306
Uva	80	495	575
Colombo North	46	1016	1062
North Western	48	704	752
Central	107	830	937
Eastern	55	158	213
Northern	56	195	251
Total	516	5439	5955
CMR	79	1784	1859
Percent	14.5	32.8	31.2

Source: The Sri Lanka Transport Board.

The table 3.22 shows the nature of the services between the RTB and private bus operators in the coordinated services operated by the Ministry of Transport. In this operation **39.4% of all operative buses, and 28.1% of all routes are within the CMR**. However, the private sector has a 41.2% share while the SLCTB has 33 % only within the CMR.

These two tables further illustrates the permanent place of the CMR in the island's transportation system. In the inter-city network, approximately, 33% of all bus services originate in the CMR, 15 % of the long distance services and 33% of other services also originate in the CMR.

Table 3.22

Coordinated Services-RTB and Private Buses

Region	Private Buses	RTB Buses	Number Routes	Total Buses
Colombo South	597	203	42	800
Colombo North	635	209	21	844
Central	696	334	74	1030
Southern	551	294	59	845
North Western	387	173	35	560
North Central	53	23	09	76
Uva	03	12	04	15
Sri Lanka	2992	1248	224	4170
CMR	1232	412	63	1644
Percentage	41.2	33.0	28.1	39.4

Source: Ministry of Transport.

NA - 9 - 89

4

Locational Analysis In Industrial Development

NA-9-90

4.0 Locational Analysis in Industrial Development

4.1 Introduction

Sri Lanka is predominantly an agricultural country. Since the country gained independence there has been a gradual growth in the industrial sector.

The first phase of industrialization came with the second World War when import substitution was made the main aim in the industrial policies and hence attempts were made to make the country less dependent on imported consumer products.

With the change of government in 1970 the Public Sector became the main instrument of industrial development. A large sector of industrial development was controlled and was state owned. There was less incentive for the growth of industries in the private sector. Industrial policy laid major emphasis on the use of local raw material, labour intensive methods and appropriate technology to meet the needs of employment.

The dawn of the 1977 era brought a complete change in the economic policies. Public sector expansion was restricted to those which could keep an even keel and no new public sector industries were allowed. On the other hand, the private sector was encouraged to promote industrial development where possible with foreign collaboration aimed at increasing exports. The main objective was employment generation but through an export oriented strategy.

Agriculture, construction and service sectors have shown limitations in increasing employment. **Industry has therefore, been considered a key sector to increase employment and to foster economic growth.**

The contribution of the manufacturing sector to the Gross Domestic Product (GDP) is only 14 % (1985) which also includes the contribution from the agricultural processing industries of tea, rubber and coconut. Out of the active labour force about 12 % is engaged in industry.

Industrial production gained high output after liberalization in 1977 although this growth rate could not be sustained. The average industrial growth rate was 5.7 % between 1978 and 1985.

However, this growth rate is low when compared with countries like Singapore, Taiwan and Korea. These countries have experienced as much as 25 % to 30 % of growth rate during their initial periods of industrial development.

Unemployment rate in Sri Lanka which was 14 % in 1985 has shown a rising trend. It is estimated that by 1989 this would rise to 19 %. It is therefore, **recognised that increasing unemployment could be satisfactorily narrowed down only through adequate industrial expansion.**

The key role of industry has been emphasized by the Finance Ministry Public Investment Programme 1987-1991 which states;

"the most dynamic role in stimulating economic growth, employment creation and export development in the medium term ahead will have to be played by the industrial sector. To adequately perform this role, this sector will have to generate rates of growth far in excess of the average 5.6 % obtained in the last few years."

The unemployment problem and the higher growth rate in the manufacturing sector may be further viewed from the Public Investment Program 1987-1991, which states;

"only vigorous, healthy, manufacturing development, backed by bold, far-reaching policy measures can improve growth prospects, ease foreign exchange constraints, and reduce the relative dimensions of unemployment that were foreshadowed above. If such growth in the manufacturing sector can be secured, it will also have strong positive multiplier effects in the growth of the non-industrial sectors."

4.2 Classification of Industry.

Industry may be classified in two ways namely by;

1. **Size and Investment.**
2. **Employment.**

In the first instance industry is grouped into three sectors as ;

1. **Large scale industries.**
2. **Small and medium scale (SMI) industries.**
3. **Cottage and rural industries.**

According to the classification followed by the Ministry of Industries, the industries with a capital investment of over rupees 2 million on plant and machinery are considered as large scale. The industries whose capital investments are between rupees 50,000 and 2 million are labelled as 'small' or 'medium' scale. Those industries with investment less than rupees 50,000 are treated as rural and cottage industries.

Nearly 99 % of the industries in Sri Lanka are in the category of small and medium scale and they are mostly privately owned.. The majority of large scale industries are state sponsored industries, namely Iron & Steel, Cement, Tyre, Ceramics, Chemicals, Fertiliser, Paper, Leather, Petroleum, Flour Milling and Hardware.

The second category of classification of industries is by employment size which is sub-grouped based on the labour factor. **Only those industries with a labour force of over 25 persons are included in the study. It was considered that the degree of impact on the transportation process generated by industries with a labour content less than 25 persons would be localized and hence negligible.** Furthermore, the scope of the study would have been too wide to handle within the ambit of resources available.

The Industrial Promotion Zone at Katunayaka has also been left out as industries in this area are concentrated at one location and the dispersal effect of location on transportation cannot be measured. The transportation of goods has also been left out as this constitutes a very wide and special field.

4.3 Regional Distribution of Industries.

The locational pattern of industries in Sri Lanka suggests that some industries are located based mainly on the factor of raw material. Hence, they may be viewed in a regional context. For instance, Public sector industries such as sugar factories have been located at Kantalai, Higurana and Pelawatte; milk processing at Ambewela and Polonnaruwa; mineral sands at Pulmoddai; Porcelain at Ukuwela, Balangoda and Negombo; and cement at Kankasanturai, Puttalam, Trincomalee and Galle. These industries are mostly state sponsored. Their locational distribution may be seen from the figure 4.1.

The district wise distribution of private sector industries is shown in figure 4.2. These industries generally belong to the category of the small scale and cottage industries except for those which were set up in industrial estates.

Figure 4.1

Location and Structure of Industries in Sri Lanka

T.B. Weerasekera. I.D.B. 1982

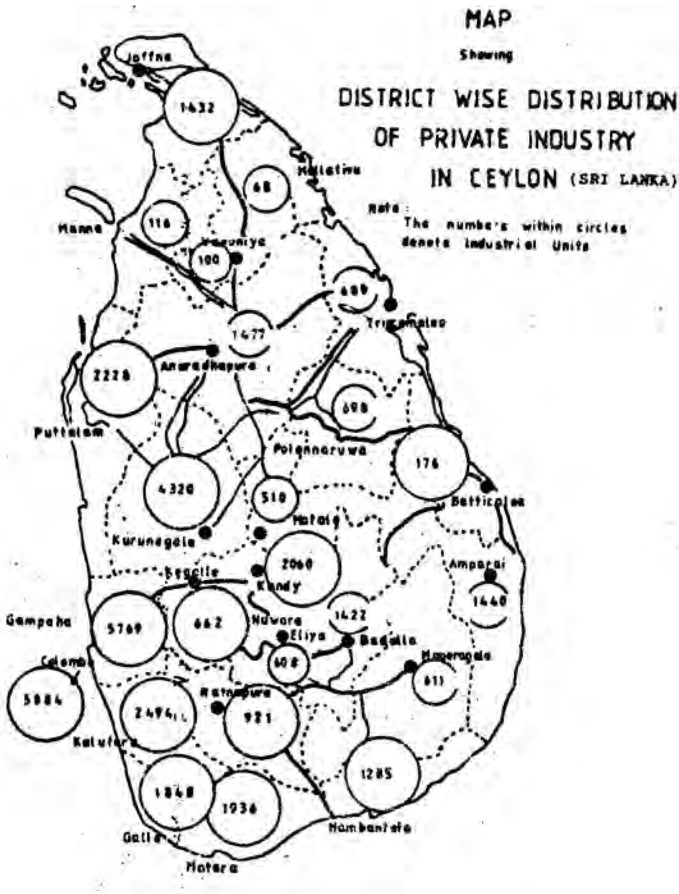


Figure 4.2

Location and Structure of Industries in Sri Lanka

T.B. Weerasekera. I.D.B. 1982

Table 4.1

Distribution of Industry in Sri Lanka

Code Number	District	Number of Industries	%	Persons Employed in 000'	%	Value of Output in Rs. Mil	%	Value Added in Rs.Mil.	%
01	Colombo	7411	7.3	112.5	17.9	13236.6	27.5	7832.3	42.2
02	Gampaha	9851	9.6	86.2	13.7	17123.2	35.6	3282.2	17.7
03	Kalutara	6677	6.5	24.9	4.0	839.8	1.7	483.7	2.6
04	Kandy	6566	6.4	46.2	7.4	1259.0	2.6	648.3	3.5
05	Matale	2052	2.0	14.2	2.3	322.9	0.7	183.4	1.0
06	Nuwara-Eliya	2065	2.0	37.8	6.0	1803.6	3.7	897.1	4.8
07	Galle	10570	10.3	37.5	6.0	1318.3	2.7	749.8	4.0
08	Matara	8723	8.5	28.9	4.6	858.9	1.8	366.4	2.0
09	Hambantota	3019	3.0	8.9	1.4	199.9	0.4	95.6	0.5
10	Jaffna	3121	3.0	18.5	3.0	1143.8	2.4	457.9	2.5
11	Mannar	563	0.6	1.8	0.3	59.3	0.1	27.0	0.2
12	Vavuniya	176	0.2	1.0	0.2	81.3	0.2	13.8	0.1
13	Mullativu	91	0.1	0.5	0.1	12.8	0.0	7.6	0.0
14	Batticaloa	2733	2.7	10.3	1.7	439.6	0.9	136.2	0.7
15	Amparai	2049	2.0	13.4	2.2	464.0	1.0	186.8	1.0
16	Trincomalee	938	0.9	4.6	0.7	2670.7	5.6	643.5	3.5
17	Kurunegala	11122	10.8	42.9	6.8	1295.8	2.7	371.4	2.0
18	Puttalam	3894	3.8	35.8	5.7	1090.0	2.0	419.6	2.2
19	Anuradhapura	2144	2.1	7.1	1.2	426.3	0.9	267.9	1.4
20	Polonnaruwa	1003	1.0	4.7	0.8	315.7	0.7	162.7	0.9
21	Badulla	2066	2.0	15.7	2.5	896.6	1.9	297.9	1.6
22	Monaragala	935	0.9	3.5	0.6	130.1	0.3	55.8	0.3
23	Ratnapura	5685	5.5	29.6	4.7	1178.9	2.5	445.3	2.4
24	Kegalle	9151	8.9	39.5	6.3	973.9	2.0	536.5	2.9
	CMR	23939	23.4	223.6	35.6	31199.6	64.8	11598.2	62.5
	Total	102605	100.0	627.1	100.0	48142.0	100.0	18569.9	100.0

Source: Census of Industry 1983. Dept. of Census and Statistics.

The setting up of industrial estates was attempted by the Industrial Development Board. Industrial Estates were set up at Ekala in Jaela, Pallekelle in Kandy, Achchuvelli in Jaffna, Boosa in Galle and also at Horana, Lunuwila and Pannala. With the development of the Mahaweli area industrial growth centres have emerged in the 'H' zone at Kalawewa and Nochiagama areas and in the 'C' zone at Mahiyangana and Ulhitiya Oya.

The table 4.1 shows the district wise distribution of industries, identified in terms of employment, value of output and the value added for the whole island. It demonstrates that nearly a quarter of the industries (23.4%) are located in the CMR employing a little over one third of the total employed population (35.6%). The most remarkable factor is that the industries located within CMR account for 64.8% of the industrial output and 62.5% of the value added in the total industrial sector of the country.

4.4 The Growth of Industrial Regions In the Colombo Metropolitan Area

There are two major approaches to the location of industry.

1. One is to look at it from the **best location for the industrial plant.**

2. The other is from the point of view of **benefits to the labour force and the community at large.**

The physical location of industry would consider optimizing conditions for the transport of raw materials and finished goods, the availability of markets and labour, effects of competition, tax and price structure etc.

The other approach considers the position of the industry in relation to other activities in the urban/rural area and primarily is concerned with how it is integrated to the overall development pattern with the intention of achieving a balanced growth and benefits to the community as a whole.

New industries have tended to be located in a few urban centres accelerating urban problems of congestion, inadequate housing and poor services. The Sri Lanka port facilities and good transportation have attracted the location of industries to the fringe areas of the City of Colombo where land had been available at relatively low cost. Industrial areas were encouraged both to the north and south of the City at Ekala and Ratmalana where basic utilities of roads, electricity, water and sanitation were readily available.

As far as the location of industries in and around Colombo were concerned they have generally had an adequate access to a major transportation network. **Almost all the factories are located within .4 km.(1/4 mile) to 1.2 km.(3/4 mile) of an 'A' or 'B' class route.**

However, this advantage is not discernible with regard to the access to labour force. **The labour input is attracted almost equally from two distinct flows, from those who live in towns and commute to work and those who live in the villages and travel to a town-(transit town) and then make another journey to work**

The economy of the Colombo Metropolitan Area of the island will depend to a large extent on the inter-relationship of various areas. **The best results would be achieved when the individual areas would take into consideration the location of the labour market irrespective of the administrative areas, and hence a physical plan is developed accordingly. A plan thus developed for the Greater Metropolitan Area should take the development aspects of the semi-rural and rural areas which contribute to development. A major contribution to this linking process is performed by planned transportation facilities which could become calculable elements in the establishment of an industry in a particular location.**

In the earlier decades satellite towns like Maharagama, Ratmalana, Homagama, Wattala etc., came into existence to relieve population and congestion pressures, and two areas of industrial activity also were created one to the North and the other to the South of the City of Colombo at Jaela and Ratmalana. People from the satellite regions began to commute both to the City of Colombo and to these industrial areas. The journey to work became longer, more costly and time consuming as congestion built up without adequate supply of corresponding transport services.

4.4.1 The Ratmalana Industrial Zone.

A major zone of industrial development has been established mainly in the Municipal area of Dehiwala-Mount.Lavinia. The first proposals for establishing industries in this area were mooted in 1950's, but industrial development grew only in the 1960's. Several advantageous conditions contributed to this growth. Among these were availability of land at low cost, an adequate supply of labour within a short range, the very good accessibility to the City of Colombo, and the cheap transport facilities that were readily available. The type of industries established are textiles and garments, petroleum products, chemicals, leather and rubber goods, wood, paper and pulp, cement asbestos, metal industries, manufacturing and assembly of electrical goods. About 20 % of the industries were established prior to 1955, 25 % from 1956 to 1970 and 50 % after 1977.

4.4.2 The Industrial Estate at Ekala.

The Ekala Industrial Estate commenced in 1962. It was the first Industrial Estate to be built. This estate is located in Ekala. The main access is from the Colombo-Negombo main route (A3) and within the vicinity of about 3 km. from the Jaela-Yakkala A33 road. It has also access to the Colombo International

Airport which is at a distance of about 9 km. The Estate is about 62 acres in extent. About 60 factory units were provided with all modern factory requirements. Industries have generally to conform to the overall policy of the Ministry of Industries and Scientific Affairs with regard to employment, use of raw materials, local machinery, fabrication and export content.

Industries established include canning and preserving of fruits and vegetables, knitted textiles and mosquito netting, textile printing, paints and lacquers, leather products, carbon paper and typewriter ribbons, brake and clutch linings, wire nails and rivets for tea chests, elastic fabrics, shoe laces and cords, motor vehicle spare parts and spring blades, kerosene cookers, ceiling fans and accessories, steel office equipment, G.I. buckets and stainless steel products. Leading firms have also set up production units for the manufacture of textiles, rubber and plastics, pharmaceuticals, chemical and engineering industries.

The industrial sector growth was only 5 percent in 1985 compared to 15 percent in the previous year. The private sector grew by 20 percent while the public sector declined by 6 percent, mainly due to output of the petroleum industry. The total production in the public and private sector increased by 9 percent.

The industrial policy continued to encourage the expansion of the export oriented industries along with the substituting industries.

4.5 The Analysis of Manufacturing Industries

The census of 1983 shows that out of 102,721 industrial establishments, 99,680 (97%) were engaged in manufacturing activities, 2916 in Mining and Quarrying and about 116 in Electricity, Gas and Water Supply. A total of 639,256 persons were engaged in the industrial sector of which 600,804 were in the manufacturing industry.

Industrial establishments which have employed 5 or more persons were classed as large scale units. These units amounted to 16,132 or 15.7 % of the total but accounted for a very high percentage of employment (72 %). In terms of value of output (92.5%) and value added (93.0%) they made the most significant contribution to the industrial sector.

Of the total gross output of Rs. 50,8444.4 million the largest proportion of Rs. 47,625.6 million was from the manufacturing sector. Compared to agriculture which employed 45.5 % of the population, manufacturing employment contributed only 9.9 % in 1981. It demonstrated only a marginal increase over the 1971 percentage of 9.3.

4.5.1 Size of Manufacturing Industry

The results of a survey carried out in 1981 show that the major proportion of manufacturing activity occurs in the larger establishments. Thus, the **industrial establishments which have employees of over 100 persons contribute between 85 % to 93 % in terms of employment, fixed capital, employee remuneration and value of production, (table 4.2)**

4.5.2 Structure of Manufacturing Industry.

Manufacturing Industry is broadly classified into nine groups according to International Standard Industrial Classification (I.S.I.C.) United Nations (1968) as from classes 31 to 39. The nine groups are as in table 4.3.

Food, Beverages and Tobacco is the largest value-added manufacturing sector. It has 33% of the manufacturing units with 36% of employment. Its value added accounts for 46% of the total. It covers a wide range of food processing activities including meat, diary, grain processing,distillation and blending of spirits and the manufacture of tobacco.

Table 4.2

The Size of Manufacturing Industry

Employment Size	Number Employed	Value Production	Fixed Capital	Salaries & Wages
	%	%	%	%
0 -49	8.5	4.0	6.3	6.2
50 -99	6.5	3.3	4.7	5.4
100-499	25.8	15.1	21.2	23.3
500-999	26.2	19.7	23.3	29.7
1000 &over	33.0	57.9	44.5	35.4
Total 100 and above	85.0	92.7	89.0	88.4
Total	100.0	100.0	100.0	100.0

Source: Survey on Manufacturing Industries- 1981.
Dept. of Census and Statistics.

Table 4.3

Sectors In Manufacturing Industry

Code No.	Description of item
31.	Food, Beverages and Tobacco.
32.	Textiles, Wearing Apparel and Leather Industries.
33.	Wood, and Wood Products Including Furniture.
34.	Paper and Paper Products, Printing and Publishing
35.	Chemicals, Petroleum, Rubber and Plastic Products.
36.	Non-Metallic Mineral Products Including Petroleum and Coal.
37.	Basic Metal Industries.
38.	Fabricated Metal Products, Machinery and Transport Equipment
39.	Other Manufactured products not elsewhere specified (n.e.s.)

Chemicals, Petroleum and Rubber is the next most productive division. This has 10% of the establishments and 11.6% of manufacturing employment and 16.7% of value-added. This sector uses a high proportion of imported raw materials.

Textiles, Wearing Apparel and Leather Products is the third most significant division. This constitutes about 22.4% of establishments and approximately 25% of employment. The value of output is 11.6% and value added amounts to 15.5%. This sector uses labour intensive methods with minimum of machinery. The value of export of textiles and wearing apparel is 42% of the total exports of manufactured products.

The newer industries are factory based and export oriented and use trained labour and capital intensive methods. **The textile group ranks first in terms of employment and contributes 42% of the total exports of manufactured goods.**

The other major contributors to value added are the Non-metallic products and the Wood and wood products. These two divisions provided 10.3% and 7.3% respectively to total employment and 6.7% and 5.6% respectively of the value added goods in total manufacturing. They are mainly of the small scale cottage industry type of manufacture and use a high content of local raw material and ranks fifth in terms of value added.

The non-metallic items include cement, bricks and tiles, asbestos and fibre glass sheets which use skilled labour. They are factory based using modern machinery. This sector is the sixth in terms of value added and acquires the seventh in terms of employment.

The wood products sector covers the plywood and plywood products, chip board, parquet flooring and floor tiles which are machine intensive and factory based industries. They rank ninth in terms of value added.

The other manufacturing division (I.S.I.C. 39) is an assortment of consumer goods such as the manufacture of costume jewellery, musical instruments, sports and athletic goods, toys and office equipment. These belong to the small scale sector.

Capacity Utilization in Industry
1977 to 1985
% Utilization of Capacity

Code Number	Major Division	1977	1980	1981	1982	1983	1984	1985
31	Food and Beverages	69	70	66	77	73	75	82
32	Textiles and leather	55	70	87	95	98	99	96
33	Wood and Furniture	71	89	81	92	75	93	86
34	Paper and Printing	70	68	75	70	71	76	86
35	Chemicals and Petroleum	61	79	76	77	63	68	61
36	Non-Metallic Products	61	82	83	85	77	75	70
37	Basic Metal Products	40	62	53	33	25	17	5
38	Fabricated Metals	54	58	68	83	81	84	89
39	Others	57	70	69	73	81	87	94
Total	60	73	74	76	74	75	74	

Source: Central Bank of Ceylon

Table 4.4

Value of Production in Millions of Rupees
1977 to 1985

Code	Major Division	1978	1979	1980	1981	1982	1983	1984	1985
31	Food and Beverages	2609	2856	3899	4496	5246	6998	8623	10497
32	Textiles and leather	1008	1128	1923	3040	3863	5136	7565	9505
33	Wood and Furniture	124	166	289	315	361	522	640	705
34	Paper and Printing	376	445	476	626	725	901	907	1187
35	Chemicals and Petroleum	3279	4508	9416	12015	13099	11888	14328	13104
36	Non-Metallic Products	592	710	1156	1250	1370	1468	1829	1854
37	Basic Metal Products	219	349	478	428	262	302	199	123
38	Fabricated Metals	590	569	620	782	904	1129	1456	1592
39	Others	55	50	54	58	74	90	106	125
	Total	8852	10781	18311	23010	25904	28434	35653	38692

Source: Central Bank of Ceylon, " Review of the Economy "

Table 4.5

Value Added in Industrial Production
1977 TO 1985

Code Number	Major Division	1977	1978	1979	1980	1981	1982	1983
31	Food and Beverages	955	1366	1417	1795	1891	2259	3276
32	Textiles and leather	269	214	227	382	513	488	759
33	Wood and Furniture	77	63	82	165	169	134	284
34	Paper and Printing	119	191	217	305	264	257	388
35	Chemicals and Petroleum	770	526	686	1249	2098	1927	1608
36	Non-Metallic Products	251	390	441	608	593	862	866
37	Basic Metal Products	29	55	84	80	80	14	81
38	Fabricated Metals	153	204	272	297	406	790	684
39	Others	16	14	11	12	16	29	41
	Total	**2462**	**2688**	**3437**	**4893**	**6030**	**6760**	**7987**

Source: The Central Bank of Ceylon

Table 4.6

Table 4.7

Relative Sectoral Distribution of Manufacturing Industry

Item	Code	Sri Lanka			CMR			% CMR/Sri Lanka		
		Establishments Number	Persons Employed	Value of Output in Mil.	Establishments Number	Persons Employed	Value of Output in Mil.	% Estab.	% Persons	% Value
Food Beverages	31	33055	215866	17705.8	5930	36783	7014.6	17.9	17.0	39.6
Textiles Leather	32	22354	131492	5507.8	4260	69948	3623.5	19.1	46.2	65.8
Wood prod. Furniture	33	11689	43894	1606.9	3286	19193	1118.7	28.1	43.7	69.6
Paper prod. Printing	34	890	14433	1440.9	560	9533	941.3	62.9	66.1	65.3
Chemicals Petroleum	35	10394	69704	16475.9	2983	34624	15551.4	28.7	49.7	94.4
Non-Metallic Products	36	10932	61683	2570.8	3065	22342	1041.2	28.0	36.2	40.5
Basic Metal Products	37	327	3833	399.3	226	3424	391.2	69.1	89.3	97.9
Fabricated Metal	38	5639	28483	1304.7	1378	17141	1078.7	24.4	60.2	82.7
Others Unspecified	39	4410	11416	613.5	1356	4668	352.9	30.7	40.9	57.5
Total		99690	600804	47625.6	23064	217662	31113.5			

Source: Sri Lanka Census of Industries, Preliminary Survey 1986
Author's Computation

4.5.3 Growth of Manufacturing Industry

The machinery installed in the manufacturing processes have been under utilized. The utilization of the manufacturing capacity is illustrated in the table 4.4. The best performance in utilizing capacity has been with the Textile manufacturing sector which increased from 55 % in 1977 to 96 % in 1986.

This has been closely followed by Fabricated metal manufacture increasing from 54% to 89% during the same period. Wood, Paper and Food processing showed an upward trend, but the worst has been in the Basic Metal industry which reduced to 5% from 40% and also the Chemical industry which fell back to the 1977 level of 61% after showing an initial growth trend. The table 4.5 shows the changes in the value of production in the manufacturing sector between 1978 and 1985. The largest increase was in Textile manufacture (120.4%) followed by Wood products (66.9%), Food and Beverages(43.2 %) and Chemicals (42.8%). The average increase for all products has been 56.5%.

Thus, it will be seen that the increase in value of production for all others sectors has been below average with the Basic Metal industry showing a negative growth rate of -6.2%. The value added to manufactured goods for the various sectors is given in table 4.6. The average figure for the value added is 56.2% between 1977 and 1985. The largest addition has been in the Textile and Garment industry with 118.0% followed by the Food industry (and least with the Chemical industry 10.3%).

The relative distribution of the various sectors in manufacturing both in the CMR and the whole island is shown in the table 4.7. When the number of industries is considered there is a high concentration in Paper and Printing of 62.9% and in Basic Metals of 69.1% in the CMR while the other sectors range from 17.9% for Food processing to 30.7% for unspecified industry. In employment, the rating is higher. Except for Food processing (17%) others range from 36% upwards reaching 89% in Basic Metals.

Population Data for the Colombo Metropolitan Area

Zone	Code Number	Total Population	Active Population	Industrial Population	Manufacturing Population	Number Industries	Number Employees
Biyagama	122	94237	32322	22087	5844	7	522
Jaela	125	119520	39845	29014	6763	34	3776
Katana	126	77985	26321	20383	7307	18	1450
Kelaniya	127	109927	39506	29045	7925	19	1763
Negombo	12B	135197	46844	38897	8949	16	2501
Wattala	12C	109635	35094	27104	5914	24	1646
Mahara	128	108392	39092	25462	5452	22	2250
Colombo Municipality	112	587647	232527	191221	24933	118	18743
Homagama	113	141752	53827	38637	6729	28	3305
Kaduwela	114	126053	44643	34556	7393	19	1376
Kesbewa	115	120892	44044	33675	9243	22	2872
Kolonnawa	116	114338	38062	28264	5887	11	1005
Moratuwa	117	134826	46697	38944	15494	27	5485
Nugegoda	118	367331	142451	113098	244555	103	23866
Avissawella	111	106402	39966	29079	4149	13	2462
Attanagalla	121	105781	36158	25461	5269	13	818
Divulapitiya	123	96746	32641	25356	6749	25	2140
Gampaha	124	116297	41670	28373	5460	10	802
Minuwangoda	129	107277	37003	26829	6014	12	2025
Mirigama	12A	111294	36474	26264	5424	8	569
Weke	12D	98475	33410	22697	3803	10	270
Aggalawatta	131	69619	24013	18000	1259	1	506
Bandaragama	132	62184	21448	14718	1863	5	41
Beruwala	133	111479	33040	23432	3194	15	374
Bulathsinhala	134	62649	24600	19360	1154	10	172
Dodangoda	135	43817	17042	11775	1344	19	716
Horana	136	122846	48322	34215	3808	9	2360
Kalutara	137	111928	37196	26449	4816	12	1264
Matugama	138	62566	21626	15367	965	15	529
Panadura	139	137694	45383	33677	7278	4	1127

Source:Dept. of Census and Statistics- Author's Computation - Table 4.8

Regression Analysis
Population and Industry

Total population

Regression Output:

Constant	-8.192815037
Std Err of Y Est	9.727784883
R Squared	0.858512358
No. of Observations	30
Degrees of Freedom	28
X Coefficient(s)	0.000230925
Std Err of Coef.	1.77165E-05

Active population

Regression Output

Constant	-5.046398906
Std Err of Y Est	9.510692098
R Squared	0.864756987
No. of Observations	30
Degrees of Freedom	28
X Coefficient(s)	0.00057529
Std Err of Coef.	4.2995E-05

Industrial Population

Regression Output:

Constant	-2.643550571
Std Err of Y Est	9.433848893
R Squared	0.866933595
No. of Observations	30
Degrees of Freedom	28
X Coefficient(s)	0.000692676
Std Err of Coef.	5.12852E-05
Regression Output:	

Manufacturing Population

Regression Output

Constant	16.11192725
Std Err of Y Est	19.17093217
R Squared	0.450488159
No. of Observations	30
Degrees of Freedom	28
X Coefficient(s)	0.0003898
Std Err of Coef.	8.1361E-05

Author's Computation

Table 4.9

Table 4.10

TOWN WITH MORE THAN 400 EMPLOYEES

"A" – "B"

C.M.U.			C.U.A.			G.C.E.C.		
TOWN	I	E	TOWN	I	E	TOWN	I	E
Colombo	62	17844	Dehiwela	10	3105	Ja-Ela	12	2062
			Mt. Lavinia	9	4311	Ekala	5	1489
			Ratmalana	32	7737	Katana	6	990
			Moratuwa	10	3897	Kotugoda	3	410
			Kohuwela	3	458	Negombo	3	692
			Angoda	4	708	Dunagaha	1	410
			Wellam-pitiya	6	1092	Kelaniya	6	402
			Padukka	2	808	Maranda-gahamulla	2	474
			Nugegoda	4	1427	Seeduwa	4	1935
			Hanwella	4	1921	Ragama	6	603
			Panni-pitiya	7	1413			
			Awissa-wella	2	1740			
			Homagama	3	790			
			Borales-gamuwa	8	1920			
			Piliyandala	3	513			
			Kotte	3	829			
			Maharagama	8	4239			
			Panadura	7	576			
			Kalutara	3	423			
			Govinna	2	769			
			Horana	7	1939			
			Waskaduwa	4	513			
TOTAL	62	17844	22	141	41128	10	49	9467

Author's Computation

Source : Dept. of Census & Statistics

Survey of Industry 1983.

In the value added the rating is still higher starting with Food processing at 39.6% and reaching 94.4% for the Chemical industry and ending with 98.0% for Basic Metals. **The extremely dominant role of the CMR in the manufacturing industry is therefore self evident.**

4.6 Industry and Population

The distribution of the population by categories together with the number of industries for each AGA division is given in table 4.8. The relationship between population distribution and the industrial distribution for the whole of the CMR by AGA divisions are examined by regression analysis and the results shown in table 4.9. **It shows very close correlation with a coefficient R=0.9276.** The extent of industrial development in the urban sector is illustrated by the table 4.10 which lists the towns employing more than 400 persons in the CMA, CUA and the GCEC

The table 4.11 shows the population, employment and the number of industries in each corresponding AGA division arranged in decreasing values together with the logarithmic values. The stated values have been ranked in decreasing order. The figures 4.3, 4.5 and 4.7 show the logarithmic values of the population, employment and the industries plotted against the rank values. They show the possible trends in growth of the varied functions over the range of values considered.

Some of the features shown by these distributions are interesting. For instance, **the population values appear to have four stages of growth in the AGA areas.** The low values rapidly increase from 40,000 to 99,000 such as AB in the figure 4.3. There is a steady growth from 100,000 to 112,000 as at CD, then increasing growth from 112,000 to 150,000 as at EF and very high growth over 300,000 at GH.

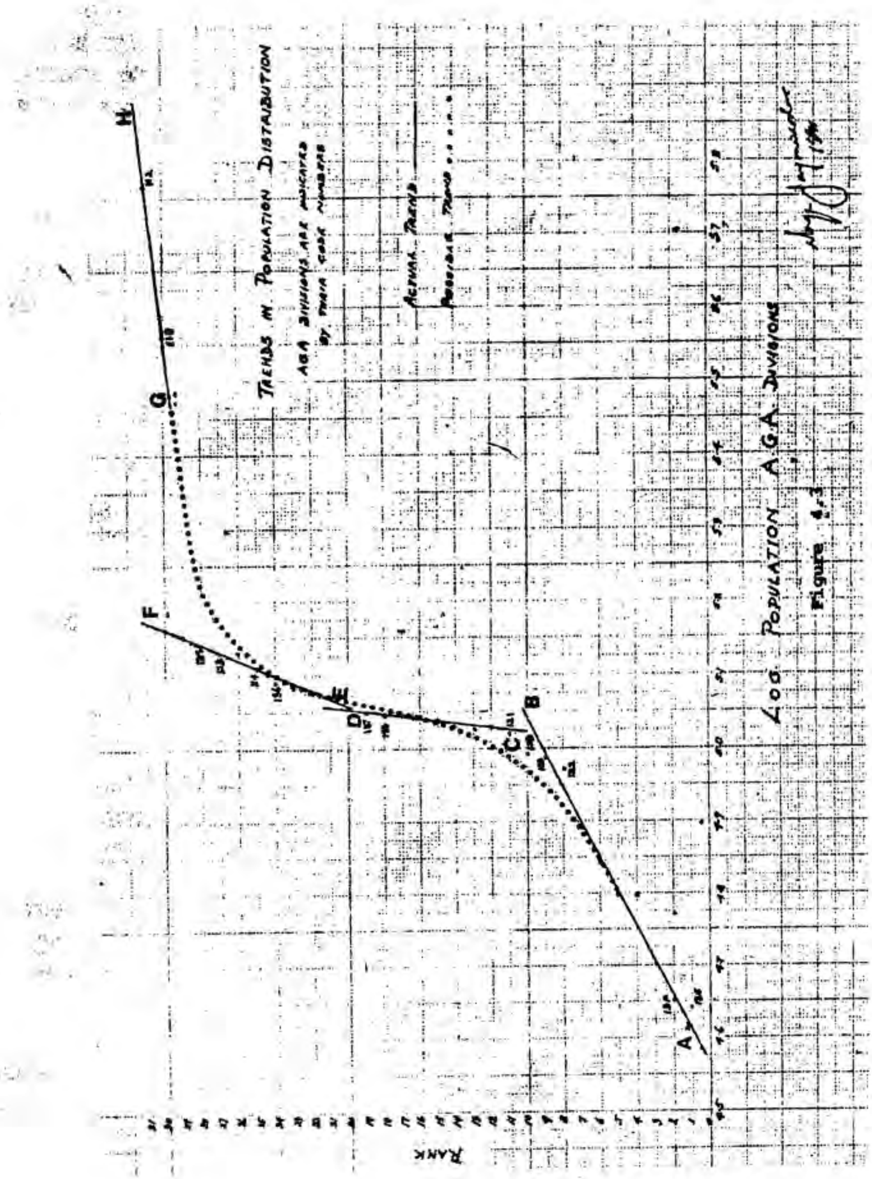
Table 4.11

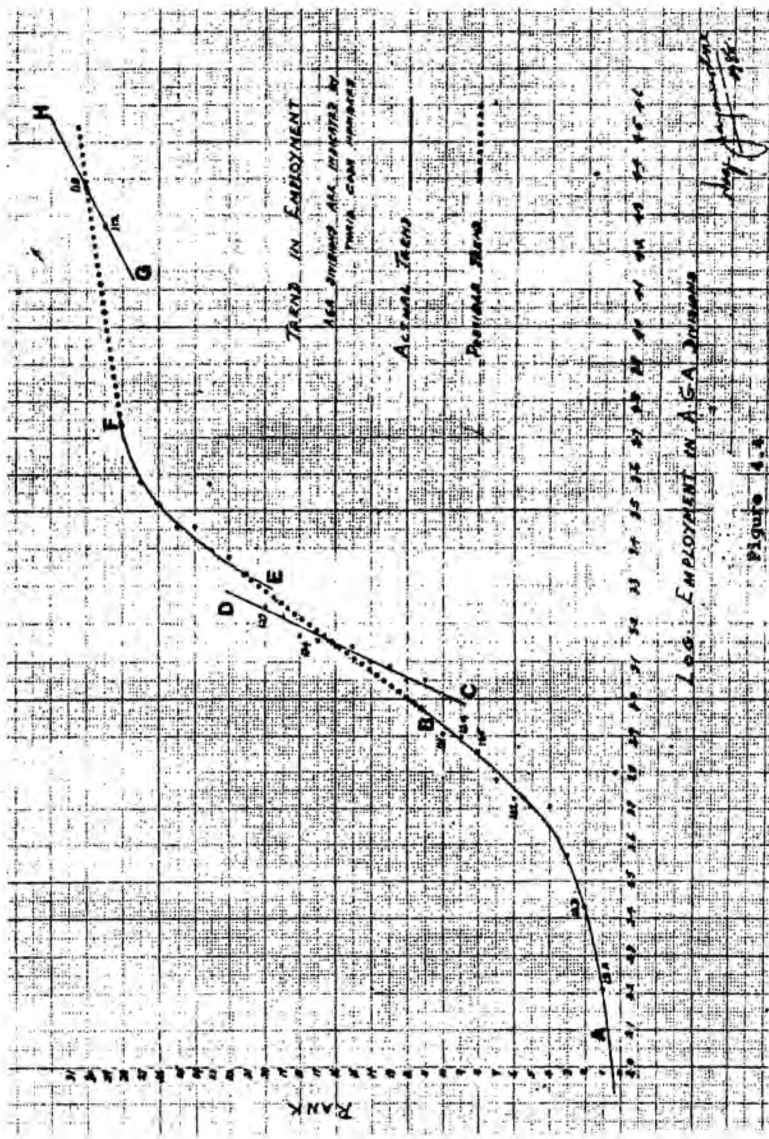
Population, Employment and Industry in AGA Divisions

Population Number	Log. Value	AGA Code	Employment Number	Log. Value	AGA Code	Industry Units	Log. Value	AGA Code	Rank Value
567,647	5.769	112	21047	4.323	118	118	2.072	112	31
367331	5.568	116	16743	4.273	112	103	2.013	116	30
141752	5.152	113	5465	3.739	117	35	1.545	125	29
137654	5.139	139	3776	3.577	125	26	1.447	113	26
135197	5.131	128	3305	3.519	113	27	1.431	117	27
134626	5.130	117	2692	[illegible]	118	25	[illegible]	122	26
126053	5.101	114	2652	3.455	128	24	1.380	120	25
122646	5.069	136	2462	3.391	111	22	1.342	115	24
120692	5.062	115	2370	3.375	136	22	1.342	129	23
117520	5.077	125	2140	3.330	123	22	1.342	116	22
116297	5.066	124	1763	3.246	127	21	1.322	128	21
114338	5.056	116	1646	3.216	120	19	1.279	136	20
111928	5.049	137	1450	3.161	126	19	1.279	127	19
111479	5.047	133	1435	3.157	134	19	1.279	114	18
111254	5.046	12A	1393	3.144	129	19	1.279	139	17
109927	5.041	127	1371	3.139	114	18	1.255	126	16
109635	5.040	126	1264	3.102	137	15	1.176	134	15
107277	5.031	129	1225	3.086	116	14	1.146	137	14
106402	5.027	111	1127	3.052	139	14	1.146	128	13
106392	5.027	126	1125	3.051	128	13	1.114	111	12
105781	5.024	121	818	2.913	121	13	1.114	121	11
98575	4.994	12L	802	2.904	124	12	1.079	12A	10
96746	4.966	123	716	2.855	135	12	1.079	138	9
94237	4.974	122	569	2.755	12A	10	1.000	124	6
77965	4.892	126	529	2.723	138	10	1.000	131	7
69619	4.843	131	522	2.718	122	10	1.000	135	6
62649	4.797	134	506	2.704	131	6	.913	133	5
62566	4.796	138	374	2.573	133	8	.903	12L	4
62184	4.794	132	270	2.431	12L	7	.845	122	3
44922	4.652	13A	162	2.210	13A	4	.602	13A	2
43617	4.642	135	41	1.613	132	1	0	132	1

Author's Computation

Source : Dept. of Census & Statistics.


TRENDS IN POPULATION DISTRIBUTION
AGA DIVISIONS ARE INDICATED BY THEIR CODE NUMBERS
ACTUAL TREND
PROBABLE TREND
A
B
C
D
E
F
G
H
RANK
LOG POPULATION A.G.A. DIVISIONS
Figure 4.3


TREND IN EMPLOYMENT
ACTUAL TREND
PROBABLE TREND
LOG. EMPLOYMENT IN A.G.A. DIVISIONS
RANK
A
B
C
D
E
F
G
H

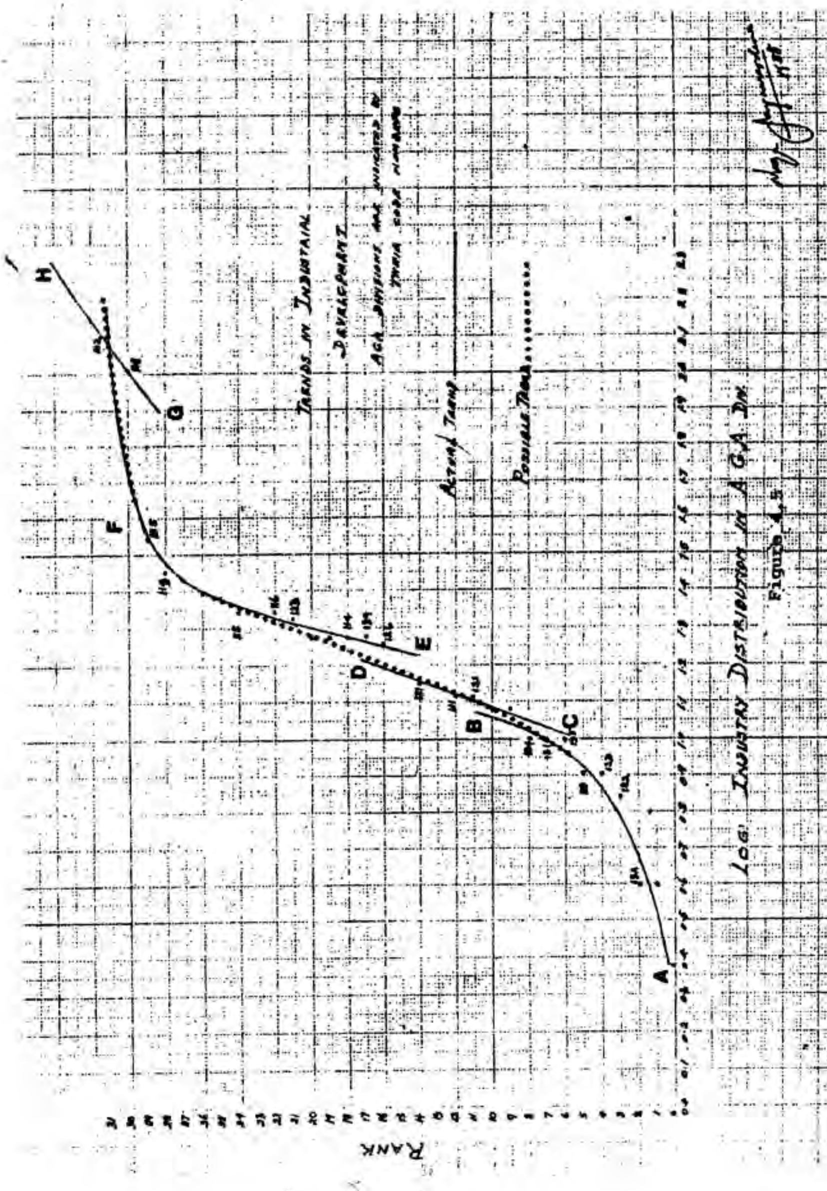

TRENDS IN INDUSTRIAL DEVELOPMENT
ACTUAL TREND
POSSIBLE TREND
A
B
C
D
E
F
G
H
RANK
LOG: INDUSTRY DISTRIBUTION IN A G.A. DIV.

Figure 4.5

Likewise, **the increase in employment could also be seen to rise in four stages at almost similar levels.** The curve 4.4 shows the initial increase AB from 40 to 1000 employees, CD from 1000 to 1500 persons with steady growth, a rapid growth EF from 1500 to 6000 employees and then a sudden jump to GH of over 18,000 and a possible growth trend line.

The growth and distribution of industry in the AGA divisions could be described in similar manner as in figure 4.5 The industries increase as in AB to 10, then a steady increase from 12 to 18 as at CD, rapid growth from 19 to 40 at EF and a high leap to more than 100 at GH. The magnitudes of the distribution of population, employment and industry at the levels stated are graphically illustrated in the figures 4.6,4.7 and 4.8.

The different levels to which the various functions have been categorised are tabulated in table 4.12. The different AGA divisions have been classified as to their general development in the manufacturing industrial sector. As before five specific levels can be easily described as illustrated in figure 4.9.

1. Highly developed AGA divisions.

High levels of population, employment and industry such as the AGA divisions of Colombo and Nugegoda.

2. Fairly developed AGA divisions.

These areas are at the 2nd level of development with all sectors at the same level such as Kaduwela, Moratuwa, Homagama, Horana, Negombo and Jaela.

3. Developing AGA Divisions

Those at the 3rd level are at a transitional stage with employment and industry at the 2nd level but areas not highly populated but at the 3rd level. These are areas like Divulapitiya, Kelaniya and Wattala. Perhaps, **there is an influx of workers from outside to supplement the work force or in the alternative the industries are more machine oriented.**

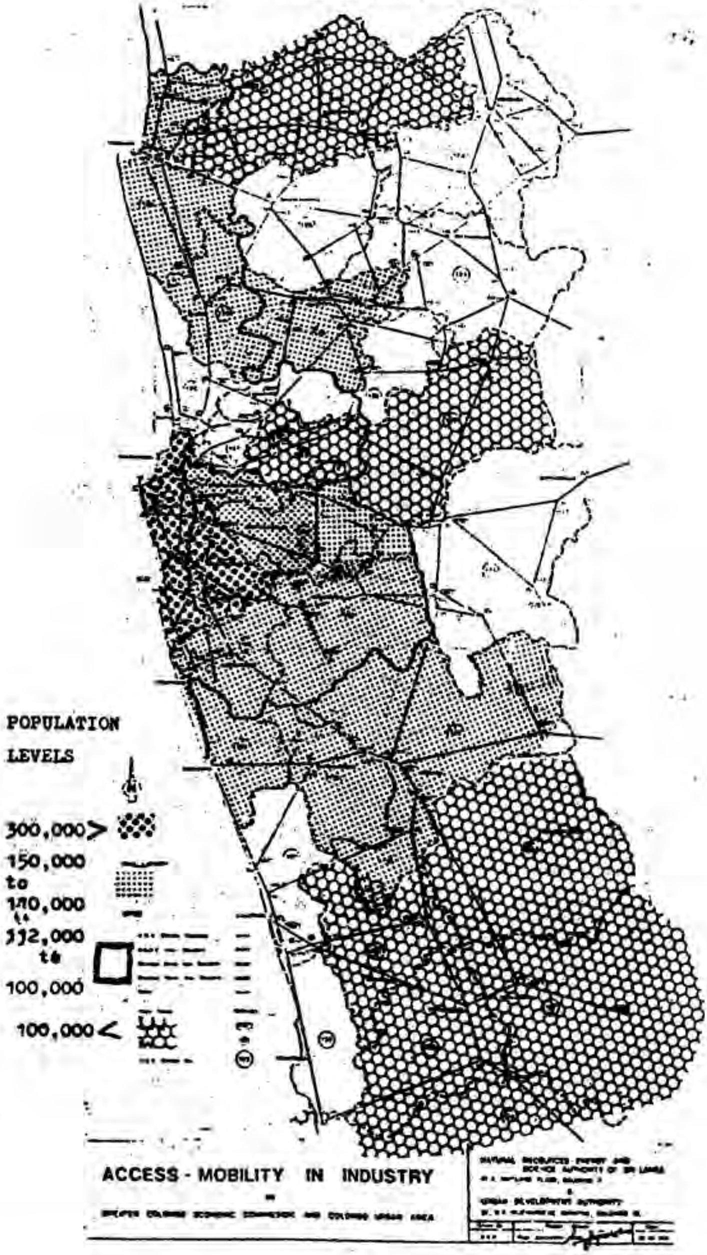


Figure 4.6

Levels of Population Distribution.

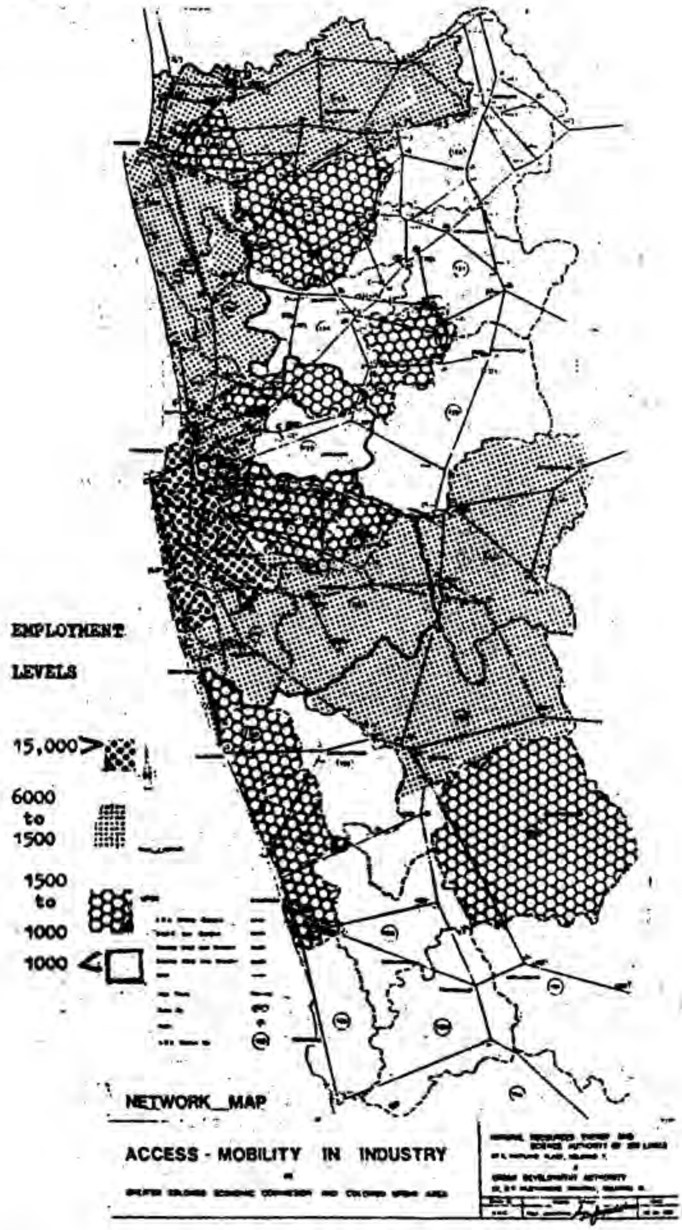


Figure 4.7

Levels of Employment

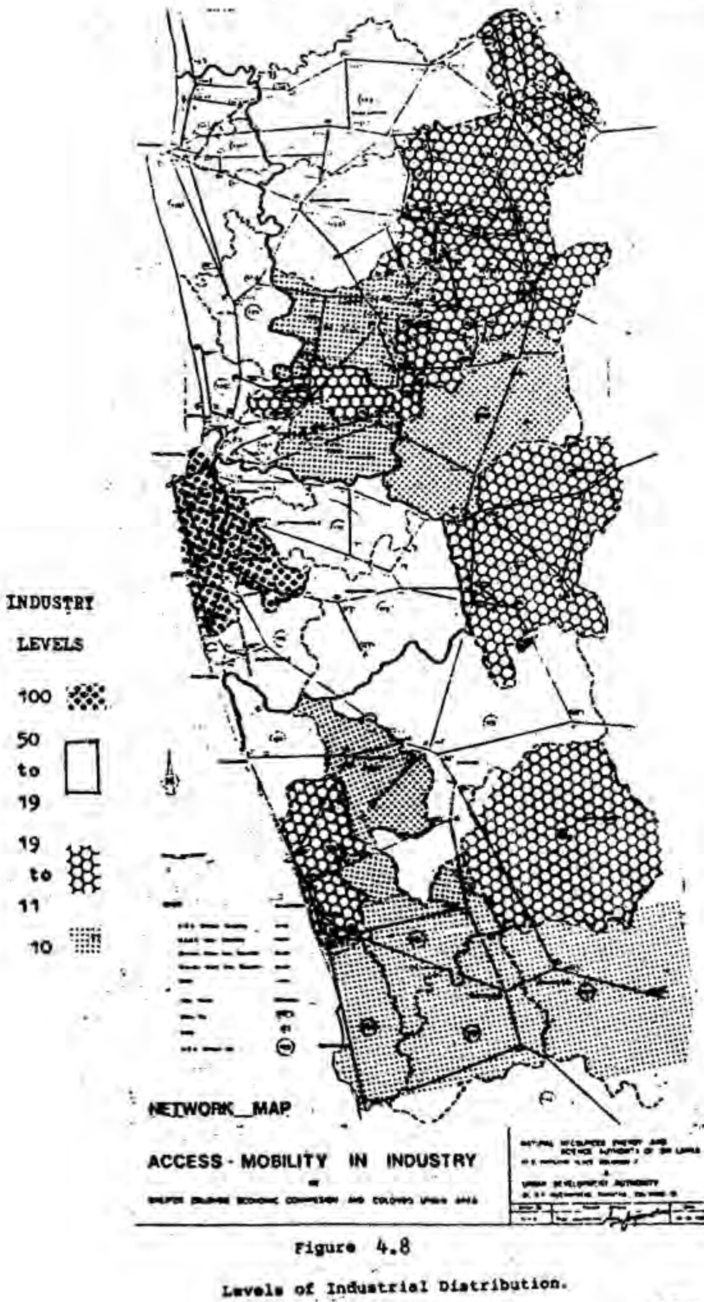


Figure 4.8

Levels of Industrial Distribution.

Table 4.12

Levels of Industrial Development

AGA Code	Population Level	Employment Level	Industry Level	Highly Developed	Developing	Transitional	Beginnings of Industrial Development					Highly Undeveloped
				All at 1st	All at 2nd	2 at 2nd 1 at 3rd	1 at 2nd 2 at 3rd	3 at 3rd	2 at 3rd	1 at 2nd 2 at 4th	1 at 3rd 2 at 4th	All at 4th
111	3	2	3				Y					
112	1	1	1	Y								
113	2	2	2		Y							
114	2	3	2			Y						
115	2	2	2		Y							
116	2	3	2			Y						
117	2	2	2		Y							
118	1	1	1	Y								
121	3	4	3						Y			
122	4	4	4									Y
123	4	2	2			Y						
124	2	4	4							Y		
125	2	2	2		Y							
126	3	3	2				Y					
127	3	2	2			Y						
128	3	4	4								Y	
129	3	3	2				Y					
131	4	4	4									Y
132	4	4	4									Y
133	3	4	4								Y	
134	4	3	3						Y			
135	4	4	4									Y
136	2	2	2		Y							
137	3	3	3					Y				
138	4	4	4									Y
139	2	3	2			Y						
12A	3	4	3						Y			
12B	2	2	2		Y							
12C	3	2	2			Y						
12D	4	4	4									Y
13A	4	4	4									Y

Author's Computation.

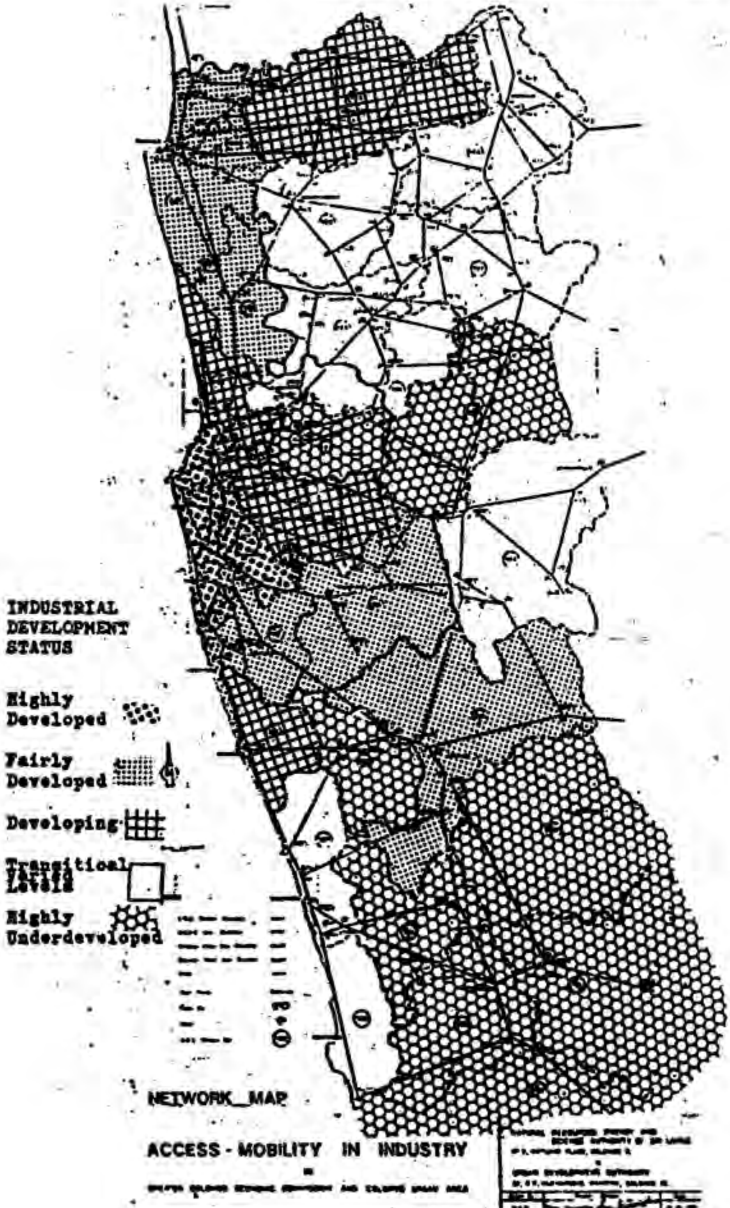


Figure 4.9

Industrial Development Status

Likewise there is another group with population and industry at the 2nd level but with employment at the 3rd level. **This definitely shows the predominance of machine oriented industry.**

4. The transitional AGA Divisions

These areas are dominated by at least two of the factors of population, employment and industry at the 3rd or 4th level. Such areas are Gampaha, Avissawella and Kalutara.

5. The highly undeveloped AGA Divisions

These are highly underdeveloped AGA areas where all factors are in the 4th stage. Such divisions are Mirigama, Biyagama, Bandaragama, Matugama etc.

4.7 Location of Industry

Due to the lack of a well defined national industrial locational policy, in Sri Lanka industries tend to concentrate in and around urban centres. The majority of industries are clustered around the main towns. The table 4.13 shows the distribution of industries in three kilometre rings radiating from Colombo Fort and figure 4.10 the cumulative distribution curve. **Fifty percent of the industries lie within 18 kilometres of Colombo while approximately two thirds of the medium and large scale industries are located within 30 kilometres of Fort. The figure 4.10 shows the dominating influence of Colombo due to impact of the Port and the administrative, financial and other infrastructure facilities.**

An assessment of the distance of industries from '**A**' and '**B**' routes was made during the sample survey. This data and its distribution is given in table 4.14. It shows that of 67 factories 46 are located on '**A**' routes and 21 are situated on '**B**' routes.

Table 4.13

Areal Distribution of Industries

Radial distance from Colombo Fort	Number of Industries	Cumulative Total	Cumulative Percentage
0-02.9	113	113	15.3
3-05.9	111	224	30.3
6-08.9	96	320	43.2
9-11.9	95	415	56.1
12-14.9	39	454	61.4
15-17.9	118	572	77.3
18-20.9	31	603	81.5
21-23.9	59	662	89.5
24-26.9	25	687	92.8
27-29.9	24	711	96.1
30-32.9	3	714	96.5
33-35.9	17	731	98.8
36-38.9	7	738	99.7
39-41.9	2	740	100

Author's Computation

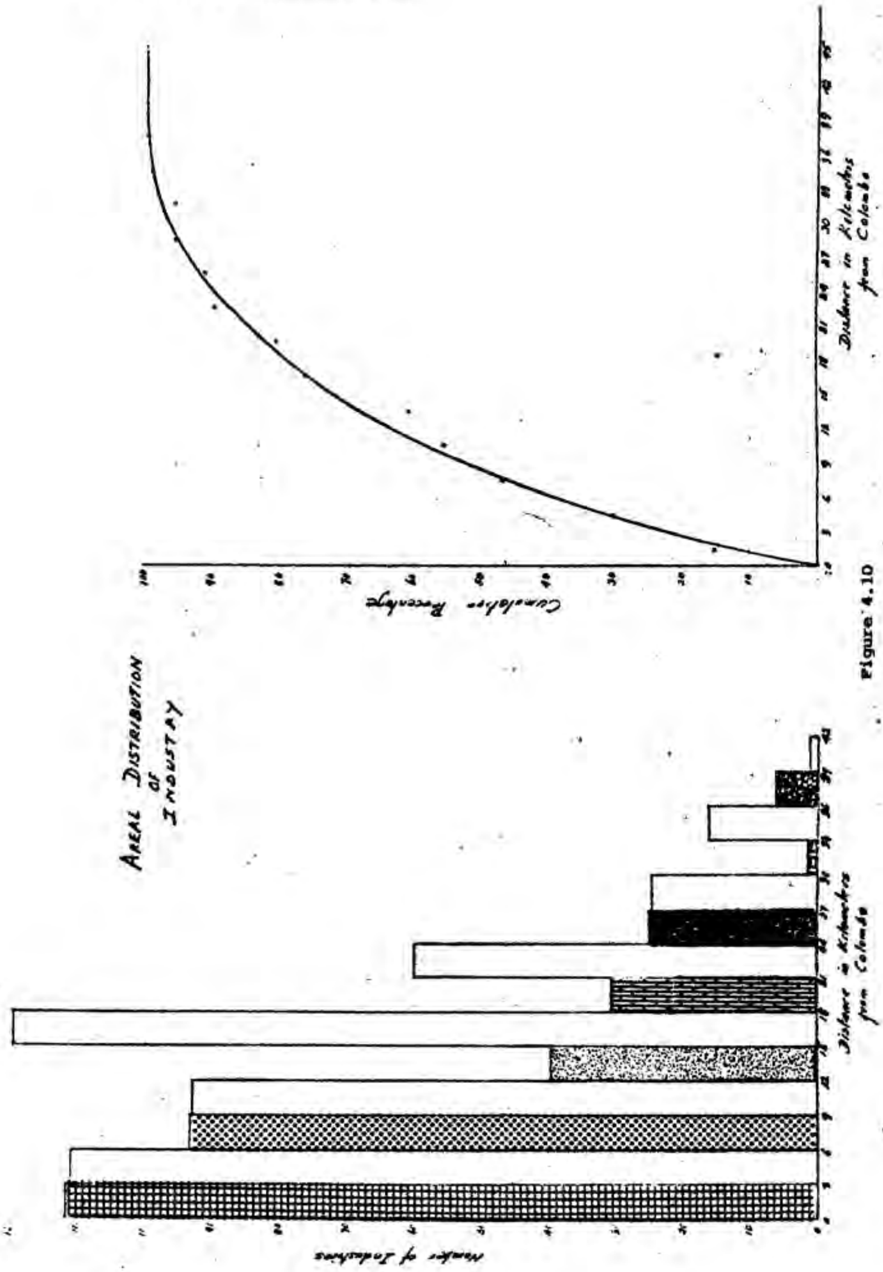

Areal Distribution of Industry
Cumulative Percentage
Distance in Kilometres from Colombo
Distance in Kilometres from Colombo
Number of Industries

Figure 4.10

Table 4.14

Location of Industry
Distance to Factories from 'A' and 'B' Roads

Colombo M.C			Colombo Urban Area			Greater Colombo Economic Commission		
Industry No.	Distance in Km.	Road Category	Industry No.	Distance in Km.	Road Category	Industry No.	Distance in Km.	Road Category
192	0	A	535	0	A	230	4.42	A
188	1.20	A	539	0.80	A	645	0.0	A
175	0.40	B	529	0.0	A	268	3.62	A
160	0.0	B	531	0.0	A	634	0.0	A
149	0.40	B	44	1.20	A	624	2.41	A
126	.80	B	67	2.41	A	655	.40	A
129	.40	B	42	.40	A	608	.40	A
115	.40	B	51	.40	A	257	.40	A
121	.40	B	56	.40	A	596	.40	A
89	.80	B	40	1.60	A	260	.40	A
88	.80	B	43	2.41	A	290	.40	A
118	.40	B	54	.40	A	639	2.41	A
102	.80	B	64	.80	A	660	.0	A
97	.40	B	35	.40	A	229	.16	A
73	.40	B	24	.80	A	246	.16	A
138	.40	B	25	.80	A	227	.80	A
			37	.40	A			
			20	1.20	A			
			14	.80	A			
			01	2.01	B			
			19	.40	B			
			33	2.41	A			
			217	2.01	B			
			494	.40	A			
			489	.80	A			
			491	.80	A			
			12	.40	B			
			509	2.01	B			
			513	.80	B			
			472	.40	B			
			431	1.20	A			
			548	1.75	A			
			203	1.60	A			
			459	2.41	A			
			460	2.41	A			

Total 16 Nos	Total 35 Nos	Total 16 Nos
2 on A	28 on A	16 on A
14 on B	7 on B	0 on B
X=.475	X=1.012	X=1.02
=0.30	=0.78	=1.39

For the whole region 46 on A, 21 on B. X=0.893 km and = 0.90

Author's Computation.

Source : Dept. of Highways & Census & Statistics.


CITY OF COLOMBO
INDUSTRIAL LOCATION MAP
ACCESS - MOBILITY IN INDUSTRY

Figure 4.11

Figure 4.12

In the CMA the average locational distance is 0.48 kilometres with a standard deviation of 0.30 km; in the CUA the locational distance is 1.01 kilometres with a standard deviation of 0.78 kilometres and in the GCEC area the distance is 1.02 kilometres with a standard deviation of 1.39 kilometres. Within the whole study area the average locational distance is 0.89 kilometres with a standard deviation of 0.90 kilometres. **This shows the importance of type of road and its connectivity in the location of factories.**

The distribution of industrial areas in the City of Colombo is illustrated in the figure 4.11 and the distribution of factories as found in the sample survey is shown in the figure 4.12.

4.8 Analysis of Industry in the CMR

Two methods are used to estimate the state of the different sectors in the manufacturing industry and their locations. These are,

1. **A form of the Location Quotient.**
2. **The Z score or the Standard score.**

4.8.1 Level of Industrial Development in the CMR

Location Quotient

The relative distribution of an economic activity in an area may be measured by a parameter known as the location quotient. It shows the extent by which each area departs from the norm. The location quotient may be defined as;

Table 4.15

Locational Quotient for Industry in the CMR

Zone	Industrial Employment	Manufacturing Employment	Ratio X_i/Y_i	Ratio $(X_i/Y_i)/(X/Y)$
111	29079	4149	0.143	0.741
121	25461	5269	0.207	1.073
123	25356	6749	0.266	1.378
124	28373	5460	0.192	0.995
128	12731	2726	0.214	1.109
129	26829	6014	0.224	1.161
12A	26264	5424	0.207	1.073
12D	22697	3803	0.168	0.870
131	18000	1259	0.070	0.363
132	14718	1863	0.127	0.658
133	23432	3194	0.136	0.705
134	19360	1154	0.060	0.311
135	11775	1344	0.114	0.591
136	34215	3808	0.111	0.575
137	26449	4816	0.182	0.943
138	15367	965	0.063	0.326
139	33677	7278	0.064	0.332
13A	10915	704	0.064	0.332
Rest of CMR	404698	65979	0.163	0.845
122	22087	5844	0.265	1.373
125	29014	6763	0.233	1.207
126	20383	7307	0.358	1.855
127	29045	7925	0.273	1.415
12B	38897	8949	0.230	1.192
12C	27104	5914	0.218	1.130
128	12731	2726	0.214	1.109
GCEC	179261	45428	0.253	1.311
112	191221	24933	0.130	0.674
113	38637	6729	0.174	0.920
114	34556	7393	0.214	1.109
115	33675	9243	0.274	1.420
116	28264	5887	0.208	1.078
117	38944	15494	0.398	2.062
118	113098	24455	0.216	1.249
CSA	287174	69201	0.241	1.249
CUA	478395	94134	0.197	1.021
CMR	1062354	205541	0.193	1.000

Author's Computation

Source: Dept. of Census and Statistics

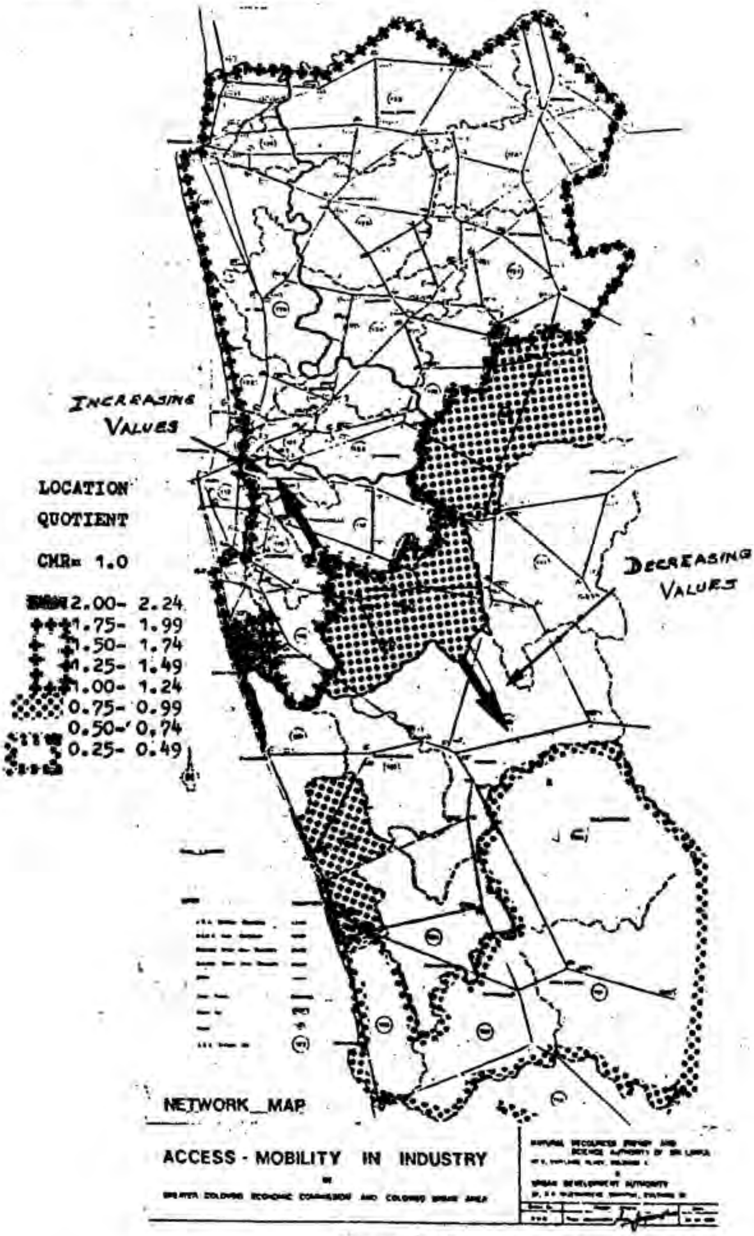


Figure 4.13

Ratios of Manufacturing to All Industry.

$Q=(X_i/Y_i)/(X/Y)$

X_i= the employment in manufacturing industry in a particular AGA division

Y_i= the employment in all industry in the same AGA division

X= the employment in manufacturing industry for the region or CMR

Y= the employment in manufacturing in all industry in the region or CMR.

The table 4.15 shows the AGA divisions, the employment in all industries, the employment in manufacturing industry, the ratio of X_i/Y_i and the ratio of X_i/Y_i to X/Y.

The ratio X_i/Y_i shows the relative degree of employment in manufacturing in each AGA division. For instance in AGA division Avissawella (111) the total industrial employment is 29,079 while the employment in manufacturing industry is 4,149. The ratio of X_i/Y_i is 0.143 or 14.3 % means that amount of the people are employed in manufacturing. The value of X_i/Y_i to X/Y is 0.741. The figure of X/Y=1.0 represents the average value for the CMR. This shows that in Avissawella AGA division the employment in manufacturing industry is below the normal value for the CMR. The values of these ratios are plotted in figure 4.13.

The highest concentration in manufacturing employment is in Moratuwa (117), followed by Katana (126). Next in value are Kelaniya, Biyagama, Divulapitiya and Piliyandala. **This figure very clearly illustrates the shift in the concentration of manufacturing employment towards the northern and north western coastline and the fall off to the south and southeast. The three AGA divisions Kalutara (137), Homagama (113) and Weke (12D) seems to divide the CMR into two distinct areas.**

Table 4.16

Distribution of Industries by Sector in AGA Divisions

AGA Code	Industrial Sectors 31	32	33	34	35	36	37	38	39	Total
122	01	01	0	0	01	03	0	01	0	07
125	01	11	03	02	04	01	0	11	02	35
126	06	07	0	0	01	04	0	0	0	18
127	0	03	02	02	05	01	01	03	02	19
128	06	05	02	0	03	0	0	04	0	21
12C	09	06	02	0	03	0	0	04	0	24
128	05	03	0	03	02	0	0	0	01	14
112	18	24	04	29	06	07	0	25	05	118
113	03	11	02	0	08	01	0	03	0	28
114	10	01	01	0	02	01	03	01	0	19
115	01	09	03	0	03	02	0	03	01	22
116	01	06	03	0	03	05	0	03	01	22
117	01	08	06	0	05	01	01	05	0	27
118	11	42	03	07	15	0	01	20	04	103
111	0	04	01	0	07	01	0	0	0	13
121	04	05	02	0	01	01	0	0	0	13
123	07	13	0	0	01	01	0	0	0	25
124	04	02	0	01	01	01	0	0	01	10
129	05	13	0	01	01	0	0	01	01	22
12A	02	02	05	0	02	01	0	0	0	12
12D	02	04	0	0		02	0	0	0	08
131	02	01	01	0	06	0	0	0	0	10
132	0	01	0	0	0	0	0	0	0	01
133	02	03	01	0	01	0	0	01	0	08
134	06	01	0	0	08	0	0	0	0	15
135	0	0	0	0	09	0	0	01	0	10
136	04	04	01	0	10	0	0	0	0	19
137	05	04	02	0	01	02	0	0	0	14
138	04	01	0	0	06	0	0	01	0	12
139	01	07	03	0	01	0	0	07	0	19
13A	02	02	0	0	0	0	0	0	0	04
Total	123	204	47	46	116	37	06	95	18	692
Mean	4.00	6.6	1.5	1.5	3.7	1.2	0.2	3.1	0.6	
Sd.Dev.	4.0	8..3	1.6	5.3	3.5	1.7	0.6	5.8	1.2	

Source: Dept. of Census and Statistics.
Author's Computation

Distribution of Z Scores by Sectors and AGA Divisions

Z Scores

AGA Code Z	Z 31 Food	Z 32 Cloth	Z 33 Wood	Z 34 Paper	Z 35 Che.	Z 36 Mine.	Z 37 BaMet	Z38 FaMet	Z 39 Other	Sum Z	Adj. Sum
122	-0.752	-0.674	-0.933	-0.279	-0.774	1.077	-0.317	-0.356	-0.483	-3.491	2.493
125	-0.752	0.534	0.908	0.098	0.073	-0.113	-0.317	1.374	1.183	2.988	8.972
126	0.514	0.051	-0.933	-0.279	-0.774	1.673	-0.317	-0.529	-0.483	-1.077	4.907
127	-1.005	-0.433	0.294	0.098	0.356	-0.113	1.350	-0.010	1.183	1.720	7.704
128	0.514	-0.191	0.294	-0.091	-0.774	0.482	-0.317	0.163	-0.483	-0.403	5.581
12C	1.273	-0.070	0.294	-0.279	-0.209	-0.708	-0.317	0.163	-0.483	-0.336	5.648
12B	0.251	-0.433	-0.933	0.287	-0.492	-0.708	-0.317	-0.529	0.350	-2.524	3.460
112	3.552	2.986	1.521	5.192	0.628	3.458	-0.317	3.800	3.683	23.634	29.618
113	-0.246	0.534	0.294	-0.279	1.203	-0.113	-0.317	-0.010	-0.483	0.583	6.567
114	1.527	-0.674	-0.319	-0.279	-0.492	-0.113	4.683	-0.356	-0.483	3.494	9.478
115	-0.752	0.293	0.908	-0.279	-0.209	0.482	-0.317	-0.010	0.350	0.466	6.450
116	-0.752	-0.070	0.908	-0.279	-0.209	2.288	-0.317	-0.010	0.350	1.889	7.873
117	-0.752	0.172	2.748	-0.279	0.356	-0.113	1.350	0.336	-0.483	3.335	9.319
118	1.780	5.078	0.908	1.062	3.181	-0.708	1.350	2.931	2.850	18.412	24.396
111	-1.005	-0.312	-0.319	-0.279	0.921	-0.113	-0.317	-0.529	-0.483	-2.436	3.548
121	0.008	-0.191	0.294	-0.279	-0.774	-0.113	-0.317	-0.529	-0.483	-2.384	3.600
123	0.767	0.776	-0.933	-0.279	-0.774	1.077	-0.317	-0.356	-0.483	-0.522	5.462
124	0.008	-0.554	-0.933	-0.091	-0.774	-0.113	-0.317	-0.529	0.350	-2.953	3.031
129	0.251	0.776	-0.933	-0.091	-0.774	-0.708	-0.317	-0.356	0.350	-1,802	4.182
12A	-0.499	-0.554	2.135	-0.279	-0.492	-0.113	-0.317	-0.529	-0.483	-1.131	4.853
12D	-0.499	-0.312	-0.933	-0.279	-0.492	-0.708	-0.317	-0.529	-0.483	-4.552	1.432
131	-0.499	-0.674	-0.319	-0.279	0.638	-0.708	-0.317	-0.529	-0.483	-3.170	2.814
132	-1.005	-0.674	-0.933	-0.279	-1.056	-0.708	-0.317	-0.529	-0.483	-5.984	0.000
133	-0.499	-0.433	-0.319	-0.279	-0.774	-0.708	-0.317	-0.356	-0.483	-4.168	1.816
134	0.514	-0.674	-0.933	-0.279	1.203	-0.708	-0.317	-0.529	-0.483	-2.206	3.778
135	-1.005	-0.796	-0.933	-0.279	1.486	-0.708	-0.317	-0.356	-0.483	-3.391	2.593
136	0.008	-0.312	-0.319	-0.279	1.768	-0.708	-0.317	-0.529	-0.483	-1.171	4.813
137	0.251	-0.312	0.294	-0.279	-0.774	0.482	-0.317	-0.529	-0.483	-1.667	4.317
138	0.008	-0.674	-0.933	-0.279	0.638	-0.708	-0.317	-0.356	-0.483	-3,104	2.880
139	-0.752	0.051	0.908	-0.279	-0.774	-0.708	-0.317	0.682	-0.483	-1.672	4.312
13A	-0.499	-0.554	-0.933	-0.279	-1.056	-0.708	-0.317	-0.529	-0.483	-5.358	0.626

Source: Author'sComputation Table 4.17

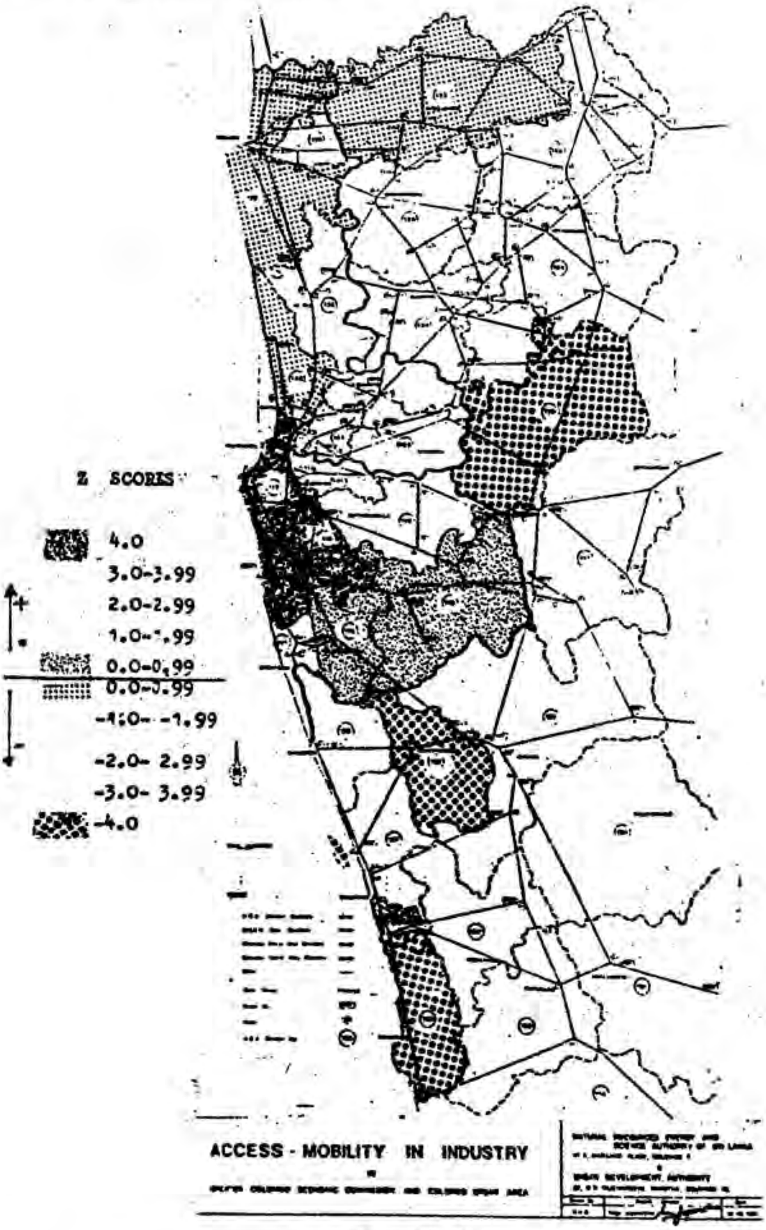


Figure 4.14

Areal Distribution of Z Score for Manufacturing Industry.

The north and north-western sectors are biased towards manufacturing industry and the south and south-eastern sectors are lagging below the average value for the CMR.

4.8.2 Relative Growth of Industry In the CMR

The Z Score Estimation.

The number of industries under 9 categories for each AGA division in the CMR are given in the table 4.16. It also gives the average value X and the standard deviations for each industry.

The Z score in the standard form is given as;

$$Z_i = X_i - X / s$$

Z_i = the standard score for the i th data

X_i = the value of the original i th data

X = the mean of all Xi.

s= the standard deviation of all X

As may be seen from the above the Z score makes use of two important properties which are comparable, namely the mean and the standard deviation. **Thus the Z score provides a basis to understand the spatial distribution of industries at AGA levels.** The Z score thus calculated for each industry and for each AGA division are tabulated in the next table 4.17. The Z scores are also summed in the totals column. These values are then ranked according to decreasing order. The various AGA divisions are categorised according to the relative values taking the CMR as the mean and having an Z value of zero .

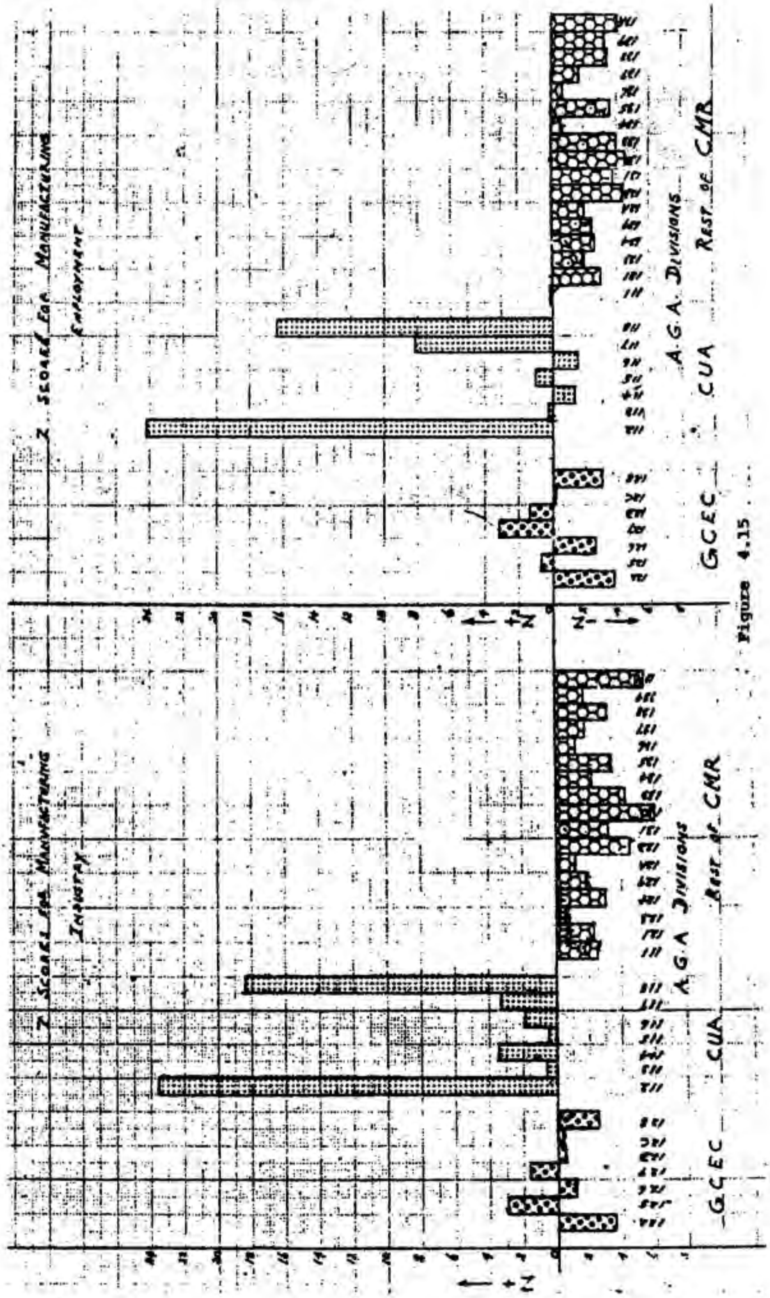

Z SCORES FOR MANUFACTURING EMPLOYMENT
GCEC
CUA
A.G.A. DIVISIONS
REST OF CMR
Z SCORES FOR MANUFACTURING INDUSTRY
GCEC
CUA
A.G.A. DIVISIONS
REST OF CMR

Figure 4.15

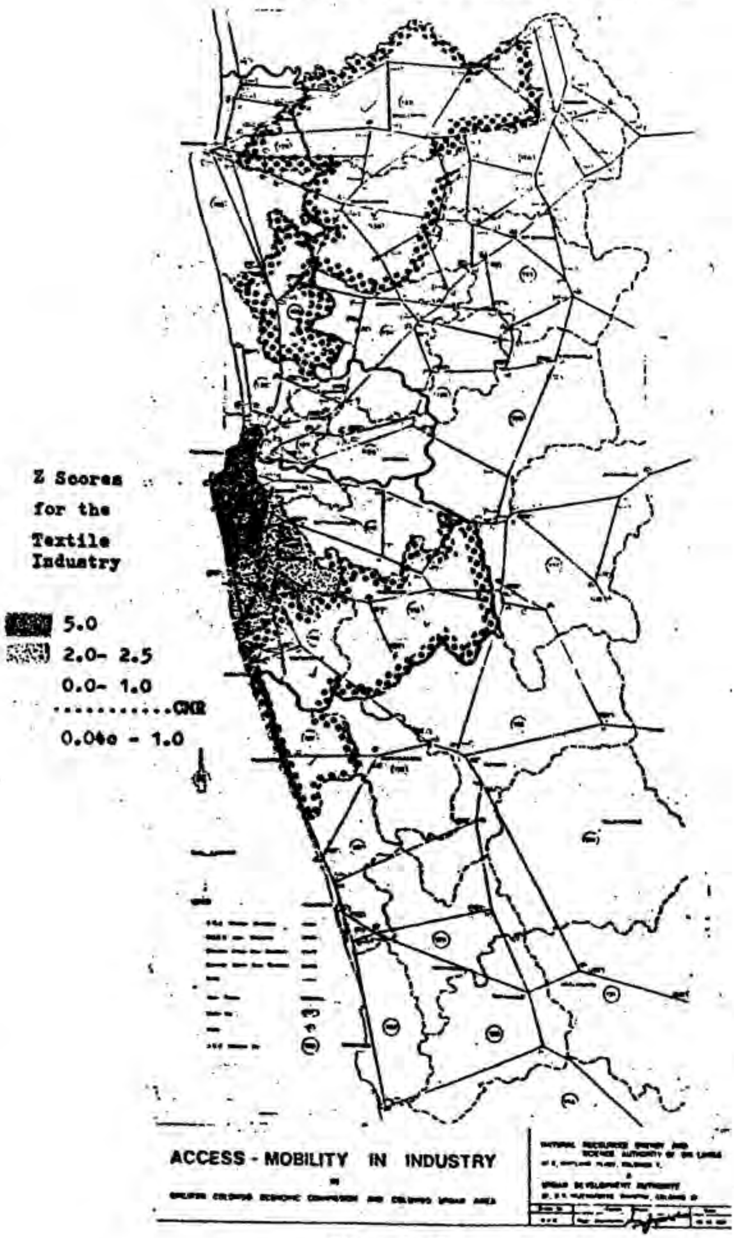


Figure 4.16

Areal Distribution of Z Scores for Textile Manufacture

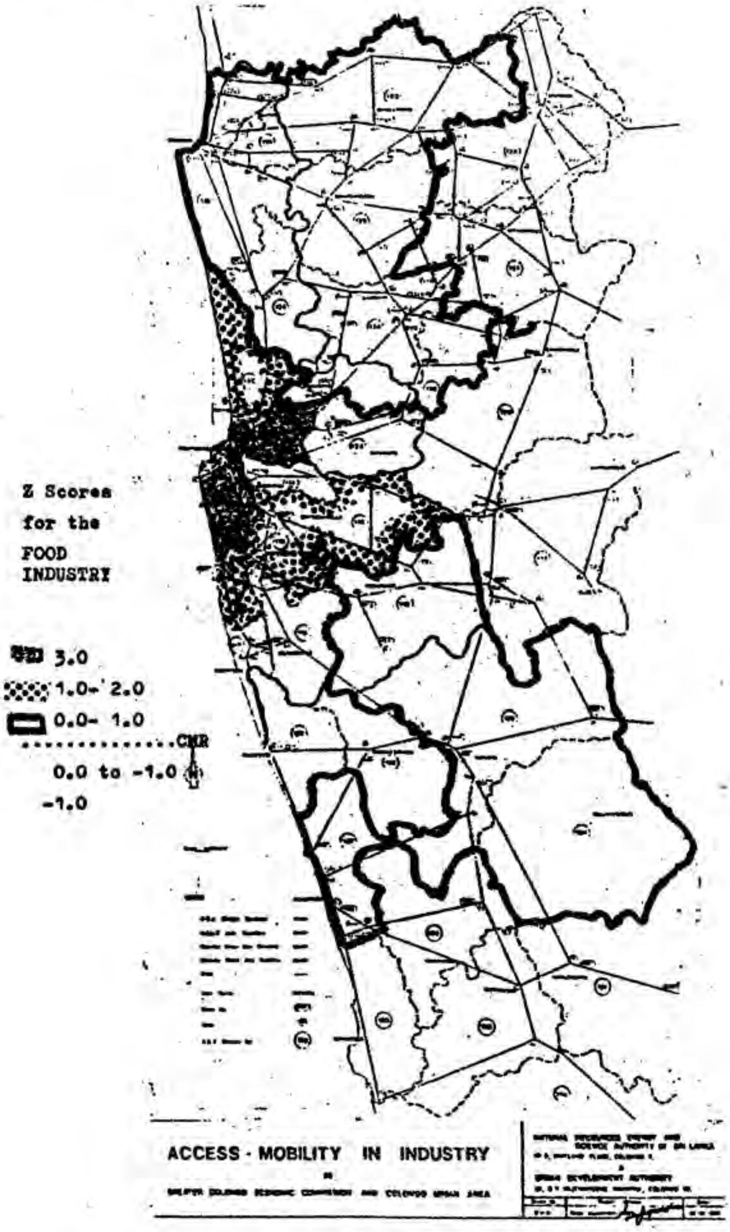


Figure 4.17

Areal Distribution of Z Scores for Food Manufacture.

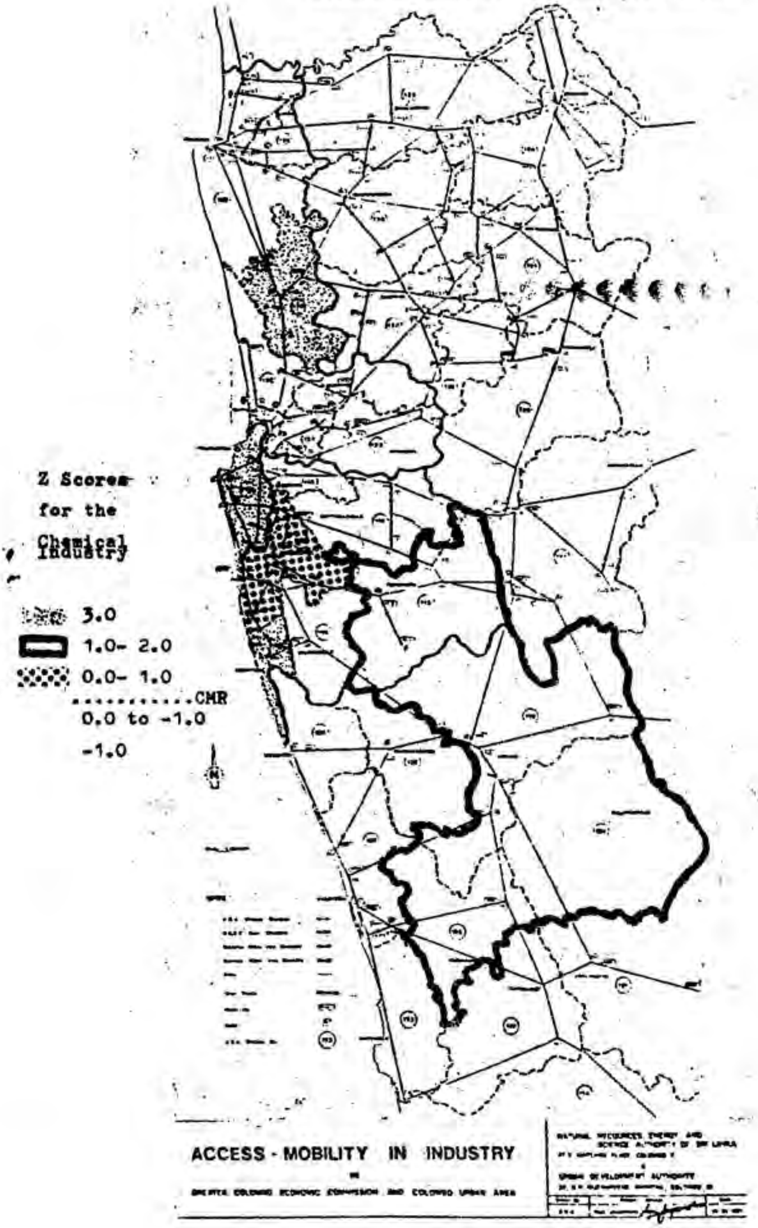


Figure 4.18

Areal Distribution of Z Scores for Chemicals Manufacture.

The relative degree of the manufacturing industry in each AGA division is shown in figure 4.14. **A plot of the manufacturing industry and the Z scores (figure 4.15) shows very clearly that the CUA leads in industry followed by the GCEC and that most of the other AGA divisions in the rest of the CMR are very dormant with a few struggling to emerge industrially.**

Using this method the distribution of the most important manufacturing industries, namely Textiles, Food and Chemicals are illustrated in the tables as well as in the figures 4.16, 4.17 and 4.18 respectively.

The same technique is used to illustrate the employment in manufacturing industry. The table 4.18 gives the figure for employment in each industrial category for every AGA division in the CMR together with the mean and the standard deviation.

The largest employment is in Textile manufacture 31,059) followed by Food Processing (13,260), Chemicals (12950) and in Fabricated Metals (10462).

The table 4.19 gives the Z score distribution of employment in various sectors of manufacturing industry in the CMR. The figure 4.19 shows the distribution of Z score values by areal distribution and the figure 4.15 the distribution by magnitude.

The figure 4.14 illustrates that the CMA and the AGA division of Nugegoda are far above the rest of the AGA divisions. Kaduwela and Moratuwa come next in value followed by Kolonnawa.

It is significant that all AGA areas in the CUA are above average. The CUA may therefore, be considered as a well formed industrial areal unit well above the performance of the other areas in the CMR. Next in importance is the GCEC area with AGA area of Jaela (125) followed by Kelaniya 127).

Distribution of Manufacturing Employment by Sectors

In AGA Divisions

		Z	Z	Z	Z	Z	Z	Z	Z	
AGA	31	32	33	34	35	36	37	38	39	Z
Code	Food	Cloth	Wood	Paper	Chem	Mine	Bas.Met	Fab.Met	Other	Sum
122	44	77	0	0	200	132	0	69	0	522
125	45	1570	0	78	483	105	0	1396	134	3811
126	814	444	0	0	37	155	0	0	0	1450
127	0	235	62	119	464	33	57	560	233	1763
12B	357	648	168	30	255	902	0	492	0	2852
12C	506	190	411	0	368	0	0	171	0	1646
12E	375	397	0	211	113	0	0	0	29	1125
112	3562	5153	241	4398	996	1187	0	2823	383	18743
113	1310	659	78	0	497	197	0	564	0	3305
114	0	1004	35	46	0	55	29	145	62	1376
115	310	1609	385	0	322	72	0	124	50	2872
116	36	522	90	0	416	0	0	26	135	1225
117	105	1681	597	0	606	544	47	1905	0	5485
118	846	13306	345	1379	3457	0	27	1582	205	21047
111	0	109	115	0	1864	374	0	0	0	2462
121	341	247	91	0	59	80	0	0	0	818
123	1157	802	0	0	28	123	0	30	0	2140
124	374	203	0	35	36	64	0	0	90	802
129	533	632	0	27	72	0	0	58	71	1393
12A	186	71	194	0	82	36	0	0	0	569
12D	52	160	0	0	58	0	0	0	0	270
131	129	40	30	0	307	0	0	0	0	506
132	0	41	0	0	0	0	0	0	0	41
133	107	175	31	0	35	0	0	26	0	374
134	320	39	0	0	0	1050	0	0	26	1435
135	0	0	0	0	674	0	0	42	0	716
136	809	185	131	0	1235	0	0	0	0	2360
137	619	284	187	0	27	147	0	0	0	1264
138	191	52	0	0	254	0	0	32	0	529
139	27	467	94	0	40	0	82	417	0	1127
13A	105	57	0	0	0	0	0	0	0	162
Total	13260	31059	3185	6323	12985	5256	242	10462	1418	84190

Source: Author's Computation

Table 4.18

Z Scores for Manufacturing Employment by Sectors In AGA Divisions

Code	31 Food	Z 32 Cloth	Z 33 Wood	Z 34 Paper	Z 35 Chemicals	Z 36 Minerals	Z 37 Bas.Metals	Z 38 Fab.Metals	Z 39 Others	Z Sum	Adjusted Sum
122	-0.565	-0.373	-0.706	-0.250	-0.311	-0.118	-0.393	-0.398	-0.539	-3.653	0.882
125	-0.563	0.229	-0.706	-0.154	0.043	-0.203	-0.393	1.510	0.974	0.737	5.272
126	0.568	-0.225	-0.706	-0.250	-0.543	-0.046	-0.393	-0.500	-0.539	-2.634	1.901
127	-0.629	-0.309	-0.280	-0.104	0.066	-0.430	2.473	0.333	2.092	3.212	7.747
12B	-0.104	-0.143	0.449	-0.213	-0.232	2.309	-0.393	0.229	-0.539	1.363	5.898
12C	0.115	-0.327	2.121	-0.250	-0.071	-0.534	-0.393	-0.347	-0.539	-0.125	4.410
12E	-0.078	-0.244	-0.706	0.009	-0.435	-0.534	-0.393	-0.500	-0.212	-3.093	1.442
112	4.409	1.674	1.658	5.134	0.825	3.287	-0.393	3.685	3.785	24.184	28.719
113	1.297	-0.138	-0.170	-0.250	0.115	0.086	-0.393	0.336	-0.539	0.342	4.877
114	-0.629	0.001	-0.466	-0.193	-0.596	-0.361	1.065	-0.285	0.161	-1.303	3.232
115	-0.174	0.649	1.942	-0.250	-0.137	-0.308	-0.393	-0.317	0.026	1.038	5.573
116	-0.576	-0.194	-0.088	-0.250	-0.002	-0.534	-0.393	-0.462	0.985	-1.514	3.021
117	-0.475	0.274	3.400	-0.250	0.269	1.180	1.970	2.324	-0.539	8.153	12.688
118	0.615	4.961	0.979	1.438	4.337	-0.534	0.960	1.845	1.776	16.377	20.912
111	-0.629	-0.360	0.084	-0.250	2.063	0.645	-0.393	-0.500	-0.539	0.121	4.656
121	-0.128	-0.304	-0.081	-0.250	-0.512	-0.282	-0.393	-0.500	-0.539	-2.989	1.546
123	1.072	-0.081	-0.706	-0.250	-0.556	-0.147	-0.393	-0.456	-0.539	-2.056	2.479
124	-0.079	-0.322	-0.706	-0.207	-0.545	-0.333	-0.393	-0.500	0.477	-2.608	1.927
129	0.154	-0.149	-0.706	-0.217	-0.493	-0.534	-0.393	-0.414	0.263	-2.489	2.046
12A	-0.356	-0.375	1.335	-0.250	-0.479	-0.421	-0.393	-0.500	-0.539	-1.978	2.557
12D	-0.622	-0.340	-0.706	-0.250	-0.513	-0.534	-0.393	-0.500	-0.539	-4.397	0.138
131	-0.612	-0.318	-0.500	-0.250	-0.158	-0.534	-0.393	-0.500	-0.539	-3.804	0.731
132	-0.629	-0.388	-0.706	-0.250	-0.596	-0.534	-0.393	-0.500	-0.539	-4.535	0.000
133	-0.472	-0.333	-0.494	-0.250	-0.546	-0.534	-0.393	-0.462	-0.539	-4.023	0.512
134	-0.159	-0.388	-0.706	-0.250	-0.596	2.776	-0.393	-0.500	-0.245	-0.461	4.074
135	-0.629	-0.404	-0.706	-0.250	0.366	-0.534	-0.393	-0.438	-0.539	-3.527	1.008
136	0.560	-0.329	0.194	-0.250	1.166	-0.534	-0.393	-0.500	-0.539	-0.625	3.910
137	0.281	-0.290	0.580	-0.250	-0.558	-0.071	-0.393	-0.500	-0.539	-1.740	2.795
138	-0.349	0.021	-0.706	-0.250	-0.234	-0.534	-0.393	-0.453	-0.539	-3.437	1.098
139	-0.590	0.188	-0.706	-0.250	-0.539	-0.534	-0.393	0.118	-0.539	-3.245	1.290
13A	-0.475	0.023	-0.706	-0.250	-0.596	-0.534	-0.393	-0.500	-0.539	-3.970	0.565

Source: Author's Computation

Table 4.19

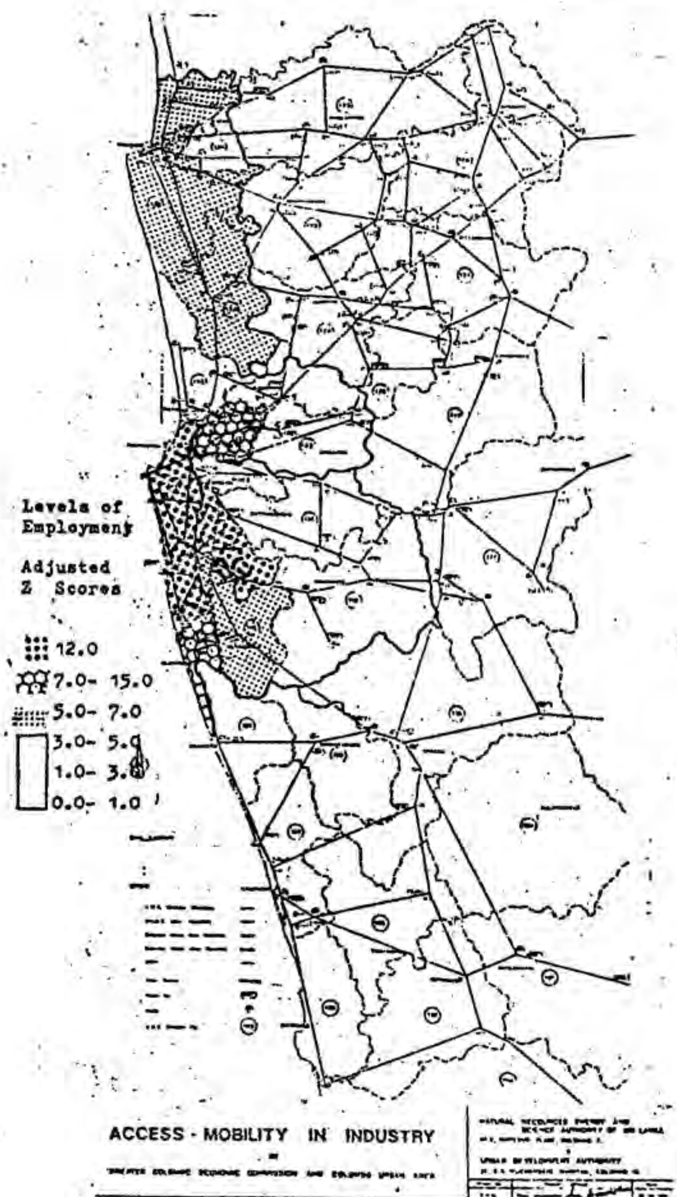


Figure 4.19
Z Scores for Employment

Percentage Distribution of Manufacturing Employment in Industrial Sectors in Each AGA Division

AGA Code	Z 31 Food	Z 32 Cloth	Z 33 Wood	Z 34 Paper	Z 35 Chemicals	Z 36 Minerals	Z 37 Bas.Metals	Z 38 Fab.Metals	Z 39 Others	Z Sum
122		14.8	0.0	0.0	38.3	25.3	0.0	13.2	0.0	91.6
125	1.2	41.5	0.0	2.1	11.9	2.8	0.0	37.0	3.5	100.0
126	56.1	30.6	0.0	0.0	2.6	10.7	0.0	0.0	0.0	100.0
127	0.0	13.3	3.5	6.7	26.3	1.9	3.2	31.9	13.2	100.0
128	12.5	22.7	5.9	1.1	8.9	31.6	0.0	17.3	0.0	100.0
12C	30.7	11.5	25.0	0.0	22.4	0.0	0.0	10.4	0.0	100.0
12B	33.3	35.3	0.0	18.8	10.0	0.0	0.0	0.0	2.6	100.0
112	19.0	27.5	1.3	23.5	5.3	6.3	0.0	15.1	2.0	100.0
113	39.6	19.9	2.4	0.0	15.0	6.0	0.0	17.1	0.0	100.0
114	0.0	73.1	2.5	3.3	0.0	4.0	2.1	10.5	4.5	100.0
115	10.8	56.1	13.4	0.0	11.2	2.5	0.0	4.3	1.7	100.0
116	2.9	42.7	7.3	0.0	34.0	0.0	0.0	2.1	11.0	100.0
117	1.9	30.6	10.9	0.0	11.0	9.9	0.9	34.8	0.0	100.0
118	4.0	63.2	1.2	6.6	16.4	0.0	0.1	7.5	1.0	100.0
111	0.0	4.4	4.7	0.0	75.7	15.2	0.0	0.0	0.0	100.0
121	41.7	30.2	11.1	0.0	7.2	9.8	0.0	0.0	0.0	100.0
123	54.1	37.5	0.0	0.0	1.3	5.7	0.0	1.4	0.0	100.0
124	46.6	25.3	0.0	4.4	4.5	8.0	0.0	0.0	11.2	100.0
129	38.5	45.3	0.0	1.9	5.2	0.0	0.0	4.2	5.1	100.0
12A	32.7	12.5	34.1	0.0	14.4	6.3	0.0	0.0	0.0	100.0
12D	19.3	59.2	0.0	0.0	21.5	0.0	0.0	0.0	0.0	100.0
131	25.5	7.9	5.9	0.0	60.7	0.0	0.0	0.0	0.0	100.0
132	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
133	28.6	46.7	8.3	0.0	9.4	0.0	0.0	7.0	0.0	100.0
134	22.3	2.7	0.0	0.0	0.0	73.2	0.0	0.0	1.8	100.0
135	0.0	0.0	0.0	0.0	94.1	0.0	0.0	5.9	0.0	100.0
136	34.3	7.8	5.6	0.0	52.3	0.0	0.0	0.0	0.0	100.0
137	49.0	22.5	14.8	0.0	2.1	11.6	0.0	0.0	0.0	100.0
138	36.1	9.8	0.0	0.0	48.1	0.0	0.0	6.0	0.0	100.0
139	2.4	41.5	8.3	0.0	3.5	0.0	7.3	37.0	0.0	100.0
13A	64.8	35.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
No. of Industries per sector	26	30	18	9	27	17	5	18	11	161

Author's Computation Table 4.20

Sectors in Manufacturing Employment
in
Each AGA DivisionBetter than Average

AGA Code	Z 31 Food	Z 32 Cloth	Z 33 Wood	Z 34 Paper	Z 35 Chemicals	Z 36 Minerals	Z 37 Bas.Metals	Z 38 Fab.Metals	Z 39 Others
122					Y	Y			
125		Y						Y	
126	Y	Y							
127		Y			Y			Y	Y
12B		Y				Y		Y	
12C	Y		Y		Y				
128	Y	Y							
112	Y	Y		Y				Y	
113	Y							Y	
114		Y							
115		Y							
116		Y			Y				
117		Y						y	
118		Y			Y				
111					Y				
121	Y	Y							
123	Y	Y							
124	Y	Y							
129	Y	Y							
12A	Y		Y						
131	Y				Y				
132		Y							
133	Y	Y							
134						Y			
135					Y				
136	Y				Y				
137	Y	Y							
138	Y				Y				
139		Y							
13A	Y							Y	
No.of Industries 161 per sector	16	21	2	1	10	3	0	7	1

Author's Computation
Table 4.21

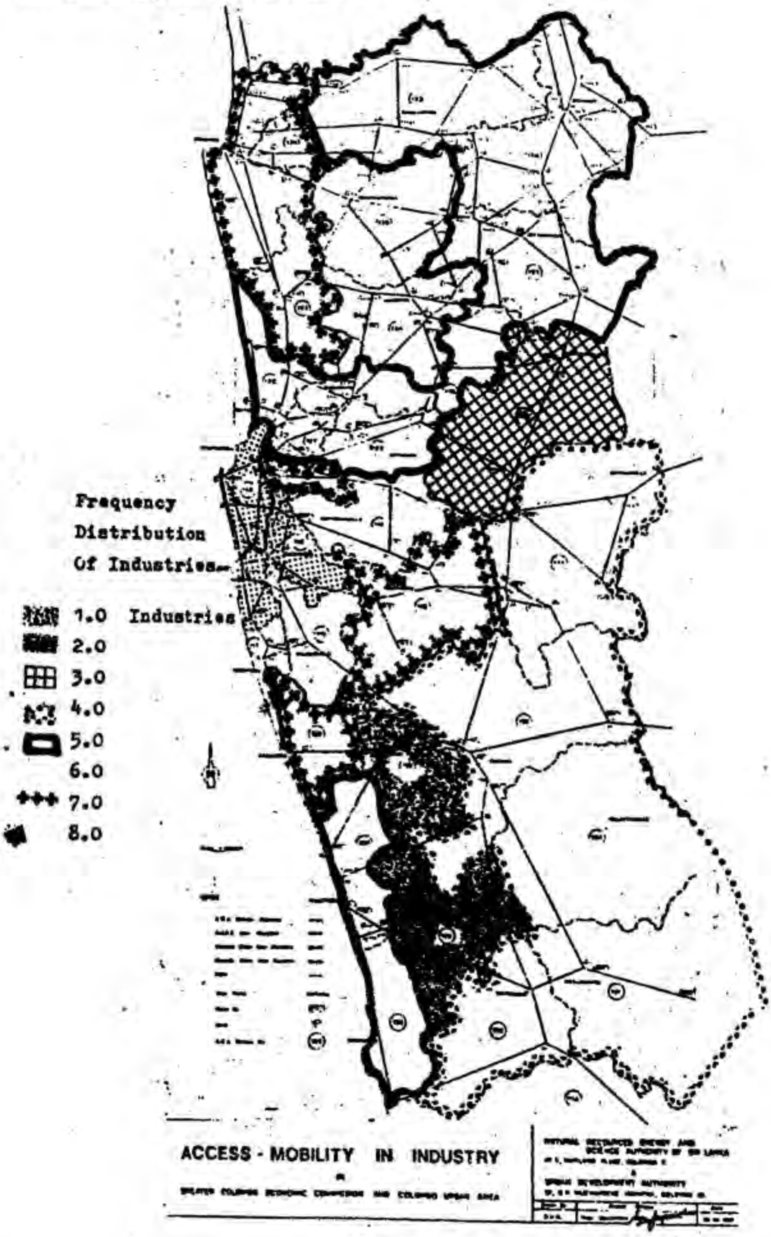


Figure 4.20

Percentage Distribution of Manufacturing Employment by Sector.

The rest of the AGA areas in the GCEC are below average with Biyagama (122) as the lowest. It is noteworthy that in the Kalutara district the AGA divisions to the south and southeast are least affected.

The lowest levels are occupied by the AGA areas of Weke(12D), Bandaragama (132), Beruwala (133) and Wallallawita (13A).

The values of the Z scores for employment are plotted by magnitude in figure 4.15 with GCEC, CUA and the rest of the CMR also grouped separately.

This figure illustrates clearly the state of employment in industrial development in the manufacturing sector in the AGA divisions. It also shows the very important role played by the AGA divisions in the CUA in manufacturing industry and the positive and controlling influence of the AGA divisions of Colombo (112) and Nugegoda (118).

4.9 Sectoral and Areal Distribution of Industry

Although the manufacturing industry is divided into nine sectors, employees are not equally distributed among all nine sectors. Some sectors do not record any employees. There is a heavy concentration of employees in a few industries. The table 4.20 gives the percentages of employment in manufacturing industry, distributed in each sector in the AGA divisions. A frequency distribution (table 4.21)shows the variation within the AGA divisions and this is illustrated in the figure 4.20.

For instance, (table 4.20) in Bandaragama (132) 100 % employment is found in the textile sector; in Nugegoda (118) employment is distributed among eight sectors ranging from 0.1 % to 63.2 %; where the lowest percentage being in the Basic Metal sector while the highest is in the Textile sector.

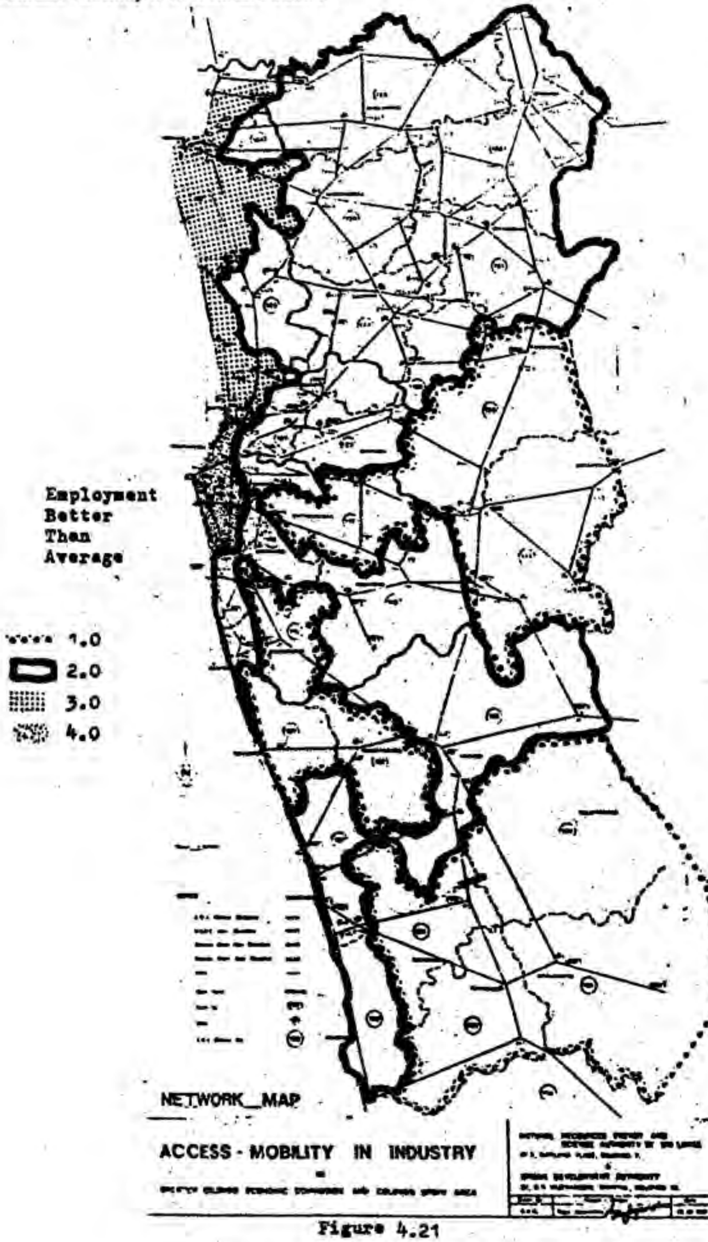


Figure 4.21

Sectors in Manufacturing Employment
Better than Average

In Colombo too (112) employment is found in eight sectors ranging from 1.3 % for sector (33) Food Processing to 27.5 % for sector(32) Textiles.

The analysis of the sectoral variation in AGA divisions enables a frequency distribution to be plotted of those sectors better than average as per figure 4.21. For instance in the eight sectors in Colombo AGA (112) division the average employment is 12.5 % per sector. Thus in AGA division of Colombo there are only four sectors above the average value. With the AGA division of Nugegoda (table 4.21) with seven sectors there are only two sectors which are above average. Though there are seven sectors in the manufacturing industry in both Nugegoda and Colombo AGA divisions, in the Colombo AGA division there is greater expansion in four sectors in the manufacturing industry, while Nugegoda AGA division only two sectors fall into this category. **It shows that Food and Garments dominate the manufacturing sector while Paper, Basic Metals, Fabricated Metals do not play any significant role except in a few AGA divisions.**

The figure 4.19 also illustrates the dominant role of employment in manufacturing industry in the CUA and the GCEC areas. The least number of employees in the manufacturing sector are in the south and southeastern regions. These two figures illustrate the relative intensity in employment.

For instance in the AGA area of Jaela (125) though manufacturing is high the employment figures are relatively low which means that the role of machine orientation is high. In AGA area of Biyagama (114) the number of industries are high though employment figures are low which means that there may be an influx of workers from outside areas to the rest of the CMR only Panadura (137) exhibits positive Z values in employment.

The comparison of the magnitudes in respect of industries and employment in figure 4.15 show some interesting phenomena. In the GCEC, Jaela (125) though high in industrial establishments employment is low while Kelaniya (127) though establishments are relatively less employment in industry is high. In the CUA the interesting feature with Kaduwela (114) and Kolonnawa is positive and high, employment scores are negative which may mean an influx from outside the area for work.

In Moratuwa (117) though Z scores for industry is low employment in industry is high. In the rest of the CMR except Kalutara (137) all others exhibit negative values.

The GCEC area is well established in this manner with industry ranging between a two and three industry sectors while in the CUA there is a full range form a single to four sectors whereas in the rest of the CMR there are only one or two sectors of industry.

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5

THE NETWORK FUNCTION

5.0 The Network Function

5.1 Network Concepts.

The transport infrastructure is a highly complex spatial system. The network which forms the basis of the infrastructure provides the understanding of the spatial structure in the region and gives an insight as to where, when and how movements take place.

For ease of understanding, the infrastructure network is transformed to a topological representation; that is, the network is represented irrespective of distance and direction. The infrastructure is idealized into a set of points called nodes or vertices and are connected by continuous lines called links, arcs or edges. Each link or edge is associated with two nodes and more than two nodes enclose space forming regions.

The network may be completely described in terms of;

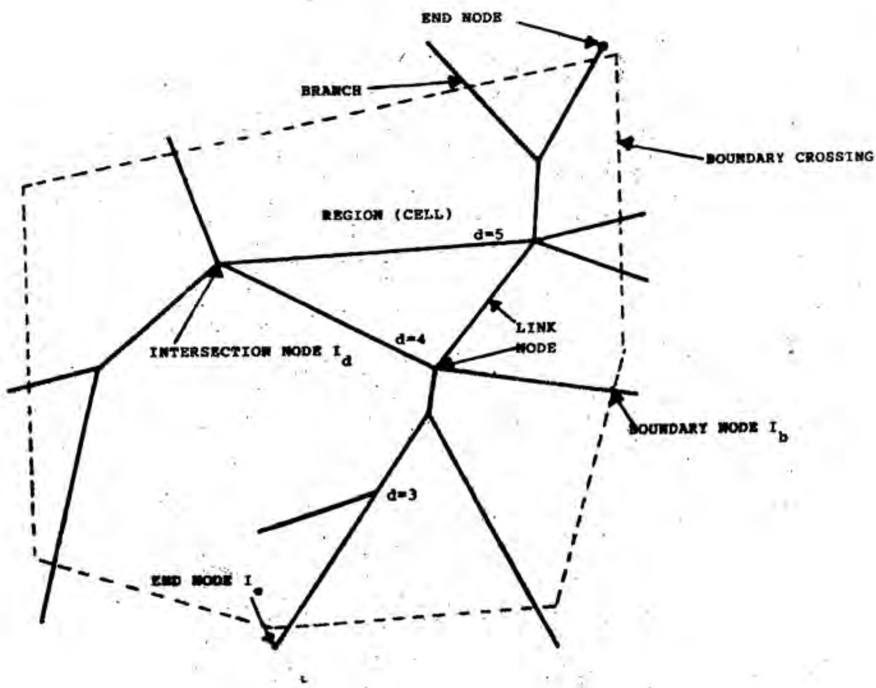
1 **Nodes,vertices,junctions or intersections.**

2 **Links, edges or sections of roads.**

3 **Regions, cells or blocks to which they are divided.**

The whole study region is divided into various cells, areas or zones with the links and nodes marked as illustrated in the figure 5.1.and shown in figure 2.3 for the CMR.

The network which gives rise to the infrastructure may be examined in four aspects as giving rise to;



NETWORK CONCEPTS

Figure 5.1

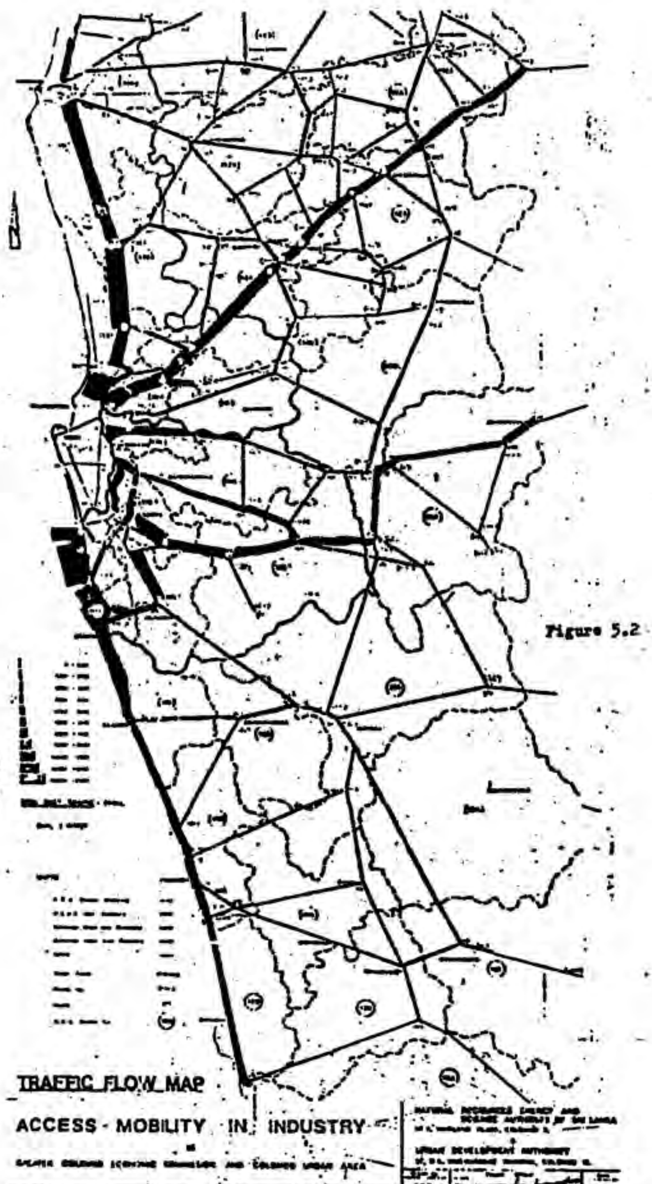


Figure 5.2
TRAFFIC FLOW MAP
ACCESS - MOBILITY IN INDUSTRY

1. **A structural system.**
2. **A physical system.**
3. **A flow system.**
4. **A land use system.**

These will **show where and how the settlements and industries are located and distributed and how they are interlinked within and outside the region reflecting the movement of people and goods.** Some nodes or towns in the transportation network are so placed that they have easy access to other towns or nodes.

Hence the **relative access is an important factor.** For instance Colombo is the main point of entry and exit to the country and the region and is therefore the main transportation centre. Negombo, Veyangoda, Avissawella, Horana, Panadura and Moratuwa form major urban centres.

When the system of nodes, links and hinterlands, varying population densities are considered a complex hierarchical structure of high and low level centres emerge (figure 3.17). How this is related to transportation can be seen from the flow pattern of vehicles (figure 5.2).

Network changes occur with lapse of time depending on many factors such as physical, economic, social and political. For whatever the situation the network performs two important functions.

1. **It provides a flow path from point to point for movements to take place.**
2. **It links locations such as residential areas to a factory, a farm to a market, a factory to a town, towns to the metropolis and so on.**

Physical access and networks, therefore, play a most significant role in the understanding of the spatial process and the associated activity patterns.

5.2 Network Measures

Two types of measures describe the idealized network structure. They are;

1. **A measure of the totality of the geometrical pattern.**

2. **A measure of the relationship between nodes and links.**

5.3 The Comparison of Networks.

A network may be considered to consist of ;

1. A number of **sub-graphs** in the network (G).

2. A number of **links (edges)** in the network (L).

3 A number of **nodes (vertices)** in the network (N).

These three factors are manipulated to show the connectivity of nodes and links to obtain indices for purposes of comparison of networks.

The network which involves the distribution of links and nodes may be described by connectivity measures such as ;

Network Connectivity in the Colombo Metropolitan Region

Zone	Code Number	Links	Inter-sections	End Nodes	Boundary Nodes	Total Nodes	Minimally Connected	Cyclomatic Number	Alpha %	Beta	Gamma	Indus-tries
Biyagama	122	7	3	1	4	8	1	0	0.00	0.88	0.39	7
Jaela	125	7	2	0	5	8	1	0	0.00	0.88	0.39	35
Katana	126	10	3	0	10	13	0	0	0.00	0.77	0.30	18
Kelaniya	127	13	6	0	8	14	0	1	4.76	0.93	0.36	19
Negombo	128	23	10	0	12	22	0	2	9.30	1.05	0.40	21
Wattala	12C	13	6	2	6	14	1	0	0.00	0.93	0.37	24
Mahara	12B	12	5	0	12	17	0	0	0.00	0.71	0.27	14
Col. Municip.	112	76	45	0	9	54	0	1	3.03	1.41	0.37	118
Homagama	113	12	4	1	10	15	1	0	0.00	0.80	0.29	28
Kaduwela	114	6	2	0	6	8	1	0	0.00	0.75	0.33	19
Kesbewa	115	14	5	0	10	15	0	1	4.35	1.00	0.33	22
Kolonnawa	116	10	5	0	4	9	1	2	0.00	0.90	0.40	22
Moratuwa	117	7	3	0	5	8	0	0	14.28	1.00	0.50	27
Nugegoda	118	35	16	2	14	32	0	4	3.28	1.09	0.37	103
Avissawella	111	19	10	2	6	18	0	2	9.09	1.06	0.42	13
Attanagalla	121	20	8	0	14	22	0	1	3.70	0.91	0.38	13
Divulapitiya	123	20	9	0	12	21	1	0	0.00	0.95	0.35	25
Gampaha	124	18	8	0	10	18	1	1	3.22	1.00	0.38	10
Minuwangoda	129	16	7	0	9	16	0	1	3.70	1.00	0.38	22
Mirigama	12A	31	16	0	12	28	0	4	7.02	1.11	0.40	12
Wele	12D	9	4	0	6	10	1	0	4.76	0.90	0.29	8
Aggalawatta	131	3	1	1	2	4	1	0	0.00	0.75	0.50	10
Bandaragama	132	3	1	0	3	4	1	0	0.00	0.75	0.44	1
Beruwala	133	4	1	0	5	6	1	0	0.00	0.67	0.33	8
Bulathsinhala	134	2	0	0	2	2	1	0	0.00	0.50	0.00	15
Dodangoda	135	5	1	0	8	9	0	1	0.00	0.63	0.29	10
Horana	136	12	6	0	11	17	1	0	0.00	0.92	0.31	19
Kalutara	137	11	5	0	6	11	0	1	5.88	1.00	0.41	14
Matugama	138	6	2	0	5	7	1	0	0.00	0.86	0.40	12
Panadura	139	3	1	0	3	4	1	0	0.00	0.75	0.33	19
Walallawita	13A	1	0	1	0	2	1	0	0.00	0.50	0.00	4

Author's Computation Table 5.1

1. **Cyclomatic Number=L-N+G**

   Non-planner Circuits=L/3(N-2)

2 **Beta Index=L/N**

3 **Alpha Index=(L-N+G/2N-5)*100**

   Planar Graphs.

   Non-planer,

   Alpha=L-N+G/.5N(N-1)-(N-1)

4 **Gamma Index=L/Lmax.**

   Planar Graphs

   Gamma

   Index=((L/3(N-2))*100

   Non-planer Graphs.

The other significant network characteristics are;

5 **the shape.**

6 **the diameter.**

7 **the spread.**

8 **the route factor**

9 **the route density.**

10 **the network density.**

Table 5.2

. Comparison of Networks

Complexity of Network		Connectivity of Network		Complexity of Structure		Degree of Connectivity	
Cyclomatic No.	Zone	Alpha Index	Zone	Beta Index	Zone	Gamma Index	Zone
13	CUA	12.15	CUA	1.20	CUA	0.41	CUA
10	CSA	9.71	CUA	1.15	CSA	0.40	CSA
7	GCEC	7.22	GCEC	1.12	GCEC	0.39	GCEC
4	12A	9.30	128	1.12	111	0.50	117
3	128	9.09	111	1.11	12A	0.50	131
3	111	7.02	12A	1.09	128	0.46	132
2	118	5.88	137	1.03	118	0.42	111
		4.76	120			0.41	137
Greater than one		4.76	127	Greater than one		0.40	128
		4.35	115			0.40	11A
1	127	3.70	129	1.00	112	0.40	12A
1	112	3.70	121	1.0	117	0.40	13A
1	115	3.28	118	1.00	121	0.39	122
1	117	3.22	124	1.00	124	0.39	125
1	121	3.03	112	1.00	129	0.38	121
1	124			1.00	137	0.38	124
1	129					0.38	129
1	137					0.37	12C
				Equal to one		0.37	118
Equal to one						0.36	127
0	122	0	122	0.95	123	0.35	123
0	125	0	125	0.93	127	0.33	114
0	126	0	126	0.93	115	0.33	115
0	12C	0	12C	0.92	12C	0.33	133
0	128	0	128	0.88	122	0.33	139
0	113	0	113	0.88	125	0.30	126
0	114	0	114	0.86	116	0.29	113
0	116	0	116	0.86	138	0.29	120
0	123	0	123	0.81	136	0.29	135
0	120	0		0.80	132	0.27	128
0	131	0	131	0.77	113		
0	132	0	132	0.76	120		
0	133	0	133	0.75	126		
0	134	0	134	0.75	114		
0	135	0	135	0.75	131		
0	136	0	136	0.71	128		
0	138	0	138	0.67	133		
0	139	0	139	0.67	135		
0	13A	0	13A	0.67	139		
				0.50	134		
				0.50	13A		

Less than one.

Author's Computation

The figure 2.3 shows the CMR divided into AGA divisions as listed. The highway system of **A and B type roads** have been reduced to **a network** as shown. Divisions, links and nodes have been coded for analysis of the highway infrastructure. The table 5.1 gives the AGA divisions, the code numbers, the links, intersections, end nodes, the boundary nodes, the total nodes, circuits minimally connected or otherwise, cyclomatic number, alpha %, beta index, and the gamma index. for the whole of the CMR

5.4 The Connectivity of Networks

The connectivity of networks may be assessed by four types of indices as indicated earlier such as;

1. **The Cyclomatic number C .**
2. **The Beta (β) index.**
3. **The Alpha (α) index**
4. **The Gamma (γ) index.**

In the table 5.2 the cyclomatic numbers show the nature of the circuits in the network, the alpha index gives the connectivity of the network, the beta index indicates the complex nature of the structure of the network and the gamma index shows the degree of connectivity of the network. All these indices are arranged in descending order for the different zones.

Network characteristics of the CMR are compared in table 5.3. It gives the zone, mileage, diameter,phi.index, long axis, intersections, area, shape, links, spread and route factor.

Network Characteristics of the Metropolitan Region

Zone	Code Num	Mile A&B km	Diam d(ml)	Dis-sect	Phi	Long Axis L km	Num Inter sect	Area A sq.km	Shape	Num Link	Spread	Route Factor
Biyagama	122	26.04	13.77	2	1.89	12.16	3	61.90	0.532	7	3.72	0.94
Ja-ela	125	18.29	11.104	3	1.65	15.84	3	79.20	0.401	7	2.61	1.26
Katana	126	20.43	6.604	2	3.09	8.62	3	22.60	0.427	9	2.27	1.07
Kelaniya	127	19.51	7.620	5	2.56	7.64	6	22.20	0.483	13	1.50	1.00
Negombo	128	61.36	18.847	7	3.26	20.22	10	127.90	0.397	23	2.67	0.91
Wattala	12C	28.53	13.154	5	2.17	16.40	6	46.20	0.218	13	2.04	0.98
Mahara(part)	128	21.10	9.797	4	2.15	13.78	3	47.90	0.334	6	2.58	1.07
Great Col.Ec.Com	GCEC	195.26	51.310	16	3.88	48.40	34	407.90	0.317	78	3.15	1.03
Colombo Municip.	112	72.46	12.697	4	5.72	12.72	45	41.08	0.322	76	8.95	1.04
Homagama	113	44.25	16.891	5	2.82	20.22	4	157.94	0.491	12	3.69	0.95
Kaduwela	114	34.32	25.046	3	1.33	16.26	2	90.81	0.436	6	5.72	1.36
Kesbewa	115	19.86	11.100	5	1.79	13.86	5	63.47	0.420	14	1.53	0.91
Kolonnawa	116	18.42	7.903	4	2.33	10.04	5	26.32	0.332	10	2.05	1.14
Moratuwa	117	9.02	4.698	3	1.92	11.32	3	19.22	0.190	7	1.50	1.21
Nugegoda	118	46.66	16.004	9	2.82	13.00	16	58.53	0.440	35	1.33	1.19
Col.Suburban Area	CSA	172.53	27.483	13	6.28	28.00	35	326.29	0.529	84	2.63	1.13
Col. Urban Area	CUA	244.99	32.056	10	7.64	30.60	80	457.37	0.488	160	1.86	1.11
Avissawella	111	35.30	21.888	7	1.63	25.46	10	237.21	0.465	19	1.96	0.74
Attanagalla	121	62.15	18.717	7	3.31	22.48	8	153.90	0.387	20	3.11	0.91
Divulapitiya	123	82.66	28.575	7	2.89	23.04	9	198.40	0.475	20	4.13	0.99
Gampaha	124	47.12	17.196	5	2.74	17.54	8	94.50	0.390	18	2.61	1.08
Mahara (part)	128	16.25	6.985	1	2.33	11.74	2	47.90	0.441	6	2.71	0.90
Minuwangoda	129	57.19	20.193	5	2.83	16.12	7	132.80	0.649	16	3.57	1.83
Mirigama	12A	97.33	27.178	6	3.38	21.36	16	187.40	0.522	31	3.14	1.22
Weke	12D	32.65	15.987	3	2.04	21.06	4	175.90	0.504	9	3.63	0.97
Aggalawatta	131	20.43	16.475	2	1.24	20.64	1	361.30	1.077	3	6.81	1.12
Bandaragama	132	10.67	8.382	2	1.27	16.68	1	84.80	0.387	3	3.56	1.11
Beruwala	133	18.29	14.351	2	1.27	14.96	1	73.00	0.413	4	9.15	1.12
Bulathsinhala	134	30.61	23.479	1	1.00	19.52	0	235.30	0.784	2	15.31	1.97
Dodangoda	135	27.81	14.906	2	1.86	16.82	1	107.60	0.480	5	5.56	0.89
Horana	136	69.78	36.324	5	1.92	28.70	6	255.60	0.394	12	5.82	1.15
Kalutara	137	40.13	18.161	5	2.21	16.12	5	77.90	0.381	11	3.65	1.25
Matugama	138	35.77	13.335	3	2.68	18.38	2	134.10	0.504	6	5.96	1.20
Panadura	139	20.97	14.616	2	1.43	13.72	1	57.50	0.388	3	6.99	1.03
Rest of CMR		705.11					82	2,614.51		188.00		1.15
Total for CMR		1,145.36					198	3,479.78		426.00		1.10

Author's Computation

Table 8.3

5.5 Network Size

One of the objectives of this study is to **examine the road network of administrative units (AGA units) or economic zones such as the CMA, CUA and GCEC in terms of size and structure of the networks and relate to variables such as the area, population etc. in order to understand the correlation between the transport network and the location of industries.**

A key feature of an intersection or node is its degree, that is, the number of links connected to it (figure 5.1). There are three types of nodes in the network, the boundary node, the end node and the intersection node.

Ib=the boundary node.

Ie=the end node.

Id=the intersection node.

N =the total number of nodes.

LB =the number of boundary links.

L=the number of links

Z=the number of zones.

A modified Euler's formula gives the number of zones in relation to the number of nodes and links.

$$Z=L+LB-N+1$$

The following may be compared.

1. **The area characteristics.**

   The area is related to the frequencies as well as the densities of the routes and intersections

Table 5.4

ROUTE CHARACTERISTICS OF THE METROPOLITAN AREA

Zone	Code Number	Gross Area sq.km	Used Area sq.km	Mileage (A&B)+C in km	Number Inter section	Number Links	Route Density per 100 sq. km.	Route Density /10000 persons	Inter-section Density per 100km	Inter-section Density 100 sq. km
Biyagama	122	61.90	39.70	26.04	3	7	42.07	2.690	11.52	4.65
Jaela	125	79.20	48.00	18.29	3	7	23.09	1.530	16.40	3.79
Katana	126	22.60	9.30	20.43	3	9	90.40	2.620	14.68	13.27
Kelaniya	127	22.20	15.70	19.51	6	13	87.88	1.790	30.75	27.03
Negombo	12B	127.90	56.10	61.36	10	23	47.97	4.510	16.30	7.82
Wattala	12C	46.20	19.90	28.53	5	14	61.75	2.800	17.53	10.82
Mahara(part)	128	47.90	27.65	21.10	3	6	44.05	1.950	14.22	6.26
Great Col.Eco.Comm.	GCEC	407.90	216.35	195.26	33	62	47.87	2.820	16.90	8.09
Colombo Municipality.	112	41.08	36.64	72.46	45	76	176.39	1.230	62.10	109.54
Homagama	113	157.94	38.21	44.25	4	12	28.02	3.120	9.04	2.53
Kaduwela	114	90.81	29.17	34.32	2	6	37.79	2.720	5.83	2.20
Kesbewa	115	63.47	22.36	19.86	5	13	31.29	1.640	25.18	7.88
Kolonnawa	116	26.32	15.17	18.42	4	9	69.98	1.610	21.72	15.20
Moratuwa	117	19.22	13.12	9.02	3	6	46.93	0.670	33.26	15.61
Nugegoda	118	58.53	40.25	46.66	16	35	79.72	1.270	34.29	27.34
Col.Subur.Area	CSA	326.29	158.28	172.53	34	65	52.88	0.580	19.71	10.42
Col. Urb. Area	CUA	457.37	194.92	244.99	79	132	53.56	1.540	32.25	17.27
Avisawella	111	237.21	32.95	35.30	10	18	14.88	3.320	28.33	4.22
Attanagalla	121	153.90	77.50	62.15	8	20	40.38	5.860	12.87	5.20
Divulapitiya	123	198.40	62.90	82.66	9	20	41.66	8.340	10.89	4.54
Gampaha	124	94.50	58.50	47.12	8	18	49.86	4.050	16.98	8.47
Mahara (part)	128	47.90	27.65	16.25	2	6	33.92	3.000	12.31	4.18
Minuwangoda	129	132.80	85.80	57.19	7	16	43.06	5.330	12.24	5.27
Mirigama	12A	187.40	93.30	97.33	16	31	51.94	8.750	16.44	8.54
Weke	12D	175.90	76.90	32.65	4	9	18.56	3.310	12.25	2.27
Aggelawatta	131	361.30	32.30	20.43	1	3	5.65	2.930	4.89	0.28
Banderagama	132	84.80	34.80	10.67	1	3	12.58	1.720	9.37	1.18
Beruwala	133	73.00	29.00	18.29	1	2	25.05	1.640	5.47	1.37
Bulathsinhala	134	235.30	45.00	30.61	0	2	13.01	4.890	0.00	0.00
Dodangoda	135	107.00	17.20	27.81	1	5	25.99	6.350	3.60	0.93
Horana	136	255.60	94.20	69.78	6	12	27.30	5.680	8.60	2.35
Kalutara	137	77.90	34.90	40.13	5	11	51.51	3.590	12.46	6.42
Matugama	138	134.10	21.00	35.77	2	6	26.67	5.720	5.59	1.49
Panadura	139	57.50	34.90	20.97	1	3	36.47	1.520	4.77	1.74

Author's Computation

Table 5.5

Industrial Relationship to Networks.

Function	Total Sum X	Average X	St. Dev.	Coef. A	Coef. B	Reg.Coef. R	R^2
Population	3,874,786	129159.5	101961.8	-6.9251	2.3195E-4	0.9474	0.8975
Active Pop.	1,389,287	46309.6	41090.6	-3.6533	5.7627E-4	0.9485	0.8997
Gross Area in km.	3479.78	115.99	81.59	32.6515	-0.0829	-0.2710	0.0734
Mileage A & B Km	1145.36	38.18	22.11	11.0501	0.3139	0.2780	0.0773
Intersection	194	6.47	8.32	7.6008	2.3865	0.7958	0.6332
Total Nodes	425	14.17	10.45	-2.9159	1.8317	0.7664	0.5874
Links	421	14.03	14.24	3.2416	1.4103	0.8046	0.6475
Route Density per 100 sq.km	1351.9	45.06	32.78	-2.1496	0.5588	0.7338	0.5385
Intersection density/100 sq.km	308.4	10.28	19.99	12.505	1.0241	0.8199	0.6723
Beta Index	25.25	0.90	0.1651	-68.4089	102.4237	0.6596	0.4351
Gamma Index	10.68	0.37	0.057	24.8492	-4.1785	-0.0094	0.00009
Diameter	125	4.17	1.98	4.6818	4.4044	0.3501	0..1225
Long Axis	504.62	16.82	4.87	44.1755	-1.2569	-0.2452	0.0601
Shape	13.61	0.454	0.1625	36.9828	-30.7414	-0.2000	0.0400
Spread	119.12	3.97	2.90	34.1029	-2.7878	-0.3237	0.1048
Route Factor	33.61	1.12	0.252	19.7888	2.8960	0.0292	0.0008
Phi	69.3	2.31	0.95	-14.5361	16.2638	0.6163	0.3798

Author's Computation

2. **The intersection frequency.**

   The intersections per 100 km and 100sq km per area may be compared

3. **The route density.**

   The route density per 100km and per 100 square kilometres may also be compared

The area and population of each zone is related to the network per 100 sq.km area and 100 km and per 1000 persons per AGA division and are shown in table 5.4.

5.6 Network as a Factor of Location of Industry

The measures that illustrate the connectivity, complexity and structure of networks have been assessed as indices and are shown in the tables 5.1 and 5.2. The characteristics of the network as shown by the different factors are shown in table 5.3 and the characteristics of the route functions are given by values as in table 5.4.

These varied factors were examined by regression analysis by factor and the results are shown in table 5.5. The following functions are seen to have a very close relationship to the number of industries in an area, such as the AGA division. These functions are;

Population

Active Population

Number of Intersections

Total number of Nodes

Table 5.6

Industrial Relations to Networks

Functions	Total Sum X	Average X	Std. Deviation	Coeff. A	Coeff. B	Regres. Coef.R	R^2
POPULATION							
GCEC	754893	107842	18116	-4.4610	.0002229	0.4642	0.2155
CUA	1592834	227548	182420	-3.1048	.0002265	0.9667	0.9346
Balance of CMR	1527054	95441	26738	3.7389	.0001016	0.4333	0.1877
INTERSECTIONS							
GCEC	36	5.14	2.55	18.5882	0.1912	0.0559	0.00313
CUA	80	11.43	15.32	20.4862	2.4450	0.8881	0.7887
Balance of CMR	80	4.71	4.43	10.7298	0.4574	0.3120	0.0974
LINKS							
GCEC	85	12.14	5.43	19.0614	0.0420	0.0262	0.00069
CUA	160	22.86	25.39	13.0313	1.5486	0.9202	0.8468
Balance of CMR	183	11.44	8.55	11.0169	0.2116	0.2885	0.0832
ROUTE DENSITY							
100 sq.km							
GCEC	397.21	56.74	24.88	25.0149	-0.0959	-0.2744	0.0753
CUA	470.12	67.16	51.94	1.7302	0.6933	0.8451	0.7142
Balance of CMR	484.57	30.29	15.05	8.0632	0.1774	0.4257	0.1812
INTER.DENSITY							
100 sq.km.							
GCEC	73.84	10.55	7.99	20.7172	-0.1088	-0.0798	0.010
CUA	180.30	25.76	37.97	24.4537	0.9308	0.8270	0.6840
Balance of CMR	54.27	3.39	2.77	11.9145	0.4490	0.1984	0.0394

Table 5.6(a)

BETA INDEX							
GCEC	6.15	0.879	0.112	1.9061	20.1068	0.2583	0.0667
CUA	6.97	0.996	0.227	-100.5982	149.67	0.7960	0.6337
Balance of CMR	13.63	0.852	0.167	6.7376	7.8649	0.2090	0.0437
MILEAGE A & B							
GCEC	195.26	27.89	15.21	19.8022	-8.2748	-0.0145	0.0002
CUA	244.99	35.00	21.62	-7.3399	1.5934	0.8061	0.6498
Balance of CMR	688.86	43.05	26.62	7.7269	0.1326	0.5206	0.2710
PHI							
GCEC	16.77	2.40	0.603	24.9505	-2.2453	-0.1556	0.0
CUA	18.63	2.66	1.45	-17.9444	24.9388	0.8462	0.7160
Balance of CMR	48.70	3.04	3.94	13.8065	-0.1212	-0.0763	0.0058
DIAMETER							
GCEC	28	4.0	1.83	15.5714	1.0000	0.2190	0.0441
CUA	33	4.71	2.06	-2.8989	10.8876	0.5245	0.2751
Balance of CMR	64	4.0	2.10	8.6496	1.1970	0.4004	0.1603
SPREAD							
GCEC	17.39	2.48	0.68	31.9523	-4.9837	0.3914	0.1532
CUA	17.15	2.45	1.67	41.7915	2.7090	0.1056	0.0111
Balance of CMR	84.96	5.31	3.28	12.9084	0.0996	0.0552	0.0002
SHAPE							
GCEC	2.782	0.40	0.103	33.2763	-34.4838	-0.4093	0.1675
CUA	2.631	0.375	0.102	50.8028	-6.3169	-0.0131	0.0002
Balance of CMR	8.20	0.513	0.186	12.8724	1.1027	0.0327	0.0001

Author's Computation

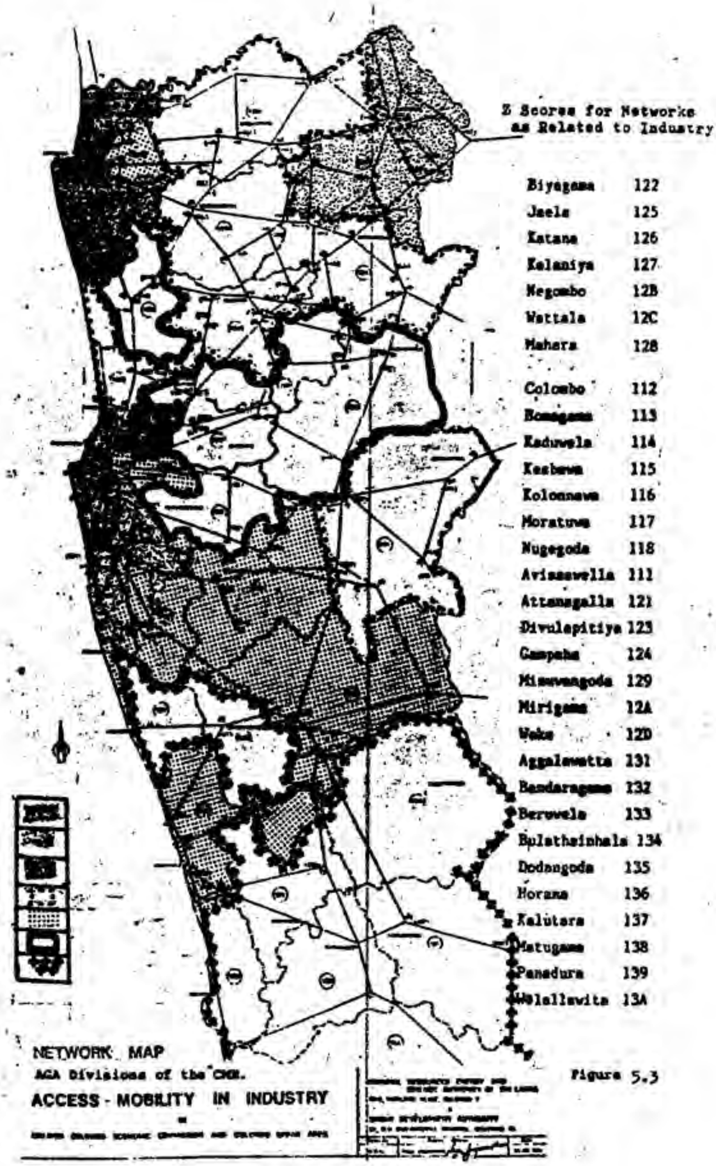

Z Scores for Networks as Related to Industry
Biyagama 122
Jaela 125
Katana 126
Kelaniya 127
Negombo 12B
Wattala 12C
Mahara 128
Colombo 112
Homagama 113
Kaduwela 114
Kesbewa 115
Kolonnawa 116
Moratuwa 117
Nugegoda 118
Avissawella 111
Attanagalla 121
Divulapitiya 123
Gampaha 124
Minuwangoda 129
Mirigama 12A
Waka 12D
Aggalawatta 131
Bandaragama 132
Beruwela 133
Bulathsinhala 134
Dodangoda 135
Horana 136
Kalutara 137
Matugama 138
Panadura 139
Walallawita 13A
NETWORK MAP
AGA Divisions of the CMR.
ACCESS - MOBILITY IN INDUSTRY

Figure 5.3

Table 5.7

Z Scores for the Colombo Metropolitan Region

Zone	Code	Inter-sections	Links	Mileage A & B	Route Density	Inter-Density	Link density	Beta Index	Phi Index	Diameter	Total Z	Adjusted Z
GCEC AREA												
Biyagama	122	-.416	-.494	-0.517	0.075	-.337	-.342	-.121	-.453	-1.016	-3.681	6.88
Jaela	125	-.416	-.494	-0.884	-.818	0.052	-.453	-.121	-.711	-.524	-4.442	6.12
Katana	126	-.416	-.353	-0.783	2.218	-.082	0.932	-.788	0.838	-1.016	-0.541	11.11
Kelaniya	127	-.056	-.072	-0.826	2.107	1.196	1.769	.182	0.268	0.460	4.944	15.51
Negombo	128	0.425	-.630	1.033	0.337	0.044	-.044	.909	1.020	1.444	4.018	14.02
Wattala	12C	-.176	-.002	-0.399	0.949	0.142	0.507	.182	-.152	0.460	1.604	1217
Mahara	128	-.176	-.146	0.637	-0.065	-.189	-.288	-1.151	-.173	-.032	-4.64	5.36
CUA AREA												
Colombo MC	112	4.629	4.352	1.503	0.723	3.696	3.839	3.089	3.666	-.032	24.502	34.50
Homagama	113	-.296	-.143	0.303	-.585	-.535	-.508	-.535	0.332	0.460	-1.993	8.07
Kaduwela	114	-.537	-.564	-0.125	-.122	-.791	-.552	-.791	-1.055	-.524	-5.358	4.64
Kesbewa	115	-.176	-.072	-0.810	-.430	0.752	0.068	0.752	-.560	0.460	-1.481	8.52
Kolonnawa	116	-.296	-.353	-0.878	1.313	0.476	0.681	0.476	0.021	-.032	-.864	9.14
Moratuwa	117	-.416	-.564	-1.324	0.291	1.396	0.548	1.396	-.420	-.524	-2.741	7.26
Nugegoda	118	1.145	1.473	0.411	1.745	1.478	1.825	1.478	0.655	2.429	8.037	18.04
Balance of CMR												
Avissawella	111	0.424	0.279	-0.078	-1.207	1.003	-.508	-.508	-.732	1.444	.148	10.15
Attanagalla	121	-.184	0.419	1.067	0.009	-.230	0.061	-.266	1.074	1.444	2.425	12.43
Divulapitiya	123	-.304	0.419	1.935	0.058	-.388	0.303	-.397	0.611	1.444	2.878	12.88
Gampaha	124	-.184	0.279	0.430	0.422	0.098	0.606	0.004	0.461	.460	1.286	11.29
Minuwangoda	129	0.064	0.138	0.857	0.120	-.280	0.606	-.309	0.558	.460	1.011	11.011
Mirigama	12A	1.145	0.250	2.556	0.513	0.055	1.272	-.108	1.365	.952	6.573	16.57
Weke	12D	-.296	-.353	-0.204	-1.033	-.279	0.000	-.618	-.291	-.524	-3.815	6.19
Agalawatta	131	-.657	1.192	-0.763	-1.644	-.866	-.909	-.810	-1.152	-1.016	-7.665	2.34
Bandaragama	132	-.657	-.353	-1.245	-1.319	-.509	-.909	-.689	-1.119	-1.016	-7.628	2.37
Beruwela	133	-.657	-.775	-0.884	-.725	-.820	-1.343	-.725	-1.119	-1.016	-7.592	2.41
Bulathsinhala	134	-.777	-.785	-0.300	-1.296	-1.256	-2.423	-.809	-1.410	-1.508	-9.648	0.35
Dodangoda	135	-.657	-.845	-0.433	-.681	-.969	-1.635	-.639	-.442	-1.016	-6.724	3.28
Horana	136	-.057	-.845	1.390	-.610	-.570	.121	-.638	-.411	0.460	-1.26	8.74
Kalutara	137	-.176	-.634	0.135	0.494	-.262	.606	-.216	-.105	0.460	-.356	9.64
Matugama	138	-.537	-.143	-0.056	-.649	-.810	-.242	-.647	.389	-.524	-3.546	6.45
Panadura	139	-.637	0.181	-0.757	-.184	-.876	-.909	-.614	-.926	-1.016	-6.432	3.37

Author's Computation

Table

Total number of Links

Route density per 100 sq.kilometers

Intersection density per 100

sq.kilometers

Beta Index

Phi Index

The above factors are further examined in respect of **AGA divisions which have been agglomerated to form economic zones such as the GCEC and the CUA.** The items are examined by regression analysis and the results are as in table 5.6. **It is seen that for the urban area of the CUA in particular the regression coefficients are at a high value ranging from 0.7960 for the Beta function to 0.9667 for the population. Except for the population, route density and the Beta function, the other values for the GCEC are low. The values for spread and shape are the highest for the GCEC. In fact the values for the rest of the CMR are higher than for the GCEC.**

The Z scores for the functions which showed a very close relationship to the number of industries have been calculated. The distribution of the Z scores are illustrated in two ways spatially as well as by magnitude. The geographical distribution is shown in the figure 5.3 and the values in the table 5.7. The figure 5.3 illustrates the level of network development in the AGA divisions. **Comparison with the levels of industrial development shows very close relationship that the network or access function has to industrial development.** As one would expect there are exceptions as illustrated by the AGA division of Mirigama which has a high value in development of the network but low in industrial development. These differences may be explained by other variables.

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6

THE ROLE OF THE HIGHWAY

6.0 The Role of The Highway

6.1 Highway Infrastructure

In a coordinated development plan of a region the major highway network forms the broad framework within which developments are seen to take place. **Thus, one of the possibilities of this study is to explore how the entire system, the number, the location and the capacity of the highway infrastructure could aid in systematic location of future industry.**

In developing a long term plan it is essential to measure the access provided by the highway infrastructure and estimate the quality of the movement function.

Therefore, **Access and Movement functions will be associated with different levels of traffic and having specific characteristics.** The highways in the CMR shown in figure 2.4 are specified by a system of intersections(nodes) and highway sections(links) as described earlier and shown in figure 5.1 and figure 2.3

6.2 Zone (AGA) Boundaries.

The boundary at which a road crosses a particular AGA division is treated as a junction or node and given the identifying number '00'. The boundary node is identified by an area code, a road code, a boundary code with the mileage. As described earlier the area code is a three digit code specifying the province, district, and the AGA division through which the road traverses.

Node Schedule

PAGE 1

	First Road		Second Road		
Area Code	Road Code	Mileage	Road Code	Mileage	Node Number
111	0105	00.508	000	00.00	00
111	0307	23.876	0316	01.524	24
111	0315	04.953	0307	27.815	53
111	0315	07.874	000	00.00	00
111	0316	03.429	000	00.00	00
111	0318	10.795	0319	00.00	23
111	0318	13.335	000	00.00	56
111	A4	40.183	B1	24.511	52
111	A4	56.896	000	00.01	11
111	A4	52.883	0319	08.362	25
111	A4	34.290	0315	00.00	54
111	A4	41.275	0318	00.00	51
111	A4	33.655	0316	00.00	55
111	B1	23.241	0105	00.00	21
112	00	00.050	000	00.00	00
112	00	00'400	000	00.00	00
112	0308	00.525	000	00.00	00
112	A2	04.636	N-04	00.00	54
112	A2	02.699	AA0001	00.00	53
112	A2	06.890	N-43	00.00	56
112	A2	00.00	N-19	00.00	51
112	A2	01.619	00	00.00	52
112	A2	08.223	00	00.00	00
112	A2	05.652	N-25	00.00	55
112	A4	00.540	N-37	00.559	65
112	A4	02.159	00	00.00	00
112	A4	00.762	N-03	07.958	66
112	AA0001	01.651	N-24	00.222	80
112	AA0001	00.711	N-39	01.302	60
112	AA0001	04.255	N-01	01.238	71
112	AA0001	00.222	N-11	01.27	78
112	AA0001	04.446	000	00.00	00
112	N-02	01.175	000	00.00	00
112	N-03	02.064	0309	00.00	74
112	N-03	06.35	N-33	00.00	77
112	N-03	00.667	B1	00.00	96
112	N-03	03.937	N-01	00.00	70
112	N-03	04.255	AA0001	03.080	75
112	N-04	00.222	N-11	03.175	81

Author's Computation

Table 6.1

6.3 Intersections or Nodes.

The junction, node, or intersection is identified by a three digit area code, a road code and mileage for the first road and a road code and mileage for the second road together with a node number. This number which identifies the node is unique as it also specifies the node as a M.C., U.C, T.C, or any other category of town.

A town in an AGA division is identified further by two more digits, an M.C by a number 01 to 10, a U.C. by a number 11 to 19 and any other town by a number 21 to 39. For example Dehiwala-Mt. Lavinia has the number 11801, the Dehiwala town 11801 and Mt.Lavinia 11802. This unique number will therefore, describe the province, district, and the AGA division and the type of urban area on the network.

The **nodes** are identified and described in a **node schedule** table (a complete table is available as an appendix) A typical schedule for the AGA division 111 is given in table 6.1. For example, in column one the location is described by a three digit area code such as 111. The next column describes the first road by a road code say 0315. The third column states the route mileage on that road as 04.953 kilometers. The fourth column identifies the second road involved by the number 0307 and the fifth column the mileage on that road up to the intersection as 27.813 kilometres. The next, column shows the intersection or node and identifies it by the number 53.

The table 6.2 gives a section of the list of the **A** class roads in the Colombo Metropolitan Region, the code specifying each road, the beginning and end mileages as well as the total mileage of the road section for both **A** and **B** class roads (a full list is available as an appendix).

ROADS IN COLOMBO METROPOLITAN REGION

Road Code	Name of Road	From Road	To Mileage	Miles
AA0001	Approach Road - New Parliament.	0.00	3.56	3.56
AA0001	Colombo - Kandy Road.	3.70	13.00	9.30
AA0001	Colombo - Kandy Road.	13.00	17.00	4.00
AA0002	Colombo - Galle - Hambantota - Wellawaya Road.	5.25	12.25	7.00
AA0002	Colombo - Galle - Hambantota-Wellawaya Road.	12.25	27.00	14.75
AA0003	Colombo - Puttalam Road.	3.50	4.50	1.00
AA0003	Colombo - Puttalam Road.	4.50	27.00	22.50
AA0004	Colombo - Ratnapura-Wellawaya-Batticaloa Road.	6.25	14.25	8.00
AA0109	Canada Friend-Ship Road.	0.00	1.49	1.49
AA0110	Wattala Deviation Road.	0.00	0.40	0.40
AB0001	Colombo - Kandy Road.	17.00	21.00	4.00
AB0001	Colombo - Kandy Road.	21.00	23.64	2.64
AB0002	Colombo - Galle - Hambantota-Wellawaya Road.	27.00	38.25	11.25
AB0004	Colombo - Ratnapura - Wellawaya-Batticaloa Rd.	14.25	36.50	24.25
AB0007	Avissawella - Hatton - N'Eliya Road.	36.50	37.00	0.50
AB0008	Panadura - Nambapana - Ratnapura Road.	0.00	6.75	8.75
AB0008	Panadura - Nambapana - Ratnapura Road.	8.75	22.68	13.93
AB0033	Ja-Ela - Ekala - Gampaha - Yakkala Road.	16.50	23.58	7.08
AB0033	Ja-Ela - Ekala - Gampha - Yakkala Road.	13.00	16.50	3.50
AB0101	Inner Ring road & Pelawatta access Road.	0.00	1.00	1.00
AB0102	Colombo - Hanwella Low Level Road.	3.50	15.00	11.50
AB0102	Colombo - Hanwella Low Level Road.	15.00	19.00	4.00
AB0103	Approach Road to Japanese Hospital.	0.00	1.53	1.53
AB0104	Negombo - Giriulla Road.	18.00	21.00	3.00
AB0104	Negombo - Giriulla Road.	21.00	23.50	2.50
AB0105	Hanwella - Pugoda Weke Urapola Road.	13.00	15.00	2.00
AB0105	Hanwella - Pugoda - Weka - Urapola Road.	8.00	13.00	5.00
AB0106	Veyangoda Ruwanwella Road.	0.00	8.00	8.00
AB0107	Katunayaka - Veyangoda Road.	15.00	17.00	2.00
AB0108	Pasyala - Giriulla Road.	0.00	12.00	12.00
AB0111	Old Colombo - Puttalam Road.	0.00	0.59	0.59
AB0112	Colombo - Old Galle Road - Panadura Rd.	0.00	1.18	1.16
AB0143	Avissawella Town Road	0.00	0.04	0.04
AB1000	Nothern Approaches to New Kelani Bridge			1.03
AB1000	Approach Road to Kaduwela Bridge	0.00	0.39	0.39

Table 6.2

Source: Road Development Authority

6.4 Road Sections or Links.

A road section or link is identified by a seven digit number. The first three digits identify the area in which the link is located. The next two digits show the origin node and the other two digits the destination node number. If the link begins or ends on a boundary it is indicated by two zeros as '00'. Hence, where the route crosses the area without any intersection it will be indicated by four zeros as '0000'. It also describes the type of road on which the link is situated as **A, B** or any other type. **It is thus a vector in the sense that both the direction and length are specified.**

The **links** are given in a **link schedule** which is contained in full in an appendix. A typical link schedule is shown in table 6.3. For example, the first column gives the road code on which the link is located A4. The second column shows the AGA area of origin of the link (111). The third column indicates the code of the origin node (54) and the next column the destination code of the node (52). The sixth column gives the code of the AGA division (111) in which the link is located. The seventh column indicates the identifying number of the link 111A5452. The last two columns describe the link length 5.893 km and the direct length 5.715 km from node to node together with the route factor(.0311). The lengths of **A** 20.022 km and **B** 15.28 km roads and the total 35.30 km for the whole AGA division are also stated

6.5 Traffic Flows.

The magnitudes of the traffic volumes over the various sections of the network in the study area were established by using two sources of data.

1. The traffic counts conducted by the former Department of Highways (DOH) and the present Road Development Authority (RDA).

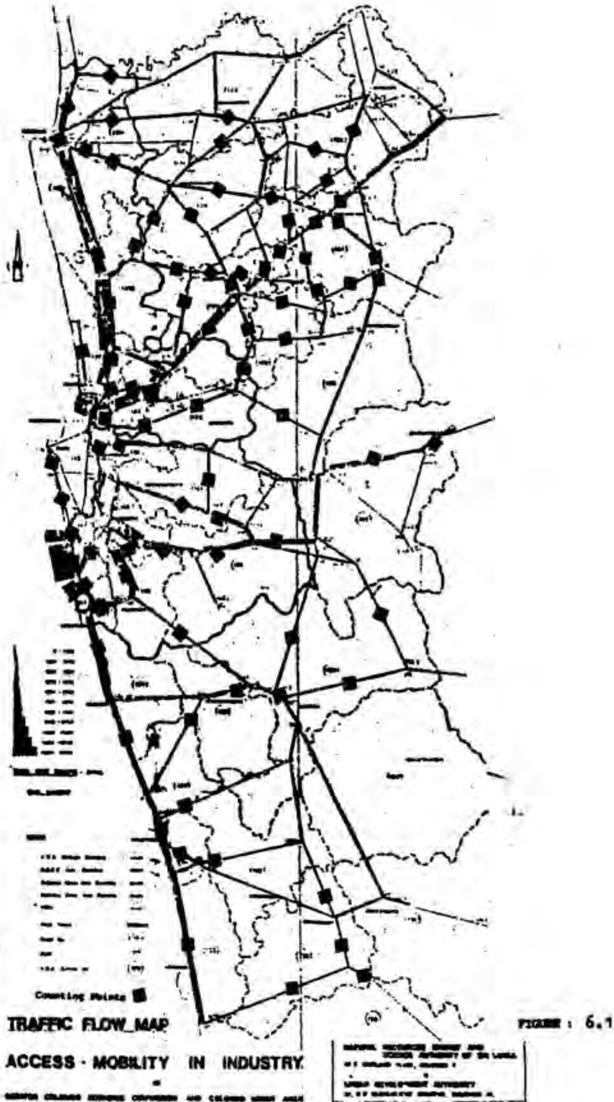
2. The traffic counts of the road engineering department of the Colombo Municipal Council (CMC)

Link Location Schedule
Colombo Metropolitan Region

ROAD CODE	ORIGIN AREA	ORIGIN CODE	DESTIN AREA	DESTIN NODE	LINK LOCATION	LINK NUMBER	LINK LENGTH	DIRECT LENGTH'	ROUTE FACTOR
A4	113	00	111	55	111	111A0055	0.7620		
A4	111	25	111	11	111	111A2511	0.0130		
A4	111	51	111	25	111	111A5125	11.6080		
A4	111	52	111	51	111	111A5251	1.0920		
A4	111	54	111	52	111	111A5452	5.8930		
A4	111	55	111	54	111	111A5554	0.6530	20.02	
B1	113	00	111	21	111	111B0021	0.6510		
0307	113	00	111	24	111	111B0024	[illegible]		
0105	111	21	120	00	111	111B2100	[illegible]		
B1	111	21	111	52	111	111B2152	0.2760		
0319	111	23	111	25	111	111B2325	0.3820		
0318	111	23	111	56	111	111B2356	0.5400		
0316	111	24	136	00	111	111B2400	0.9050		
0307	111	24	111	53	111	111B2453	0.9370		
0318	111	51	111	23	111	111B5123	0.7950		
0315	111	53	136	00	111	111B5300	2.9210		
0315	111	54	111	53	111	111B5453	4.9530		
0316	111	55	111	24	111	111B5524	1.5240	15.28	35.30
A2	112	51	112	52	112	112A5152	1.6300		
A2	112	52	112	53	112	112A5253	1.0800		
A2	112	53	112	54	112	112A5354	1.9360		
AA0001	112	53	112	78	112	112A5373	0.2230		
A2	112	54	112	65	112	112A5465	1.0160		
A2	112	55	112	56	112	112A5556	1.2390		
A2	112	56	118	00	112	112A5600	1.3340		
A4	112	64	112	65	112	112A6465	0.339		
A4	112	65	112	66	112	112A6566	0.2230		
A4	112	66	118	00	112	112A6600	1.3970		
AA0001	112	71	112	00	112	112A7100	0.1910		
AA0001	112	75	112	71	112	112A7571	1.1740		
AA0001	112	78	112	79	112	112A7879	0.4890		
AA0001	112	79	112	80	112	112A7980	0.9400		
AA0001	112	80	112	75	112	112A8075	1.4280	14.83	
0308	112	74	116	00	112	112B7400	0.50	0.53	
N-03	116	00	112	96	112	112N0096	0.3490		
N-19	112	51	112	57	112	112N5157	0.1910		
N-19&06	112	51	112	67	112	112N5167	1.8420		
N-44	112	51	112	84	112	112N5184	0.1910		
N-23	112	52	112	90	112	112N5290	0.3810		
N-04	112	54	112	81	112	112N5481	0.2230		
N-25	112	55	112	91	112	112N5591	0.2420		
00	112	94	116	00	112	112N9400	0.0500		
00	112	95	12C	00	112	112N9500	0.4000		

Source: Author's Computation

Table 6.3


Counting Points
TRAFFIC FLOW MAP
FIGURE : 6.1
ACCESS - MOBILITY IN INDUSTRY

Typical Traffic Flow Distribution in the CMR

ROAD CODE	LINK LOCATION	LINK NUMBER	24H.Flow 5 day	24H.Flow 7 day	Peak Hour	Peak Hour Volume	Cars	Buses Buses	Mini Larries	Light Larries	Medium Com.Veh	Heavy Cycles	Motor Total Volume
							Percentage Distribution						
A4	111111A5125	3319	3778	6/7	280	29.2	10.5	22.7	1.6	9.6	12.5	13.9	100.0
A2	112112A5253	38728											
A2	112112A5455	41111											
A2	112112A5600	32576											
A4	113113A5254	4849											
0312	113113B0000	2069	2337	17/18	180	17.0	17.3	14.7	2.6	11.2	9.8	27.4	100.0
0307	113113B5400	527	631	10/11	50	19.9	17.2	20.2	8.2	6.4	0.0	28.1	100.0
0307	114114B0025	2753	3217	8/9	245	18.4	8.3	27.1	3.6	10.5	12.1	20.0	100.0
0307	114114B2500	3189											
B1	114114B0051	2776	3115	9/10	225	20.9	6.3	31.1	1.6	12.7	10.2	17.2	100.0
0311	114114B5125	940											
0312	115115B2123	7181											
0306	115115B5300	1096											
NA1	116116A5200	26948											
0309	116116B2251	4124											
0308	116116B0022	1920											
0309	116116B0022	19557											
A2	117117A5251	14786											
A2	117117A0052	12036	11584	17/18	1068	34.2	6.4	21.1	11.5	8.0	0.5	18.3	100.0
0321	117117B5153	1893.0											
0322	117117B5352	2515.0											
A4	118118A0054	18657.0											
A2	118118A0103	20567.0											
A2	118118A0300	17312.0											
A2	118118A5101	22788.0											
A4	118118A5759	11659.0		7/8	1050.0	33.0	6.0	11.0	1.0	7.0	22.0	20.0	100.0
A4	118118A5900	7163.0											
0320	118118B0059	1630.0											
0305	118118B0300	3604.0											
0301	118118B1458	4668.0											
0302	118118B1560	2219.0											
0324	118118B5153	2575.0											
0305	118118B5658	1589.0											
A4	118118A5900	7163											
0301	118118B6214	2221											
0107	121121B0025	1141											
A1	121121A2400	5918											
A1	121121A5324	6149											

Table 6.4 Author's Computation

6.6 Data on Traffic Counts

Data sources have been restricted to counts on **A and B** routes and the **principal routes** within the CMC. The traffic flow data have also been adjusted to the base year of study 1984 at an assumed growth rate of 4% per annum. Traffic data have been recorded usually as 6 hr., 12 hr., 16 hr., or 24 hr. at various sections of roads as the needs arose. The traffic counting points and the traffic flows in the CMR are shown in figure 6.1. For purposes of comparison these flows have been converted to a standard 24 hr. flow. They have also been converted to standard passenger-car units to take into effect the character of these mixed vehicles in traffic flow.

The typical traffic flows on road sections in the CMR are given in table 6.4 and table 6.5 *and the traffic flows for the whole island are illustrated in figure 3.22. The traffic flows in the CMA are shown separately in figure 6.2. and show the high intensities of traffic particularly on the Colombo-Galle road and the approaches to the City limits The figure 6.1 shows clearly the concentration of traffic on the main roads and high volumes extending to less than 30 km. from Colombo. **This also show the dominating influence of the Capital City of Colombo on the location of industries.**

In the table 6.4 is shown the total flow characteristics of a route section by section. For instance, the route A4 is shown located in AGA division 111.at the top of the table The link number indicates that the link is in AGA division 111 on the A route and that the node numbered 51 is connected to that numbered 25. It carries a 24 hour traffic volume of 3319 p.c.u's. The peak hour is from 6 to 7 A.M. and the peak hour volume is 280 vehicles. The percentage distribution of the different type of vehicles using the road section is also stated.

The mileages of A and B routes on the network and the total milage of A and B routes ; the vehicle travel in vehicle kilometers on A and B routes as well as on both with the areas of

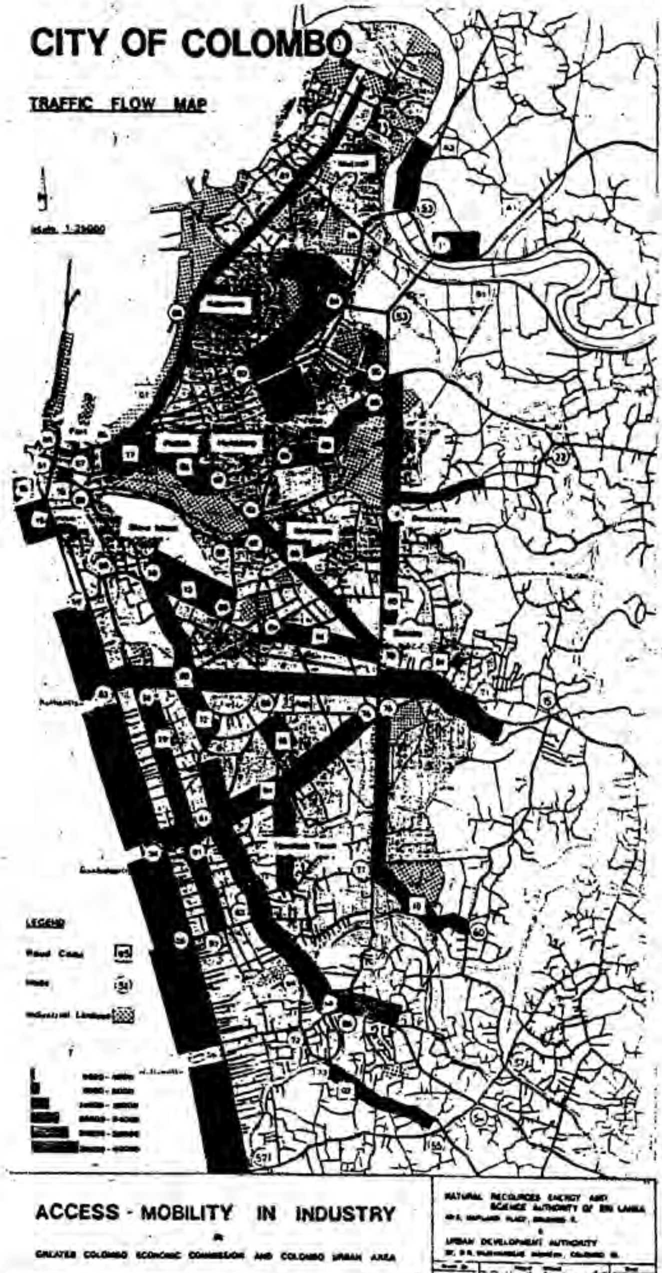

CITY OF COLOMBO
TRAFFIC FLOW MAP
LEGEND
ACCESS - MOBILITY IN INDUSTRY

Figure 6.2

Table 6.5A

Page,

ROUTE DIREC	DA	MO	YR	D	DISTRICT	LOC	TOWN
Dematagoda Road	29	9	1983	4	Colombo	Dematagoda Junction	Dematagoda
Base Line Road Orugodawatta Side	29	9	1983	4	Colombo	Dematagoda Junction	Dematagoda
Base Line Road Borella side	29	9	1983	4	Colombo	Dematagoda Junction	KOSGODA
Kolonnawa Road	29	9	1983	4	Colombo	Dematagoda Junction	Dematagoda
Baseline Road Orugodawatta Side	30	9	1983	5	Colombo	Dematagoda Junction	Dematagoda
Baseline Road Borella side	30	9	1983	5	Colombo	Dematagoda Junction	Dematagoda
Dematagoda Road	30	9	1983	5	Colombo	Dematagoda Junction	Dematagoda
Kolonnawa Road	30	9	1983	5	Colombo	Dematagoda Junction	Dematagoda
Colombo-Galle Road Colombo Side	6	10	1983	4	Colombo	Dehiwala Junction	Dehiwala
Colombo-Galle Road Mt.Lavinia Side	6	10	1983	4	Colombo	Dehiwala Junction	Dehiwala
Hill Street	6	10	1983	4	Colombo	Dehiwala Junction	Dehiwala
STATION ROAD	6	10	1983	4	Colombo	DEHIWELA JUNCTION	Dehiwela
Colombo-Kesbewa	11	5	1983	3	Colombo	Pamankada Bridge	Pamankada
Colombo-Hanwella	11	5	1983	3	Colombo	Wellampitya Bridge	Wellampitiya
Colombo Kesbewa Pokunuwita Rd	2	5	1983	4	Colombo	Pamankada Bridge	Pamankada
Kollupitiya-Sri Jayawardanapur	11	5	1983	3	Colombo	Welikada Junction	Welikada
Kollupitiya-Sri Jayawardanapur	12	3	1982	5	Colombo	Near Police Station	Rajagiriya
Cotta Road	11	3	1982	4	Colombo	Aurvedic Hospital	Rajagiriya
Colombo-hanwella	4	3	1982	5	colombo	Wellampitiya Bridge	Wellampitiya
Colombo-Galle	5	3	1982	5	colombo	Dehiwala Bridge	Dehiwala
Colombo-Ratnapura	3	3	1982	3	colombo	Kirulapana Bridge	Kirulapana
Peliyagoda-Puttalam Road	1	2	1982	1	colombo	Victoria Bridge	Peliyagoda
Colombo-Kandy	26	2	1982	5	colombo	New Kelani Bridge	Peliyagoda
Colombo-Kesbewa	25	2	1982	2	colombo	Pamankada Bridge	Pamankada
Nungamuwa-Meliewa Rd	4	4	85	2	Kalutara	5th k.m.	Horaketiya
Makewita-Matammana Rd	10	5	85	5	Gampaha	4th km	Matammana
Ganemulla-Weligampitiya-Rd						3rd km	Galahitiyawa

Source : Road Development Authority

Table 6.5B

Page 1

LOC	T	DISTRICT	CARS	BUSES	MINI	LORR	HEAVY	MOTOR	BICY	CARTS	FTOT	GTO
Dematagoda Junction	8	Colombo	1529	444	378	382	0	604	1091	0	3337	442
Dematagoda Junction	0	Colombo	6277	1543	1571	2788	0	2400	3461	0	14579	1768
Dematagoda Junction	0	Colombo	6307	1369	1371	2562	0	2258	1645	0	13907	1555
Dematagoda Junction	9	Colombo	1576	433	481	693	0	674	912	0	3857	476
Dematagoda Junction	9	Colombo	4792	1580	1519	2544	0	2105	3121	0	12628	1574
Dematagoda Junction	7	Colombo	5604	1315	1460	2432	0	2292	3483	0	13174	1668
Dematagoda Junction	9	Colombo	2254	527	434	521	0	856	2132	0	4692	682
Dematagoda Junction	0	Colombo	1791	599	600	852	0	761	1685	0	4605	629
Dehiwala Junction	6	Colombo	14057	3140	4100	4862	0	3472	2525	0	29631	3215
Dehiwala Junction	1	Colombo	13989	2381	3815	2925	0	3370	2363	0	26478	2884
Dehiwala Junction	8	Colombo	2035	465	996	342	0	693	537	0	4551	508
DEHIWELA JUNCTION	9	Colombo	1012	701	1204	167	0	530	580	0	3611	419
Pamankada Bridge	9	Colombo	5503	762	593	720	0	1565	1150	0	9151	1050
Wellampitya Bridge	2	Colombo	1492	706	816	1426	6	1304	2681	0	5061	858
Pamankada Bridge	3	Colombo	5329	776	609	677	0	1477	1277	0	9106	1038
Welikada Junction	0	Colombo	6035	1298	1213	1166	0	1377	1721	0	11089	1281
Near Police Station	9	Colombo	6538	160	119	1397	0	2331	3239	60	10545	1509
Aurvedic Hospital	4	Colombo	2799	2051	985	534	0	1121	4057	97	7490	1244
Wellampitiya Bridge	2	colombo	1125	855	443	1274	0	954	2421	70	4651	714
Dehiwala Bridge	5	colombo	15339	3608	3210	2919	0	4154	2682	75	29238	3199
Kirulapana Bridge	2	colombo	8962	2285	1335	1567	0	3273	3307	63	17442	2081
Victoria Bridge	3	colombo	5721	2596	2371	2734	0	2000	3611	0	15362	1891
New Kelani Bridge	5	colombo	10483	1164	1529	4017	0	4286	4726	0	22209	2701
Pamankada Bridge	1	colombo	4044	1138	532	863	0	1086	1058	40	7663	876
5th K.M.	7	Kalutara	40	26	0	56	0	136	327	0	266	39
4th Ps	9	Gampaha	40	32	0	39	0	160	259	0	271	51
3rd La			112	93	122	188	0	194	229	5	709	94

LOC DISTRICT	PCCAR	PCBUS	PCMIN	PCLOR	PCHEA	PCMOT	PCBIC	PCCAR	RT	RT	KMS
Dematagoda Junction Colombo	45.8	13.3	11.3	11.4	0.0	18.1	32.7	0.0	M	0	-
Dematagoda Junction Colombo	43.1	10.6	10.8	19.1	0.0	16.5	21.0	0.0	M	0	-
Dematagoda Junction Colombo	45.6	9.8	9.9	18.4	0.0	16.2	11.8	0.0	M	0	-
Dematagoda Junction Colombo	40.9	11.2	12.5	18.0	0.0	17.5	23.6	0.0	M	0	-
Dematagoda Junction Colombo	37.9	12.6	12.0	20.1	0.0	17.3	24.7	0.0	M	0	-
Dematagoda Junction Colombo	42.7	10.0	11.3	18.5	0.0	17.5	26.5	0.0	M	0	-
Dematagoda Junction Colombo	50.2	11.2	9.2	11.1	0.0	18.2	45.4	0.0	M	0	-
Dematagoda Junction Colombo	38.9	13.0	13.0	18.5	0.0	16.6	36.6	0.0	M	0	-
Dehiwala Junction Colombo	47.4	10.6	13.8	16.4	0.0	11.7	8.5	0.0	A	2	9.0
Dehiwela Junction Colombo	52.8	9.0	14.4	11.0	0.0	12.7	8.9	0.0	A	2	9.0
Dehiwela Junction Colombo	45.2	10.2	21.9	7.5	0.0	15.2	11.8	0.0	B	0	-
DEHIWELA JUNCTION Colombo	28.0	19.4	32.3	4.6	0.0	14.7	56.3	0.0	B	0	-
Pamankada Bridge Colombo	60.1	8.3	6.5	8.0	0.0	17.1	12.7	0.0	B	5	8.0
Wellampitya Bridge Colombo	25.5	13.4	13.9	24.3	0.0	22.9	45.7	0.0	B	1	7.0
Pamankada Bridge Colombo	60.7	8.5	7.1	7.4	0.0	16.2	14.0	0.0	B	5	8.0
Welirada Junction Colombo	54.4	11.7	10.9	10.5	0.0	12.4	15.5	0.0		1	5.0
Near Police Station Colombo	62.1	1.5	1.1	13.2	0.0	22.1	30.7	0.4		1	5.0
Aurvedic Hospital Colombo	37.4	27.4	13.2	7.1	0.0	15.0	64.8	1.3	B	0	-
Wellampitiya Bridge colombo	24.2	18.4	9.5	27.4	0.0	20.5	52.1	1.5	B	1	-
Dehiwala Bridge colombo	52.5	12.3	11.0	10.0	0.0	14.2	9.2	0.3	A	2	9.0
Kirulapana Bridge colombo	51.4	13.1	7.8	9.0	0.0	18.8	19.0	0.4	A	4	8.0
Victoria Bridge colombo	37.4	15.7	15.5	17.9	0.0	13.6	23.6	0.0	A	3	0.0
New Kelani Bridge colombo	47.0	5.2	6.9	21.6	0.0	19.2	21.2	0.0	A	1	5.0
Pamankada Bridge colombo	52.8	14.9	6.9	11.3	0.0	14.2	13.8	0.5	B	5	8.0
5th K.M. Kalutara	18.0	9.8	0.0	21.1	0.0	51.1	122.9	0.0	C	0	-
4th km Gampaha	14.8	11.8	0.0	14.4	0.0	59.0	88.2	0.0	C	0	-
3rd km	15.8	13.1	17.2	26.5	0.0	27.4	32.3	0.7	C	0	-

Table 6.5C

all the AGA divisions in the CMR are summarised in table 6.6..

6.7 Intersection Coverage Factor

One of the important findings in examining the network and traffic flows in the CMR has been what may be called the **Intersection Coverage Factor**

The table 6.7 shows the results of an analysis which records the AGA divisions, code numbers, the node numbers, the traffic flows into and out of an intersection, the radial distance to Colombo from the intersection and what is called the sum of links. **This term is the total length of all links connected to any particular node within each AGA division.** This length which has been called the sum of links is proportional to the area covered by the radius vector described with the node as the centre.

When the total traffic flows into and out of these nodes are compared it is observed that those nodes which have larger coverage have larger flows within each division. Thus, in general when a particular AGA division is considered **those nodes which have the higher values of the total length of links have a greater attractive power for traffic.** The table also shows that **those nodes which have shorter radial distances from Colombo and larger coverage factors have larger traffic loadings.**

For instance, the Jaela AGA division 125 has three important intersections 52, 21, and 51. The length of links to node 52 is 8.89 km, for nodes 21 and 51 the lengths are 7.11 and 5.79 km respectively. The radial distances are 17.60, 19.90 and 18.10 kilometers while the traffic flows are 28000, 12000, and 23000 vehicles per day respectively. In this instance, at the Jaela intersection (52) the sum of links 8.89 kilometers is the largest, radial distance 17.60 is the least and traffic flows are the highest.

Traffic and Route Data in AGA Divisions
Colombo Metropolitan Region

Zone	Code Number	Total Area sq.km. sq. km.	A Route in km	B Route in km	A & B Routes in km	Vehicle Km A Roads	Vehicle Km B Roads	Vehicle Km A & B Roads
Biyagama	122	61.90		26.04	26.04		44.37	44.37
Ja-ela	125	75.20	12.45	5.84	18.29	120.40	15.37	133.76
Katana	126	22.60		20.43	20.43		30.34	30.34
Kelaniya	127	22.26	6.86	12.65	19.51	70.36	27.90	98.26
Negombo	129	127.90	18.95	42.51	61.36	158.37	73.67	232.04
Wattala	12C	46.20	8.97	19.56	28.53	122.20	33.74	155.93
Mahara	128	47.90	6.73	30.62	37.35	55.88	46.72	100.60
Greater Col.Econ.Comm.	GCEC	407.90	53.86	157.62	211.51	527.21	270.08	797.30
Colombo Municipality	112	41.00	14.83	57.10	71.93			
Homagama	113	157.94	15.49	28.75	44.24	68.52	45.59	110.11
Kaduwela	114	90.81		34.32	34.32		78.38	78.38
Kesbewa	115	63.47		19.86	19.86		90.40	90.40
Kolonnawa	116	26.32	7.79	10.63	18.42	30.30	46.09	76.39
Moratuwa	117	19.22	4.70	4.32	9.02	64.51	10.67	75.18
Nugegoda	118	50.53	17.65	29.00	46.65	243.38	182.38	425.75
Colombo Suburban Area	CSA	320.29	45.63	126.88	172.51	402.91	453.49	856.41
Colombo Urban Area	CUA	457.37						
Avissawella	111	237.21	20.02	15.28	35.30	80.11	16.70	96.81
Attanagalla	121	153.90	29.64	32.52	62.16	94.03	36.07	130.10
Divulapitiya	123	199.40	4.19	78.47	82.66	12.57	153.90	133.14
Gampaha	124	94.50	25.91	21.21	47.12	129.01	44.25	173.25
Minuwangoda	129	132.80	2.25	34.94	37.19	4.51	115.72	120.23
Mirigama	12A	187.40	32.72	64.61	97.33	92.09	64.61	156.70
Wake	12D	175.90	3.35	32.65	36.00	6.70	40.72	51.99
Agalawatte	131	361.39		20.43	20.43		40.86	40.86
Bandaragama	132	84.80	8.13	2.79	10.92	23.62	2.79	26.41
Beruwala	133	73.00	14.35	3.94	18.29	71.76	3.94	75.70
Bulathsinhala	134	235.30		30.61	30.61		47.50	47.50
Dodangoda	135	107.00		27.81	27.81		27.81	27.81
Horana	136	233.60	20.28	49.50	69.78	27.05	60.80	87.86
Kalutara	137	77.90	13.08	27.05	40.13	61.72	36.96	98.68
Matugama	138	134.10		35.77	35.77		37.48	37.48
Panadura	139	57.50	20.87		20.87	91.00		91.00
Bal.Col.Metro.Area	B.CMR	2,724.91	194.89	497.58	692.47	694.18	730.31	1424.49
Tot. Col.Metro.Area	CMR	3,499.18	309.21	839.21	1,148.42	1624.29	1483.89	3078.19

*Author's Compilation

Table 6.6

Intersection Cover Factor

AGA Division	Code. No.	Node No.	Sum Links	Radial Dist. Colombo km	Traffic Flow Veh.km 000'	Intersection	
Biyagama	122	22	15.66	19.80	5000	Delgoda	
		52	9.22	12.90	5000		Makola South
Jaela	125	52	8.89	17.60	28000	Jaela	
		21	7.11	19.90	12000		Ekala
		51	5.79	18.10			23000
Katana	126	51	7.81	30.10			
		52	3.81	28.70			5000
Kelaniya	127	22	8.38	7.30	22000	Dalugama	
		21	8.13	8.80	4000		Kelaniya
Negombo	128	55	15.11	30.30		Negombo	
		59	12.57	29.30			13000
Wattala	12C	52	8.18	8.30	13000	Wattala	
		23	7.44	11.60	26000		Mahabage
Mahara	12B	55	10.41	14.30	22000	Kadawata	
		53	5.33	12.80	10000		Mahara
Homagama	113	54	20.19	23.00	13000	Godagama	
		52	16.38	18.70	14000	Kottawa	
		53	6.20	21.50			8000
Kaduwela	114	25	21.21	17.60	8000	Athurugiriya	
		51	20.18	16.30	6000	Kaduwela	
Kesbewa	115	23	12.12	17.10	13000	Piliyandala	
		21	9.65	12.20	10000		Boralesgamuwa
Kolonnawa	116	51	12.75	11.80	8000	Ambatale	
		22	9.61	5.90	7000	Wellampitiya	
Moratuwa	117	52	4.83	16.10	37000	Lunawa	
		51	5.06	16.90	22000		Katubedda
Nugegoda	118	03	8.45	13.10	43000	Ratmalana	
		59	7.72	13.30	22000	Maharagama	

Source: Author's Computation Table 6.7(a)

Intersection Cover factor

AGA Division	Code. No.	Node No.	Sum Links	Radial Dist. Colombo km	Traffic Flow Veh.km 000'	Intersection	
Avissawella	111	25	21.50	30.20	10000	Pawakpitiya	
		51	20.90	28.40			8000
Divulapitiya	123	23	21.59	41.80	8000	Badalgama	
		55	17.02	44.90			8000
Gampaha	124	51	13.26	22.20	8000	Kirindiwita	
		52	11.94	24.40	12000		Gampaha
		23	10.29	27.00			16000
Minuwangoda	129	21	19.40	28.20	10000	Minuwangoda	
		55	15.75	32.20			8000
Mirigama	12A	52	16.59	38.20	2000		
		55	12.10	44.80			10000
		22	10.29	40.30			14000
Weke	12D	52	21.65	27.80	5000	Kapugoda	
		25	20.19	34.10	5000		Kirindiwela
Agalawatta	131	21	20.45	55.70	6000	Aggalawatta	
Bandaragama	132	21	9.90	29.30	7000	Bandaragama	
Beruwala	133	24	17.20	58.60	6000	Alathgama	
Dodangoda	135	51	16.30	46.60	3000	Nebode	
Horana	136	11	17.02	34.30	6000	Horana	
		22	26.67	42.50	3000		Ingiriya
		54	8.86	31.40	8000		Pokunuwita
Kalutara	137	51	15.11	35.60	9000		
		52	12.32	38.20			11000
		11	11.25	40.70	12000		Kalutara
Matugama	138	21	20.00	54.50	3000	Matugama	
		51	20.66	59.30			3000
Panadura	139	11	20.80	25.60	13000	Panadura	

Author's Computation

Table 6.7(b)

These features are illustrated in the figure 6.3 and shows specifically the intersections where;

1. the traffic flow is highest in any AGA division by a circular dot

2. the intersection coverage in any AGA

   division is largest by a square figure

3. the traffic flows are highest and intersection coverage is largest in any AGA division, that is coincidence, by a circular dot and a square figure together.

A further analysis of the table 6.7 shows that;

In AGA divisions where data on multiple intersections are available (table 6.7) two facts are taken into consideration.

1. Whether an **intersection** with the **highest traffic flows** is the same as the **intersection** with the **largest sum of links.**

2. Whether an **intersection** with the **highest traffic flows** is the same as the **intersection** with the **least radial distance**

Analysis shows that of 27 AGA divisions in the CMR 20 AGA divisions have multiple intersections. Of these 20 divisions there is coincidence in 13 divisions between intersections with the highest traffic flows and the largest intersection coverage, that is 65% agreement. There is a coincidence of 9 divisions with the highest traffic flows and the shortest radial distance, that is 45% agreement. But there are only 7 divisions where the highest traffic flows are coincident with both the largest intersection coverage and the shortest radial distance , that is 35%.

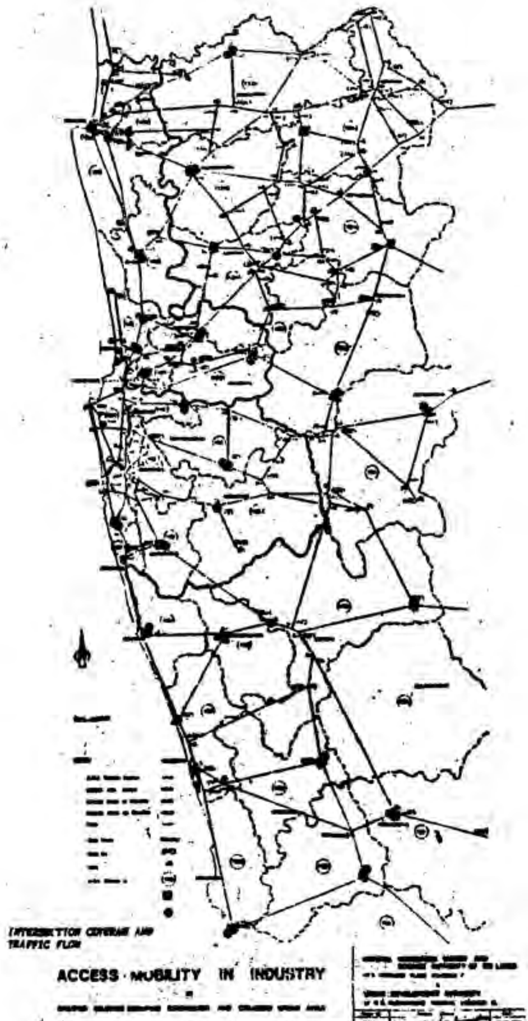


Figure 6.3

Further detailed analysis shows that;

1. That there is coincidence between the highest traffic flows and the largest intersection coverage in 4 out of 5 divisions in the GCEC(80%); 5 out of 6 divisions in the CSA(83.3%) and 4 out of 9 in the rest of the CMR(44.4%).

   It is seen that the agreement is greatest where urban activity is highest and that it appears to have a direct relationship to the degree of urbanization.

2. The coincidence between intersections with the highest traffic flows and the least radial distance is 2 out of 5 in the GCEC(40%); 3 out of 6 in the CSA(50%) and 4 out of 9(44.4%) in the rest of the CMR.

Within the GCEC, in the AGA divisions of Jaela(125) and Kelaniya(127) the traffic flows are particularly high reflecting the industrial activity in the zone and the proximity to Colombo. Likewise in the CSA, in the AGA division of Nugegoda(118) traffic intensities are very high particularly at the Ratmalana intersection showing the high degree of industrial activity in the area. In the rest of the CMR the traffic flows are high at intersections in the AGA divisions which are industrially developing such as in Kalutara, Panadura and Avissawella.

From this analysis it is clear that there is a very close correlation between traffic flow, intersection coverage and radial distance to the dominant city in the region.

A most important conclusion, therefore, is that this methodology enables a network to be analysed to locate the traffic loading points and identify potential development centres even before any other planning and transport studies are undertaken.

NA-9-194

7

INFLUENCE OF THE LAND VALUE

7.0 Influence of the Land Value

7.1 Land Values

In almost all landuse planning issues transport is a critical factor. The level and standard of transport determines the spatial spread. Therefore, in determining landuse policy, in this instance manufacturing industrial policy, access-mobility implications have to be carefully considered.

This is indeed a difficult task in evaluation. Land uses are closely linked to land prices. The figure 1.3 shows the close links of land uses to land prices and changes which could occur and the relevance to access-mobility.

Of the various policies which are important in accelerating or retarding land use changes one that relates to **investments in highway development is critical.** This is because **highway capacity and speed are important determinants of access to parcels of land and, therefore, to its value and potential for other uses.**

In the estimation of a market value of the land for industrial use several factors have to be taken into consideration with regard to the possible development sector. **This would include various types of interest in land. For instance, the value of land could be increased by improving the quality through capital expenditure, or by altering the use of a site or of a building or by a possible combination of the two. In this study the price of land is related to its location and employment opportunities.** Consideration for housing by an employee is guided by its location and costs, travel time and travel costs. On the other hand, the selection of a location for industry may be related to the vehicle miles of travel.

Industrial Land Values in the AGA Divisions
Colombo Metropolitan Region

Zone	Code Number	Total Area sq.km.	Land Values 19.01.1975 in Rupees	Land Values 01.01.1984 in Rupees
Biyagama	122	61.90	150 - 200	1500 - 3000
Ja-ela	125	79.20	250 - 500	3000 - 5000
Katana	126	22.60	150 - 200	1000 - 1750
Kelaniya	127	22.20	300 - 500	3500 - 5000
Negombo	128	127.90	N.A	N.A
Wattala	12C	46.20	300 - 600	4000 - 7000
Mahara	128	47.90	200 - 350	2750 - 3500
Colombo Municipality	112	41.08	1000 - 2000	20000 - 30000
Homagama	113	157.94	200 - 350	2750 - 3500
Kaduwela	114	90.81	250 - 500	3500 - 4500
Kesbewa	115	63.47	250 - 500	2750 - 3250
Kolonnawa	116	26.32	350 - 600	6000 - 10000
Moratuwa	117	19.22	500 - 600	7000 - 12500
Nugegoda	118	58.53	600 - 750	8000 - 15000
Avissawella	111	237.21	150 - 250	1500 - 2500
Attanagalla	121	153.90	100 - 250	750 - 1750
Divulapitiya	123	198.40	100 - 250	750 - 1750
Gampaha	124	94.50	250 - 500	3000 - 5000
Minuwangoda	129	132.80	150 - 200	1000 - 2250
Mirigama	12A	187.40	100 - 200	750 - 1500
Weke	12D	175.90	75 - 150	500 - 1250
Agalawatta	131	361.30	75 - 150	750 - 1500
Bandaragama	132	84.80	100 - 225	750 - 1500
Beruwala	133	73.00	150 - 200	1000 - 2500
Bulathsinhala	134	235.30	75 - 100	750 - 1750
Dodangoda	135	107.00	100 - 200	750 - 1750
Horana	136	255.60	150 - 200	2000 - 3000
Kalutara	137	77.90	200 - 300	3000 - 5000
Matugama	138	134.10	100 - 175	1000 - 2000
Panadura	139	57.50	350 - 750	4000 - 7500

Source: Valuation Department

Table7.1

7.2 Land Value and Industrial Location

The prices of industrial land by way of AGA divisions for the years 1975 and 1984 together with the extent of the areas is given in table 7.1.

The table 7.2 showed data in relation to land values, the mileages of **A** and **B** roads, vehicle kilometres, the road density per square kilometre, the vehicle kilometres per square kilometre, categories of populations and industries in each AGA division. A close look at the table 7.2 with respect to land prices in 1984 and the major industries established in each zone show the following relationships;

1. **In the AGA areas of Nugegoda (118), and Moratuwa (117) the land prices are high as these zones are close to Colombo. But in these areas most of the industries were set up at the beginning of the industrial activity in Sri Lanka. Land prices have now gone up due to urbanization and non-availability of land suitable for industrial location and because of policy guidelines introduced by the Urban Development Authority and the Central Environmental Authority(CEA).**

2. **In Jaela (125), and Homagama (114) which are relatively far from Colombo land prices are less with the result that industries have shifted to these areas.**

3. **In Divulapitiya (123), Minuwangoda (129), and Katana (126) where land prices are much lower than the above areas newly developing industries show a close correlation between land values and the location of industries.**

Traffic,Route and Land Values in AGA Divisions
In the Colombo Metropolitan Region

Zone	Code Number	Area sq.km. sq. km.	Road km A & B Roads	Road Density km/sq.km	Vehicle Km. on	Vehicle Km/sq. km A&B Roads	Radial Dist	Land Val / Perch A&B Roads	Total Population	Active Population km	Industrial Population Rs.	Manufact. Population	Number of Industries
Biyagama	122	61.90	26.04	0.419	44.37	716.00	19.80	3000	94,237	32,322	22,087	5,844	7
Ja-ela	125	79.20	18.21	0.228	135.76	1718.00	17.60	5000	119,520	39,845	29,014	6,763	35
Kattana	126	22.60	20.41	.870	30.34	1519	30.10	1750	77,985	28,321	20,383	7,307	18
Kelaniya	127	23.20	19.51	.900	98.26	4446	7.30	5000	109,927	39,306	29,045	7,925	19
Negombo	128	127.90	61.36	.477	232.04	1813	30.30	n.a	135,197	46,844	38,897	8,949	21
Wattala	12C	46.20	29.51	.630	153.93	3990	8.30	7000	1009,635	35,094	27,104	5,514	24
Mahara	128	47.50	37.31	.771	100.60	2096	14.50	3500	54,196	18,546	12,731	2,726	14
Greater Colombo /Eco. Commission	GCEC		487.36	6.520	797.34				796,607	238,478	170,241	51,228	138
Colombo Municipality	112		41.88	1.736				30000	587,647	232,527	191,221	24,933	118
Homagama	113		137.36	0.278	110.11	697.00	23.00	3500	141,752	53,827	38,637	6,729	28
Kaduwela	114		90.61	0.372	78.38	806.00	17.60	4500	126,053	44,643	34,556	7,393	19
Kesbewa	115		63.47	0.317	90.40	1433.00	17.10	3250	120,892	44,044	33,675	9,343	22
Kolonnawa	116		26.32	0.697	76.59	2946.00	11.80	10000	114,338	38,002	28,264	5,887	22
Moratuwa	117		19.22	0.474	73.18	3957.00	16.10	12500	134,826	45,697	38,944	15,494	27
Nugegoda	118		38.33	0.797	425.75	7316.00	13.10	15000	367,331	142,451	113,098	244,555	103
Colombo Suburban Area		CSA		328.79	4.531	886.41				1,000,190	369,724	287,174	69,201221
Area									1,092,829	402,281	478,390	94,124	339
Colombo Urban Area	CUA												
Attanagalla	111		237.21	0.148	96.81	408.00	30.20	2500	108,402	39,908	29,079	4,149	13
Attanagalla	121		153.90	0.403	120.10	844.00		1756	105,781	36,158	25,461	5,288	13
Dompe	123		198.46	0.419	133.14	472.00	41.80	1750	96,746	32,641	25,336	6,709	25
Gampaha	124		44.50	0.485	175.25	1524.00	22.20	3000	116,297	41,670	28,773	5,480	10
Minuwangoda	129		132.40	0.429	120.23	994.00	28.20	2250	107,277	37,003	26,829	6,004	22
Mirigama	12A		187.40	0.519	156.70	838.00	38.20	1500	111,294	36,474	26,264	5,424	12
Wattala	12D		173.50	0.205	51.99	292.00	27.80	2250	98,473	33,410	22,097	1,803	8
Agalawatta	131		301.30	0.053	40.00	113.00	55.30	1500	69,019	24,015	10,000	1,299	10
Bandaragama	132		84.80	0.129	29.41	321.00	29.30	1500	62,184	21,448	14,718	1,463	
Beruwala	133		73.08	0.347	75.70	1037.00	58.00	2500	111,479	35,040	23,632	1,194	
Bulathsinhala	134		235.30	0.132	47.50	207.00		1000	62,049	24,000	19,300	1,154	3
Dodangoda	135		107.40	0.262	27.81	260.00	46.60	1750	43,817	17,042	11,773	1,444	
Horana	136		255.40	0.273	87.66	343.00	34.50	3000	122,846	48,322	34,213	7,998	14
Kalutara	137		77.90	0.313	98.68	1265.00	37.90	3000	113,928	37,198	26,449	4,515	14
Matugama	138		134.10	0.289	37.68	281.00	54.30	2000	62,366	21,626	13,367	967	12
Panadura	139		37.39	0.631	51.00	1569.00	25.60	7300	137,999	45,383	33,677	7,278	19
Rest.Col.Metro. Area	R.CMR		2724.51		1424.40				1,426,272	563,359	464,696	131,479	211
Total Colombo Metro.Area	CMR		3399.18		3078.19				3,919,798	1,484,888	1,062,354	256,651	693

Author's Computation

Table 7.2

7.3 Relation of Land Price To other Factors

The variables given in table 7.2 were analysed by regression with respect to industrial land values for 1984 and the results are listed below in table 7.3 with r and r^2 coefficients.

Of the various variables the road density, vehicle kilometre density, total population and the number of major manufacturing industrial units show high values of r^2. These values are shown in several plots against land values and are shown in figures 7.1, 7.2, 7.3, and 7.4 respectively.

Table 7.3

Regression Analysis Results

	r	r^2
Kilometres in AGA division	1137	0129
Kilometre density per sq.km.	.8004	.6404
Vehicle kilometres in zone	.6085	.3703
Vehicle kilometre density/sq.km	.8711	.7588
Radial distance to Colombo	-.5820	3388
Major industrial units in zone	.8773	7696
Total population in zone	.9212	.8486
Active population in zone	.9127	.8329
Industrial population in zone	.9200	8465
Manufacturing population in zone	.8696	.7562

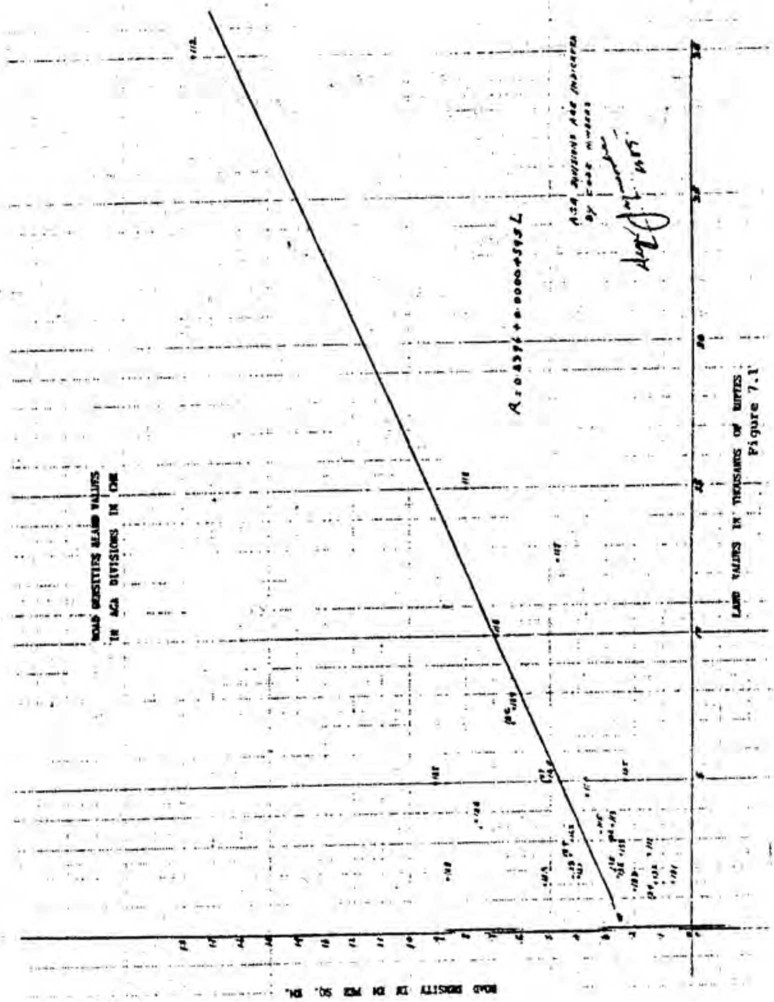
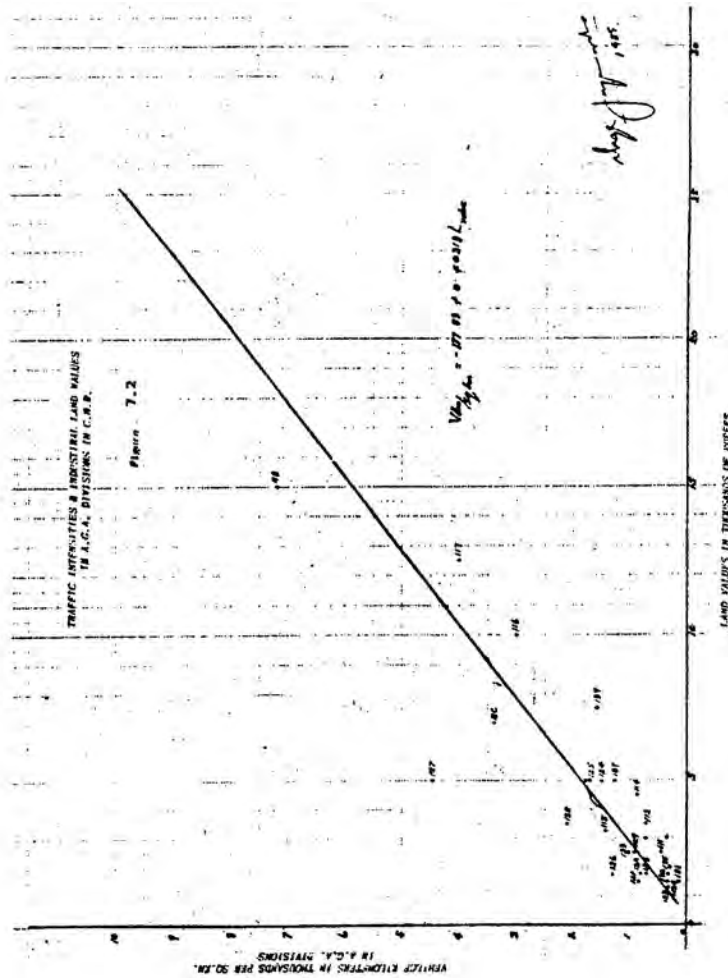

LAND VALUES IN THOUSANDS OF RUPEES
ROAD DENSITY IN KM PER SQ. KM.

Figure 7.1


TRAFFIC INTENSITIES & INDUSTRIAL LAND VALUES IN A.G.A. DIVISIONS IN C.B.D.
Figure 7.2
LAND VALUES IN THOUSANDS OF RUPEES
VEHICLE KILOMETERS IN THOUSANDS PER SQ.KM.
IN A.G.A. DIVISIONS

The regression equations are as follows;

1. The road density per square kilometre (**R**) in the AGA division is related to the industrial land value (**L**) by the expression and is shown in figure 7.1.

   $$R=0.23956 + .000045948L$$

   This relationship shows that greater the penetration into the land or the degree of access, greater is the potential for the location of industry as reflected by the demand for industrial land.

2. Vehicle kilometres (**V**) per square kilometre in the AGA division is linked to the industrial land value (**L**) by the relationship figure 7.2.

   $$V=-177.83 + 0.40313L$$

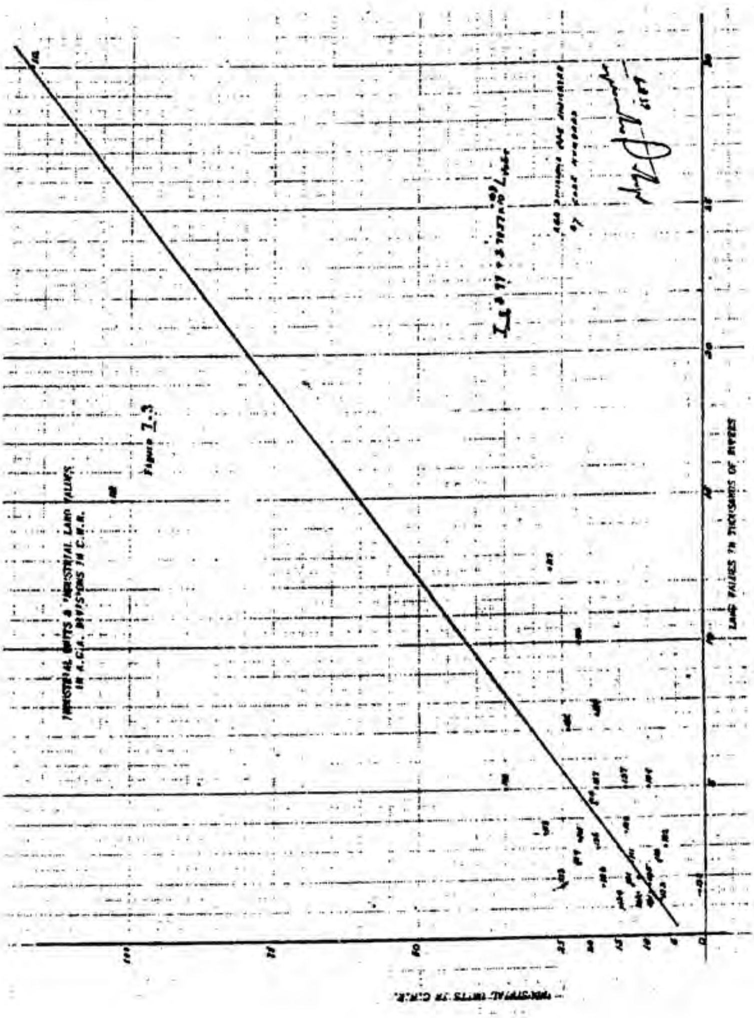
   This expression shows that the greater the amount of travel as shown by the value of vehicle-kilometres the greater is the degree of communication or travel and hence the demand for industrial land as indicated by the price.

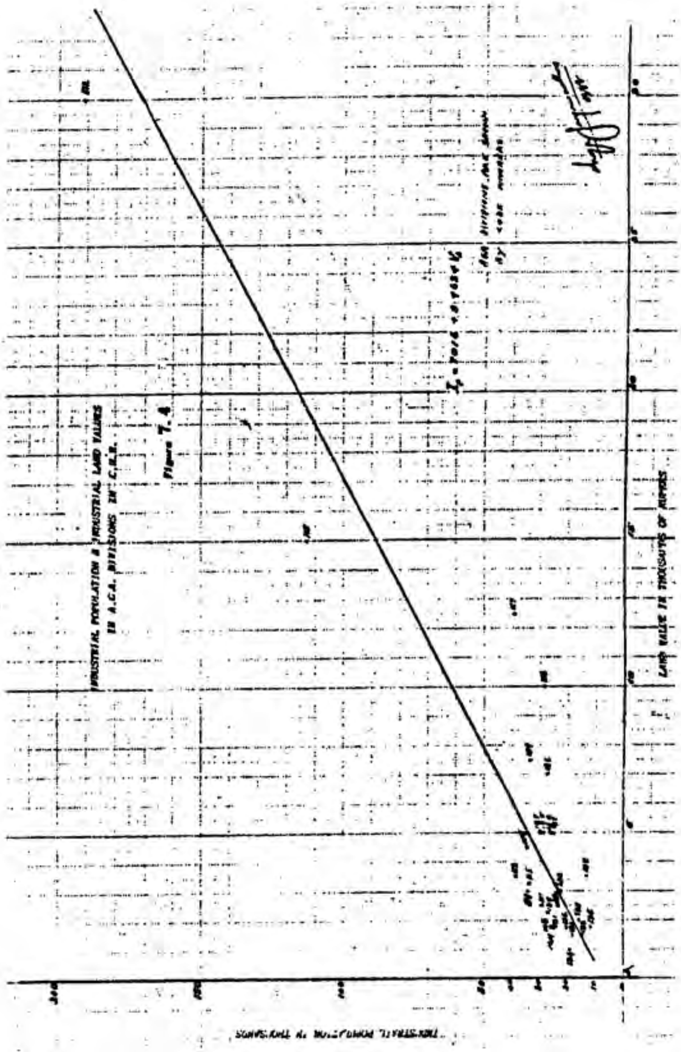
3. Industrial units (**I**) per AGA division and the land value (**L**) are interrelated by the expression:

   $$I=3.9734 + 0.003786L$$

   This is shown in figure 7.3

   This relationship indicates that as the number of industrial units in the given area increase the demand for land increases as more and better infrastructure and communication facilities are provided and consequently the price of industrial land increase in value.




INDUSTRIAL POPULATION & INDUSTRIAL LAND VALUES
IN A.C.A. DIVISIONS IN C.B.D.
Figure 7.4
LAND VALUE IN THOUSANDS OF RUPEES

4. The dependency of the land value (**L**) on the active population (**P**) in AGA divisions is shown by the equation figure 7.4.:

$$P=12846 + 6.5727L$$

This relationship indicates that the price of industrial land is proportional to the active population. This means that the land values depend on an adequate and ready access to an active labour market. This will also imply the existence of a satisfactory road network as well as a mass transport system.

7.4 Land Values and Access-Mobility

The figure 7.5 illustrates the spatial distribution of industrial land values, the number and location of major industrial units in the various AGA divisions and the intensity of traffic flows on the **A** and **B** route network.

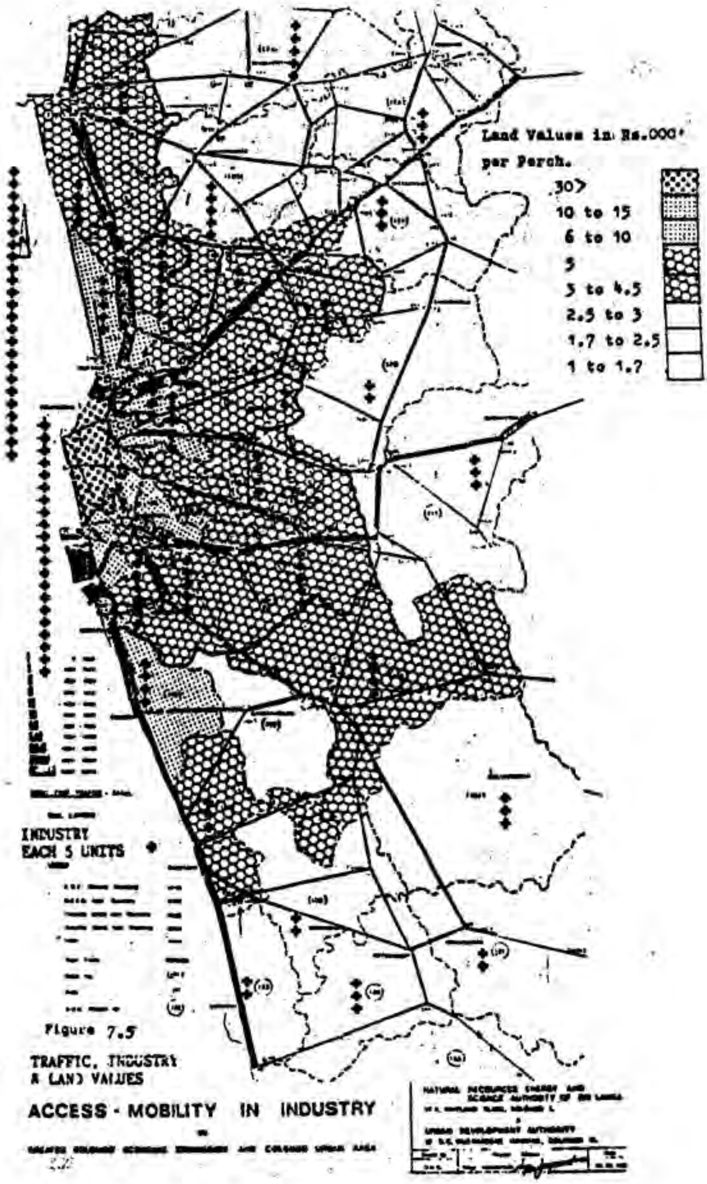
This figure shows explicitly the following;

1. **The very high land values, the very high traffic flows and the concentration of large number of industries in the CMA.**

2. **The gradual fall off in land prices as the distances increase from Colombo and the fall off in traffic volumes.**

3. **The high values of land and traffic flows along the major highways radiating from Colombo.**

4. **That where access to Colombo - the dominant city in the region- is low and connectivity to the major road network is poor, traffic flows as well as major industries are low in scale.**


Land Values in Rs.000' per Perch.
30>
10 to 15
6 to 10
5
3 to 4.5
2.5 to 3
1.7 to 2.5
1 to 1.7
INDUSTRY
EACH 5 UNITS
Figure 7.5
TRAFFIC, INDUSTRY & LAND VALUES
ACCESS - MOBILITY IN INDUSTRY

The above figures and the regression equations confirm the proposition made in the conceptual formulation of the model and as illustrated in the figure 1.3 that the location of industrial units (landuse) and land values are intimately linked not only to access but also to vehicle movements, that is, to access-mobility.

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8

IMPACT OF PUBLIC TRANSPORT

8.0 Impact of Public Transport

8.1 Public Transport

The study area consists of varied types of built up zones ranging from high density urban to low density rural. The public transport network contains links within the CMR which represent the main transport network -the **A** and **B** route system. There are other links on which the public bus system operates but these have not been taken into account as their contribution was consideredof minor importance. In the travel analysis the 24 hour data are used as it is the repetitive travel cycle and the most stable for the average day.

The bus is a very flexible vehicle which could be operated in both urban and rural areas in a variety of conditions ranging from high frequency limited stops to those on high density or low frequency networks.

In the development of future plans the possibilities of major changes in the highway network are limited. But with public transport there could be many options including changes in vehicle capacities, frequencies of operation and routes.

But the most important aspect in a comprehensive and flexible service is the level of mobility it offers to the public to get about their daily activities. The level of demand and the service offered would represent the measures of its performance.

The growth of the passenger service vehicles and new registration of Motor Coaches & Omnibuses as from 1979 to 1985 operated both by the state and the private sector is shown

Estimated Bus Traffic

1973–1985

Year	Bus Kms 000'	Pass. Kms billions	Passengers millions
1973	403948	16.755	1,441.3
1974	377972	14.417	1,283.0
1975	396683	15.216	1,370.6
1976	398558	16.612	1,471.5
1977	402629	17.461	1,567.3
1978	454752	20.373	1,787.6
1979	481835	22.186	1,907.9
1980	516616	22.700	1,856.8
1981	493544	18.491	1,427.8
1982	481856	18.720	1,398.0
1983	457500	16.884	1,272.5
1984	416815	15.613	1,056.3
1985	390338	14.495	962.9

Source:Operations Division, SLCTB

Table 8.2

in table 8.1.

Table 8.1

Growth of Public Passenger Vehicles

Year	Private	SLCTB
1979	1575	747
1980	2658	788
1981	2330	24
1982	2533	555
1983	3748	521
1984	3926	325
1985	3553	95

Source: Dept. of Motor Traffic.

The historical growth of passenger kilometres of the SLCTB from 1973 to 1985 is shown in table 8.2. The passenger kilometres operated by the public sector decreased in 1974 due to a fare increase of 70 % consequent to the fuel price increases. From then onwards the operations increased till 1980 when the private sector came into the scene.

Though there are no seasonal changes as such but there are holiday, national and religious functions taking place particularly in April, August and December. Generally the months of March and September are fairly stable in traffic flows and free of peaks. This is particularly so in the month of September. **Hence, the statistics of bus operations for September 1984 maintained by the CTB have been used as the sample for the analysis of bus operations.** The log sheet kept by the conductor of the bus and the depot operator form the main source of information. This information is supplied to the Regional Centres where they are scheduled and analysed. The typical data sheet for the month of September 1984 for bus

REGION — CURTH
111 HOMAGAMA DEPOT

SRI LANKA CENTRAL TRANSPORT BOARD — Table 8.3

SUMMARY OF OPERATIONAL STATISTICS FOR THE MONTH OF AUGUST 1985

ROUTE	AV.C	SCH.KM	OP.KM	D.KM	POB	REV	F/KM	R/KM	PG.KM	ST.KM	L.F.	AV.P.J
EX	60	109	189		49	132	15.00	.70	880	11,340	7.7	10.0
SC	60	1,004	859		2,504	4,059	15.00	4.73	27,040	51,540	52.5	10.8
011	40	6,300	2,442		1,000	14,038	15.74	5.75	89,187	97,680	91.3	49.5
112	40	2,703	358		415	11,184	14.57	3.22	6,964	21,480	32.4	11.3
122	60	45,995	47,028		54,174	165,570	10.38	3.52	1,595,164	2,821,680	56.5	29.4
122/02	60	24,966	5,659		6,102	13,959	10.04	2.47	139,034	339,540	40.9	22.8
122/03	60	54,222	27,333		34,337	69,456	9.64	2.54	719,006	1,639,380	43.8	20.9
122/04	60	93,792	20,630		44,326	80,450	12.05	2.01	426,070	1,717,800	34.4	14.1
124	60	32,134	11,677		11,597	25,300	10.92	2.17	232,418	700,620	33.1	20.0
125/02	60	76,416	53,994		88,414	212,929	9.38	3.94	2,270,032	3,239,640	70.0	25.7
125/03	60	2,860	643		573	1,785	11.62	2.77	15,361	38,700	39.6	26.8
125/04	60	3,401	2,779		2,254	7,085	13.28	2.55	53,351	166,740	31.9	23.7
125/05	60	14,280	24,758		40,494	83,494	10.79	3.37	759,745	1,486,080	51.1	18.8
126	60	1,554	597		1,481	[illegible]	10.03	5.41	32,223	35,820	89.9	19.2
126/01	60	9,703	6,412		9,547	17,322	11.60	2.71	148,818	384,720	38.6	15.6
128	60	2,044	717		1,274	2,492	20.67	3.48	12,071	43,020	28.0	9.5
128/01	60	22,746	10,[illegible]		33,014	58,975	18.90	2.74	269,709	1,115,340	24.1	8.2
128/02	60	19,642	8,511		20,349	29,476	27.17	3.46	100,407	511,860	21.1	5.4
128/03	60	3,956	3,069		16,897	23,504	39.60	6.17	59,234	228,540	25.9	3.5
128/04	40	2,951	2,045		14,903	[illegible]	40.0[illegible]	5.21	37,055	113,800	32.5	2.5
129/01	60	30,514	26,750		56,724	[illegible]	25.73	3.83	406,591	1,605,400	25.3	7.1
130/01	99	121,745	72,613		145,487	263,634	12.60	3.63	2,092,333	7,190,667	29.0	14.4
191	60	30,169	926		1,648	3,476	15.00	3.75	23,173	55,560	41.7	14.1
203	40	13,409	10,035		10,383	38,[illegible]	[illegible]	3.87	207,859	401,400	51.7	11.4
219	50	19,270	8,768		16,690	[illegible]	24.39	3.06	112,575	448,400	25.1	6.7
239/01	50	8,606	8,777		15,969	[illegible]	21.49	[illegible]	138,539	438,850	31.5	8.7
239/02	50	15,326	13,260		22,194	[illegible]	[illegible]	[illegible]	137,783	663,000	20.7	6.2
255	60	3,439	1,792		2,999	4,624	[illegible]	[illegible]	28,508	103,920	27.4	9.5
293	60	30,218	25,[illegible]		68,143	121,449	23.[illegible]	4.67	510,076	1,559,400	32.7	7.5
299	50	4,739	6,445		12,840	[illegible]	20.09	3.52	80,737	322,250	25.0	6.3
307	60	2,441	1,347		1,196	[illegible]	10.26	2.63	34,522	80,820	42.7	28.9
308	40	5,037	1,750		[illegible]	[illegible]	23.11	2.16	16,335	70,000	23.3	5.5
336	40	71,951	16,179		52,110	79,734	22.44	4.87	350,065	970,740	36.1	6.7
364	40	6,507	5,468		11,872	[illegible]	[illegible]	[illegible]	60,063	218,720	31.4	6.0
366	40	9,767	9,490		16,209	[illegible]	[illegible]	[illegible]	121,024	379,600	31.8	7.5
577	40	3,770	1,211		1,492	[illegible]	[illegible]	[illegible]	9,698	48,520	19.9	5.7
597	60	47,693	30,211		67,273	101,451	15.00	3.34	676,340	1,812,660	37.3	10.1
698	60	23,774	14,095		24,901	40,769	22.97	2.67	177,488	845,700	20.9	7.1
DEPOT TOTALS	41	839,372	501,128		923,890	1,757,246	14.18	3.49	12,395,177	31,981,007	38.7	13.4

BUS OPERATIONAL CHARACTERISTICS

IN THE METROPOLITAN AREA

1,984

Depot Location	Number Routes	Average Capacity in seats	Operated Kilo-meters	Passengers Millions	Revenue Millions	Fare/km per passenger	Passenger Kilo-meters	Seat Kilo-meters	Load Factor	Average Pass.Trip in km
Kadawata	39	62	652,902	1,799,942	2,689,554	18.09	14,936,968	41,050,425	36.4	8.4
Kotahena	24	59	284,545	654,875	1,096,834	18.47	5,939,727	17,033,840	34.8	9.1
Ja-Ela	42	57	662,164	1,052,264	2,071,836	16.82	12,319,817	38,001,515	32.4	11.7
Negombo	43	58	749,796	956,264	2,467,083	13.36	18,442,368	43,530,352	42.1	19.3
Av.GCEC. AREA	37	59	587,382	1,115,834	2,081,327	16.67	12,909,730	34,904,604	36.5	12.2
Homagama	39	58	533,509	930,226	1,741,346	14.05	12,393,087	30,974,310	40.0	13.8
Kottawa	33	56	398,574	812,195	1,314,013	18.87	6,962,917	22,692,160	30.8	8.6
Maharagama	25	61	509,162	1,493,202	2,001,496	16.03	11,893,345	31,301,528	37.9	8.0
Mattakkuliya	21	48	705,870	1,327,642	3,405,464	15.75	21,618,720	35,208,296	61.4	16.3
Maradanamulla	24	50	668,157	1,581,609	2,845,527	17.45	16,308,241	33,637,850	48.7	10.3
Moratuwa	19	82	432,788	1,141,216	1,637,617	17.23	9,503,715	37,280,975	34.8	8.3
Ratmalana	33	61	536,821	1,653,212	2,313,594	16.67	13,876,054	34,431,880	40.2	8.4
Talangama	25	57	384,481	1,506,423	144,725	18.75	11,440,243	33,494,894	34.1	7.6
Udahamulla	18	57	466,202	1,675,386	2,171,271	21.62	10,093,768	26,740,446	37.5	6.0
Av.Col Urb.Area	26	57	839,589	1,343,408	1,952,808	17.47	12,671,119	30,617,718	40.4	9.7
Aluthgama	33	55	315,967	454,554	1,216,818	14.89	8,172,370	17,638,220	46.2	18.0
Angoda	10	48	157,408	332,493	704,313	19.11	3,685,019	7,697,150	47.8	10.2
Avissawella	59	48	652,571	914,138	2,334,671	16.72	13,939,890	31,758,530	43.9	15.3
Deraniyagala	29	50	142,877	243,084	660,075	16.74	3,944,169	7,175,100	54.9	16.2
Divulapitiya	15	55	357,223	452,500	1,320,108	13.49	8,305,997	19,835,836	41.8	18.4
Gampaha	39	56	432,788	722,904	1,455,565	16.82	8,653,078	24,440,120	35.4	12.0
Horana	42	56	607,142	869,381	2,063,405	14.66	14,072,083	34,324,310	40.9	16.2
Kalutara	33	54	444,069	818,384	1,688,882	16.19	10,432,042	24,236,423	43.0	12.7
Kirindiwela	21	45	377,417	549,595	1,202,119	15.33	7,839,818	17,254,296	45.4	14.3
Mathugama	45	52	452,411	760,908	1,716,372	16.50	10,400,189	23,529,562	44.2	13.7
Nittambuwa	38	58	755,233	1,052,968	2,486,078	14.87	16,721,382	42,601,170	39.2	15.9
Panadura	44	56	630,066	1,137,393	2,140,813	17.06	12,542,359	35,327,920	35.5	11.0
Av.Rest of CMR.	35	53	443,763	692,382	1,545,751	16.03	9,394,859	23,519,886	45.2	14.5
Av.Col.Metro.Area	33	54	523,565	1,060,527	1,844,428	16.72	11,874,963	29,780,546	40.1	13.1

Source: SLCTB Table 8.4 Author's Computation

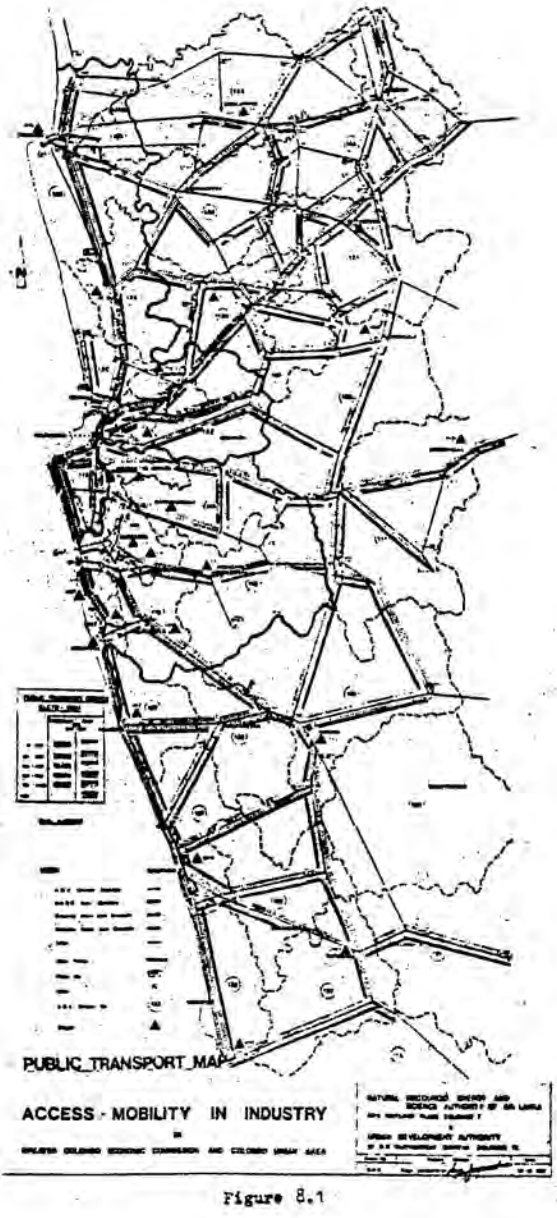


Figure 8.1

Table 8.5

BUS TRANSPORT DATA

PASSENGER KM./PER DAY 1984 S.L.C.T.B.

AREA	CODE1	CODE2	AVE.AMOUNT	TOT.AMOUNT
111	11,124	11,155	36.36	
	11,124	11,153	154.83	
	11,125	11,111	354.83	
	11,151	11,100	47.21	
	11,151	11,125	392.57	
	11,154	11,121	3.32	
	11,154	11,151	391.14	
	11,154	11,154	394.46	
				1,774.72
	11,121	11,751	403.44	
	11,153	13,622	146.17	
				549.61
	11,354	11,155	358.10	
	11,354	11,124	177.65	
	11,355	11,121	165.58	
	11,451	11,151	48.64	
	11,800	11,100	56.09	
	12,052	11,121	16.56	
	13,623	11,124	33.26	
	13,751	11,121	300.22	
				1,156.90
				3,481.23
112	11,251	11,264	996.46	
	11,251	11,275	64.24	
	11,253	11,251	687.48	
	11,264	11,266	720.59	
	11,274	11,275	173.65	
	11,275	11,266	2.05	
	11,296	11,274	173.65	
				2,818.11
	11,251	11,653	1.43	
	11,251	12,051	439.15	
	11,251	11,652	1,161.49	
	11,264	11,523	320.69	
	11,266	11,854	718.54	
	11,275	11,862	151.95	
	11,296	11,651	127.37	
				2,920.62
	11,653	11,296	175.09	
	11,852	11,253	825.39	
				1,000.48
				6,739.21
113	11,352	11,354	554.94	

Source: SLCTB Authors Computation

BUS TRANSPORT DATA

Table

SEAT KM. PER DAY 1984 S.L.C.T.B.

AREA	CODE1	CODE2	AVG.AMOUNT	TOT.AMOUNT
111	11124	11153	83.17	
	11124	11155	51.61	
	11125	11111	638.53	
	11151	11125	721.13	
	11151	11100	102.27	
	11154	11151	711.92	
	11154	11121	5.38	
	11155	11154	717.31	
				3,031.32
	11121	11751	335.98	
	11153	13622	83.17	
				419.15
	11354	11155	667.65	
	11354	11124	95.54	
	11355	11121	282.44	
	11451	11151	106.10	
	11523	11155	14.74	
	12052	11121	17.58	
	13623	11124	61.38	
	13751	11121	23.70	
				1,275.13
				4,725.60
112	11251	11274	12.25	
	11251	11264	915.25	
	11251	11264	1,299.60	
	11251	11275	95.54	
	11253	11251	2,691.61	
	11264	11266	621.93	
	11264	11251	20.40	
	11264	11266	840.63	
	11274	11296	127.37	
	11274	11275	446.83	
	11275	11274	127.37	
	11275	11266	7.01	
	11296	11274	446.83	
				7,552.66
	11251	12051	1,049.40	
	11251	11652	1,331.01	
	11251	11653	196.40	
	11251	11652	761.72	
	11264	11523	854.29	
	11266	11254	1,455.54	
	11275	11662	319.51	
	11296	11651	285.97	
	11296	11653	127.37	
				6,381.21

operations of the Homagama depot is shown in table 8.3. From this data it is possible to deduce some information on the supply and characteristics of the quality and quantity of the bus operating system. This data has been processed and table 8.4 gives the **operational characteristics of the bus services in the whole of the CMR.** The passenger kilometers (PG.Km) and the seat kilometers (ST.Km) operated per month on any particular route were obtained from the statistical record similar to that for the Homagama depot (table 8.3).

The express services and the long distance services were ignored as it was very unlikely that they would have been used by the workers to any appreciable extent. It is then assumed that these values are uniformly distributed on links throughout that particular route. These values were then tabulated in the form of a route-link matrix. These distributed values were summed up for each link in the public transport network to give the total travel in passenger kilometers and seat kilometers for each route for each applicable AGA division in the CMR. These values are plotted and illustrated in figure 8.1. Typical values for the AGA divisions of 111 and 112 for passenger kilometers and AGA divisions of 139 and 13A for seat kilometers are shown in tables 8.5 and 8.6 respectively. The values for all routes within each AGA division are accumulated and divided by the area to obtain an average value for the AGA area per square kilometre both for passenger as well as seat kilometers.

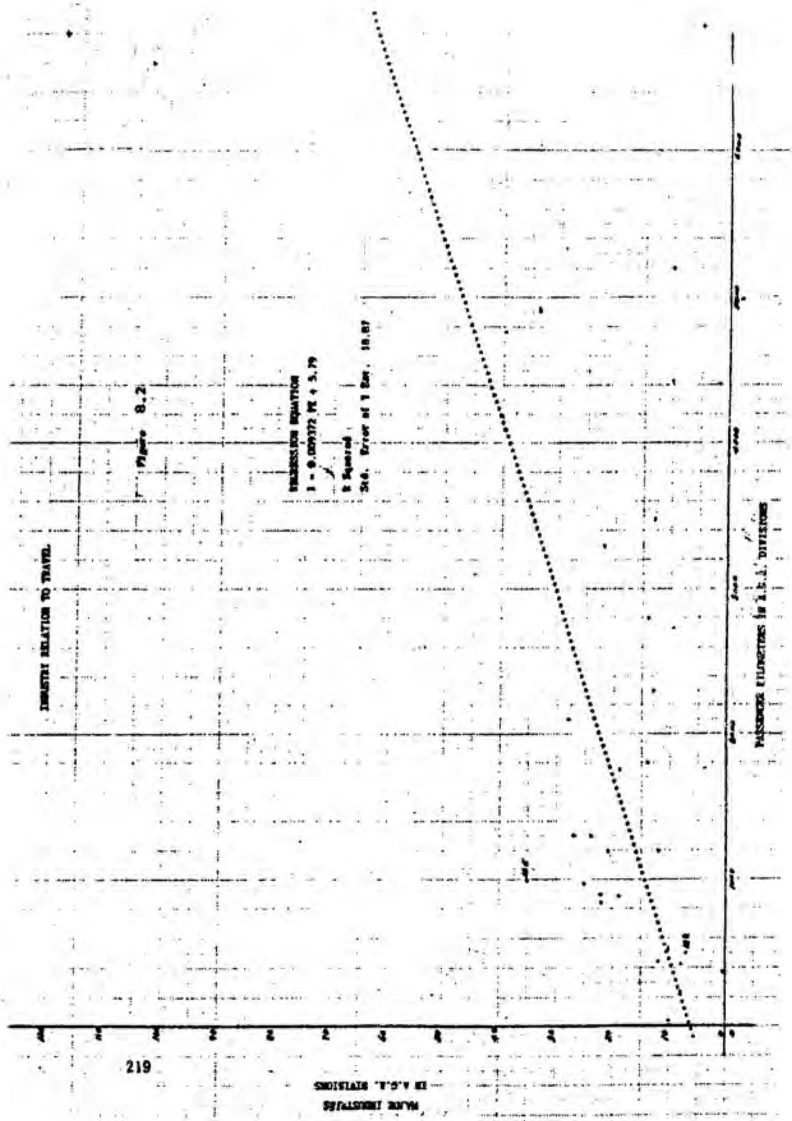
8.2 The Demand for Travel.

The demand for travel is shown by the number of people and the distances they travel. This product called the **passenger kilometre** is an index of demand. The table 8.7 shows the passenger travel in the CMR by AGA divisions and by various regions for a typical day in September 1984.

Passenger Travel in Passenger Kilometers per Day in September 1984 Colombo Metropolitan Region

Zone	Code Number	Total Population	Passenger Kilometre	Passenger Km /1000 Persons	Area Sq. Km.	Passenger Km /sq.Km	Number Industries
Biyagama	122	94237	505.89	5.37	61.9	8.17	7
Ja-Ela	125	119520	1,015.42	8.50	79.2	12.82	35
Katana	126	77985	207.72	2.66	22.6	9.19	18
Kelaniya	127	109927	5,152.58	46.87	22.2	232.10	10
Negombo	12B	135197	1,153.74	8.53	128	9.02	21
Wattala	12C	109635	1,298.07	11.84	46.2	28.10	24
Mahara	128	108392	2,787.84	25.72	95.8	29.10	14
Greater Col.Eco.Comm.	GCEC	700697	12,121.26	17.30	466	328.59	129
Colombo Municipality	112	587647	6,730.21	11.47	41.1	164.08	118
Homagama	113	141752	2,127.00	15.01	158	13.47	28
Kaduwela	114	126053	872.20	6.92	90.8	9.60	19
Kesbewa	115	120892	844.15	6.98	63.5	13.30	22
Kolonnawa	116	114338	3,285.02	28.73	26.3	124.81	22
Moratuwa	117	134826	1,322.40	9.81	19.2	68.80	27
Nugegoda	118	367331	6,615.37	18.01	58.5	113.03	103
Colombo Suburban Area III		CSA	1998192	18,066.14	14.99	416	36.19
Colombo Urban Area	CUA	1993839	21,966.35	13.69	487	47.68	339
Avissawella	111	106402	3,481.23	32.72	237	14.69	13
Attanagalla	121	105701	2,305.58	21.80	154	14.98	13
Divulapitiya	123	90746	906.80	9.99	190	4.87	25
Gampaha	124	116287	4,420.29	38.09	94.5	46.87	18
Minuwangoda	129	107277	904.37	8.43	79.2	11.42	22
Mirigama	12A	111294	1,217.13	10.94	187	6.49	12
Weke	120	98475	428.65	4.35	176	2.44	8
Aggalawatta	131	69619	36.14	0.52	361	0.10	10
Bandaragama	132	62184	368.82	5.93	84.8	4.35	1
Beruwala	133	111479	215.44	1.93	73	2.95	8
Dodangoda	135	43817	540.21	12.33	107	5.05	10
Horana	136	122846	1,752.35	14.26	257	6.83	19
Kalutara	137	111928	1,806.63	16.14	77.9	23.19	14
Matugama	138	62566	417.52	6.67	134	3.11	12
Panadura	139	137694	126.19	0.92	57.5	2.19	19
Rest.Col.Metro.Area	R.CMR	1626271	18,996.36	11.68	2279	8.34	
Tot. Col.Metro.Area	CMR	3919798	53,062.80	13.54	3192	16.62	

Source: SLCTB Author's Computation Table. 8.7



It gives the total population in 1981, passenger kilometers, the passenger kilometers per 1000 of the population, the area, passenger kilometers per sq. kilometre, and the number of major industries in each AGA division.

The figure8.2 shows a plot of the major industries and the passenger kilometers for all AGA divisions in the CMR. This gives a fair degree of correlation and the regression analysis results are also shown.

8.3 Supply of Services.

The supply of bus services and the extent to which it is made available to the passengers is measured by the quantity called the **seat mile or seat kilometre**. A bus with say 40 seats which moves 10 kilometers will have a seat capacity of 40 seat-kilometers. Similarly the figures obtained for the seat kilometers for each AGA area are given in table 8.8 for all zones. It shows the population in 1981, the extent of the area, seat kilometers, seat kilometers per 1000 persons, seat kilometers per square kilometre, and the number of major industries for all AGA divisions in the CMR. The figure 8.3 shows a plot of major industries and seat kilometers in AGA divisions. It shows a higher correlation than with passenger kilometers and the results of the regression analysis are also given.

8.4 System Performance

The services performed by the public transport operations have to be assessed regularly to enable adequate standards to be maintained. For this purpose key performance indicators

Passenger Travel per Day in Seat Kilometers
in September 1984
Colombo Metropolitan Region

Zone Number wise	Code Number	Total Population	Seat Kilometer	Seat.Km per 1000 Persons	Area Sq. Km.	Seat Km per sq.Km	Indus-
Biyagama	122	94237	851.65	9.04	61.9	13.76	7
Ja-ela	125	119520	1,680.50	14.06	79.2	21.22	35
Katana	126	77985	485.34	6.22	22.6	21.48	18
Kelaniya	127	109927	9,740.40	88.61	22.2	438.76	10
Negombo	12B	135197	2,062.71	15.26	127.9	16.13	21
Wattala	12C	109635	3,309.25	30.18	46.2	71.63	24
Mahara	128	108392	4,810.23	44.38	95.8	50.21	14
Greater Col.Eco.Comm.	GCEC	700697	22,940.08	32.74	458.8	50.00	129
Colombo Municipality	112	587647	18,021.70	30.67	41.08	438.70	118
Homagama	113	141752	3,664.95	25.85	157.9	23.20	28
Kaduwela	114	126053	1,763.70	13.99	90.81	19.42	19
Kesbewa	115	120892	2,704.07	22.37	63.47	42.60	22
Kolonnawa	116	114338	7,299.70	63.84	26.32	277.34	22
Maharagama	117	134826	7,149.69	53.03	19.22	371.99	27
Nugegoda	118	367331	20,910.08	56.92	58.53	357.25	103
Colombo Suburban Area	CSA	1005192	43,492.12	43.27	416.3	104.48	221
Colombo Urban Area	CUA	1592829	61,513.82	38.62	457.4	134.49	339
Avissawella	111	106402	4,725.60	44.41	237.2	19.92	13
Attanagalla	121	105781	4,056.02	38.34	153.9	26.35	13
Divulapitiya	123	98746	2,081.37	21.51	198.4	10.49	25
Gampaha	124	116297	6,889.38	59.26	94.5	72.90	10
Minuwangoda	129	107277	2066.13	19.75	79.2	26.07	22
Mirigama	124	111294	2,088.16	18.58	187.4	11.04	12
Weke	12D	98475	717.99	7.29	175.9	4.08	8
Agalawatta	131	69619	205.46	2.95	361.3	0.57	10
Bandaragama	132	62184	1,275.00	20.50	84.8	15.04	1
Beruwala	133	111479	810.61	7.27	73	11.10	8
Dodangoda	135	43817	947.53	21.62	107	8.86	10
Horana	136	122846	4,685.71	38.14	256.6	18.26	19
Kalutara	137	111928	6,063.80	54.18	77.9	77.84	14
Matugama	138	62566	1,088.53	17.40	134.1	8.12	12
Panadura	139	137694	2,774.51	30.15	57.5	48.25	19
Rest.Col.Metro.Area	R.CMR	1626272	40,454.80	24.88	2279	17.75	196
Tot. Col.Metro.Area	CMR	3919798	53,062.80	13.56	3192	16.62	656

Source: SLCTB Author's Computation

Table 8.8

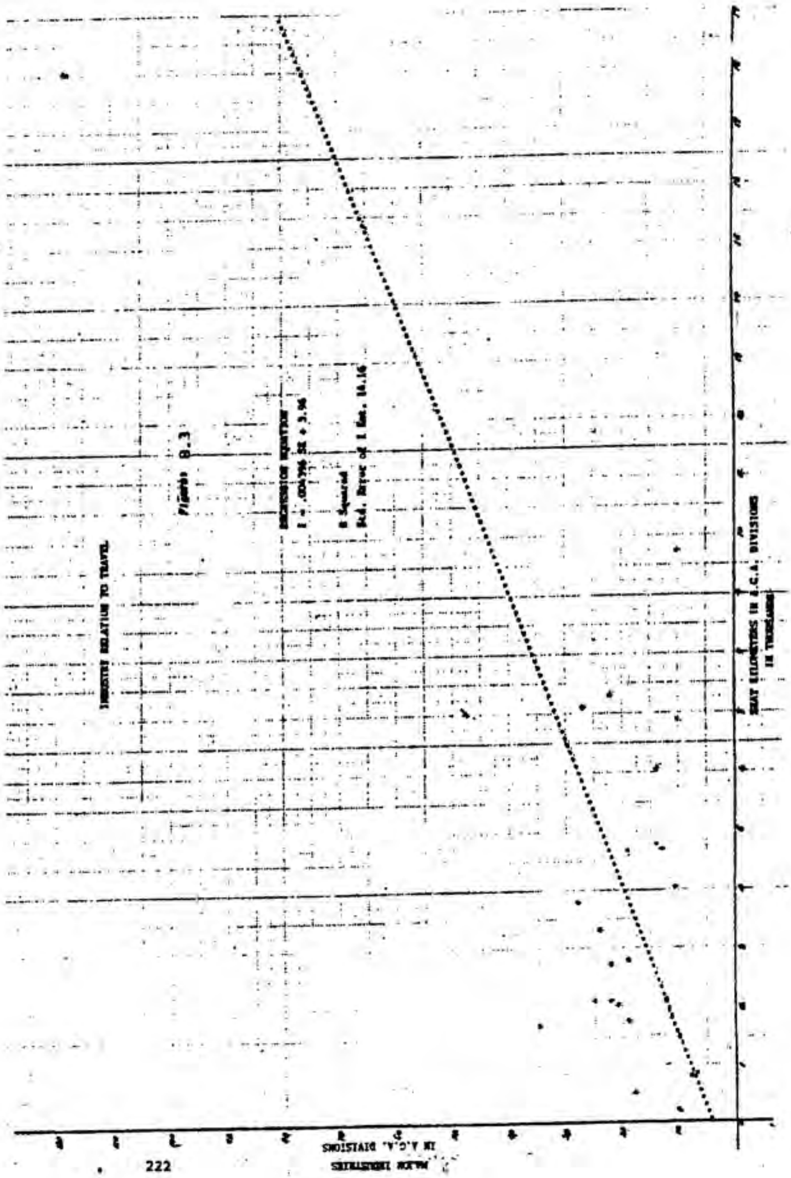


Figure 8.3
INDUSTRY RELATION TO TRAVEL
REGRESSION EQUATION
R Squared
222

Frequency Distribution of Public Transport

Seat Kms per Day	Passenger Km Kms per Day	Frequency
0 - 50	0 - 50	66
51 - 100	51 - 100	33
101 - 200	101 - 200	44
201 - 300	201 - 300	10
301 - 400	301 - 400	12
401 - 500	401 - 500	2
501 - 600	501 - 600	3
601 - 700	601 - 700	6
701 - 800	701 - 800	5
801 - 900	801 - 900	2
901 -1000	901 -1000	4
1001-1100	1001-1100	0
1101-1200	1101-1200	1
1201-1300	1201-1300	2
1301-1400	1301-1400	1
1401-1500	1401-1500	
1501-1600	1501-1600	
1601-1700	1601-1700	
1701-1800	1701-1800	
1801-1900	1801-1900	
1901-2000	1901-2000	
2001-2100	2001-2100	
2101-2200	2101-2200	
2201-2300	2201-2300	
2301-2400	2301-2400	
2401-2500	2401-2500	
2501-2600	2501-2600	

Source: SLCTB Author's Computation

Table 8.9

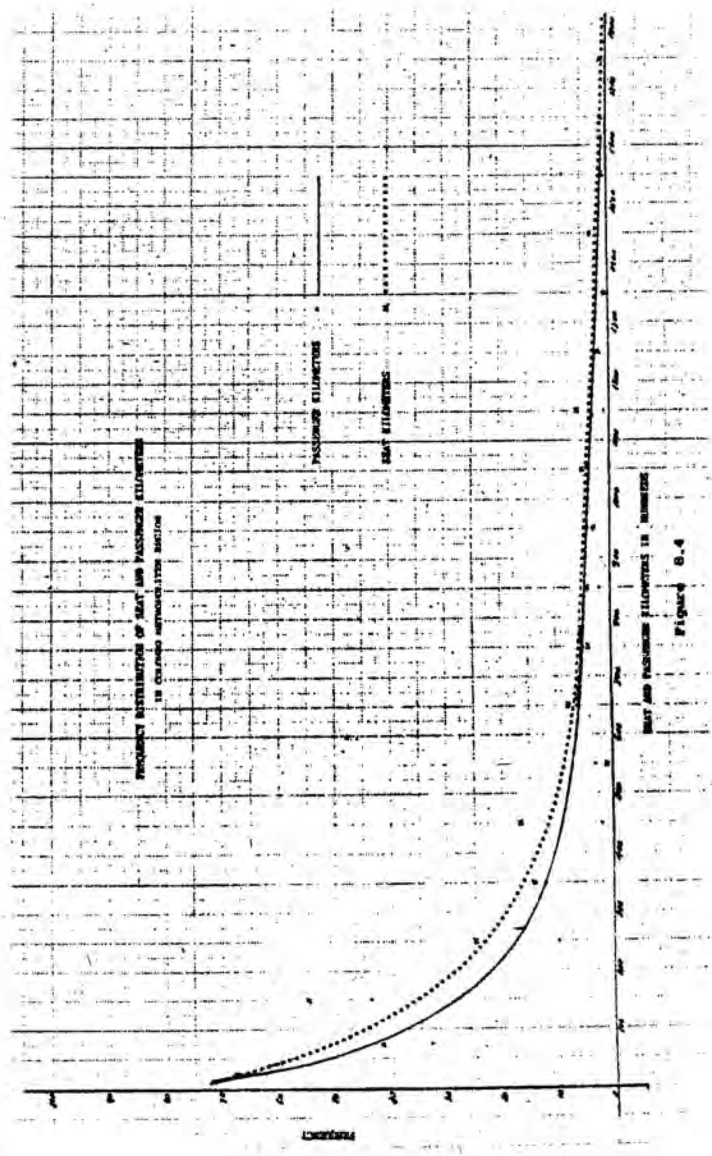


Figure 8.4

have been chosen.

The assessment of the system performance could be gauged from four factors;

1. **The intensity of use of the system by the people.**

2. **The opportunity offered by the system.**

3. **The degree of access-mobility offered by the system.**

4. **The transit service factor.**

In this study the main concern is with manufacturing industrial workers or the economically active persons. The number of passengers carried compared to the capacity of the system is a key indicator of productivity. The number of passengers carried per bus per day is a measure of the efficiency of the service. For a well managed system the value is 1000- 1500 passengers per bus per day.

The frequency of occurrence of passenger and seat kilometers distributed throughout the CMR network and obtained as explained earlier is shown in table 8.9. A plot of this distribution is shown in figure 8.4. It shows that between 50 to 550 seat and passenger kilometers the frequency variation is very wide, from 10 to 55. For larger values the differential is low.

Travel in the CMR has also been analysed with Z scores. The zone numbers, codes, seat and passenger kilometers with the respective Z scores are tabulated in the table 8.10. The distribution of these Z scores with respect to the AGA divisions is given in table 8.11.

The figures 8.5 and 8.6 show the areal distribution of the values of Z scores shown in table 8.11. The figures show that the passenger kilometers in the Colombo district are in great demand.

Travel in the Colombo Metropolitan Region

Z Score Distribution

Zone	Code Number	Seat Kilometre	Z Score	Passenger Kilometre	Z Score
Biyagama	122	851.65	(0.712)	505.89	-0.708
Ja-ela	125	1,680.50	(0.541)	1,015.42	-0.435
Katana	126	485.34	(0.787)	207.72	-0.867
Kelaniya	127	9,740.40	1.119	5,152.58	1.785
Negombo	12B	2,062.71	(0.462)	1,153.74	-0.361
Wattala	12C	3,309.25	(0.206)	1,298.07	-0.287
Mahara	128	4,810.23	0.104	2,787.84	0.517
Colombo Municipality	112	18,021.70	2.825	6,739.21	2.636
Homagama	113	3,664.95	(0.132)	2,127.00	0.162
Kaduwela	114	1,763.70	(0.524)	872.20	-0.511
Kesbewa	115	2,704.07	(0.335)	844.15	-0.526
Kolonnawa	116	7,299.70	0.616	3,285.02	0.783
Moratuwa	117	7,149.69	0.586	1,322.40	-0.271
Nugegoda	118	20,910.01	3.420	6,615.37	2.551
Avissawella	111	4,725.60	0.086	3,481.25	0.889
Attanagalla	121	4,056.02	(0.052)	2,985.58	0.250
Divulapitiya	123	2,081.37	(0.451)	986.80	-0.464
Gampaha	124	6,889.38	0.532	4,429.20	1.397
Minuwangoda	129	2065.13	(0.462)	904.37	-0.494
Mirigama	12A	2,098.16	(0.461)	1,217.13	-0.326
Weke	12D	717.99	(0.739)	428.65	-0.749
Agalawatta	131	205.46	(0.845)	36.14	-0.961
Bandaragama	132	1,275.00	(0.625)	368.82	-0.781
Beruwala	133	810.61	(0.720)	215.44	-0.864
Dodangoda	135	947.53	(0.692)	540.21	-0.699
Horana	136	4,685.71	0.078	1,752.35	-0.039
Kalutara	137	6,063.80	0.362	1,806.63	-0.011
Matugama	138	1,088.53	(0.663)	417.52	-0.755
Panadura	139	2,774.51	(0.316)	126.19	-0.911

Source: Author's Computation

Table8.10

Passenger Kilometer Distribution by AGA Divisions

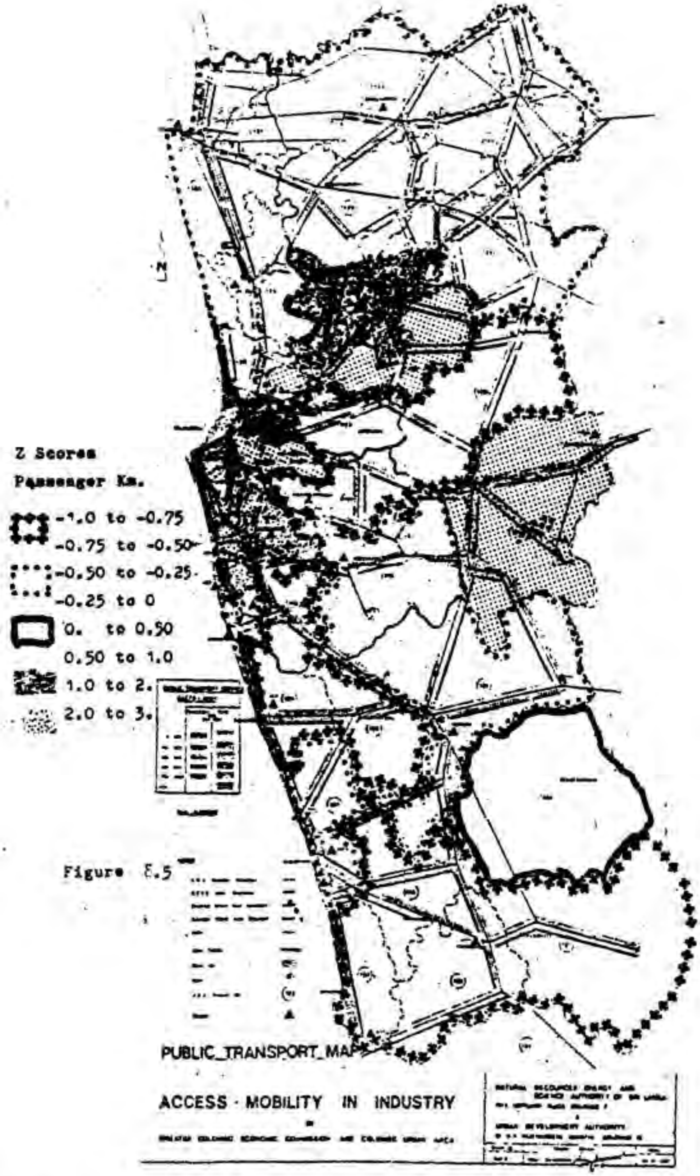
Z Score Range			AGA Divisions
-1.0	-	0.75	126 ;131; 132; 133; 138. 139.
-0.75	-	0.50	122; 114; 115 ;12D ;135.
-0.50	-	0.25	125; 12B; 12C; 123; 129. 12A.
-0.25	-	0	136; 137.
0	-	0.50	113; 117 ;121.
0.50	-	1.0	128; 116; 111.
1.0	-	2.0	127; 124.
2.0	-	3.0	112; 118.

Seat Kilometer Distribution by AGA Divisions

Z Score Range			AGA Divisions
-1.0	-	0.75	126 ; 131.
-0.75	-	0.50	122; 114; 12D; 135; 125 ;132; 133;138.
-0.50	-	0.25	12B ; 123; 129; 12A; 115; 139.
-0.25	-	0	12C ;113; 121.
0	-	0.50	128, 111, 136, 137.
0.50	-	1.0	116 ;117; 124.
1.0	-	2.0	127.
2.0	-	3.0	112.
>3			118.

Source: Author's Copmutation

Table 8.11


Z Scores
Passenger Km.
-1.0 to -0.75
-0.75 to -0.50
-0.50 to -0.25
-0.25 to 0
0. to 0.50
0.50 to 1.0
1.0 to 2.
2.0 to 3.
Figure 8.5
PUBLIC_TRANSPORT_MAP
ACCESS · MOBILITY IN INDUSTRY

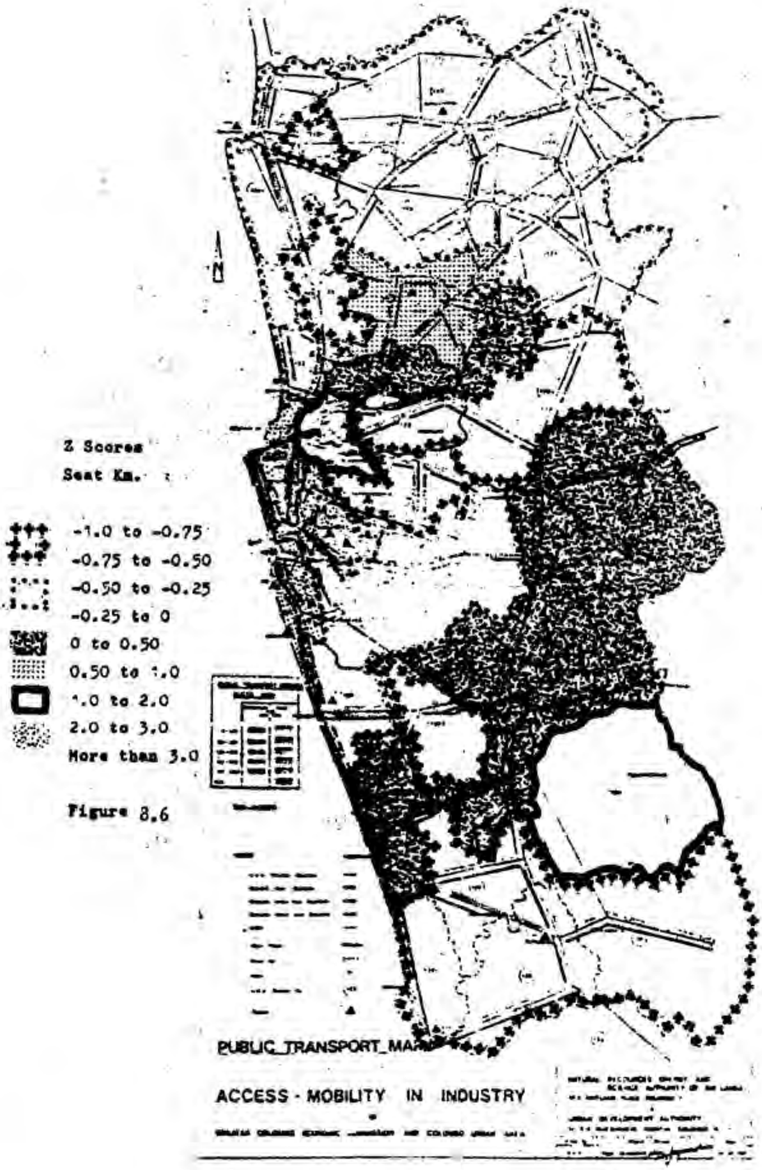

Z Scores
Seat Km.
-1.0 to -0.75
-0.75 to -0.50
-0.50 to -0.25
-0.25 to 0
0 to 0.50
0.50 to 1.0
1.0 to 2.0
2.0 to 3.0
More than 3.0
PUBLIC_TRANSPORT_MAP
ACCESS - MOBILITY IN INDUSTRY

Figure 8.6

But in the northern part of Gampaha district the demand is less and in the Kalutara district it is still less. On the contrary, with seat kilometers there is heavy supply both in the Colombo district and the greater part of the Kalutara district.

It has not been possible to assess the number of buses operating on each route per day and the frequency of the services. Therefore, a different unit of measurement has been used to assess both the demand and the supply of mass transport. **This is the intensity of both supply and demand, as it then becomes a comparable unit for each AGA division. These values have been calculated per 1000 persons as well as per sq. kilometre. The regression analysis shows that the value per sq.kilometre is a better parameter to assess both demand and usage for each AGA division.**

8.5 Vehicular Use and the Quality of Transport Service.

The quality of service performed by the transport system is greatly affected by the level of income of the users, the perceived value of time, acceptable standards and the area of operation. In the mass transport system which is used by the great majority of **urban and sub-urban workers** the main factors which are indicative of the **level of service** are the **waiting time**, the **journey time** and the **walk time** or the distance to the bus stops.

The type of vehicular use and the income distribution of urban and suburban workers in manufacturing industry in the CMR (CMA, CSA, GCEC) are shown in table 8.12 The table illustrates that the largest proportion of workers use both public

Vehicular Use and Income Distribution of Workers in Manufacturing Industry

Vehicle Used	Type	Income Group in Rupees										
		< 500	501 750	751 1000	1001 1200	1201 1500	1501 1750	1751 2000	2001 2500	More 2500	Total	Perc. %
Own Vehicle	1	1	10	14	10	10	1	0	0	1	47	7.2
Private Transport	2	0	13	8	4	3	0	0	0	0	28	4.3
Public Transport	3	2	39	20	13	5	1	0	0	0	80	12.4
Official Transport	4	0	0	0	0	0	0	0	1	0	1	0.1
Private & Public	5	17	205	144	70	21	4	3	1	1	466	72.2
Private & Official	6	0	0	0	0	0	0	0	0	0	0	0
Public & Official	7	0	0	1	0	0	0	0	0	0	1	0.1
Pri.Pub.& Official	8	0	0	0	0	0	0	0	0	0	0	0
Own Vehicle & Pri.	9	0	0	0	1	0	0	1	0	0	2	0.3
Own Vehicle & Pub.	10	0	0	0	0	0	0	0	0	0	0	0
Own Vehicle & Off.	11	0	0	0	0	0	0	0	0	0	0	0
Other	12	0	13	6	0	1	0	0	0	0	20	3.1
TOTAL		20	280	193	98	40	6	4	2	2	645	100
Perccentage		3.1	43.4	29.9	15.1	6.2	0.9	0.6	0.3	0.3	100	
Cumulative %		3.1	46.5	76.4	91.6	97.8	98.7	99.3	99.6	100		

Source: Sample Travel Survey   Author's Computation

Table 8.12

Figure 8.7

INCOME DISTRIBUTION OF WORKERS

IN C.M.R.

Spatial Distribution of Vehicular Use in Representative AGA Divisions in the CMR

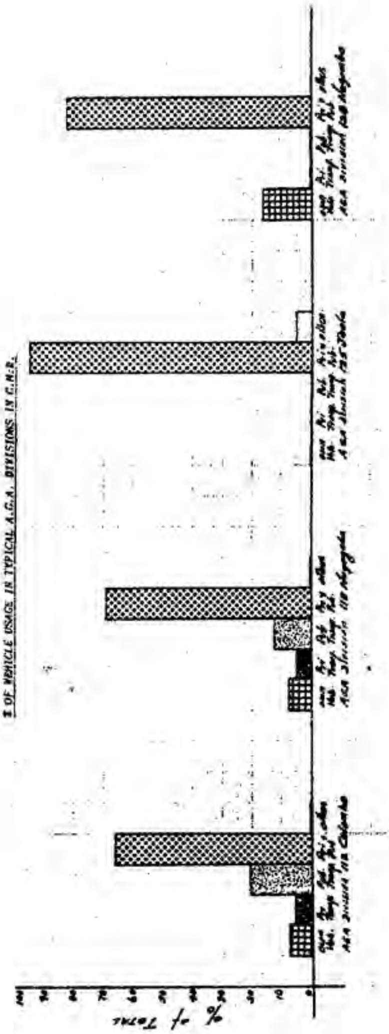
Zone	AGA	Division	Own	Private	Public	Private	Other	Total
CMA	112	Colombo MC	7.5	5.6	20.7	66	0	100
CSA	118	Nugegoda	7.5	5	12.5	69.3	0	100
GCEC	125	Jaela	0	0	0	95	5	100
GCEC	128	Negombo	17.6	0	0	82.3	0	100

Source: Sample Travel Survey   Author's Computation

Table 8.13

Figure 8.8

% OF VEHICLE USAGE IN TYPICAL A.G.A. DIVISIONS IN C.N.R.



and private transport services (72.2%). The next largest group uses exclusively public transport (12.4%). Those who use their own vehicle amounts to 7.2% while the private vehicle users are 4.3%. **Thus, 84.6% of the industrial workers use the mass transport namely, the private and the public bus services.**

This relationship between the vehicular use and the income level reveals that the biggest number of employees who use mass transportation fall into the groups which derive monthly incomes of Rs.501 to Rs.750, and Rs.751 to Rs.1000. They account for 43.4% and 29.9% respectively. It may, therefore, be deduced that since 76.4% of the employees receive income less than Rs.1000 they belong to the semi-skilled or labour category

This labour sector is also the biggest employee category in any type of manufacturing industry and this analysis shows that it cannot afford to use any other means of travel except mass transport. Therefore, one of the important locational factors for industries as illustrated in this study is the presence of a good road network and the availability of mass transport services.

The income distributions of workers in the CMA, CSA and the GCEC are illustrated in figure 8.7. The incomes in the CMA and the CSA are skewed and are more or less alike except that the CMA distribution is more spread out than that of the CSA. Almost 50% of the workers earn less than Rs.750 per month and 99% earn less than Rs.1750. The incomes in the GCEC are more normally distributed.

Travel Mode of Urban and Suburban Workers

Typical AGA Divisions in CMR

Region	Zone Code	AGA Division	Travel Mode Walk	Cycle	Motor Cycle	Car	Passenger Vehicle	CTB Bus	Total
CMA	112		32	2	3	1	36	45	119
%		Colombo	26.9	1.7	2.5	0.8	30.3	37.8	100
CSA	118		235	217	5	1	245	278	791
%		Nugegoda	29.7	3.4	0.6	0.1	31	35.1	100
GCBC	125		10	0	0	0	19	17	46
%		Jaela	21.7	0	0	0	41.3	37	100
	128		15	3	0	0	14	13	45
%		Katana	33.3	6.7	0	0	31.1	28.9	100

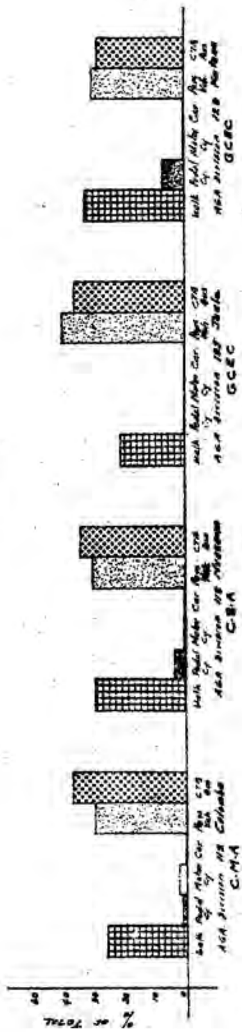
Source: Sample Travel Survey 1985

Author's Computation

Table 8.14

Figure 8.9

TRAVEL MODE OF URBAN AND SUB-URBAN WORKERS
TYPICAL A.G.A. DIVISIONS IN C.M.R.



Walking Distance From Home to Bus Stop

Typical AGA Divisions in CMR

Region	Zone Code	AGA Division	Walking Distance in Miles Less .25	0.25 to.50	.50 to.75	.75 to 1.0	More than 2.0	Total
CMA	112	Colombo	32	12	4	1	0	53
%				60.4	22.6	7.5	1.9	100
CSA	114	Kaduwela	53.6	28.6	1.8	10.7	0	100
%								
%	115	Kesbewa	66.7	16.7	5.6	11.1	0	100
%	116	Kolonnawa	37	55.6	3.7	3.7	0	100
%	117	Moratuwa	75	25	0	0	0	100
%	118	Nugegoda	57.7	25.2	6.3	3.8	2.3	100
GCEC	125	Ja-ela	41	5	6	4	0	57
%			71.9	8.8	10.5	7	0	100
%	126	Katana	66.7	0	0	0	0	100
%	127	Kelaniya	80	20	0	0	0	100
	12B	Negombo	25	14	4	2	0	48
%			52	29.2	8.3	4.2	0	100
%	12C	Wattala	50	50	0	0	0	100
Average			402	172	41	31	9	687
			58.5	25	6.1	4.5	1.3	100

Source: Sample Travel Survey 1985 Author's Computation

Table 8.15

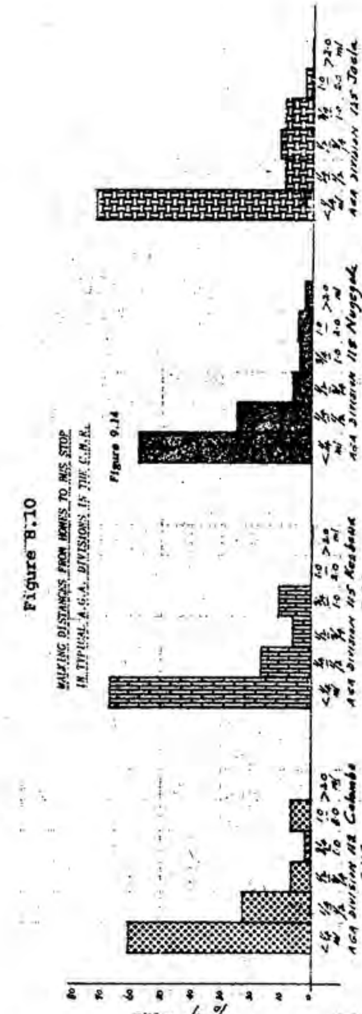


Figure 8.10
WALKING DISTANCES FROM HOMES TO BUS STOP
IN TYPICAL A.G.A. DIVISIONS IN THE C.M.R.
Figure 9.14
% of Total

The table 8.13 and shows the percentage spatial distribution of vehicular use in representative AGA divisions in the (CMR),CMA, CSA and the GCEC. **This further reinforces the assumption that the location of industries are to a large extent guided by the availability of mass transport.**

In the GCEC area which has a larger number of manufacturing industries the greater number of workers use mass transport. For example, in Jaela AGA (125) division 95% of the workers and in Negombo AGA (12B) division 83% use mass transport. But in the CSA in Nugegoda AGA (118) division 69.3% use this means of transport. On the other hand in the Colombo AGA (112) division (CMA) with relatively a lesser number of manufacturing industrial establishments accounts only for 66% of the workers using mass transport. These are illustrated in figure 8.8 for the typical AGA divisions of Colombo(112), Nugegoda(118), Jaela(125), and Katana(128)

This shows clearly the close relationship between the transport facilities and the location of industries in the study area.

The travel modes of urban and suburban workers in representative AGA divisions in the CMR as given in table 8.14 also show the close relationship between industrial workersandmasstransport,thosewhouse thepassengervansand the SLCTB buses. For example, in the Jaela AGA division which has a higher number of industrial concerns records 78.3% of workers as using the public bus as the main mode of transport. In the CMA with a lesser number of industries only 68.1% of workers use mass transport. On the other hand greater proportions 26.69% in Colombo and 29.7% in Nugegoda walk to work. These are illustrated in figure 8.9 for the typical AGA divisions of Colombo(112), Nugegoda(118), Jaela(125) and Katana(128).

The time taken to walk to and from the homes and the work

Walking Distance from Bus Stop to Work Station Colombo Metropolitan Region

Region	Zone	AGA	Walking Distance in Miles						
	Code	Division	Less .25	0.25	0.50	0.75	1.0	>2	Total
CMA	112		48	13	1	1	0	0	63
%		Colombo	98.6	24.5	1.9	1.9	0	0	100
CSA	114	Kaduwela	68.5	24.1	5.6	0	1.9	0	100
%%	115	Kesbewa	76.5	23.5	0	0	0	0	100
%	116	Kolonnawa	81.5	11.1	3.7	3.7	0	0	100
%	117	Moratuwa	93.8	3.1	0	0	3.1	0	100
	118	Nugegoda	314	53	7	5	11	4	397
%			79.7	13.5	1.8	1.3	2.8	1	100
GCEC	125	Jaela	36	11	2	2	2	0	53
%			67.9	20.8	3.8	3.8	3.8	0	100
%	126	Katana	0	0	0	100	0	0	100
%	127	Kelaniya	100	0	0	0	0	0	100
	12B	Negombo	32	10	5	1	0	0	48
%			66.7	20.8	10.4	2	0	0	100
%	12C	Wattala	100	0	0	0	0	0	100
Average			520	107	19	13	14	4	677
			76.8	15.8	2.8	1.9	2	0.6	100

Source: Sample Travel Survey

Author's Computation

Table 8.16

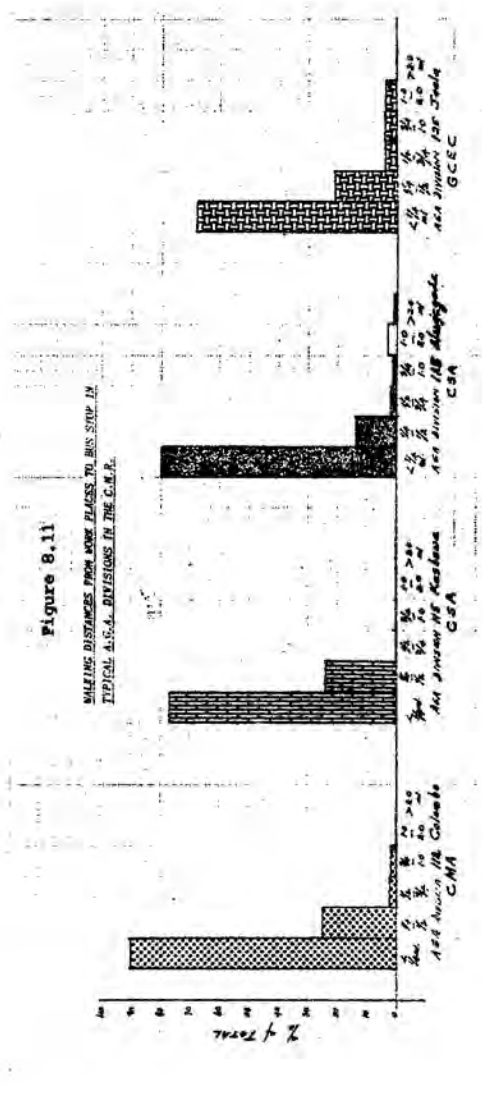


Figure 8.11

WALKING DISTANCES FROM WORK PLACES TO BUS STOP IN TYPICAL A.G.A. DIVISIONS IN THE C.M.R.

places of the workers to the bus stops depend on the distances between the bus stops and the respective places. **The distances the passengers have to walk to bus stops is the index of the coverage provided by the bus services.** Typical walking distances from homes to bus stops in representative AGA divisions of the CMR are given in table 8.15. It illustrates that on the average 58.5% of the workers have to walk less than o.25 miles to and from the home to the bus stop. This is shown in figure 8.10 for the typical AGA divisions of the Colombo(112), Kesbewa(115), Nugegoda(118) and Jaela(125).

While this is so, as much as 76.8% of the workers have to walk less than o.25 miles to and from the bus halt to the place of work(table8.16). This is illustrated in the figure 8.11 for the typical AGA divisions of Colombo(112), Kesbewa(115), Nugegoda(118) and Jaela(125). Of the workers 83.5% have to walk less than 0.50 miles from their homes while 92.6% of workers have to walk less than 0.50 miles form their place of work to the bus stops. This table and the figure illustrate that the workers are serviced by a good road network.

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9

ACCESS-MOBILITY IN INDUSTRIAL LOCATION

9.0 Correlation ; Access-Mobility in Industrial Location

9.1 Inter-relationships

As outlined in the methodology in figure 2.2, the analysis of socio-economic factors, access and mobility relationships have been developed systematically at various stages. The physical and demographic features and prices of industrial land as related to industry were identified as well as the network and route characteristics. The close association of traffic intensities and public transport services to the location of industries was also demonstrated.

The main parameters which have the greater association to the location of manufacturing industry may now be listed as follows;

A. GENERAL FACTORS

1. **Active Population**
2. **Price of Industrial Land**

B. ACCESS FACTORS

3. **Road Density**
4 **Link Density**
5. **Intersection Density**
6. **Phi Index**
7. **Beta Index**
8. **Radial Distance to Colombo**
9. **Intersection Coverage Factor**

Access-Mobility Relationships to Industry

Zone	Code Number	Traffic Density Vehicles sq.km	Land Value 1984 Rupees	Link Density / 100 sq. km	Inters Density / 100 sq.km	Seal Km.	Inter-section Traffic Flow Veh. Km	Road Density / 100 sq.km	Active Population	Inter-section Cover Factor	Radial Dist. Colombo Km.	Beta Index	Phi Index	Indust Density / 100 sq. km
Biyagama	122	717	3,000	11.31	11.32	832	3,000	42.00	32322	12.4	16.35	0.88	1.97	11.31
Ja-ela	125	1,714	5,000	8.83	16.40	1,681	21,000	25.09	39845	7.3	18.53	0.88	1.65	44.19
Katana	126	1,342	1,750	39.82	14.68	483	5,000	90.40	25321	5.8	29.40	0.77	3.09	79.65
Kelaniya	127	4,426	5,000	38.56	30.75	9,740	13,000	87.88	39306	8.3	8.05	0.93	2.56	85.58
Negombo	12B	1,814	4,000	17.98	16.30	2,063	13,000	47.97	45844	13.8	29.80	1.05	3.26	16.42
Wattala	12C	3,375	7,000	30.30	17.53	3,309	19,500	61.75	35094	7.8	9.95	0.93	2.17	51.95
Mahara	128	1,050	3,500	12.53	9.83	4,810	16,000	38.98	39092	7.9	13.65	0.71	2.15	14.62
Homagama	113	697	3,500	7.60	9.04	3,665	11,670	28.02	53827	14.5	21.07	0.80	2.62	17.73
Kaduwela	114	863	4,500	6.61	5.83	1,764	7,000	37.79	44643	20.7	16.95	0.75	1.33	20.92
Kesbewa	115	1,424	3,250	20.48	25.18	2,704	11,500	31.29	44044	10.9	14.65	1.00	1.79	34.66
Kolonnawa	116	2,910	10,000.	34.19	21.72	7,300	7,500	69.98	38882	11.2	8.85	0.90	2.33	83.59
Moratuwa	117	3,912	12,500	31.22	33.26	7,150	29,500	46.93	46097	5.0	16.50	1.00	1.92	140.48
Nugegoda	118	7,274	15,000	59.80	34.29	20,910	32,500	79.72	142451	8.1	13.20	1.09	2.92	175.98
Avissawella	111	408	2,500	7.39	28.33	4,726	9,000	14.88	39986	21.2	29.30	1.06	1.63	5.48
Attanagalla	121	845	1,750	13.00	12.87	4,056	5,000	40.38	36158	0.0	0.00	0.91	3.31	8.45
Divulapitiya	123	671	1,750	10.08	10.89	2,081	8,000	41.66	32841	19.3	43.35	0.95	2.89	12.60
Gampaha	124	1,833	5,000	19.05	16.98	6,889	12,000	49.86	41670	11.8	24.53	1.00	2.74	10.58
Minuwangoda	129	903	2,250	12.05	12.24	2,065	9,000	43.06	37005	17.6	30.20	1.00	2.83	16.57
Mirigama	12A	836	1,500	16.54	16.44	2,068	8,670	51.94	36474	13.0	41.10	1.11	3.58	6.40
Weke	12D	296	1,250	5.16	12.25	718	5,000	18.56	33410	31.8	30.95	0.90	2.04	4.55
Aggalawatta	131	113	1,500	0.83	4.89	205	6,000	5.65	24013	20.4	55.70	0.75	1.24	2.77
Bandaragama	132	311	1,500	3.54	9.37	1,275	7,000	12.50	21448	9.9	29.30	0.75	1.27	1.18
Beruwala	133	1,037	2,500	2.74	5.47	811	6,000	25.05	33040	17.2	58.60	0.67	1.27	10.96
Dodangoda	135	260	1,750	4.67	3.60	948	3,000	25.99	17042	16.3	46.60	0.63	1.86	9.35
Horana	136	344	3,000	4.69	8.60	4,686	5,670	27.30	48322	17.5	36.07	0.92	1.92	7.43
Kalutara	137	1,267	5,000	14.38	12.46	6,064	10,670	51.51	37196	12.9	38.17	1.00	2.21	17.97
Matugama	138	281	2,000	4.47	5.59	1,089	4,000	26.67	21626	20.3	56.90	0.86	2.68	8.95
Panadura	139	1,583	7,500	5.22	4.77	2,775	13,000	36.47	45383	20.8	25.60	0.75	1.43	33.04

Author's Computation

Table 9.1

Intercorrelation Matrix of Factors (Correlation r)
In Industrial Location

Factor	Tra Den X1	Land Va X2	Link Den X3	Int Flow X4	Seat Km X5	Int Den X6	Road Den X7	Pop. X8	Int CP. X9	Rad Dist X10	Beta In X11	Phi In X12	Ind Den.
Traffic DensityX1	1.0000	0.8730	0.8840	0.8111	0.8605	0.7560	0.7019	0.7513	0.4748	0.5112	0.4021	0.2269	0.9120
Land ValueX2		1.0000	0.6393	0.8223	0.7846	0.6217	0.4901	0.7152	0.3514	0.4736	0.3140	0.0000	0.8653
Link DensityX3			1.0000	0.5643	0.7420	0.7785	0.8897	0.5491	0.5474	0.5308	0.4109	0.4272	0.8482
Intersection FlowX4				1.0000	0.6886	0.6654	0.3445	0.7009	0.4454	0.4499	0.4005	0.0663	0.7635
Seat KilometerX5					1.0000	0.6848	0.3471	0.8562	0.3594	0.4431	0.4620	0.2556	0.7543
Intersection Den.X6						1.0000	0.5185	0.5334	0.4327	0.5396	0.6933	0.2502	0.7362
Road Density X7							1.0000	0.3718	0.5197	0.4568	0.3251	0.5784	0.6702
Population X8								1.0000	0.1881	0.3556	0.4300	0.6682	0.6676
Intersec. Cov. Fac. X9									1.0000	0.3857	0.1382	0.3259	0.4733
Radial Distance X10										1.0000	0.2516	0.1552	0.4322
Beta Index X11											1.0000	0.5357	0.2869
Phi Index X12												1.0000	0.1631
Industrial Density ID													1.0000

Author's Computation

Table 9.2

C. MOBILITY FACTORS

10 Traffic Intensity

11 Intersection Traffic Flow

12. Seat Kilometers

The values of these factors for all AGA divisions in the CMR are given in table 9.1. All those factors which have low regression coefficients have not been taken into consideration. Correlations between various factors have been worked out and are listed in an inter correlation matrix in table 9.2 in the order of decreasing coefficients of regression with industrial density for each AGA division for all AGA divisions in the CMR.

9.2 Regression Analysis

In the mobility analysis CMA has been ignored as the data relating to this factor could not be estimated with accuracy. Likewise the AGA divisions of Bulathsinhala and Wallalawita have also been ignored.

The last column in the table 9.1 shows how industrial is related toother factors. **Traffic density (0.9120) in an AGA division is the lead factor followed by the price of industrial land (0.8653) and the density of links (0.8482). The intersections in an area seem to play a key role.**

This is seen from the fact that intersection flow (0.7625) and intersection density (0.7362) have appreciably high values. Next in importance is the **supply of public transport** as shown by the **factor for the seat kilometers (0.7543).** The other factors which have values above 0.5 are road density and population.

It may be seen from the second row that land values are mostly affected by intersection flow (0.8223) and seat kilometers (0.7846).

Access-Industry Regression Factors with CMA

Zone	Code Number	Link Density / 100 sq. km	Inters Density / 100 sq.km.	Road Density / 100 sq.km	Phi Index	Beta Index	Indust Density /100 sq.km.	I	I Act. I Est.
Biyagama	122	11.31	11.52	42.06	1.89	0.88	11.31	31.46	-20.15
Ja-Ela	125	8.83	16.40	23.09	1.65	0.88	44.19	25.46	18.73
Katana	126	39.82	14.88	90.40	3.09	0.77	79.65	68.96	10.69
Kelaniya	127	58.56	30.75	87.88	2.56	0.93	85.58	114.07	-28.49
Negombo	128	17.88	16.30	47.97	3.26	1.05	16.42	20.23	-3.81
Wattala	12C	30.30	17.53	61.75	2.17	0.93	51.85	65.12	-13.17
Mahara	12B	12.53	9.83	38.98	2.15	0.71	14.62	21.97	-7.35
Colombo MC	112	185.80	109.54	176.39	5.72	1.41	287.24	306.46	-19.22
Homagama	113	7.40	9.04	28.82	2.62	0.86	17.73	1.37	16.36
Kaduwela	114	6.61	5.83	37.79	1.33	0.75	20.92	29.87	-8.95
Kesbewa	115	20.48	25.18	31.20	1.79	1.00	34.66	48.54	-13.88
Kolonnawa	116	34.19	21.72	69.98	2.33	0.90	83.59	72.25	11.34
Maharagama	117	31.22	33.26	46.93	1.92	1.00	140.48	71.60	68.88
Nugegoda	118	59.80	34.29	79.72	2.92	1.09	175.98	108.75	67.23
Avissawella	111	7.39	28.33	14.88	1.63	1.06	5.48	28.30	-22.82
Attanagalla	121	13.00	12.87	40.38	3.31	0.91	8.45	4.27	4.18
Divulapitiya	123	10.08	10.89	41.06	2.89	0.95	12.60	9.86	2.74
Gampaha	124	19.05	16.98	49.86	2.74	1.00	10.58	32.84	-22.26
Minuwangoda	129	12.05	12.24	43.06	2.83	1.00	16.57	16.05	0.52
Mirigama	12A	16.54	16.44	51.94	3.58	1.11	6.40	14.75	-8.35
Weke	12D	5.16	12.25	18.56	2.06	0.90	4.55	8.73	-4.18
Aggalawatta	131	0.83	4.89	5.65	1.24	0.75	2.77	7.17	-4.40
Bandaragama	132	3.54	9.37	12.50	1.27	0.75	1.18	15.45	-14.27
Beruwala	133	2.74	5.47	25.05	1.27	0.67	10.96	17.50	-6.54
Bulathsinhala	134	0.85	0.00	13.01	1.00	0.50	6.38	8.94	-2.56
Dodangoda	135	4.67	3.60	25.99	1.86	0.63	9.35	6.73	2.62
Horana	136	4.89	8.60	27.30	1.92	0.92	7.43	14.06	-6.63
Kalutara	137	14.24	12.46	51.51	2.21	1.00	17.97	36.49	-18.52
Matugama	138	4.47	5.59	26.67	2.68	0.86	8.95	-5.02	13.97
Panadura	139	5.22	4.77	36.47	1.43	0.75	33.04	24.77	8.27

Author's Computation

Table 9.3

Access-Industry Regression Analysis
with CMA

Step	Constant		Coefficient(b)						
	X1	X2	X3	X4	X5		R	R2	Standard Error
1.00	4.055	1.467					0.919	0.845	25.056
2.00	3.556	1.343	0.229				0.920	0.845	25.480
3.00	3.930	1.380	0.216	-0.012			0.920	0.845	25.965
4.00	21.037	1.102	0.796	0.601	-19.388		0.935	0.874	23.949
5.00	11.908	1.377	0.382	0.506	-21.062	20.685	0.935	0.874	24.398

Regression Equation is

$$I = 11.91 + 1.38\ X1 + 0.38\ X2 + 0.51\ X3 - 21.06\ X4 + 20.69\ X5$$

Industrial Density = I ; Link Density = X1 ; Intersection Density = X2 ;
Road Density = X3 ; Phi Index = X4 ; Beta Index = X5

Author's Computation

Table 9.4

Acccess Industry Factors for Regression

without CMA

Zone	Code Num	Link Den. / 100 sq.km	Inters Den. / 100 sq.km	Road Den. / 100 sq.km	Phi Index	Beta Index Factor	Inter-sect. Cover Km.	Rad. Dist. Colom sq. km	Ind. Den. / 100 Den.	I Est. Ind.	I Act. - I Est.
Biyagama	122	11.31	11.52	42.06	1.89	0.88	12.4	16.35	11.31	19.44	-8.13
Jaela	125	8.83	16.40	23.09	1.65	0.88	7.3	18.53	44.19	27.15	17.04
Katana	126	39.82	14.68	90.40	3.09	0.77	5.8	29.40	79.65	78.88	0.77
Kelaniya	127	58.56	30.75	87.88	2.56	0.93	8.3	8.05	85.38	136.58	-51.00
Negombo	12B	17.98	16.30	47.97	3.26	1.05	13.8	29.80	16.42	21.67	-5.25
Wattala	12C	30.30	17.53	61.75	2.17	0.93	7.8	9.95	51.95	63.07	-11.12
Mahara	128	12.53	9.83	38.98	2.15	0.71	7.9	13.65	14.62	25.28	-10.66
Homagama	113	7.60	9.06	28.02	2.62	0.80	14.3	21.07	17.73	5.45	12.28
Kaduwela	114	6.61	5.83	37.79	1.33	0.75	20.7	16.95	20.92	9.79	11.13
Kesbewa	115	20.48	25.18	31.29	1.79	1.00	10.9	14.65	34.66	55.83	-21.17
Kolonnawa	116	34.19	21.72	69.98	2.33	0.90	11.2	8.85	83.59	74.41	9.18
Moratuwa	117	31.22	33.26	46.93	1.92	1.00	5.6	16.50	140.48	89.80	50.68
Nugegoda	118	59.80	34.29	79.72	2.92	1.09	8.1	13.20	175.98	136.34	39.64
Avissawella	111	7.59	28.33	14.88	1.63	1.06	21.2	29.30	5.48	31.71	-26.23
Attanagalla	121	13.00	12.87	40.38	3.31	0.91	0.0	0.00	8.45	10.10	-1.65
Divulapitiya	123	10.08	10.89	41.66	2.89	0.95	19.3	43.35	12.60	6.12	6.48
Gampaha	124	19.05	16.98	49.86	2.74	1.00	11.8	24.53	10.58	31.55	-20.97
Minuwangoda	129	12.05	12.26	43.06	2.83	1.00	17.6	39.20	16.57	8.69	7.88
Mirigama	12A	16.54	16.44	31.84	3.58	1.11	13.0	41.10	6.40	15.30	-8.90
Wele	12D	5.16	12.25	18.56	2.06	0.90	31.8	30.95	4.55	3.53	1.02
Agalawatta	131	0.83	4.89	5.63	1.24	0.75	20.4	55.70	2.77	9.03	-6.26
Bandaragama	132	3.54	9.37	12.50	1.27	0.75	9.9	29.30	1.18	17.72	-16.54
Beruwala	133	2.74	5.47	25.85	1.27	0.67	17.2	58.60	10.96	16.19	-5.23
Dodangoda	135	4.67	3.80	25.99	1.86	0.63	16.3	46.60	9.35	11.14	-1.79
Horana	136	4.69	8.60	27.30	1.92	0.92	17.5	36.07	7.43	3.00	4.43
Kalutara	137	14.24	12.46	51.51	2.21	1.00	12.9	36.17	17.97	22.52	-4.55
Matugama	138	4.47	5.59	26.67	2.68	0.86	20.3	56.90	8.95	-3.15	12.10
Panadura	139	5.22	4.77	36.47	1.43	0.75	20.8	25.60	33.04	6.23	26.81

Author's Computation

Table 9.5

Access-Industry Regression Analysis without CMA

Step	Constan	Coefficients(b) X1	X2	X3	X4	X5	X6	X7	R	R2	STD Error
1.00	-5.11	2.28							0.85	0.72	23.21
2.00	-12.16	1.91	0.94						0.86	0.73	23.04
3.00	10.44	3.22	0.10	-0.77					0.87	0.75	22.63
4.00	22.08	2.71	0.43	-0.28	-12.72				0.88	0.78	21.95
5.00	41.63	2.35	1.18	-0.19	-8.96	-41.14			0.88	0.78	22.26
6.00	42.28	2.37	1.08	-0.20	-9.50	-36.42	-0.14		0.88	0.78	22.77
7.00	38.21	2.28	1.30	-0.13	-10.24	-38.63	-0.34	0.22	0.89	0.79	23.17

Industrial Density=I; Road Density=X3; Phi Index =X4;

Beta Index=X5; Intersection Cover Factor=X6; Radial Distance=X7

Regression Equation is;

$$I = 38.2090 + 2.2760\ X1 + 1.2983\ X2 - 0.1323\ X3 - 10.244\ X4 - 38.626\ X5 - 0.3423\ X6 + 0.2154\ X7$$

Author's Computation

TABLE 9.6

Link density is mainly controlled by road density (0.8897), intersection flow by population (0.7009), seat kilometers by population (0.8562), intersection density by beta index (0.6933) and the road density by the Phi index (0.5784), intersection coverage factor by road density (0.5857), radial distance by industrial density (0.4522) and Beta index by the Phi index (0.5357). A number of regression models of industrial location as related to access, mobility, access-mobility as a conjoint factor and all other factors considered have been developed as stated below;

1. **Access with CMA**
2. **Access without the CMA**
3. **Mobility without the CMA**
4. **Access-Mobility without the CMA**
5. **All Relevant Factors without the CMA**

Stepwise regressionanalysis has been carried out and the table 9.3 shows the data for the first case with access only and with the CMA included. The table 9.4 shows the results of the stepwise regression analysis. Five factors were considered and the regression coefficient (R) is seen to increase from 0.9192 in step one to 0.9349. The coefficient of determination (R squared) increases from 0.845 to 0.874 and the standard error decreases from 25.056 to 24.398. This means that **with the CMA included the location of industries may be explained by access alone by 87.4% with an error of 24.40.**

The data for the second case shown in table 9.5 is with access only and without the CMA but with radial distance from Colombo and the Intersection Coverage Factor included. The results of regression analysis is shown in table 9.6. In this case the regression coefficient rises from 0.8482 to 0.8861 whereas the coefficient of determination increases from 0.7195 to 0.7851. The standard error has decreased from the previous value to 23.167.

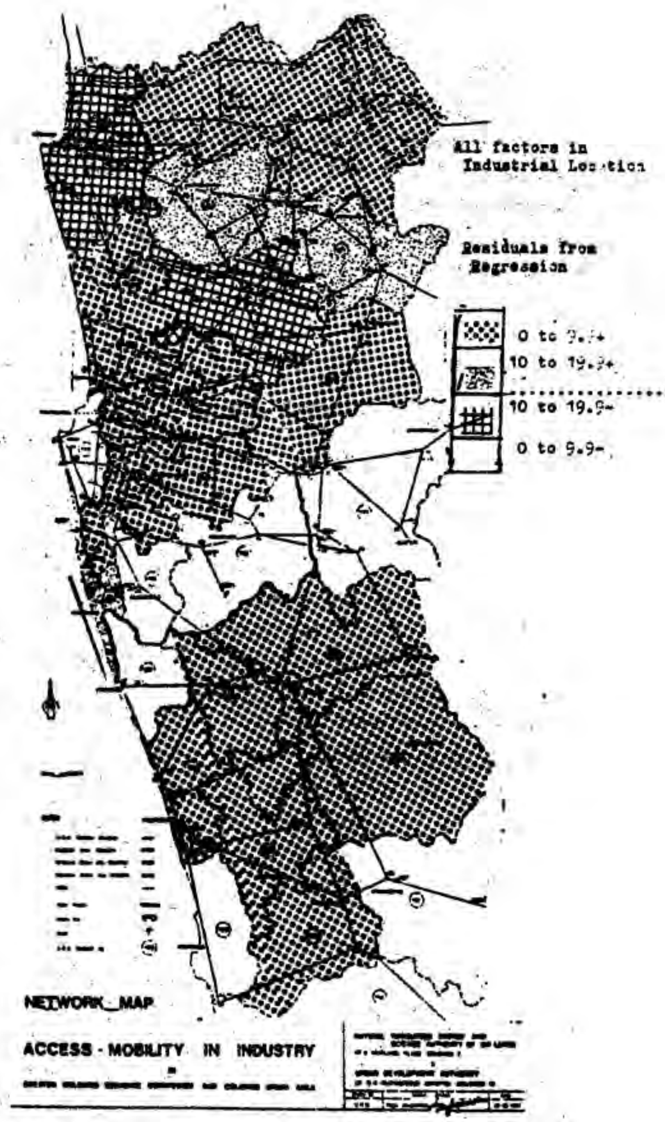
All factors in
Industrial Location
Residuals from
Regression
0 to 9.9+
10 to 19.9+
10 to 19.9-
0 to 9.9-
NETWORK MAP
ACCESS - MOBILITY IN INDUSTRY

Figure 9.1

Mobility and Industry Factors for Regression without CMA

Zone	Code Number	Traffic Density Vehkm sq.km	Seat K.meters	Inter-section Traffic Flow Veh. Km	Indust Density / 100 sq. km	I Estimate Indust Density	I Actual minus I Estimated
Biyagama	122	717	852	5,000	11.31	13.76	-2.45
Ja-ela	125	1,714	1,081	21,000	44.19	44.97	-0.78
Katana	126	1,342	485	5,000	79.65	30.42	49.23
Kelaniya	127	4,426	9,740	15,000	85.58	102.59	-17.01
Negombo	12B	1,814	2,063	13,000	16.42	43.95	-27.53
Wattala	12C	3,375	3,309	19,500	51.95	85.55	-33.60
Mahara	128	1,050	4,810	16,000	14.62	22.03	-7.41
Homagama	113	697	3,663	11,670	17.73	12.52	5.21
Kaduwela	114	863	1,764	7,000	20.92	17.25	3.67
Kesbewa	115	1,424	2,704	11,500	34.66	32.47	2.19
Kolonnawa	116	2,910	7,300	7,500	83.59	63.98	19.61
Moratuwa	117	3,912	7,150	29,500	140.48	98.86	41.62
Nugegoda	118	7,274	20,910	32,500	175.98	170.89	5.09
Avissawella	111	408	4,726	9,000	5.48	2.70	2.78
Attanagalla	121	845	4,056	3,000	8.45	13.26	-4.81
Divulapitiya	123	671	2,081	8,000	12.60	12.29	0.31
Gampaha	124	1,833	6,889	12,000	10.58	38.29	-27.71
Minuwangoda	129	905	2,085	9,000	16.57	18.77	-2.20
Mirigama	12A	836	2,088	8,670	6.40	16.85	-10.45
Weke	12D	296	718	5,000	4.35	2.99	1.36
Aggalawatta	131	113	205	6,000	2.77	-0.75	3.52
Bandaragama	132	311	1,275	7,000	1.18	3.51	-2.33
Beruwala	133	1,037	811	6,000	10.96	22.51	-11.55
Dodangoda	135	260	948	3,000	9.35	0.99	8.36
Horana	136	344	4,686	5,670	7.43	-0.23	7.66
Kalutara	137	1,267	6,064	10,670	17.97	24.06	-6.09
Matugama	138	281	1,089	4,000	8.95	1.77	7.18
Panadura	139	1,583	2,775	13,000	33.04	37.11	-4.07

Author's Computation Table 9.7

Mobility-Industry Regression Analysis
without CMA

Step	Constant	Coefficients					
		X1	X2	X3	R	R squared	Std. Error
1	-4.215	0.0247			0.9120	0.8317	17.9790
2	-3.729	0.0275	-0.0012		0.9139	0.8353	18.1388
3	-5.809	0.0260	-0.0012	0.0004	0.91477	0.8368	18.4276

Regression Equation is:

$$I = -5.80669 + 0.02596\ X1 - 0.0019\ X2 + 0.00040\ X3$$

Industry = I:	Traffic Intensity = X1
Seat Km. = X2	Intersection Traffic Flow = X3

Author's Computation

Table9.8

Regression Analysis -Factors in Industrial Location

Step	Constant	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	R	R Squar	Std. Err.
						Coefficients										
1	-4.215	0.025												0.912	0.832	17.979
2	-9.309	0.018	0.004											0.923	0.852	17.204
3	-19.692	-0.003	0.008	1.524										0.947	0.897	14.666
4	-25.485	-0.008	0.007	1.810	0.001									0.950	0.903	14.486
5	-24.713	-0.005	0.008	1.783	0.009	-0.001								0.953	0.908	14.417
6	-24.576	-0.005	0.008	1.813	0.001	-0.001	-0.055							0.953	0.908	14.753
7	-1.350	-0.015	0.010	3.983	0.001	-0.002	-1.045	-0.943						0.965	0.930	13.181
8	-10.567	-0.018	0.010	4.290	0.001	-0.004	-0.965	-0.990	0.000					0.969	0.939	12.658
9	-8.828	-0.017	0.010	4.265	0.001	-0.004	-0.952	-0.997	0.000	-0.093				0.969	0.939	12.993
10	-21.715	-0.019	0.011	4.282	0.001	-0.004	-0.652	-0.970	0.001	-0.592	0.447			0.976	0.952	11.825
11	4.233	-0.015	0.010	3.054	0.001	-0.004	0.817	-0.445	0.001	-0.480	0.512	-83.060		0.980	0.961	11.041
12	9.756	-0.014	0.010	2.909	0.000	-0.004	1.121	-0.525	0.001	-0.343	0.494	-84.870	5.751	0.981	0.963	11.087

The Regression Equation is;

$$I = -9.75606 - 0.0141X1 + 0.00997X2 + 2.90879X3 + 0.00045X4 - 0.0038X5$$
$$+ 1.12117X6 - 0.5254X7 + 0.00057X8 - 0.3428X9 + 0.4961X10 - 84.873X11 + 5.7509X12$$

Traffic Intensity= X1; Land Price= X2; Link Density= X3; Intersection Traffic Flow= X4Seat Km= X5;
Intersection Density= X6; Road Density= X7; Population= X8; Intersection Cover Factor= X9;
Radial Distance= X10; Beta Index= X11 Phi Index= X12.

Author's Computation

Table 9.11

This implies that **excluding the CMA the access function explains industrial location by 78.51% with a standard error of 23.17.**

The data for mobility only without the CMA are given in table 9.7 with the results of regression in the table 9.8 where traffic density, seat kms and intersection traffic flow are considered. It may be observed that in this case the regression coefficient has risen to a high value of 0.9148 and R squared to 0.8368 but with an increase in the standard error. Thus, **mobility alone explains 83.68% of the industrial location with a standard error of 17.84.**

Data where all access and mobility factors are considered without the CMA as shown in table 9.1 are subjected to regression analysis and the results are given in the table9.9together with the residuals due to the regression shown in the figure 9.1.

When both access and mobility are considered without the CMA 89.2% of industrial locations could be attributed to the transport function and locations could be predicted with an error of 17.84

In the final instance where populations and price of land are considered in addition to the access-mobility function without the CMA 98.10% could be explained and the locations be predicted with a standard error of 11.09.

Thus, the postulate made at the beginning of the study regarding the access-mobility as a conjoint factor in the location of major industries is amply illustrated and justified by this research.

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10

CONCLUSIONS, RECOMMENDATIONS AND FURTHER RESEARCH

10.0 Conclusions Recommendations And Further Research

10.1 Conclusions.

The analysis of industry showed that 97% of all industries were in manufacturing. It revealed that of all industries in the island 23.4 % were located in the CMR, employing 35.6 % persons, with a value of output of 64.6 % and a value added amount of 62.5 % thus, emphasizing the role of industry in the CMR. It was also shown that the major industries with employment of over 100 persons each, contributed to the major proportion of employment (85% to 93%), fixed capital, employee income and value of production.

In terms of population the CMR has the highest density. It was demonstrated that the populations were very closely related to industrial distribution in particular the active population.

The growth trends of the three variables population, employment and industry among the AGA divisions were closely related to each other. They indicate definite threshold levels, with four stages of growth from low to high levels.

Further analysis indicates that industry in the CMR could be categorized into five clear levels namely, highly developed, developing, two stages of transition and a highly undeveloped stage.

An important feature of location is the clustering of industries around the City of Colombo which is clearly illustrated in the distribution of industry in the CMR. The dominating influence of the City of Colombo is apparent when radial distances of the location of industries are computed; 50% of industries are within 10 km.; 80% within 18 km.; and 99% within 36 km. of Colombo Fort. Furthermore, the influence of the main infrastructure may be seen from the fact that 63% of the industries analysed were located close to A routes and the balance of 37% were within the vicinity of B routes. The average distance of an industrial location is less than half a kilometre in the CMA and approximately one kilometre in the CSA and the GCEC from A or B route.

The sharp disparity in location is very clearly seen by the concentration of manufacturing employment towards the north and north western coastline and the decline towards the south and southeast as shown by the areal distribution of the location quotient among the AGA divisions.

The Z score distributions of industry and employment by AGA divisions show the highly advantageous position of the CUA and the GCEC and the controlling influence of the AGA divisions of Colombo and Nugegoda when compared with the rest of the AGA divisions in the CMR. Where industrial diversification is considered, again it is apparent that the AGA divisions in the CUA and the GCEC areas are in a highly advantageous position.

The analysis shows that of all network parameters the densities of intersections, links, and roads play a very prominent role followed by the Beta and Phi functions in industrial location. These factors when combined into a Z score shows clearly the levels of network development. The industrial location and industrial diversification emphasize the close affinity of the network or access function to industrial development. When the infrastructure system of links and nodes are considered with population densities a highly complex structure of high and low level urban centres emerge which bear a close relationship to the pattern of vehicle flows and industrial location.

An interesting finding is the intersection coverage factor which may be considered a new network function. It measures the coverage provided by the links connected to an intersection in a network. It is associated with the total length of links connected to an intersection to the total traffic flow through the intersection.

Together with the least radial distance to the most dominant urban centre in the region this enables a preliminary identification in planning, of potential growth centres (traffic loading points) even before detailed traffic studies are carried out in any particular region.

As has been postulated land values have a close relationship to access and mobility. This is well illustrated by the relationship of land price to road density, vehicle density and number of industries.

The major factors controlling mobility which are related to industrial location are traffic intensity, intersection traffic flows and seat kilometers per AGA division. The traffic intensity in an AGA division which is measured by the vehicle kilometers per square kilometre is very closely related to the number of industries in the zone. This function measures the extent of influence of goods, person and service transport facilities in the zone.

The Public Bus transport system is the principal means available to the people for person transport. The surveys show that 80 to 87 percent of workers use both the private and public transport bus services. The performance of the public bus services were evaluated using the operational statistics of the SLCTB. From these data two operational characteristics namely, passenger and seat kilometers by AGA divisions were examined and they show strong relationships to the number of industries located in the respective AGA divisions in particular the seat kilometer function.

Several regression analyses incorporating each of these factors as well as multiple regression analysis have indicated the effect of these factors on industrial location. The regression model with network factor and vehicle densities measure the effect of infrastructure and the totality of both goods and person movements. But the model of industries with network factors and seat kilometers evaluates the effect of infrastructure and passenger movements

This research work has helped to focus the role of the following major factors in the location of industry;

1. **The Active Population**
2. **The Price of Industrial Land**
3. **The Network Characteristics of A and B routes such as the densities of roads, links and nodes and their ratios. High intensity locations where the network is well knit and maintained.**
4. **The density of vehicular traffic in the zone.**
5. **The density of seat kilometers in public transport. High intensity use of the Public transport services.**

10.2 Recommendations based on Research

If the areas to the south-east, east and the north-east of the Colombo Metropolitan Region are to be industrially developed to provide for increase in employment opportunities it is imperative to implement policy measures to;

1. **Attract the active population to low density areas where the land prices are minimal** from the surrounding areas perhaps as a floating population so as to increase it above the threshold levels as shown in the study. It is now apparent that the development to the East of Colombo is minimal. It is necessary, **if industry is to develop to the East that access has to be first improved.** Road transport has evolved as the main mode of transport in this study. It will remain as a most important factor due to short haul and short distances of travel.

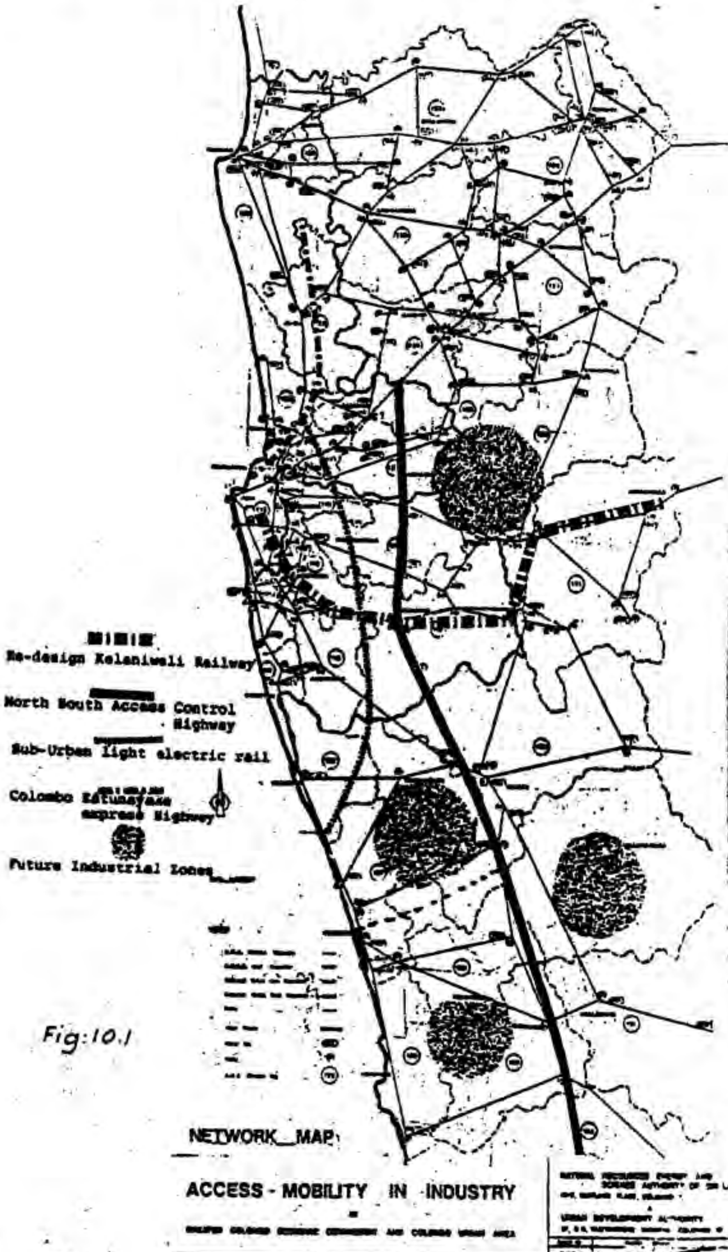
Re-design Kelaniweli Railway
North South Access Control Highway
Sub-Urban light electric rail
Colombo Katunayake expressé Highway
Future Industrial Zones
NETWORK MAP
ACCESS - MOBILITY IN INDUSTRY

Fig:10.1

One major factor to achieve this would be to **improve the transport network by upgrading and suitable design of links** to facilitate movement of workers. It is very necessary to keep in view the importance of the transport infrastructure as other networks such as water supply, drainage, power and telecommunications follow the highway networks.

2 **Improve the quality of public transport as well as the quantity** by increase in the seat kilometers and the frequencies of operation

3. **Locate industries so that travel times as well as travel costs for labour are maintained at affordable levels, for example as shown in figure 10.1.**

Unemployment is seen as a major cause of our social, ethnic and economic problems that we are facing today. It is also realised that it is through manufacturing industry that we can over come the main constraints to increased employment.

Transport has been shown to be a critical factor in the location of industry. It is important to realise that in commercial energy use transport takes a 55% share with industry using 22%. Furthermore, transport uses almost exclusively imported fossil fuel. Therefore, policies to conserve and minimize energy usage are as essential.

We have also seen that the **main constraints** to the expansion of industry out side the City of Colombo are:,

1. The **difficulty of access** to the main A and B road system.

2. The **low service levels** of the Public Transport system which the working population is using almost exclusively

3. The **long distances that labour has to travel** to work and the **relatively very high cost of travel which is about about 25% of salary for the labour sector.**

However, the following factors could induce industrial location outside of the CMA;

1. Mainly due to **poor access**, the prohibitively **high price levels of the land** in and around the City of Colombo and the **very low price levels outside.**

2. The **high levels of travel time to Colombo from outside.** It takes about 1.1/2 to 2 hours to travel to Colombo in the morning from a place such as Panadura on the main Colombo-Galle road which is only 17 miles away. Likewise, it takes about the same time to travel to Colombo from Homagama on the main High Level road which is also about the same distance to Colombo.

3 At the **present rate of expansion of sub-urban towns** it will be necessary to **enlarge the present road network** to cater to the increasing traffic from the East and the South of Colombo. This will also necessitate the **provision of expensive by-pass schemes** for some towns like Nugegoda and Maharagama.

From considerations of the foregoing facts **a combined spatial and transport strategy is recommended for the development of the Colombo Metropolitan Region as well as a larger section of the Southern Province.** If well designed and implemented it could take us far into the 21st century in the development process.. What is therefore, **recommended is the implementation of a multi-sectoral lead project in the following manner.**

1. The **Kelani Valley Railway Line** divides the Colombo Metropolitan Region(CMR) into two approximately equal areas. It also **forms the major line of access to the East of Colombo and the underdeveloped areas to the East, North-East and the South-East of Colombo.** Therefore, **it is recommended that this railway line be redesigned and strengthened as a fast and economical major access base to undertake the multi-sectoral development of the CMR.**

   It could be redesigned as a light electric rail as shown to be feasible in an earlier study*. Or in the alternative convert it into an electrified broad gauge railway with a container station system for rapid transport of freight to the Port. This should be taken as an **independent proposition and be not linked to the general electrification of the railways.**

2. This **rapid transit rail be linked to the development of urban centres** with towns such as Nugegoda, Maharagama, Homagama, Kottawa, Padukka etc. **The urban development be designed around the rail centres so that the public transport system could be linked to it and hence induce fast real estate development. This will also economize in the provision of service infrastructure. It is important to realise that the greater and faster returns are from this type of investment than from transportation**

3. Industrial development is least and employment minimal towards the South and the South-Eastern sector of the CMR. **A South-Eastern partial access-controlled Highway may be built about 15 to 20 kilometers from the coastline and linked to the Rail System as shown in figure,10.1.**

**Sri Lanka Transport Sector Study(Energy Conservation), Ministry of Power and Energy. July 1985.*

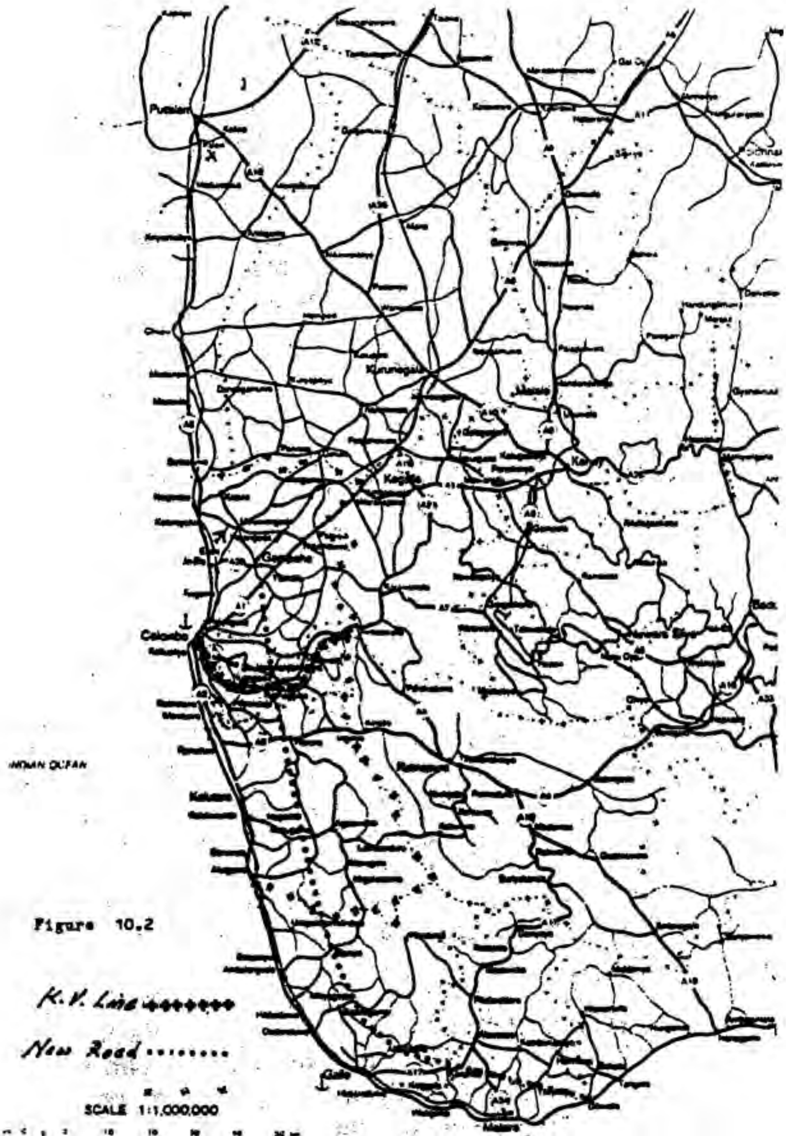
Puttalam
Kurunegala
Kegalle
Colombo
INDIAN OCEAN
Galle
Matara
K.V. Line
New Road
SCALE 1:1,000,000

Figure 10.2

It may pass through the least industrially developed areas to form a watershed between the agricultural land inland and the developed coastal belt, service the agricultural land inland and link places like Gampaha, Biyagama, Kaduwela, Homagama, Horana,/Ingiriya, Matugama, Elpitiya, Akkuressa up to Dickwella on the Southern Coast as illustrated in figure 10.2. **There are several other reasons as to why such a highway is required to be built.** The Colombo-Galle road which skirts the sea is subject to severe erosion. In any case this road will become necessary as the present Colombo -Galle road is congested and as the development in the South is accelerated. Further, a number of towns such as Aluthgama, Bentara, Ambalangoda, Balapitiya, Dodanduwa and Hikkaduwa will soon require costly bypasses due to expansion and growing traffic needs.

4. Increase the efficiency of the existing A and B road network by suitable design of appropriate links.

5. **Construct a light electric railway to service the sub-urban areas, provide a fast bypass from the North of Colombo to the South of the City and link up all the major highways and railway lines as shown in figure 10.1.** This railway could commence between Panadura and Kalutara and be connected to the Southern Railway. It could pass on the far side of the Bolgoda Lake and the Panadura River and pass through Bandaragama, Kottawa, Battaramulla, crossover the Kelani River and pass through the Biyagama industrial zone. Proceeding further north it may be connected to the Ragama rail station and be effectively linked to the Colombo-Katunayaka Expressway. **It would provide interchange for people from Katunayaka, Jayawardenapura, and Kalutara areas and form**

a complete link between the road and rail systems as shown in the figure, while bypassing Colombo but with direct access to the City and the Colombo Urban Area.

6. Co-ordinate the road and rail functions with the rail as the main system and the bus services as the feeder system from rural areas.

7. Improve the Public Transport System.

8. These will enable workers to travel conveniently from their homes with the minimal cost.

10.3 What indeed would be the benefits?

1 **The greatest benefit would be that we will take industry to the least developed areas. We will be bringing it closer to the poorer sectors of the people and induce growth in those areas.** It is important to keep in mind that it is more economical and convenient to transport raw materials and manufactured products to and from factories rather than move daily an army of workers to industrial sites and back. We will thus, **take industry to the people instead of bringing people to industrial locations creating a host of problems.**

2. **Travel times to work and back and travel cost would be minimal** and perhaps workers would be able to use other modes of travel like cycles to travel from their homes and thus not create conditions for workers such as those that we have produced at Katunayaka Investment Promotion Zone.

3 **Induce the growth of new urban centres** and thus accelerate real estate development

4. Reduce the tendency to **migrate to Colombo and the coastal towns** and hence **reduce the pressure ,stress and pollution on the coastal belt and thus enhance the environment.**

5. **General development of the economy of the whole region**

6. Provide large and **expanding opportunities** to the **construction industry** and thus create an expansive area for employment which could very well continue to the 21st century

However, these suggestions have to be considered within the **concepts of a total coordinated road/rail and person-goods transportation system in a well balanced industrial development plan** if we are to increase employment, income and living standards of our people.

There is little that land use planners could do once the transport policies are executed and vice versa. **Hence close coordination between these two activities and integration into a National Development Policy and the clear formulation of more meaningful and enlightened industrial and transport policies are needed.**

10.4 Further Research

Further research on the following areas are suggested;

1. The effect of the transportation of persons, goods and services on concentrated locations of industry such as at the Katunayake Investment Promotion Zone or the Biyagama Investment Zone

2. The role of containerized goods movement on industrial location.

3. The Public Transport System and the travel patterns of industrial workers and the effect on industrial location.

4. The Public Transport system and goods haulage and the influence on the location of small industries.

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BIBLIOGRAPHY

BIBLIOGRAPHY

1 **Adler H A;**
Sector and Project Planning in Transportation. World Bank

2 Alan Hay ;
Transpot for the Space Economy

3 Allison;
Environmental Planning. Unwin.

4 Ang,H.H.&Tang, W;
Probability Concepts in Engineering, Planning & Design, Vol.1
New York, John Wiley & Sons,Inc. 1975.

5 Arthur & Judith Getis;
Christaller's Central Place Theory
-The Journal of Geography. Arthur Andersen & Co

6 Ayeni Bola;
Concepts and Techniques in Urban Analysis. Croom Helm. London. 1979.

7 **Balcombe R.J;Rutherford D.J,& Walmsley D.A;**
A parametric model of inter-city
passenger transport. TRRL. Lab.Report 607, 1973.

8 Bankovic Radovan;
Modem methods of determining transport passenger services.
SYMPPIS 74, Herceg. Novi. Oct. 1974.

9 Barber G;
Growth determinants in the Canadian Urban Systems

10 Barltell R.S;Edmondson D.R,& McCarthy S.P
Hull Freight Study TRRL Report 846; 1978

11 Barttett M.S
An Introduction to Stochastic Processes.

12 Batty, M.;
Urban Modelling. N Y. Cambridge University Press. 1976

13 Bawyer D.P.and Fry A.T;
Techniques for Rural Highway Traffic Prediction.
-T.; Route factors. Traf. Eng. & Control. Jan. 1976.

14 Bemstien Samuel J.;
Modelling the Urban-Suburban Complex; Traffic Quarterly.

15 Berry Brian J.L. & Pred Allan;
Central Place Studies,
Regional Science Research Institute. Bibliography sem., 1961.

16 Berry Brian.;
An Indicative Approach to the Regionalization of
Econ.Develop.Univ.Press

17 Blatner Irwin.;
Transportation Facilitation Centre Concept;
Transp. Facilities Workshop; A.S.C.E. N.Y. May 1974.

18 Blumen I; Kogan M; Mc Carthy P.J.
The Industrial Mobility of Labour a Probability
Process. Ithaca.N.Y. Cambell Press.

19 Blunden.W.R.:
The Land Use Transport System.

20 Bourne L.S. & MacKinnon R.D.
Urban Systems Development in Central Canada.
Selected Papers; University of Toronto Press.

21 Boyce R.R.:
Bases of Economic Geography.

22 Bracken Ian :
Urban Planning Methods- Research and Policy Analysis. Methuen. 1981.

23 Briggs.:
Field work in Urban Geography.

24 Bruton Micheal J.
;Introduction to Transportation Planning; Hutchinson & Co. Ltd.

25 Buchanan C.D. and Partners;
The Canterbury Traffic Study, Oct. 1970.

26 Buchanan Report;
Traffic in Towns.

27 Bureau of Transport Economics;
New Techinques for Transport Systems Analysis.
Australian Road Research Board., Victoria.

28 Burton and Cherry.:
Social Research Techniques for Planners.

29 Button,K.J and Gillingwater,D.:
Transport, Location and Spatial Policy. Gower Publishing
Corp.England.

30 Carter Harold.;
The Study of Urban Geography. Edward Arnold.

31 Catanese Anthony J;
Scientific Methods of Urban Analysis.University of Illinois;London.

32 Central Bank of Ceylon;
Annual Report. 1983.

33 Central Bank of Ceylon;
Bulletin Dec. 1984

34 Chadwick.:
A Systems View of Planning.

35 Chapman R.A, Gault Helen E & Jenkins Ian A;
The operation of urban bus routes;Traffic Engineering & Control;July/Aug./Sept. 1977.

36 Charlesworth J.A.;
Control & Routeing of Traffic in a Road Network.;Traffic Engineering and Control. Oct. 1979.

37 Chisholm Michael;
Rural Settlement & Land Use.-Johann Heinrich Von Thunen-Hutchinson University Library London 1962.

38 Cochrane R.A.:
A More General Form of the Gravity Model.
Traffic Engineering and Control. July 1976.

39 Colin Lee.
Models in Planning.

40 Collins Lyndhurst and Walker David F.:
Locational Dynamics of Manufacturing Activity. John Wiley & Sons.

41 Colony David G;
Alam Abdul.B.Shah;Modelling Social Impacts of Urban Highways;
Trans.Eng.Jour. American Society of Civil Eng. May 1976.

42 Colston Research Society;
Regional Forecasting;Syp Univ of Bristol. Butterworths 1970.

43 Commonwealth Bureau of Roads;
Guidelines for Data Collection.
Australian Roads Service. April 1967.

44 Cordey-Hayes M.
Towards operational urban development models

45 Colston Papers No.22
Regional Forecasting.

46 Country Roads Board;.
Road Design Manual. Victoria Australia.

47 Cowley and Steely.
Sub-Regional Planning Studies.

48 Creighton Roger L.:
Urban Transportation Planning. Univ.ersity of Illinois Press. Chicago..

49 Cresswell Ray.:
Urban and Public Transport. The Construction Press. N.Y. 1979.

50 Currer E.U.H and Connor M.G.D.;
Commercial traffic; its estimated damaging effect, 1945-2005
T.R.R.L. Lab. Rep. 910. 1979.

51 **Daggett Stuart;**
Principals of Inland Transportation- the system of Alfred Weber.
Harper & Brothers 1955.

52 Dalton R, Garlick J, Munshall R,& Robinson A;
Modem Techniques in Geography. Philip.

53 Daniels Alan & Yeates Donald.;
Basic Training in Systems Analysis. E.L.B.S. 1979.

54 Daniels P.W. and Warnes A.M.;
Movement in Cities. Methuen & Co .Ltd. N.Y. 1980..

55 Daniels P.W. and Warren A.M.:
Spatial Perspectives in Urban Transport and Travel.

56 Davies J.B.
Behaviour of the Ontario-Quebec Urban System by size distribution.

57 Dennis Neuzil;
Pre. transit patronage est.for Small Urban Areas via
Transit Service Factor. Traf. Eng.& Cont.1975.

58 Denys Mandy.;
Transport. Penguin Books. 1968.

59 Dept. of Census and Statistics;
Sri Lanka Census of Industry-1983, Preliminary

60 Dept. of Census and Statistics:
Statistical Abstract of Sri Lanka. My. of Plan Implementation. Sri Lanka 1982.

61 Dept. of Census and Statistics;
Labour Force and Socio-Economic Survey;Sri Lanka.80/81

62 Dept. of Census and Statistics;
The Economically Active Population. Sri Lanka. 1981.

63 Dept. of Transport.U.K.;
Highway Road Layout and Geometry.Dept. Standard 709/81, 1981.

64 Dept.of Trans. Australian Road Research Board
New Techniques for Transport System Analysis.

65 Dept. of Urban Development. Washington.D.C.
Planned Industrial Parks. June 1969.

66 Dept. of the Environment.;
Hull Industrial Location and Freight Transport Study. 1979.

67 Devney John & Vaughan Rodney;
Distribution of transit traffic and facilities.
Traffic in Toronto. Traf. Eng.& Control Nov. 1984.

68 Douglas Allan. A.:
Grid Reference Coding: Application to Transportation Studies.
Traf. Eng. & Control. Nov. 1976.

69 Downers J.D.,Johnson S & Morrel.;
Household person trip generation models TRRL. 401 1978

70 Draper V.R. and Smith H.:
Applied Regression Analysis. John Wiely 1966.

71 Duncan N.C.;
Rural speed/ flow relations.; T.R.R.L. Lab.Report. 651.-1974.

72 E.C.A.F.E.;
Highway Classification and Design Standards for Asian Highway
Indian Roads Congress. May. 1970.

73 E.C.E.;
Seminar on the use of Systems of Models in Planning (E/ECE/EC. AD/11) 1974.

74 Economic Review;
Ports and Shipping, Aug. 1986; Research Dept, People's Bank ;Sri Lanka.

75 Estall .R.C. and Buchanan R.O.:
Industrial Activity and Economic Geography
Hutchinson University Library. 1970

76 Evans L. and Herman R.:
A Simplified Approach. to Calculation.of Fuel Consumption.in
Urban Traffic Systems. Traf.Eng.&Cont. Aug./Sept. 1976.

77 Everson and Fritzgerald;
Inside the City. Geographical Magazine, Oct.1973.

78 **Fernando Lloyd ;**
Planning and Structural Adjustment;
Sri Lanka Association of Economists. Annual Sess. Dec. 1985.

79 Freeman.T.W.;
Geography and Planning; Hutchinson.University Library. London.

80 **Gabriel Roth.;**
Paying for Roads. A Penguin Special. 1967

81 Garrison W.L.& Marble D.F;
The Structure of Transportation Networks
U.S. Dept. of Commerce. Washington D.C. 1961.

82 Glasson. John;
An Introduction to Regional Planning. Hutchinson.

83 G.C.E.C. Publication;
Sri Lanka's Investment Promotion Zones. Dec 1979.

84 G.C.E.C. Regional Planning Department;
GCEC Urban Development Invetment Project.

85 G.C.E.C. Publication.
Sri Lanka's Export Processing Zones

86 Gerald Breese;
Urbanization in Newly Developing Countries.
Modernization of Traditional Societies Series

87 Gerlough Daniel L. & Frank C. Barnes.;
Poisson and other Distributions in Traffic.
ENO Foundation for Transportation. 1971

88 Gerlough Daniel L. & Huber Mattew J.;
Statistics with Applications to
Highway Traffic Analysis. ENO Foundation . 1978.

89 Gordon B. Davies.;.
Introduction to Computers. McGrow Hill

90 Grayhill,F.;
Theory and Application of the Linear Model.
North.Sect. Mass. Dultbury Press. 1976.

91 **H.M.S.O.: Ministry of Transport;**
National Land Use Classification.

92 H.M.S.O.: Ministry of Transpört;
Industrial Demand for Transport.

93 H.M.S.O: Ministry of Transport ;
Standard Classifications for Traffic and
Transportation London. 1964

94 H M.S.O. Ministry of Transport;
Standard Industrial Classification. London. 1959.

95 Habitat
U.N. Conference on Human Settlements (A/Conf. 70/15) 1976.

96 Haggett Peter and Chorley Richard J.;.
Network Analysis in Geography.Edward Arnold 1969.

97 Haggett Peter;.
Locational Analysis in Human Geography. Edward Arnold. 1971

98 Haggett, Cliff & Frey;.
Locational Models.

99 Haggett Peter;.
Integrated Models in Geography.

100 Hall Peter;.
Urban and Regional Planning. David & Charles. London 1975.

101 Hammond R. & Mc. Cullagh P.S;.
Quantitative Techniques in Geography, Clarendon Press.

102 Heggie.Ian G;.
Transport Engineering Economics.

103 Hermann Frank V.;.
Population forecasting methods
U.S.Bureau of Public Roads, Wash. D.C. Jan. 1964

104 Hermann P.G.;
Forecasts of vehicle ownership in counties and county borroughs in Gt.Britian RRL LR 200 1968

105 Hobbs. F.D.;.
Traffic Planning and Engineering.

106 Holroyd E.M. and Scraggs D.A.;
Waiting times for buses in London.
R.R.L.. Ministry of Transport. July. 1966

107 Hoover Edgar M;
Land Use Competition.Location of Economic Activity
MacGrow Hill. N.Y. 1948.

108 Hosse'H.A.:
Aspects of Industrial Location in the ECAFE Region.
Sec. Paper E/CN.11/Inr/Ind. Conf./L.20. 1915.

109 Howard K.;
Quantitative Analysis for Planning Decisions. Macdonald & Evans Ltd.

110 Howe J.D.G.F.&Tennent B.S.;
Forecasting rural road travel in developing countries for studies of land use. TRRL 754 1977

111 Howe J.D.G.F.;
Rural Road Distribution in Kenya; L.R. 414. R.R.L. Report 1971.

112 Howe J.D.G.F.;
The sensitivity of traffic estimatesw for road planning in developing countries. LR 516 TRRL. 1973

113 Howe J.D.G.F.;
The value of time savings for road improvements.
A study in Kenya RRL LR372. 1971

114 Hoyle B.S.:
Spatial Aspects of Development. John, Wiley & Sons

115 Hoyle B.S.:
Transport and Development.

116 Hsu Jinde and Surti H. Vasant.:
Demand Model for Bus Network.
Transportation Engineering Journal. ASCE. Aug. 1976

117 Hudson. F.S.;
A Geography of Settlements. Macdonald & Evans.

118 Hutchinson B.G.
Principals of Urban Transport System Planning. McGraw Hill. 1974.

119 **I.B.R.D. & I.D.A.;.**
Highway Cost Performance Model
Economics Dept. Working paper No. 62. Feb. 1970.

120 I.B.R.D. & I.D.A;
Transport Network Model Economics Dept. working paper No.62. Feb1970.

121 I.B.R.D. & I.D.A.;.
Dahomey Land Transport Study Models. : Economics Dept.
working paper No.87. Sept. 1970

122 Institution of Transportation Engineers;
Transportation and Traffic Engineering
Handbook; Prentice-Hall 1976

123 International Road Transport Union;
Standardization of maximum weights and
sizes of Road vehicles.; Jan. 1972

124 International Road Federation;.
Report on the World Meeting. Tokyo Japan 1977.

125 Irving J.M.; Oakley C.F. and Ramsey J.B.H;.
The Updating from an O.D. Matrix ,
a maximum likelihood approach. Traf.Eng.& Control. Sept. 1986

126 Isard W.;.
Location and Space Economy.

127 **Jackson M.R.;**
An aid to sub-regional. land-use/transportation. plan.
destination selection. Traf. Eng. & Control July/Aug. 1977.

128 Jackson.M.R;.
Surveys for Town and Country Planning.

129 Jacobs G.D, Maunder D.A.C. and Fouracre P.R.;
A comparison of bus operations.
in cities of developed and developing countries. Tr.En.&Con. Jun79

130 Jacobs G.D.,Maunder D.A.C. & Fouracre P.R.;
Character. of conventional public
transport. services in Third World Cities. Traf.Eng.& Cont. Jan.1986.

131 Jansen G.R.M. and Boney P.H.L.;
Urban Road Network Size; some Dutch findings.
Traffic Engineering and Control. Oct. 1975

132 Japan International Co-operation Agency;
Feasibility. Study of Colombo-Katunayaka
Expressway Project; Supp. Report on the Reg. Economy. April 1983.

133 Japan International Cooperation Agency;.
The Feasibility Study on Colombo-Katunayake
Expressway & New Port Access Road. Colombo January 1984.

134 Jayawardene Nagananda :
Transportation in Sri Lanka . Review Paper .
S.L.A.A.S. 23 rd Annual Session Dec. 1977.

135 Jayawardene Nagananda:
Sectoral Policy Paper. Traffic and Tranportation,
Urban Development Authority. March 1982. Colombo.

136 Jayawardene Nagananda;
Strategic Plan for Infra. Network for Freight Transport in
Colombo.; Urban Development Authority,

137 Jayawardene Nagananda;
Towards Better Highways in Sri Lanka.
Institution of Engineers, Sri Lanka.

138 Jayawardene Nagananda;
Traffic and Transport Demand Estimatefor the Central Area, Colombo Fort; 1979-1986
Urban Development Authority Nov. 1980.

139 Jayawardene Nagananda;
Transport Policy in Development Control.
Sri Lanka Association.for the Advancement. of Science. Colombo Dec. 1982

140 Jayawardene Nagananda;
Choice of Investment.Criteria in the Urban Transport Sector
Sri.Lanka. Development.Planing.Review.Vol. 2. No.1. June 1983.

141 Jayawardene Nagananda;
Energy Demand Management and Conservation
Road Transport. My of Power & Energy, Sri Lanka:

142 Jean Perraton and Richard Baxter:
Model, Evaluations and Information Systems for Planners.

143 Jolliffe J.K. & Hutchinson T.P;.
A behavioural explanation.of the association. between
bus and passanger. arrivals at a bus stop. University.of London.1974.

144 **Khasnabis S. and Poole R.M.;**
Synthesizing Travel Patterns for a Small Urban Area
Traffic Engineering and Control . Aug. 1975.

145 Kimm Charles C.;
Application.of Demorgraphic & Economic Models to
Regional.Transport Planning.
Battelle Memorial Institute. Ohio. U.S.A.

146 Kingsley Thomas G.;
Strategic Development Planning for the Colombo Metropolitian
Region. U.N./U.D.A. Dec. 1979.

147 Knneckeberg and Silvers;.
Urban Planning Analysis.

148 Kresge D.T. and Roberts P.T;
Systems Analysis and Simu.Models Vol. 2.
Tech.of Tran. Plan.1971. The Brookings Inst. Wash.D.C.

149 **Lamb.G.M., Bloxsom A.M and Eastman C.R.;**
Bristol Area Land-Use/ Transportation Study
Traffic Engineering and Control, Dec.1975.

150 Lane, Powel, Smith.;
Analytical Transport planning.

151 Last A. & Leak S.E.;
Transept- a bus model . Traf. Eng. & Control Jan. 1976

152 Leake G.R. & Gray J.E.;
Trip generation of selected industrial groups.
Traf.Eng. & Control. Feb. 1981.

153 Lee. C.:
Models in Planning. Pergamon Press. N.Y. 1974

154 Lesley, L.J.S.:
Optimum Bus Stop Spacing. Traffic Engineering and Control Oct/
Nov. 1976

155 Levinson Herbert .S;
Transportation Plans . Colombo Central Area

156 Lowry, Ira S.;.
A Short Course in Model Design. Macmillian 1970

157 Lyons D.J.;
Bus travel in town centres. Traf. Eng. & Control 1969.

158 **MacKennon, Hodgson and Bonshell;.**
Trans.network models for the Ontario & Quebec
system of Cities; Urban System Dev. in Central Canada

159 Mackinder I.H.,Evans S.E. & May R;
The distribution of household income in trip
generation. Traf. Eng. & Control. Dec. 1975.

160 Mackinder I.H.; Evans S.E. and May R.:
The Distribution of Household Income in
Trip Generation. Traffic Engineering and Control. Aug.1975

161 Margaret Roberts.;.
An introduction to Town Planning

162 Martin P.H.;
Bus services in small towns TR 848 1978

163 Martin B.V. & Daly P.N;
West Yorkshire Transportation Studies. The Analytical
Approach. Traf. Eng. and Control. Dec .1978.

164 Martin K.M.& Dalvi M.Q;
The Comparison of accessibility by Public and Private
Transport. Traf. Eng. and Cont Dec.1976/78.

165 Malcolm Moseley J.:
Accessibility. Methuen & Co. Ltd. 1979

166 Massam Bryan H.;
Spatial Search. Pergamon Press. 1980

167 Mc Kenzie R.P. and Goodwin P.B.;
Dynamic Estimation of Public Trans.Demand Elasticity
some new evidence. Traf.Eng.& Control. Feb.1986.

168 Mc. Laughlin. J. Brian;
Urban and Regional Planning. Faber and Faber 1969.

169 Meck J.P.;
The Role of Economic Studies in Urban Trans. Planning. U.S.Bureau
of Public Roads. Wash. D.C.

170 Meyer.:
Techniques of Transport Planning, Systems Analysis and Simulation
Models.

171 Michael Roe.:
Structure Modelling for Trip Distribution. Traffic Engineering and Control. May 1985

172 Ministry of Planning and Employment;
The Five Year Plan, 1972-76; The Government of Ceylon, Nov. 1971

173 Ministry of Planning;
Transport Requirements of the GCEC Area. Interim Report Oct. 1980

174 Minshall.:
An Introduction to Models in Geography.

175 Mitchell, R.B, and Rapkin C;
Urban Traffic, A Function of Land Use, Columbia University Press, N.Y. 1954

176 Modem Techniques in Geography.:
1. Networks in Geography; 2.Correlation Techniques Philip & Son.

177 Monkhouse F.J. and Wilkinson H.R.;.
Maps and Diagrams. Methuen & Co. London. 1978.

178 Moroney, M.J.:
Facts from Figures. Penguin Books.

179 Mosely.:
Growth Centres in Spatial Planning.

180 Mullen P, Bursey N.C. and White M.T.;
Telford Transportation Study. Traffic Engineering and Control. March 1976.

181 Mullen P, Bursey N.C.,& White M.T.;
Telford Transport Study, New Techniquesin the model.of trip generation.& modal split. Traf.Eng.& Control.Mar.1976.

182 Ministry of Finance and Planning.
Transport Statistics in Sri Lanka. 1979-1983.

183 Ministry of Trans. Mathematical Advisery Unit;
On the Concept of Generalized Cost in Traffic Models. Research Notes.

184 Nathaniel.;
Evaluations in the Planning Process.

185 National Ass.of Australian State Road Authorities.;
Guide to Traffic Engineering Practice.1970

186 National Research Record;
Statistical and Mathematical Aspects of Traffic; H.R.R.118 Highway Research Board. Wash.D.C. 1966.

187 Neptuen John and Dacey Micheal.:
A Graph Theory Interpretation of Nodal Regions. Papers of the Regional Science Association. (1961).

188 Neuil D.
Pre Transit Patronage Est.for a Small Urban Areas via Transit Service Factor
Traf.Eng. & Cont./ 75.

189 Noffendorf Hugh & Copley Geoffrey;
The South Yorkshire trip generation model.
Traf. Eng. & Control. Feb. 1981.

190 O'Flaherty C.A. and Mangan D.O.;
Bus passenger waiting times in central -areas.
Centre for Transport Studies, Leeds

191 O'Sullivan Patrick, Holtzclaw G.D. & Barber G.
Transport Network Planning. Groom Helm.

192 O.E.C.D.:Paris;
Two lane Rural Roads.

193 Ogden K.W.;
Modelling urban freight generation. Traf. Eng.& Control Mar. 1977.

194 Oliver ,R.M. and Potts,R.B.:
Flows in Transportation Networks. New York.
Academic Press. Inc. 1972.

195 Opperheim, N..:
Applied Models in Urban and Regional Analysis. Prentice-Hall,Inc. 1980.

196 Overguard K.P.;
Traffic Estimation.in Urban Transportation Planning. Technical University of
Denmark. Report 34. 1965

197 Patankar P.G.:
Urban Mobility in Developing Countries. Popular Prakashan.

198 Pelican.:
Access for All.

199 People's Bank Research Department;
Economic Review August 1986.

200 People's Bank Research Department.;
Economic Review June 1982

201 Perera A.L.S.:
A Study of Location of Industries in Sri Lanka. University of Moratuwa.Dec.1976.

202 Perera A L.S;.
Some aspects of Implementation of U.D.A. locational Policy
U.D.A. Workshop July 1983.

203 Peter E. Lloyd and Peter Dicken.:
Location in Space.

204 Peter Haggett, Andrew Cliff and Allan Frey.:
Locational Analysis in Human Geography.

205 Pike D.H., FullerP.I. and White M.T.
Telford Transportation Study.
Traffic Engineering and Control. Feb. 1976.

206 Project Planning Centre for Developing Countries.;
Road Cost Components.
Seminar on Road/Rail and Freight Studies. Mar. 1981. Colombo.

207 P.T.R.C.;
Highway Planning- University of Warwick. U.K. Summer July. 1975.

208 **Quandt,R.E:**
The Demand for Travel: Theory and Measurement; Lexington; Mass. D.C.

209 Quarnby.:
Choice of Travel Mode for the Journey to Work. Journal of Transport
Economics and Policy. 1967

210 R.R.L. Technical Paper. 46 :
The London Birmingham Motorway
Traffic and Economics.

211 Road Research Laboratory, London;
Zoning for Urban Travel Studies LN/415?MAT(1964).

212 Rakusen R.H.:
Public Tran. Aspects of the Ply.& Env. Tran.Study. Bus Net.& Service Improvements Traf. Eng. Con. Nov. 1976.

213 Rhind David.:
A Census User's Handbook. Methusen 1983

214 Richardson, Harry.W.:
Elements of Regional Economics. Macmillian 1973.

215 Roads and Transportation of Canada.:
Urban Transportation Planning Guide.
University of Toronto Press.1977.

216 Road Research Laboratory., U.K;
Research on Road Traffic.

217 Robinson and Bamford;
Geography of Transport.

218 Rogers A.:
Matrix Analysis of Interregional Population Growth and Distribution.
Berkley California.

218 Rogers,A.:
Matrix Methods in Urban and Regional Analysis.
Prentice-Hall, Inc. 1980.

219 Rogers.:
Statistical Analysis of Spatial Dispersion.

220 Ruhl A.and Dobson G.G;
Travel Demand Modelling and Decision Making in the Amsterdam
Region. Traf. Eng.& Control. May 1976.

221 Sant M.E.C;
Industrial Movement and Regional Development.

222 Schoon J.G. and Levinson Herbert S.;
New Concepts in Urban Parking;
Transportation Engineering Journal. A.S.C.E.

223 Scott Robert S.;
Analitical Assignment Models. Traffic Quartly.

224 Scott Wilson Kirkpatrick & Partners;
Trunk Roads Maintenance Project
Sri Lanka. Aug.1985.

225 Seddon P.A.and Day M.P;
Bus passenger waiting times in Greater Manchester.
University of Salford. Jan. 1974.

226 Self Peter,
The Planning of Industrial Location;
University of London Press.

227 Self G.F., Coombe R.D. & Blair I;
West Yorkshire Transportation Studies,
Development of Country Plan. Traf. Eng. & Control. May 1979.

228 Senior M.L. and Williams H.C.W.L.:
Model -Based Transport Policy Assessement".
Traffic Engineering and Control. Sept. & Oct. 1977.

229 Sharma Satish C. and Soliman Afifi H.:
Traffic Generation from Land Development
Proposals. Transportation Engineering Journal. May.1976.

230 Sharp C.H.:
Macmillian Studies in Economics.

231 Silver J and Stowers J.R.;
Pop., Eco. & Land Use Studies in Urban Trans. Plan.;
Bureau of Public Roads. July 1964.

232 Skinner R.J;
Bus Planning methods. Traf. Eng. & Control, Sept./Oct./Nov. 1980.

234 Smith David M.:
Patterns in Human Geography. Penguin Education. 1977

235 Smith Jose' A.
Regional Inequalities in Internal Communications.-The Case of Uganda.

236 Smock R.B.:
A Comparative Description of a Capacity Restrained Traffic Assignment
Highway Research Board 1963.

237 Sri Lanka Ports Authority;
Port Statistics Sri Lanka 1976-1985.

238 Sri Lanka Ports Authority;
Ports of Sri Lanka 1983.

239 Sri Lanka Ports Authority.;
Port Statistics. Series 111 1973-1982

240 Stanford L.Optner.;
Systems Analysis. Penguin Books.

241 Steer J.K.;
Factors influencing the planning and design of bus terminals.
Traf. Eng.& Control Aug/Sept. 1979.

242 Stienbrink.:
Optimization of Transport Networks. Wiley.

243 Stoper Peter R and Meyburg Amem H. ;
Urban Transportation Modeling and Planning
D.C.Heath & Co; Lexington Books.Mass. 1978.

244 Stoper,P. and Meyburgh,A.:
Travel Demand Modeling. Lexington Mass. D.C.Heath & Co.

245 Sullivan Patrick ;
Transport Network Planning. Crom

246 Taaffe Edward J. and Gauthier Howard L.
Geography of Transportation.
Prentice Hall 1973.

247 Taaffe Edward J. and Gauthier Howard L.:
Foundations of Economic Geography.

248 Tanner J.C.;
Analysis of Carriageway widths. RRL. LR. 294 1969.

249 Tanner J.C.;
Vehicle Mileage in the USA and Britain. RRL. Report 31. 1966.

250 Taylor M.A.;
Studies of Traffic in Gloucester, Northampton and Reading. LR. 14 1968

251 The Netherlands Institute of Transport.
Transport decisions in an Age of Uncertainity
Martius Nijhoff. The Hague 1977

252 The National Capital Development Commision;
Tommorrow Canberra.
Australian National University Press. Canberra 1970.

253 Transportation Research Board.:
Urban Travel Demand Forecasting.
Special Report 143. Washington D.C. 1974.

254 Transportation Research Board:
Bus Use of Highways. Report 155,
National Research Council. Wash.D.C. 1975.

255 T.R.R.L.;
A guide to the structural design of bitumen surfaced roads
Road Note 31. 1977. H.M.S.O.

256 T.R.R.L.;
A guide to the structural design of pavements for new roads.
Road Note 29. 1970. H.M.S.O.

257 T.R.R.L.;
Transport Policies in Sri Lanka ; Seminar on Road/Rail and Freight Studies. March 1981. Colombo.

258 T.R.R.L.;
The New Road Investment Model (2) RTM TRRL Symposium;

259 TRRL.;
Factors affecting public transport patronageReport 413.
Dept. of Environment 1977

260 TRRL Symposium;
The Management of Urban Freight Movements. TRRL 309 1977

261 TRRL.;
Symposium on the costing of bus operations. Sym. Report 180 UC 1975

262 TRRL.;
Swindon Freight Study. TRRRL Sup. Report 158 UC

263 TRRL.;
The Kenya road transport cost study. No. 672 1975.

264 TRRL
Bus route costing for planning purposes.Sup. Report 108 UC 1974

265 Tulpule A.H. ;
Recent trends in vehicle use in USA & Britan LR. 354 1970

266 Tulpule A.H.;
An analysis of some world transport statistics.
TRRL Lab. Report 622 1974

267 Tulpule A.H.;
Forecasts of vehicle traffic in Gt.Britian LR. 543 1973

268 Tulpule A.H.;
Trends in transport of freight in Gt. Britian LR. 429 1972

269 Tumbers Janice A.;
Traffic Survey at 1300 sites LR 206. 1968

270 U.N. ;
Indicators of the Quality of Urban Development. (ST/ESA/56). 1977

271 U.N. ;
The Develpoment of Integrated Data Bases for Social, Economic and Demographic Statistics. (57/ESA/)

272 U.N.;
Integration of Economic and Physical Planning (ST/ESA/36) 1975

273 U.N.;
Inter-regional Seminar on New Towns (DP/UN/INT-72-053) 1973
U.N.Methods for proj. of urban and rural populations;
Pop.Studies No. 55. (ST/ESA/SER. A/55) 1974.

274 U.N.E.S.C.O;
Low Cost Roads. Butterworths. London . 1967.

275 UNCHS.;
Data Management for Urban and Regional Development 1981

276 U.N, New York;
Establishment of Industrial Estates in Underdeveloped Countries. 1961.

277 U.N;
Colombo Metropolitian Region-Urban Area Development Plan. Vol.2. April 1978.

278 U.N;
Introduction to Transportation Planning. N.Y. 1967.

279 Urban Development Authority, Sri Lanka
City of Colombo Development Plan. Nov. 1985.

280 Urban Development Authority, Sri Lanka;
City of Colombo Development Plans.Sept.1982.

281 Urban Mass Transport Administration;
Use Oriented Material for UTPS. An Introd.to Travel
Forecasting. A self inst.text. Wash. D.C. 1977.

282 U.S. Burea of Public Roads.;
Traffic Assignment Manual. Washington D.C. June 1964

283 U.S. Bureau of Public Roads;
Calibrating and Testing a Gravity Model for Any Size Urban
Area. Washington D.C. 1965

284 U.S. Dept. of Commerce;
Chicago Area Transportation Study; Vol.1; Vol.2; Vol.3; 1959.

285 U.S. Bureau of Public Roads.
Highway Planning Technical Report.

286 U.S. Bureau of Public Roads.
Origin and Destination Traffic Studies.

287 U.S. Bureau of Public Roads.
Guidelines for Trip Generation Analysis

288 Vagale L.R.:
Location and Design of Industrial Estates.
Urban Development Authority, Sri Lanka. 1982..

289 Vagale L.R.
Planning for Developmentof Industrial Areas-Locational and Spatial
Design Criteria. U.D.A.

290 Vaughan Rodney;
Traffic in Toronto-overview & demand Traf. Eng. & Control Sept,
Oct.,Nov.,Dec. 1984.

291 Votaw David F. & Levinson Herbert S.;
Elementary Samplying for Traffic Engineers.
ENO Foundation for Transportation.

292 Weerasekera T.B;
Location and Structure of Industries in Sri Lanka.
U.D.A. seminar.1983. Colombo.

293 Werner Christian.
The Role of Topology and Geometry in Optimal Network Design.
The Reg. Sci. Association, 21.(1968).

294 White Peter :
Planning for Public Transport. Hutchinson of London. 1976.

295 Williams, I.
Calibration Techn.for Doubly-Const.Gravity Models
Trans.Research. 10(1976).

296 Wilson A.G.:
Papers in Urban and Regional Analysis.

297 Wilson A.G.
Some problems in urban and regional forecasting:

298 Wilson Andrew G.
A Family of Spatial Interaction Models and Associated Developments. Env. & Plan. 3(1971)

299 Wilson Andrew.
Inter-regional Commodity Flows Entropy Maximizing Approaches.
Geog. Analysis 2,No. 3(July 1970).

300 Wilson.:
Urban and Regional Models in Geography and Planning.

301 Wirasinghe S.C.;
Some approaches to future intercity travel demand est.for Public Transit. S.L.A.A.S.May 30. 1984.

302 Woelfle. R.M;.
A Guide to Better Technical Presentations.

303 World Bank.;
Urban Economic & Planning Models. Assessing the Potential for Cities in Developing Countries. Staff Paper 25.

304 World Bank.
Urban Transport. May 1975.

305 World Bank;
A Review of Highway Design Practices in Developing Countries. May 1975.

306 World Bank;
Urban Sector Report. Sri Lanka. 1984.

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