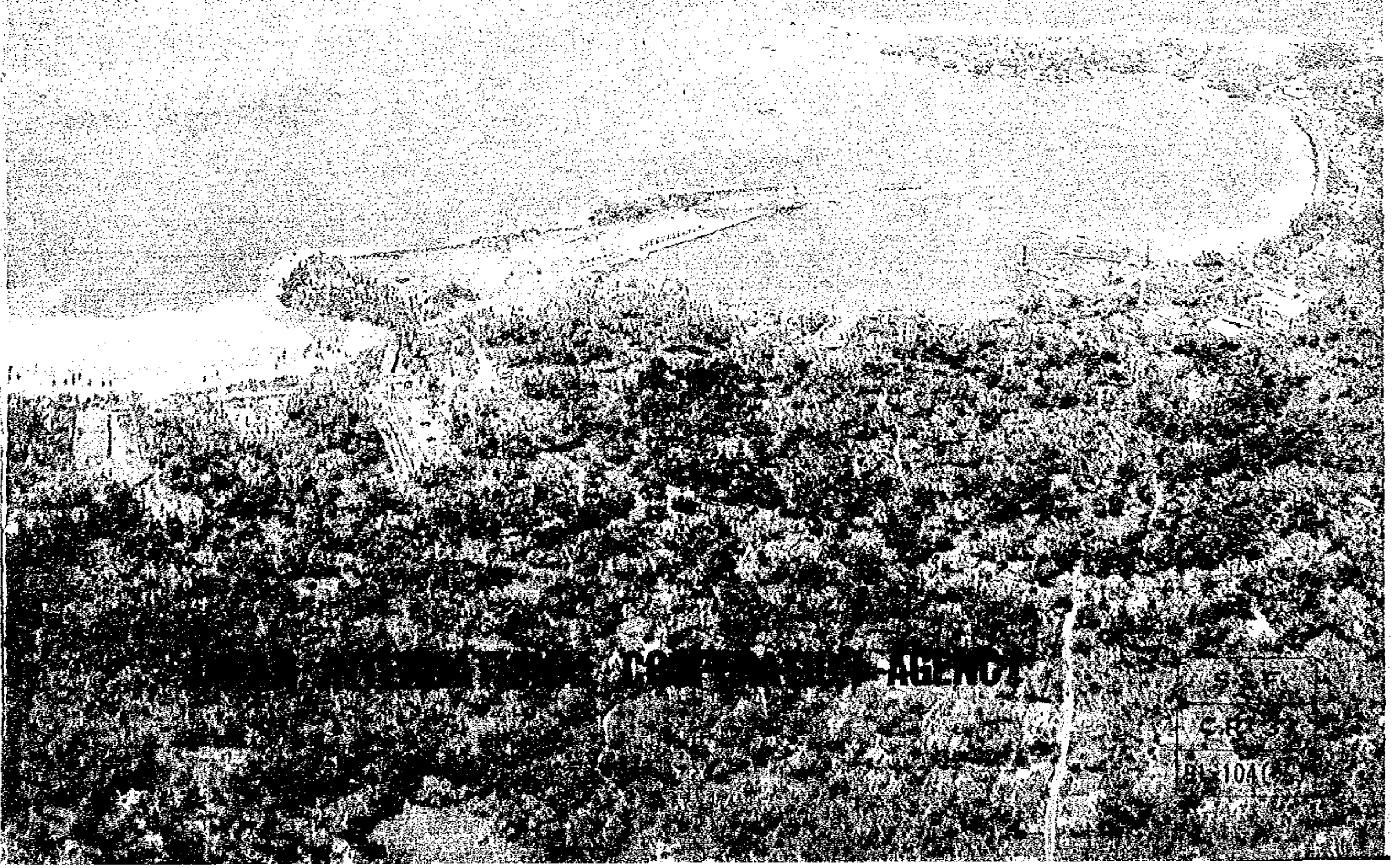
FINAL REPORT

THE STUDY ON THE DEVELOPMENT OF THE PORT OF GALLE IN THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

NOVEMBER 1991



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PREFACE

In response to a request from the Government of the Democratic Socialist Republic of Sri Lanka, the Government of Japan decided to conduct a feasibility study on the Development of the Port of Galle and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Sri Lanka a study team headed by Mr. Haruo Okada, Executive Director of the Overseas Coastal Area Development Institute of Japan, four times between September 1990 and September 1991.

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

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

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

November 1991

Kensuke Yanagiya
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

November 1991

Mr. Kensuke Yanagiya
President
Japan International Cooperation Agency

Dear Mr. Yanagiya

It is my great pleasure to submit herewith the Final Report for the Study on the Development of the Port of Galle in the Socialist Republic of Sir Lanka.

The report is the result of studies carried out by the Overseas Coastal Area Development Institute of Japan(OCDI) and Japan Port Consultants, Ltd.(JPC) at the contract of the Japan international Cooperation Agency(JICA). The study team conducted four field surveys between September 1990 and September 1991.

Based on the findings of these surveys and on data and information collected and analyzed in Japan, the masterplan was formulated with a target year of 2005. Moreover, the short-term development plan was formulated with a target year of 1997, including a feasibility study.

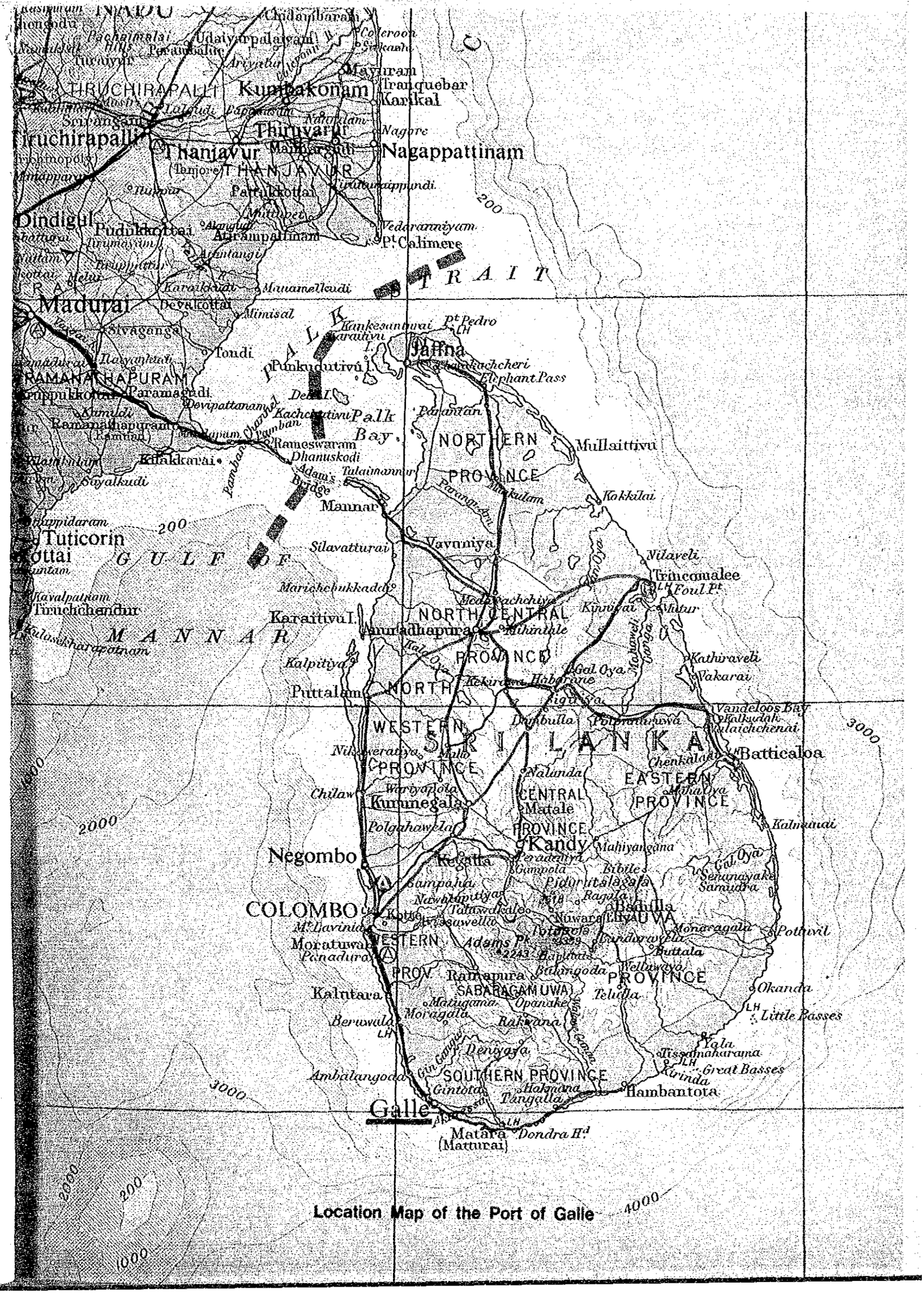
The study shows that the development of the Port of Galle is extremely important. We, therefore, earnestly hope that measures will be taken to implement this project.

On be half of the study team, let me express my heartfelt thanks for the generous cooperation, assistance and warm hospitality extended to the study team during their stay in Sri Lanka.

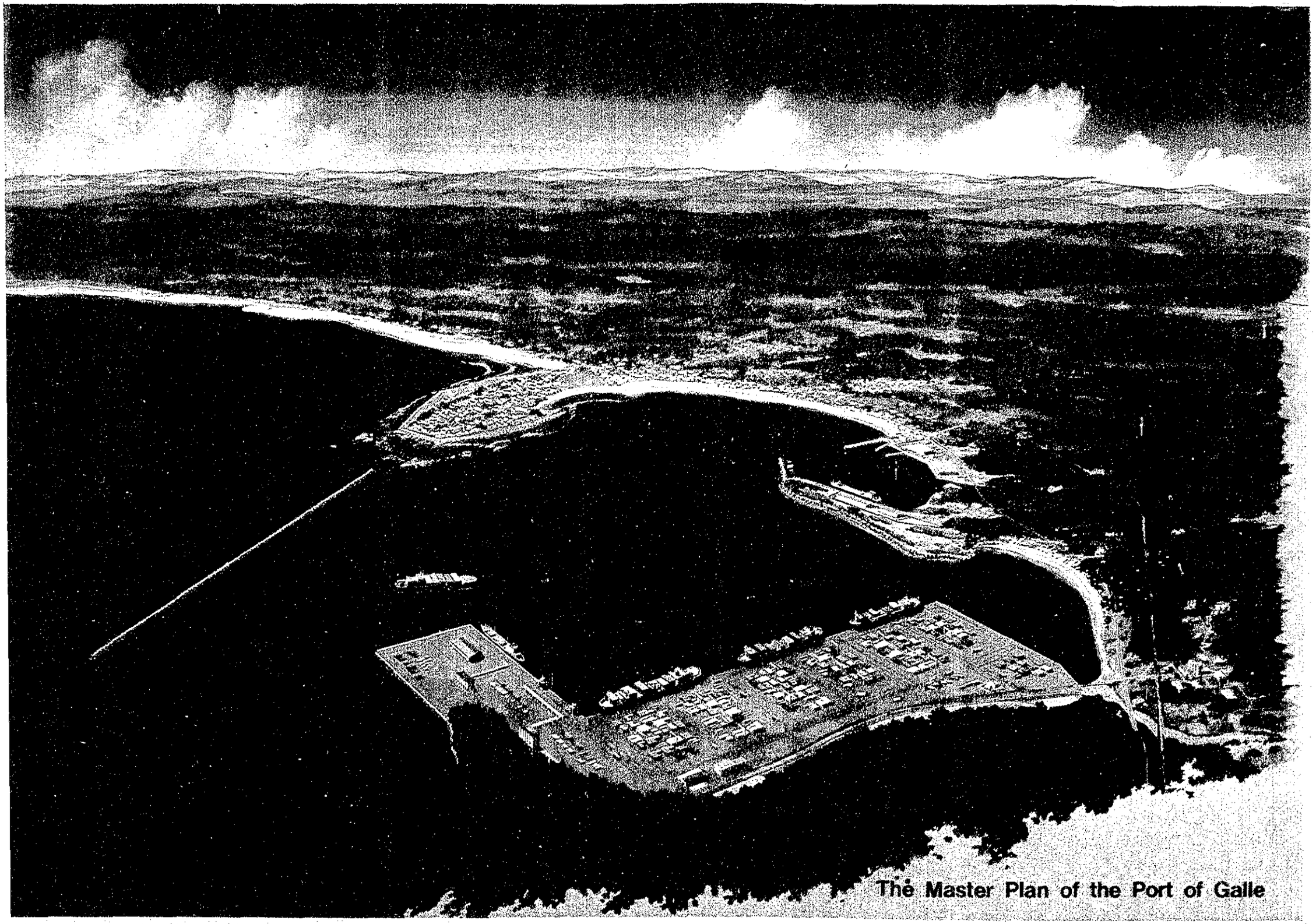
Our thanks are also due to the Japan International Cooperation Agency, the Ministry of Foreign Affairs, the Ministry of Transport, the Japanese Embassy and the JICA Office in Sri Lanka for their valuable advice and assistance during the field surveys and preparation of this report.

Yours Faithfully,

Haruo Okada
Leader
Japanese Study Team for the Development
of the Port of Galle
(Executive Director, Overseas Coastal
Area Development Institute of Japan)



Location Map of the Port of Galle



The Master Plan of the Port of Galle

Abbreviation List

A	ADB	Asian Development Bank
	APL	American President Lines
	ASEAN	Association of South-East Asian Nations
	ave.	average
B	BOD	biochemical oxygen demand
	BOT	build, operate and transfer
	BXCL	Bengal Express Container Line
C	C°	centigrade
	CC	Sri Lanka Cement Corporation
	CCD	Coast Conservation Department
	CFC	Ceylon Fertilizer Corporation
	CFC	conversion factor for consumption
	CFS	container freight station
	CIF	cost, insurance and freight
	COBRA	Continental Britain Asia Container Service
	COD	chemical oxygen demand
	CPC	Ceylon Petroleum Corporation
	CSC	Ceylon Shipping Corporation
	CSL	Ceylon Shipping Lines
D	DL	datum level
	DWT	dead weight tonnage
E	EC	European Community
	EIRR	economic internal rate of return
	EPZ	export processing zone
F	FAO	Food and Agriculture Organization of the United Nations
	FIRR	financial internal rate of return
	FOB	free on board
	F/S	feasibility study

G	GB	gigabyte(s)
	GCEC	Greater Colombo Economic Commission
	GDP	gross domestic product
	GNP	gross national product
	GRT	gross registered tonnage
	Gwh	gigawatt(s)-hour
H	ha	hectare(s)
	HP	horsepower
	hr	hour
	HWL	high water level
	HWOST	high water of ordinary spring tide
I	IBRD	International Bank for Reconstruction and Development
	IMF	International Monetary Fund
J	JCT	Jaye Container Terminals
	JICA	Japan International Cooperation Agency
K	kg	kilogram
	kHz	kilohertz
	km	kilometer(s)
	kv	kilovolt(s)
L	L-M	Little and Mirrlees
	LOA	length over all
	LWOST	low water of ordinary spring tide
M	m	meter(s)
	mm	millimeter(s)
	Mn.	million
	MSL	mean sea level
	MOST	Ministry of Surface and Transport
	M.T.	metric ton(s)
	Mw	megawatt(s)

N	n.a.	not available
	NFS	National Fertilizer Secretariat
	NIES	Newly Industrializing Economics
	NNP	New North Pier
	NWSDB	National Water Supply and Drainage Board
O	OCC	opportunity cost of capital
	OECD	Organization for Economic Cooperation and Development
	OECF	Overseas Economic Cooperation Fund of Japan
Q	QCT	Queen Elizabeth Container Terminal
	QEQ	Queen Elizabeth Quays
R	r	correlation coefficient
	Rs	Rupees
S	SAARC	South Asian Association of Regional Cooperation
	SCF	standard conversion factor
	SDR	special drawing right(s)
	SLR	Sri Lanka Railways
	SLRTBs	Sri Lanka Regional Transport Boards
	SLPA	Sri Lanka Ports Authority
T	TEU	twenty-foot equivalent unit
U	UAE	United Arab Emirates
	UDA	Urban Development Authority
	UK	United Kingdom
	US	United States
	USA	United States of America
	USAID	United States Agency for International Development
	USSR	Union of Soviet Socialist Republics
W	WDL	work datum level

Exchange Rate

US$1.00 = Rs.41.00 = ¥138.85

FINAL REPORT

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CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. Significance of the development of the Port of Galle

From the international shipping points of view, the Port of Galle offers a very advantageous location. It is extremely important to take advantage of this favorable location. Therefore, we should pay attention to its possible function as transshipment base for container cargo. There has been a tendency for large container vessels to decrease their number of port calls as the size of the vessels increases, a tendency which is seen as economically favorable. As a result, economically advantageous ports are selected as hub ports in the main world shipping route. The Port of Colombo is one of those ports. And because of its more advantageous location, the Port of Galle has the potential to become a more productive hub port than Colombo. In terms of its distance from the main shipping route, it is expected that the Port of Galle will serve as a distribution terminal for bulk cargo such as wheat in southwest Asia by using its locational advantage, which is possible scenario for the future of the international bulk cargo transportation.

Viewed from the nation-wide port development policy, it is necessary to construct a new port to supplement certain shortcomings of the Port of Colombo, in light of the fact that expansion of the Port of Colombo is impossible due to physical restrictions. Therefore, it is a matter of significance to develop the Port of Galle for Sri Lanka.

Development of the Southern Province is given the highest priority by the Government of Sri Lanka. This province has remained economically stagnant because it lacks the necessary industries capable of absorbing highly educated labor forces. Industrial development, therefore, should be facilitated as soon as possible for economic development of the province. In this sense, the development of the Port of Galle, in that it will help spearhead regional development as well as support industrial development, is considered quite important.

2. Master Plan to the year 2005

Cargo throughput of the Port of Galle at the year of 2005 is estimated at 713,000 TEU of container, 1,523,000 tons of other cargo. Wharves

mainly for handling container and bulk cargo are newly planned in the Galle Bay, leaving the existing berth to service the conventional vessels.

Alignment of new port facilities in the bay is determined only after the natural conditions such as waves and soil, present condition of land utilization and potential for future development have been carefully examined. The Galle Bay is attacked by both swells all through the year and wind-waves during southwest monsoon season that come through the mouth of the bay facing southwest. Therefore, it is indispensable to construct long breakwaters to secure calmness in the inside water area. There are scattered rocks in the surface layer covering almost the entire bottom of the bay and therefore it is necessary to dredge much amount of rocks to accommodate large vessels like the container vessel. In order to select the optimal construction site of port facilities, we formulated five alternatives to compare construction costs, the calmness of basin, future potential and so on. The selected plan, in which the front of Rumassala Hill is reclaimed to build a new wharf, is cost-effective in that the dredging cost is cheaper than the other alternatives because of the large depth and deep rock bed. The contents of the master plan are; 3 container berths (depth; -14m, length; 1050m), 2 general/bulk cargo berths (depth; -14m,-12m, length; 510m), 1 oil berth (depth; -7.5m, length; 120m, inside of the existing breakwater). A channel with a width of 300m and a depth of 14m, and a southwest breakwater with a length of 1300m are planned. Also other facilities, handling equipment, yard, warehouse, road, railways and so on are planned.

3. Short Term Development Plan up to the year 1997

(1) Content of the plan

The cargo throughput at the year of 1997 is estimated at 226,000 TEUs of container, 597,000 tons of other cargoes. Assuming that break bulk cargo is handled at the existing berth, as in the master plan, 1 container berth (depth; -14m, length; 350m),1 feeder berth (depth; -9m, length; 170m), 1 general/bulk cargo berth (depth;-12m, length;240m) and 1 oil berth (depth; -7.5m, length; 120m) are planned. The southwest breakwater (length; 1,200m) and the east breakwater (length; 165m) are also planned. Besides these,

handling equipment, warehouses and so on are also planned.

(2) Construction Cost and Implementation Program

Cost estimation was carried out based on preliminary design of facilities and the implementation program. The number of days available for construction on the sea is limited due to high waves, especially during the southwest monsoon season. Therefore, the implementation schedule is rigorous one to ensure that the service begins at the beginning of 1997. Total construction cost amounts to US$ 334.61 mill and foreign portion is US$ 245.29 mill accounting for 73.3%.

(3) Management and Operation Program

A new organization needs not to be established to administrate and operate port facilities that are to be newly constructed. The present organization presided over by the residential manager should be enlarged and strengthened. The financial aspects of this project present some difficulties (see below). Hence, allocation of personnel should be restricted to the minimum level to secure economic operation.

(4) Evaluation

Comprehensive evaluation is carried out through an economic analysis in which implementation of the project is evaluated from the national economic point of view and through financial analysis in which profitability of the project itself and financial soundness of the administration body are evaluated.

In an economic analysis, evaluation is carried out by the internal rate of return(IRR) calculated through cost benefit analysis. The objective of this project is to promote the development of the Southern Province through the development of the Port of Galle and the introduction of handling of transshipment container cargo is to spearhead the same objective. We took the revenue earned from the transshipment cargo and the savings from the inland transportation cost for local cargo as a benefit and compared it with the project cost. Considering that the breakwater, basin and channel contribute to all the facilities including ones to

be constructed in the bay after the completion of the short term plan, we divided the construction cost of them into a short term plan and a later plan. On this basis, the calculated IRR is 8.15% with 35 years of project life. This figure judged only marginally feasible compared with the international benchmark. However, since some indirect benefits, such as the increase of employment and income related to port activities in the hinterland are likely to result from this project and providing that other projects in the Southern Province development plan are promoted so that full utilization of port facilities can be achieved, this project is ranked as one to be implemented.

In the financial analysis, we calculated the financial internal rate of return (FIRR) by the discount cash flow method and made tables of financial statements. There is some margin for fare-hike comparable to those of neighboring countries concerning the handling charge of container transshipment. Then, 20% fare-hike is assumed. It is also assumed that 85% of the construction cost is loaned by the Government; a low interest long term loan is provided by the foreign country and the rest of it is procured from local financial organizations. The construction cost of the breakwater and channel for the initial cost is too vast to burden SLPA within the short term plan, and nor do these facilities bring any direct benefit. Therefore, it is assumed that the SLPA will not bear that construction cost.

Financial internal rate of return is calculated at 4.99% on the basis of these conditions. This rate is higher than the average procurement interest rate of 4.03%, thereby preserving the profitability of the project. On the other hand, according to estimated financial statements of the SLPA, financial soundness of the SLPA is maintained solely from the profit provided by port activity in Colombo. Therefore, we conclude that this project is feasible from a financial aspect from both the viewpoints of profitability and financial soundness providing that the SLPA does not pay for the construction cost of the breakwater and channel.

Recommendations

The development of the Port of Galle is not only the best way to utilize its advantageous location and increase national profits for Sri Lanka; it would also reap benefits for the Southern Province. Based on these projections, the development of the Port of Galle is of prime importance.

Based on the analysis it was found that the implementation of a single port project is only marginally viable from an economic point of view, as construction costs would be higher due to the need for a long breakwater to secure calmness in the basin and because the hinterland area of the port is underdeveloped. It is, however, judged to be a project worth launching, one that will spearhead development of the Southern Province, provided that other projects in the Province are facilitated as planned and industrial development keeps pace with the port development so that full utilization of port facilities can be achieved. For the implementation of this project, we strongly recommend that the following steps be taken:

(1) It is indispensable to foster port related industries in the hinterland to increase feasibility. Accordingly, prospect precisely the concrete schedule of port utilization through examining feasibility of port related industries in the development plan of the southern province.

(2) Introduction of container transshipment cargo is the key to success in the initial stage of this project. Accordingly, utilization of the port by desirable clients such as big shipping lines should be secured. It is necessary to get promises from the shipping lines that the port will indeed be called on.

(3) As the development of the Port of Galle is an important project for spearheading the development of the Southern Province, some special strategical decision should be made to ensure that the expected results are realized. Namely, the Sri Lankan Government should offer financial incentive to promote this project. It is impossible financially to implement this project for SLPA, when the

construction cost of breakwater and channel dredging is paid without the full support of the Government.

(4) Self-help by SLPA itself is also needed. SLPA should make an effort to accumulate internal reservation through an efficient operation in the Colombo port, which would result in financial soundness. Finally it is necessary to carefully inspect the change of the financial condition after beginning the construction of the new berth.

PART I GENERAL DESCRIPTION OF PRESENT CONDITIONS

1 INTRODUCTION

1-1 Background of the Study

Sri Lanka's international trade is on the rise due to the economic development of the country. The Port of Colombo, the main port in the country, plays a very important role as a transshipment port in world shipping because of the development of containerization in shipping and Colombo's advantageous location between the West and the East.

In particular, by dint of the formulation of a master plan through Japanese technical cooperation and construction of port facilities using Japanese yen loans, more rapid growth of transshipment cargo volume has been brought about, and Colombo Port is now contributing not only to the development of Sri Lanka's trade but also to the accumulation of foreign currency.

As the amount of container cargo handled at this port is still increasing, the SLPA is now constructing new port facilities. However, it is acknowledged that there are many difficulties in enlarging the port facilities because of the physical condition of the port. Therefore, the necessity of formulating a plan for a port supplementary to the Port of Colombo is increasing.

Since the Port of Galle (hereinafter referred to as "the Port") is located not far from the Port of Colombo and is very close to major shipping routes, the Port has a high priority as a port supplementary to the Port of Colombo.

However, the southern region of this country is comparatively underdeveloped, and development of this region is one of the most important subjects for the country. Therefore, there are high hopes that the Port's development will spearhead the development of this region.

On the basis of the situation described above, the Government of Sri Lanka has requested the Government of Japan to provide technical cooperation in conducting a study for development of the port of Galle.

1-2 Objectives of the Study

Based on the above, the objectives of the study are summarized as follows:

(1) To prepare a Master Plan for the development of the Port of Galle up to the year 2005 to spearhead the regional development of the Southern Province.

(2) To conduct a Feasibility Study of the Short Term Development Plan for the Port of Galle within the framework of the Master Plan. A Short Term Development Plan shall be prepared for the period up to 1997, giving consideration to adequate arrangement of the main breakwaters and channel alignment to secure safe navigation as an urgent necessity.

(3) To make technical transfer to the counterparts in the process of the study.

1-3 Scope of the Study

(1) Collection and analysis of the existing data and information

(2) Field observation and analysis of natural conditions
   1) Sounding
   2) Topographic survey
   3) Sonic prospecting
   4) Boring
   5) Investigation of anomalous waves
   6) Transformation of waves
   7) Evaluation of calmness in the Bay of Galle

(3) Formulation of conceptual alternatives
   1) Evaluation of coastal area development potential
   2) Analysis of future industrial development and projection
   3) Port traffic projection in 1997 and 2005
   4) Evaluation of the capacity of the Port of Colombo
   5) Estimation of conceptual alternatives

(4) Formulation of the master plan
   1) Estimation of port facilities required
   2) Formulation of the layout plan of facilities

3) Rough designs, approximate cost estimates
and implementation programs
4) Consideration of environmental aspects

(5) Formulation of the short-term development plan
1) Layout plan of port facilities and other relevant infrastructure
2) Preliminary structural designs, implementation programs
and cost estimates
3) Port management and operation

(6) Feasibility analysis of the short-term development plan
1) Economic analysis
2) Financial analysis

(7) Formulation of an urgent plan

The study will be carried out according to the flow chart shown in Figure 1-1-1.

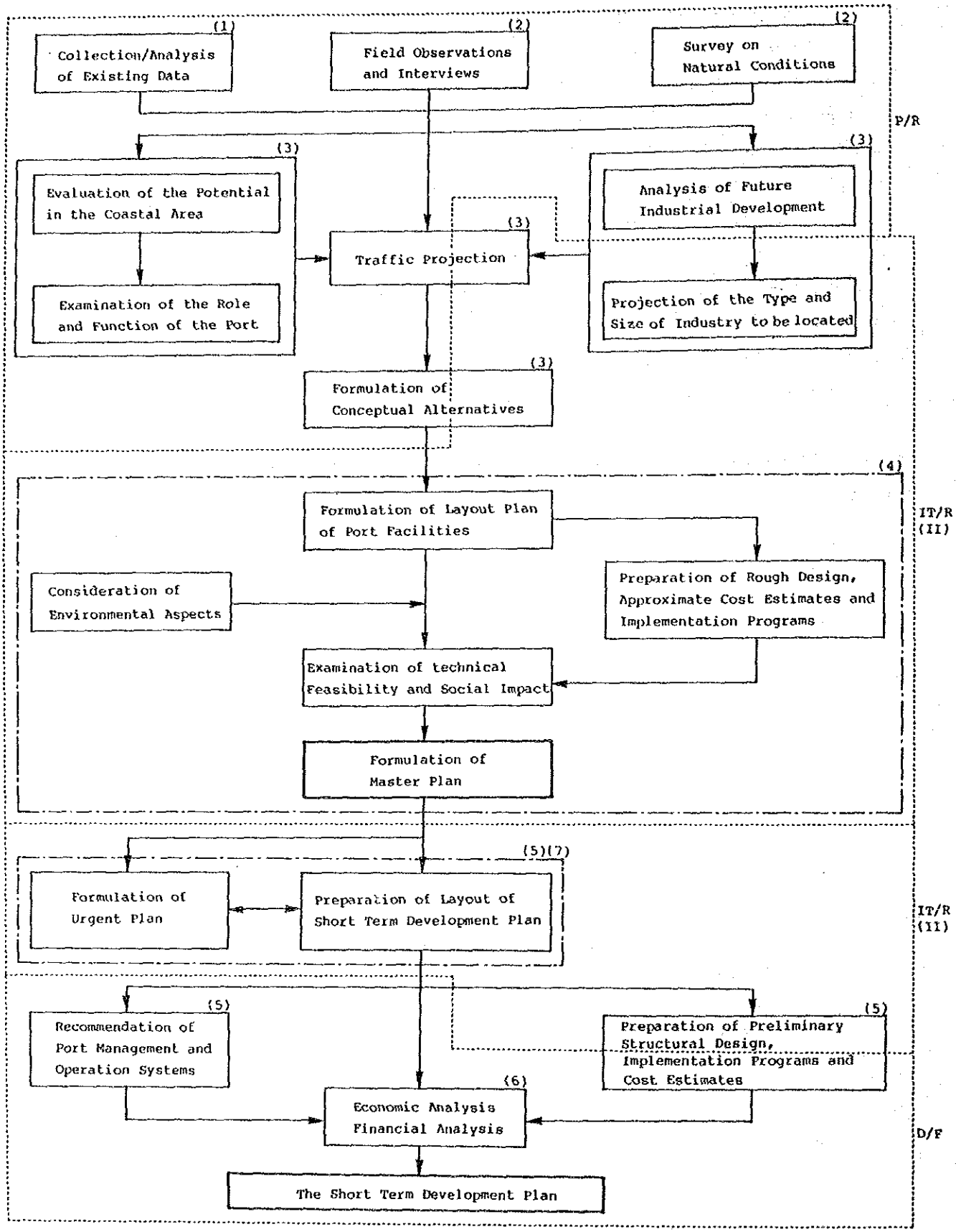

Fig. 1-1-1 Overall Study Flow

1-4 Study Schedule

The study was conducted as follows:

(1) Presentation of the Inception Report, the first field survey, presentation of the Progress Report: Sept.-Dec. 1990
(2) Preparation of the Interim Report(I): Dec.1990-Feb.1991
(3) Presentation of the Interim Report(I), the second field survey: Mar.-Apr. 1991
(4) Preparation of the Interim Report(II): Apr.-May 1991
(5) Presentation of the Interim Report(II), the third field survey: May 1991
(6) Preparation of the Draft Final Report: May-Sept. 1991
(7) Presentation of the Draft Final Report: Sept. 1991
(8) Submission of the Final Report: Nov. 1991

1-5 Organization of the Study Team

The JICA study team is composed of ten specialists. Their names and responsibilities are listed here.

Name	Responsibility
Haruo OKADA	Team Leader, Overall Management
Hozumi KATSUTA	Port Planning
Kunihiko IWATA	Regional Planning
Toshihiko KAMEMURA	Industrial Location
Yukio KAMEI	Cargo Forecast, Economic Analysis
Norio UEMURA	Port Operation, Management, Financial Analysis
Toshiro ICHIZONO	Design of Port Facilities
Hisashi AONO	Natural Conditions I (Meteorology/Oceanography)
Mitsutaka IMAMURA	Construction Method/Cost Estimate
Kenji TORIMAE	Natural Conditions II (Soil/Topography)

2 GENERAL DESCRIPTION OF SRI LANKA

2-1 Geography and Topography

Sri Lanka, an island in the Indian Ocean, is located at the east-southeast tip of the Indian subcontinent and situated from 6 to 10 degrees north latitude and from about 80 to 82 degrees east longitude. Sri Lanka has a maximum length of 432 km and a maximum width of 224 km and an area of about 65,000 km^2.

Sri Lanka is separated from the subcontinent with the distance less than 30 km at Adam's Bridge in the Park Strait, as well as by the Gulf of Mannar (See Figure 2-1-1). The northern part from the center of the island is almost all plains, while the southern part is mountainous and surrounded by coastal plains. The highest point in Sri Lanka is Pidurutalagala Peak, 2,524 m above sea level, in Nuwara Eliya District.

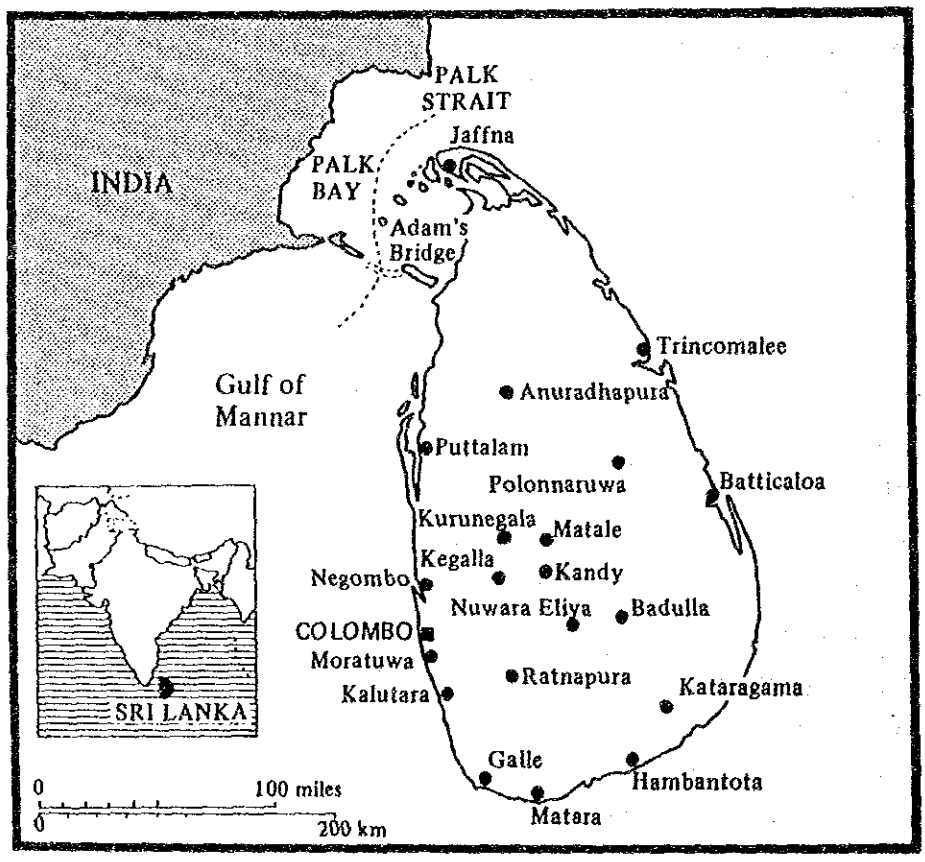

Figure 2-1-1 Democratic Socialist Republic of Sri Lanka

The island consists of 9 provinces: Western, Central, Southern, North-Western, Sabaragamuwa, Northern, Eastern, Uva and North-Central, and 25 districts, such as Colombo, Kandy, etc. The capital of Sri Lanka is Sri-Jayawardenepura (Kotte).

2-2 Climate

The climatic year in Sri Lanka can be divided into distinct periods, i.e., the Southwest Monsoon period from May to September, the Northeast Monsoon period from December to February and two intermonsoonal periods. The southwest quarter of the island receives 500mm to 4,000mm of rain and the rest of the island receives less than 500mm of rain in the Southwest Monsoon period. On the other hand, the whole island receives 500mm to 2,500mm of rain in the Northeast Monsoon period. Through the year, the southwest quarter of the island receives much rain. The area receiving more than 75 inches (1,905 mm) of rain is called the Wet Zone and the area with less than 75 inches is called the Dry Zone.

The temperature is almost constant through the year, at about 26°C. The maximum temperature varies from 29.4°C to 32.6°C, while the minimum ranged between 22.3°C and 25.5°C in Colombo in 1978. The average temperature in Nuwara Eliya of hill country is around 16°C.

The average humidity is relatively high, at more than 75%.

30-year average annual rainfall and maximum and minimum temperature at selected stations are shown in Appendix I-2-1.

2-3 Socioeconomic Activities

2-3-1 Population

According to the estimation of Central Bank of Sri Lanka, the total population of Sri Lanka at the end of 1989 was 16.81 million, compared with 16.59 million at the end of 1988. The average growth rate of the population from 1980 to 1989 was about 1.5% per annum. The data estimated based on the 1971 and 1981 censuses are shown in Appendix I-2-2.

The average population density of Sri Lanka was 257 persons per km2 in 1988. The most densely populated districts were Colombo (2,871) and Gampaha (1,096), while the most sparsely populated districts were Mullaitivu (36) and Vavuniya (56).

The population of Sri Lanka is mainly made up of Sinhalese, as well as a few other ethnic groups such as Sri Lankan Tamil, Indian Tamil, Sri Lankan Moors, Burghers and Malays. According to the 1981 census, Sinhalese comprise 74% of the total population and the share of the Sri Lankan Tamils, Indian Tamils, Sri Lankan Moors, Burghers and Malays in the total population were 12.7, 5.5, 7.0, 0.3 and 0.3%, respectively. The religious affiliations as enumerated in the 1981 census showed that of the total population 69.3% were Buddhists, 15.5% Hindus, 7.6% Christians (of which 90% were Roman Catholics) and 7.5% were Muslims.

2-3-2 National Income

In 1989, the Sri Lanka economy achieved a relatively modest rate of economic growth. The gross domestic product (GDP) of Sri Lanka at current prices in 1989 was Rs.228,373 million, an increase of 12.2% over 1988. And the GDP at 1982 constant prices in 1989 is Rs.121,729 million. The growth rate is 2.3%, compared with a growth rate of 2.7% in 1988. The average annual growth rate of GDP from 1982 to 1989 is about 3.7%. This rate is slightly lower than the value predicted by the government of Sri Lanka because of interruptions by a series of civil disturbances.

The sectoral composition of GDP is shown in Appendix I-2-3. The average growth rate of value-added in the agricultural sector was only 1.5%, due to difficulty in increasing production of three major crops: tea, rubber and paddy. However, growth of 6.0% was in the manufacturing sector due to the contribution of factory industries, especially in the private sector. Consequently, the agricultural sector's share of GDP decreased from 26.4% to 22.7%, while that of the manufacturing sector increased from 14.4% to 16.8%. Sectors with high average growth rate are the public administration sector, the banking sector and the mining sector. Sectors with low average growth rate are the service sector and the construction sector.

The gross national product (GNP) of Sri Lanka at current prices and at 1982 constant prices in 1989 were Rs.222,467 and Rs.118,791, respectively. The per capita GNP at current prices was US$367 in 1989.

Table 2-3-1 Per Capita GNP of Sri Lanka (1985-89)

Year	1985	1986	1987	1988	1989
US$	337	354	360	375	367

Source: Central Bank of Sri Lanka

2-3-3 Trade

The characteristics of Sri Lanka's trade are exports of primary products such as tea, rubber and coconut products, and imports of consumer goods such as rice, flour, sugar, milk, motor cars & cycles and miscellaneous goods as well as imports of intermediate goods such as petroleum, fertilizer, chemicals, paper, wheat and textiles and investment goods such as machinery. Accordingly, fluctuations in the international prices of tea, rubber and coconut products have an important effect upon the Sri Lankan economy as well as the balance of trade and the national income. However, the export of industrial products, especially textiles & garments has increased remarkably in recent years.

The balance of trade of Sri Lanka has been in the red, but this shows a downward trend. The balance in 1989 reflected a trade deficit of Rs.24,050 million (SDR 521 million), which was 8% lower than the previous year's deficit of Rs.24,102 million (SDR 564 million) on a SDR basis. Exports, imports and balance of trade are shown in Appendix I-2-4.

Export growth in 1989 was entirely reflected by a 16% increase in industrial exports and a 2% increase in agricultural exports. The value of mineral exports, in contrast, fell by 5% in 1989. Thus, export composition has gradually changed. The most noticeable changes were the rise in the share of industrial exports from 48% to 51% and a corresponding decrease in the share of agricultural exports from 43% to 39%, from 1988 to 1989. Textiles and garments continued to be the major export category, accounting for 31% of total exports in 1989. Meanwhile, the share of plantation crops in total exports dropped further to 35%. Major exports

and their shares are shown in Appendix I-2-5.

The import growth in 1989 was entirely reflected in a 11% increase in consumer goods and a 4% increase in intermediate goods. The value of investment goods, in contrast, fell by 8% in 1989. The most noticeable changes in imports was a rise in the share of consumer goods and a corresponding decrease in the share of investment goods from 1988 to 1989. Major imports and their shares are shown in Appendix I-2-6.

The exchange rate of the Sri Lankan Rupee against other major currencies in recent years are summarized in Table 2-3-2.

Table 2-3-2 Exchange Rate Movements

(Sri Lanka Rupees per Units of Foreign Currency)

Currency	1980	1983	1986	1989	1990
U.S.Dollar	8.9990	25.0000	28.5200	40.0000	39.9200
U.K.Pound Sterling	42.6955	35.8938	41.7691	65.0400	76.3869
German Deutsche Mark	9.2125	9.1050	14.6727	23.7002	25.5955
French Franc	3.9750	2.9744	4.4337	6.9354	7.6351
Japanese Yen	0.0836	0.1071	0.1794	0.2816	0.2766
Indian Rupees	2.2875	2.3531	2.1645	2.3603	2.2939

Source: Central Bank of Sri Lanka

Note: 1) Each value is at the end of the year except 1990.

2) The year of 1990 means the the end of August 1990,to be exact.

2-3-4 Prices

The average annual rates of increase in consumer prices in Sri Lanka in the past five years and the past ten years were 8.5% and 12.6%, respectively. The annual rate of increase in 1989 was 11.6%. Among commodities, the rise in clothing and fuel prices was remarkable.

The average annual rate of increase in wholesale prices in Sri Lanka over the past five years was 3.7% and the annual rate of increase in 1989 was 9.0%. The commodities whose prices rose the fastest were fuel, metal products and electric appliances.

2-3-5 Employment

Current information on the employment and labour market situation in Sri Lanka is limited. In the mid-1970s, the unemployment rate has exceeded 20% reflecting a quantitative insufficiency in the volume of employment opportunity. However, major changes in the country's economic and social policies, such as the acceleration of the development efforts and the undertaking of a number of lead projects, were introduced in 1977, and unemployment began to decline in 1978, probably for the first time during the previous 20 years. The unemployment problem in Sri Lanka was both the result of an increase in the size of entrants into the labour force, with better education and higher aspirations, as well as the slow growth of the economy.

A Labour Force & Socioeconomic Survey was carried out by the Department of Census and Statistics in 1985/86. The survey estimated the economically active population, or the labour force, at 5,131,749 employed persons and 840,252 unemployed persons, making a total labour force of 5,972,001 persons. The unemployment rate was about 14%.

2-4 Transportation

The railway and road transport network of Sri Lanka had been developing according to the transport demand for plantation products, such as coffee, rubber and coconuts. And the development of the Port of Colombo heralded the creation of an export-import oriented economy.

2-4-1 Railway

The railway system in Sri Lanka is at present operated by the Sri Lanka Railways (SLR) as a government department under the Ministry of Transport. The system has a total track length of 1,394km of broad gauge and 59km of narrow gauge.

The 120km broad gauge line from Colombo to Kandy, constructed in 1865, was Sri Lanka's first railway. Extended in several stages over bridges and passing through many tunnels, it traversed the hill country to terminate at Badulla, the capital of Uva Province. From Polgahawela, on

the line to Kandy, an important extension was constructed to the Northern Coast to reach Kankesanthurai in 1905, with three branch lines to Trincomalee and Batticaloa on the East Coast and to Mannar on the West Coast. The broad gauge network was completed by the Southern Coastal line skirting the South-West Coast to Matara in 1895 and a line to Puttalam in 1926 (see Figure 2-4-1).

The SLR as of 1985 operated its broad gauge track of 1,394km with 237 locomotives and 1,366 passenger coaches along with 3,840 goods wagons. The SLR gained 60% of its revenue from passenger transport and 40% from carrying of goods.

In 1989, the SLR carried 1,677 million passenger-km, as compared with 1,859 million in 1988, a decrease of 9.8%. The SLR also carried 178 million ton-km of freight, as compared with 198 million in 1988, showing a decrease of 10.1% (see Appendix I-2-7).

During 1989, civil disturbances forced a heavy toll on the railway network in the country. Altogether, 50 railway stations and six trains were destroyed, while 38 bridges were damaged. According to the Central Bank of Sri Lanka, the cost of losses and damages was estimated to be over Rs.200 million.

2-4-2 Roads

Colombo, being the country's administrative and commercial center, is connected to district capitals and the main urban centers through a road network of Class A roads, which are paved and bitumen-surfaced. There are 4,050km of such roads, which are supported by a network of Class B roads connecting other important towns. These are metaled and bitumen-surfaced and have a total length of 4,875km. Minor roads are classified as Class C, D and E. Class C roads, which total 10,409km, are primary agricultural roads and local roads with a single lane. They are mostly metaled but a small percentage is graveled. Class D roads, with a total length of 5,418km, are graveled roads, generally motorable during dry weather. Class E roads, totaling 714km, are bridle paths and unspecified roads, the majority of which are not motorable (see Figure 2-4-2). The public roads length mentioned above are based on 1985 statistics.

Sri Lanka has a total of 86,200km of roads of all categories, of

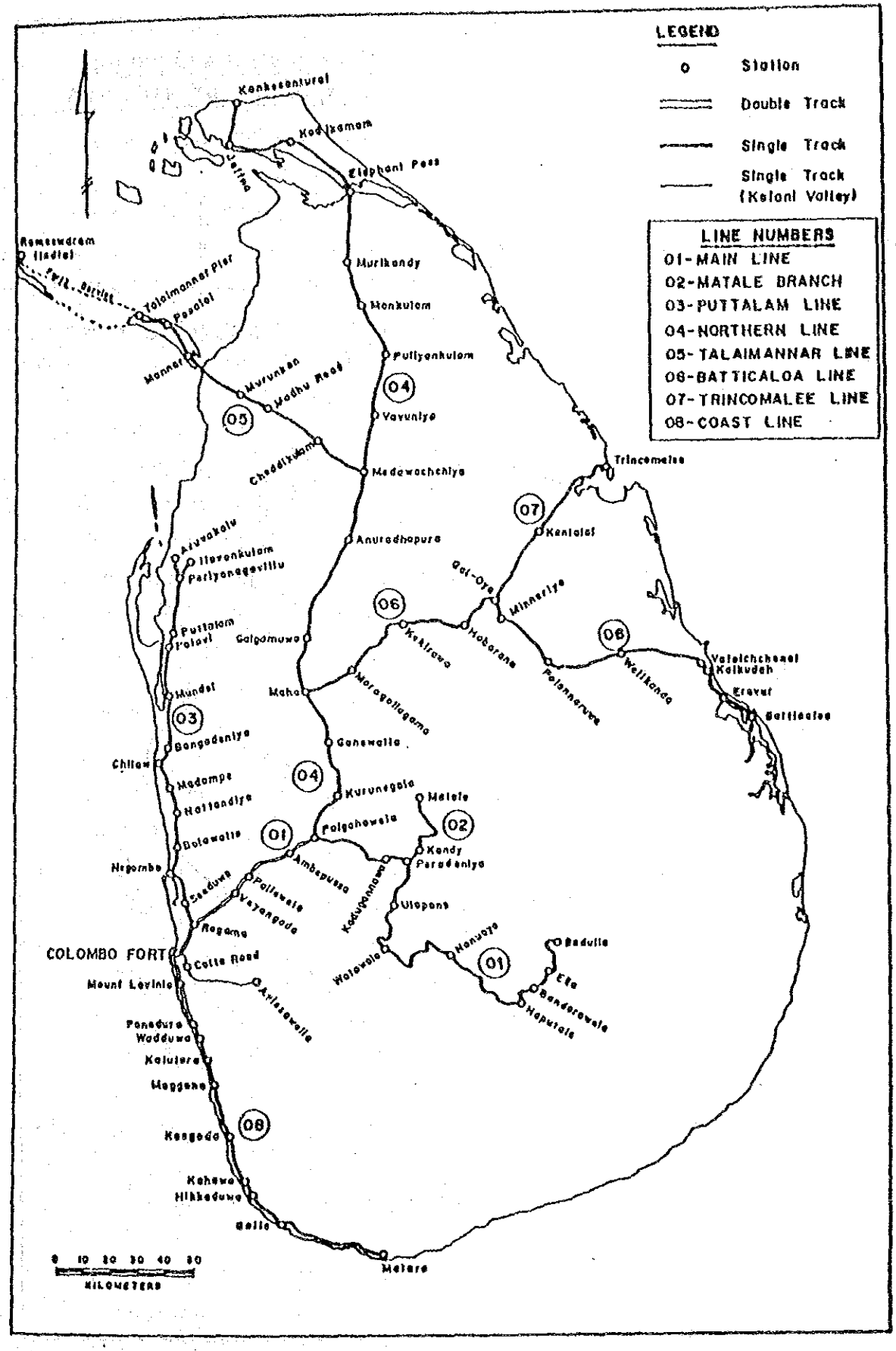

Figure 2-4-1 Sri Lanka Railways System Map

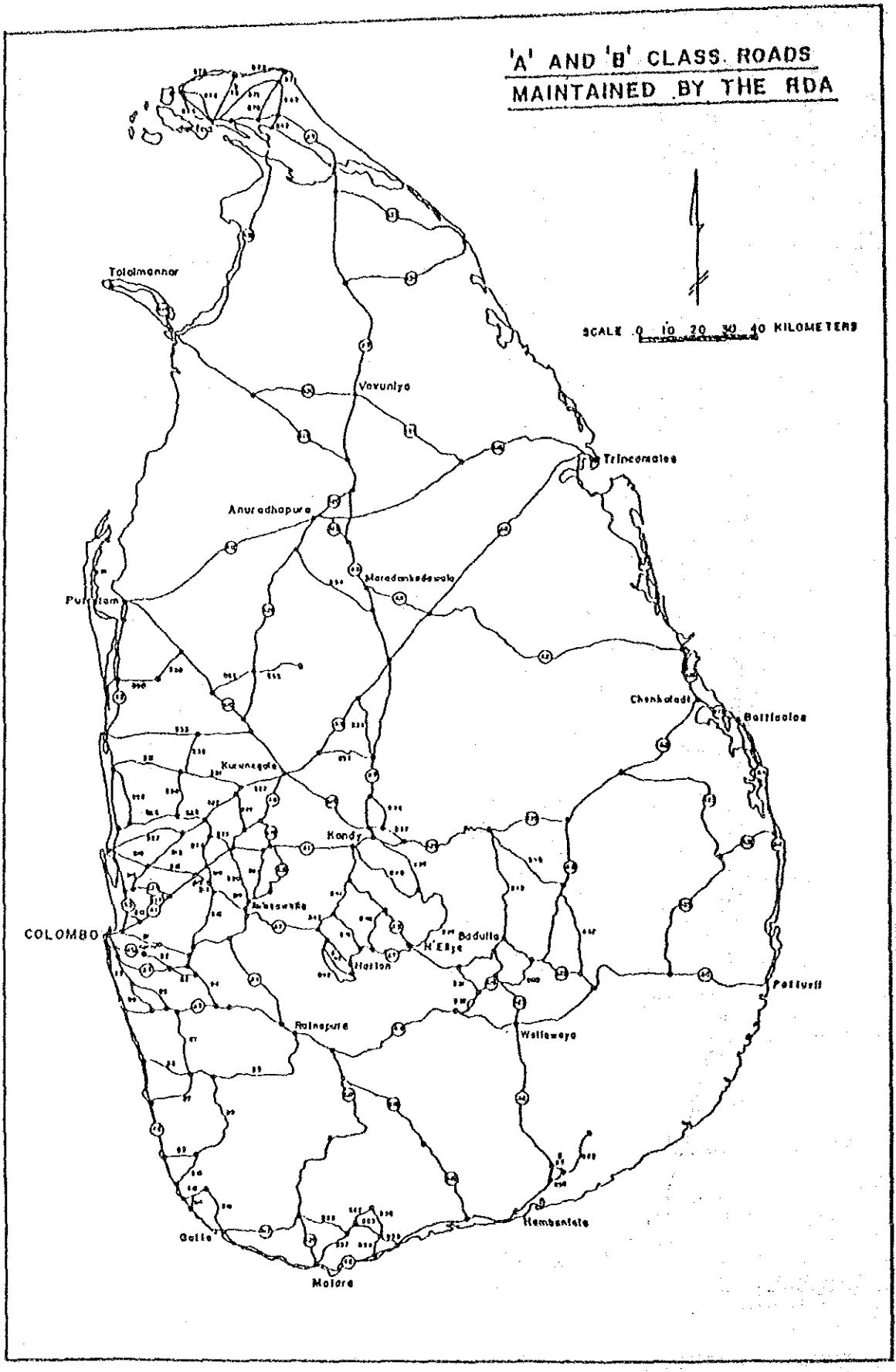

Figure 2-4-2 Sri Lanka Road System Map

which 29,747km are bitumen-surfaced. The Department of Highways maintains 25,466km (25,684km in 1988) of roads, which are mentioned above paragraph; local authorities maintain another 40,600km of roads; and other agencies maintain about 20,000km of roads. The total length of roads available for motor transport is about 30,000km. The all-island road density is 1.31km per km^2; the density of paved roads is 0.45km per km^2.

Motor traffic has shown fairly rapid growth since 1975, the most noticeable increase being in motorcycles and private coaches (a kind of minibus), showing more than ten and twenty-fold increases between 1975 and 1988, respectively. Private cars also increased about from 92,000 to 187,000 during the same period. The increase in goods transport was also significant growing from about 40,000 in 1975 to 109,000 in 1988. Tractors and trailers also showed an increase, from about 29,000 in 1975 to 85,000 in 1988 (see Appendix I-2-8).

Passenger service in Sri Lanka are provided by the Sri Lanka Regional Transport Boards (SLRTBs) and the private sector. In 1989, the SLRTBs had about 13,630 buses, compared with 13,370 buses in 1988. The buses carried 12,980 million passenger-km, compared with 15,413 million in 1988, a decrease of 15.8%. Most road haulage is handled by private goods transporters and own-account operators through container carriers, lorries, vans, tractors, trucks and bullock carts. There are no firm data and it is difficult to estimate the magnitude of the services provided by the road haulers. Appendix I-2-9 shows the passenger kilometers of road transport by the SLRTBs.

The scale of the SLRTBs's operations declined sharply in 1989 due to civil disturbances. A total of 376 buses were completely or partly destroyed. The Central Bank of Sri Lanka estimated a capital loss of Rs.322 million to the SLRTBs. Passenger services provided by the private sector also recorded a considerable decline owing to continuous disruption. About 65 buses belonging to the private sector were destroyed during the disturbances in 1989.

2-4-3 Sea Transport

Until recent times, sea transport in the island was handled by foreign shipping companies. In 1954, the Ceylon Shipping Lines Ltd. (CSL) was formed. CSL now operates as a subsidiary of the Ceylon Shipping

Corporation (CSC) and provides a coastal shipping service together with a feeder service linking Indian ports and those of other countries with Colombo.

Ship haulage in Sri Lanka is provided by Colombo, Galle and Trincomalee ports. These ports are managed and operated by the Sri Lanka Ports Authority (SLPA), which was established as a government-owned corporation in 1979. In recent years, the port of Colombo has been modernized in order to expand its capacity to cater to the requirements of larger vessels with container facilities. The port of Colombo now can satisfactorily function as a pivotal port handling transshipment containers in this region (see Figure 2-4-3).

The number of vessels arriving at the port of Colombo increased from 2,327 in 1988 to 2,548 in 1989. However, the volume of cargoes handled decreased by 9% to 10.429 million tons in 1989. The main reason for the decrease was the decision by American President Lines (APL), following the civil disturbances in Sri Lanka, to stop using Colombo as a pivotal port for its feeder service to Karachi and Bombay (this function is now carried out by Fujairah) and to Calcutta and Chittagong (this function is now carried out by Singapore). Also, the civil disturbances in and of themselves, separate from APL's decision, helped cause the decrease in the volume of cargoes. However, the total cargoes handled at the ports of Trincomalee and Galle increased by 36% and 23%, respectively, in 1989 despite the civil disturbances. The cargoes handled at the three ports in the last decade are summarized in Table 2-4-1.

Table 2-4-1 Cargo Tonnage Handled at Three Ports

(Unit: '000 Tonnes)

Year	Colombo	Trincomalee	Galle
1980	5,720.1	255.1	46.2
1981	5,186.1	722.8	40.0
1982	5,831.0	576.2	18.3
1983	6,090.2	912.5	38.6
1984	6,637.7	947.2	37.4
1985	7,338.0	1,127.3	69.3
1986	8,517.8	1,180.1	168.9
1987	9,681.7	1,013.9	226.0
1988	11,469.4	873.5	173.7
1989	10,428.9	1,184.2	213.7

Source: Port Statistics, SLPA

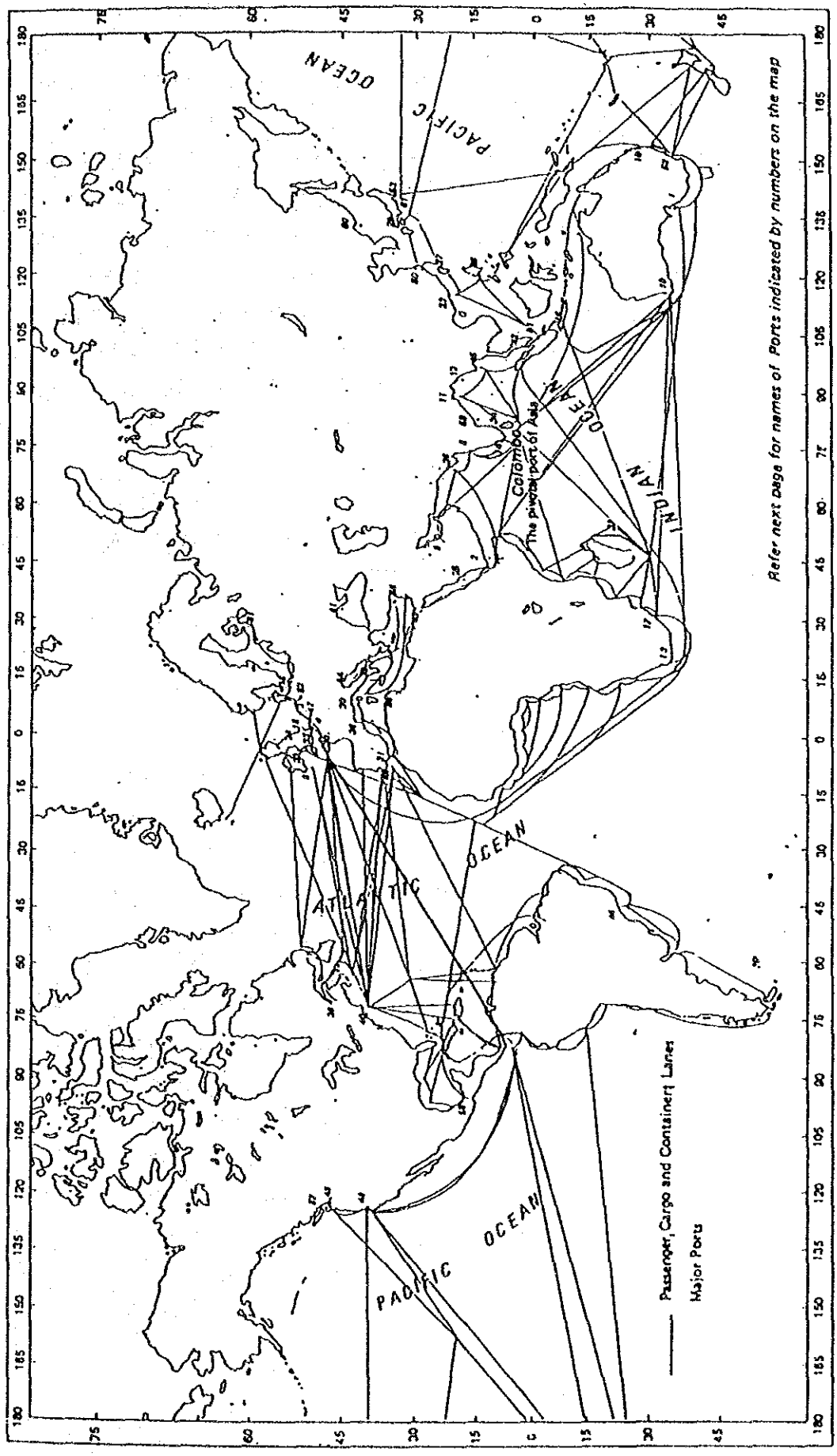

Figure 2-4-3 Shipping Lanes from Port of Colombo

2-4-4 Air Transport

Sri Lanka has one modern international airport at Katunayake, about 30km north of Colombo, which was constructed in 1961 with foreign assistance. Modernization and expansion of the airport complex was completed in 1988. The project included the construction of a second runway, expansion of the apron and the construction of fully equipped passenger and cargo terminals. The airport now has the capacity to handle over one million embarking/disembarking passengers per annum.

Air Lanka, the national carrier, was founded in 1979 to replace Air Ceylon and now operates a fleet of five Tristars and one B737, of which two aircraft are owned by the airline. It provides international services to 24 cities in 19 countries.

Air Lanka carried approximately 720,000 passengers in 1988, compared with 580,000 in 1987. Appendix I-2-10 shows the passenger-kilometers and ton-kilometers of the freight by air transport.

3 GENERAL DESCRIPTION OF THE SOUTHERN PROVINCE

The Southern Province, which seems to be the hinterland of the Port of Galle, is one of the country's nine provinces, and is located along the entire southern coast of Sri Lanka. The Southern Province is divided into the three districts of Galle, Matara and Hambantota, whose areas are about 1,650 km^2, 1,280 km^2 and 2,610 km^2, respectively. The total area of the Southern Province is 5,540 km^2, of which 46 km^2 is inland water areas.

Galle and Matara districts in the wet zone had average rainfalls of 2,580 mm and 2,790 mm per annum between 1981 and 1985. Hambantota District in the dry zone had a rainfall of 1,320 mm per annum during the same period.

3-1 Socioeconomic Activity

3-1-1 Population

In 1989, the population of the Southern Province was 2.10 million, 12.5% of Sri Lanka's population. The average annual growth rate in the Southern Province from 1981 to 1989 was 1.35%. This was a little lower than the national rate of 1.44% in the same period. The population increase rates in Galle, Matara and Hambantota districts were 1.1%, 1.0% and 2.3%, respectively, in this period. The populations of these three districts ranked sixth, ninth and fifteenth among Sri Lanka's 25 districts. Table 3-1-1 shows the population of the Southern Province between 1981 and 1990.

The population densities of the three districts in 1988 were 547, 569 and 188 person per km^2 and ranked seventh, fifth and fifteenth, respectively, in Sri Lanka.

More than 90% of the people of the Southern Province are Sinhalese. About 10% of Sri Lanka's Malays live in Hambantota District, but their share of the district's population is only 1%. Also, more than 90% of the people of the Southern Province are Buddhists.

Table 3-1-1 Population of Southern Province (1981-90)

(In thousands)

Year	Galle	Matara	Hambantota	Southern Province Sub Total	Share (%)	Sri Lanka
1981	815	644	424	1,883	12.6	14,988
1982	824	650	434	1,908	12.6	15,189
1983	833	657	444	1,934	12.5	15,416
1984	842	663	455	1,960	12.6	15,599
1985	851	670	465	1,986	12.5	15,837
1986	861	677	476	2,014	12.5	16,117
1987	870	684	487	2,041	12.5	16,361
1988	880	690	498	2,068	12.5	16,586
1989	889	697	510	2,096	12.5	16,806
1990	899	704	522	2,125		

Source: 1) Census of Population and Housing
2) Galle Municipal Council

3-1-2 National Income

There are no reliable estimates of provincial GDPs in Sri Lanka, except a survey called "Strategy for the Accelerated Development of the Southern Province of Sri Lanka", carried out by the Marga Institute.

The estimates indicated that the Southern Province's GDP at 1982 factor cost prices was Rs.9,331 million, nearly 9.9% of the national GDP. The population of the Southern Province was 12.6% of the total population of the country, which means the per capita GDP of the Southern Province was considerably lower than the national average (see Table 3-1-2).

Table 3-1-2 Per Capita GDP of Southern Province (1982)

	Unit	Southern Province	Sri Lanka
GDP	(Mil.Rs.)	9,331	94,679
Share	(%)	9.86	100.00
Per Capita GDP	(Rs.)	4,890	6,233

Source: Marga Institute

Note: GNP is defined according to international criteria as the sum of GDP and net investment income from abroad. It is difficult to apply this concept at the provincial level.

3-1-3 Employment

As mentioned in Clause 3 of Chapter 2 in this Part, information on the employment/unemployment growth trends and pattern in Sri Lanka have to be pieced together from fragmentary data. Reliable data and statistics on the employed/unemployed population are not available and the data from the censuses and surveys present a number of problems, such as noncomparability between surveys, different reference periods and timing of surveys.

According to estimates by the Central Bank of Sri Lanka, employment in the public and private sectors in Sri Lanka in 1989 increased moderately by 3.9% and 3.3%, respectively. The Government has a plan to reduce unemployment from its present level of about 18% to an acceptable level of 6% by 1994. However, this seems to be a formidable task, as it would require annual economic growth of 7-8%.

The Southern Province is one of the regions of the country that have been worst-affected by the chronic problems of high unemployment and slow growth that characterise the Sri Lanka's economy in general. This is because the province has not participated adequately in the post-1977 phase of rapid economic growth, due to lead projects and the large-scale investments being located elsewhere.

The province's number of unemployed people in 1981 was about 148,000, nearly 16% of all the unemployed people in Sri Lanka, according

to the Census of Population and Housing 1981. The population of the Southern Province was 12.6% of the total population of the country in 1981. Appendix I-3-1 shows the unemployment rate in the Southern Province in 1990, which was provided by Galle Municipal Council. The unemployment rate of 26.0% was rather high compared with the national level of 18.0% in 1989. The unemployment rates in Galle, Matara and Hambantota districts were 27.4%, 28.0% and 20.2%, respectively, in the same year.

3-2 Industrial Activity

3-2-1 General

The sectoral composition of GDP at 1982 factor prices in the Southern Province is shown in Appendix I-3-2.

The largest productive sector in the Southern Province is agricultural sector, which contributes approximately 30.3% of the total value added, compared with 26.4% of that of the nation in 1982 (22.7% in 1989). The share of manufacturing sector is low, at 9.4% of the total, compared with 14.4% on a national basis in 1982 (16.8% in 1989).

3-2-2 Agriculture

There are some agricultural activities in the Southern Province, Galle, Matara and Hambantota. The sectoral GDP of agriculture in the Southern Province was 11.3% of the national GDP as shown in Appendix I-3-2, slightly lower than the population ratio. The Southern Province accounts for only 8.5% of Sri Lanka's area, but the cultivated areas' ratio by main crops are 12.5% (paddy), 15.0% (tea), 13.7% (rubber), 12.0% (coconuts) and 78.4% (cinnamon), respectively.

The main agricultural crops in the Southern Province are paddy, tea, rubber, coconuts and cinnamon, as mentioned above. The production of these crops is shown in Table 3-2-1 and the extent areas of these crops is shown in Appendix I-3-3.

Table 3-2-1 Production of Agricultural Crops in Southern Province

Crops	Unit	Southern Province	Share (%)	Sri Lanka	Year
Paddy	(000 Tons)	295.2	14.3	2,063	1989
Tea	(000 Tons)	31.21	15.0	207.7	1989
Rubber	(000 Tons)	14.95	13.5	110.7	1989
Coconuts	(Mn.Nuts)	264.2	10.6	2,486	1989
Cinnamon	(Tons)	8,146	84.0	9,700	1988

Source: 1) Department of Census and Statistics
2) Galle municipal Council
3) Central Bank of Sri Lanka

(1) Paddy

Paddy cultivation in Galle and Matara districts is behind in terms of mechanization compared with the rest of the country. Also, the per hectare yield is considerably low compared with the production levels in the major paddy-producing areas. Major problems affecting paddy cultivation are erratic rainfall and iron toxicity, acidic and saline soil in certain parts of the districts, especially along the coastal belt.

On the other hand, Hambantota District is considered a major paddy-producing area. The yield levels are higher than those in the rest of the country. There is also a high use of machine power and fertilizer. Irrigation is well-facilitated and some projects are in progress.

(2) Tea

The climatic conditions in Galle and Matara districts are considered suitable for tea. However, this is not true of Hambantota District, where tea cultivation takes up 135 ha, 0.4% of the Southern Province. Together, both districts accounted for about 15.0% of the country's tea output in 1989. The share of low-grown tea is

currently 40% of Sri Lanka's total tea exports, and about 60% of it is produced in Galle and Matara districts.

(3) Rubber

While in Galle and Matara districts rubber is an important crop, it occupies an insignificant position in Hambantota District. The rubber extent in Hambantota District was only 0.3% of that of the Southern Province in 1986. According to recent inquiries, some rubber growers have switched from rubber to tea as the income and profits from tea are more attractive.

(4) Coconuts

The three districts of Galle, Matara and Hambantota together had 50,200 ha under coconut in 1984, which is about 12.0% of the national figure. Hambantota District has the largest extent (20,809 ha) and Galle District the lowest (12,886 ha). The production in the Southern Province was 264 million nuts in 1989, which is about 10.6% of national production.

(5) Cinnamon

Some spices are important minor crops in the Southern Province. The production of cinnamon is predominant, accounting for about 84% of national production.

3-2-3 Industry

The level of manufacturing activity in the Southern Province is low and the structure is relatively undiversified. The sectoral GDP of manufacturing in the Southern Province was only 6.4% of the national GDP, as shown in Appendix I-3-2. It was around one-half of the population ratio.

The industries in the Southern Province are mainly agro-based. Such industries consist of the processing of agricultural products: paddy, tea, rubber, coconuts and cinnamon. Main factories in the Southern Province at present are shown in Table 3-2-2.

Table 3-2-2 Factories in the Southern Province

	Galle	Matara	Hambantota
Public Sector	Plywood Cement	Fertilizer	Salt Tilewalls
Private Sector	Leather Rubber Metal Textile	Metal Soap	
Small Industries	Carpentry Coir Textile	Carpentry Coir Textile Ceramics Lace	

Source: The National Atlas of Sri Lanka 1988

3-2-4 Fishery

Sri Lanka, an island country, has a coastline 1561 Km in length and 230,000 Km^2 as its exclusive Economic Zone.

Marine fishing in the country takes place all around the coast but is mainly confined to the continental shelf area. The area of the shelf is about 28,000 Km^2, with the Southern Province having 5,100 Km^2 of this, or 18.2%, and Galle District 2,150 Km^2, or 7.7%.

The fishing fleet of Sri Lanka consists of around 28,000 Vessels of which 2,945, or around 10%, are in the Southern Province, of which 770, or around 3%, are confined to Galle District.

Fish production in 1989 was 205,286 tons. The number broken down by the three sub-sectors is 157,411 tons for coastal, 8,155 tons for offshore and deep sea and 39,720 tons for inland fisheries. The peak production year for fish in Sri Lanka was 1983. Thereafter, there has been a decline in production predominantly on account of the civil disturbances in the two major fish-producing areas in the north and east of the country, which account for nearly 60% of the coastline of Sri Lanka (see Appendix I-3-4).

In the case of the Southern Province, its share of the nation's fish production rose sharply from 13.0 % in 1983 to 18.5% in 1984. Production of fish in the Southern Province and Galle District in 1989 was 34,142 tons and 12,885 tons, respectively (see Appendix I-3-5).

The fishing industry provides employment, and the number of fishermen in the Southern Province and Galle District is 11,370 persons and 3,590 persons, respectively.

The Government's harbour and anchorage construction program has resulted in the construction of 10 fisheries harbours with breakwaters and marine structures at the following locations:

1. Mutuwal (Colombo)
2. Galle
3. Beruwela
4. Mirissa
5. Tangalle
6. Myliddy
7. Cod-Bay (Trincomalee)
8. Mannar
9. Valachchenai
10. Kirinda

These are shown in Figure 3-2-1, and of the harbours described above, there are four, Galle, Mirisa, Tangalle and Kirinda, in the Southern Province.

Galle has most of the facilities required to support small-scale fishing as well as industrialized fishing. These consist of a five ha basin area, a quay wall of 192 m, a jetty of 91 m, boat lifting slipway, a frozen fish storage facility with a capacity of 2,400 tons and a freezing capacity of 16 tons. This also has the capacity to produce 50 tons of flake ice per day and an ice storage capacity of 150 tons. Unfortunately, however, the cold room complex has been shut down since January 1986.

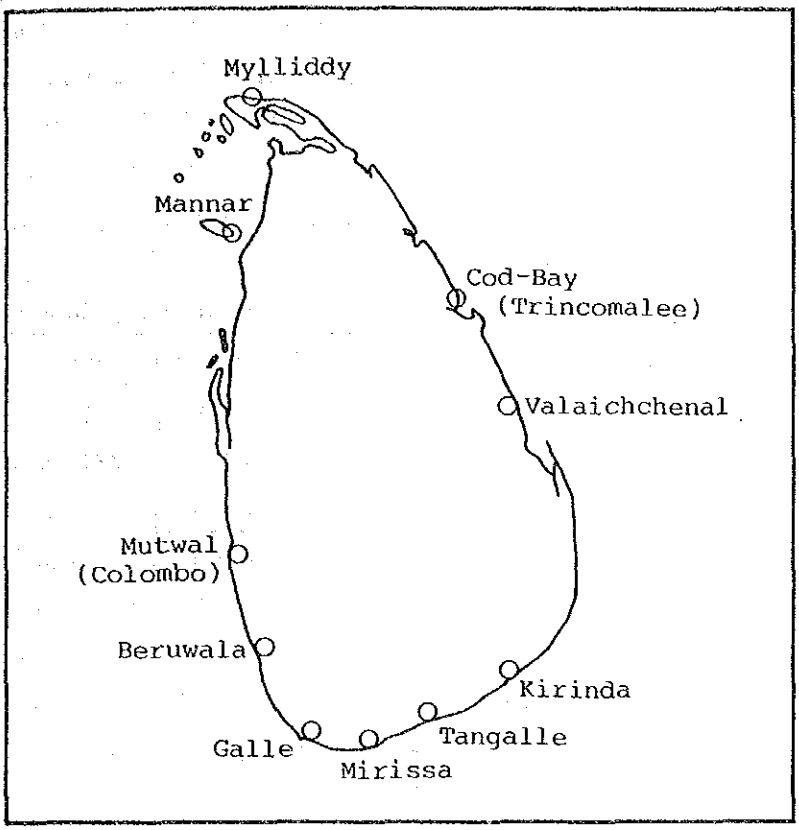

Figure 3-2-1 Location of Fishery Harbour

3-2-5 Tourism

(1) Trend up to the Present in Sri Lanka

The number of tourist arrivals reached 407,230 in 1982 which was the peak year, and decreased to a half that amount in 1987. This phenomenon was caused by the eruption of civil disturbances in 1983. But tourism is gradually increasing.

In terms of area, tourist from Western Europe, which is the first group, are decreasing. Yet, tourist from other Asian countries who make up the second group, have been increasing since 1987, and Asia's share of tourists coming to Sri Lanka will be the highest in the near future. North America, Eastern Europe, Australasia and so forth are the third group. The number of arrivals from the countries in the third group has been much smaller than these of the first two groups in the past decade (see Appendix I-3-6).

Revenue from tourism accounts for 3 4% of foreign receipts. Though this percentage is small, the revenue from tourism helps the economy (see Table 3-2-3).

Table 3-2-3 Tourist Reciepts

(Unit: Million Rs.)

	1985	1986	1987	1988	1989
Tourist Receipts	2,233	2,300	2,415	2,438	2,750
Foreign Receipts	52,574	53,367	63,142	71,468	82,761
Ratio	4.25%	4.31%	3.83%	3.41%	3.32%

Source: Review of the Economy, Central Bank of Sri Lanka

(2) Tourism Resources

The main points regarding tourism can be described in the five following items:

1) Beach Resorts

Resorts are found all along the Indian Ocean shore, particularly, in the area extending toward south from Colombo. In this area these are well-designed resort facilities. This area is a world-famous resort. For instance, Hikkaduwa is well-known for its coral reefs. Other beach resorts include Bentota, Galle, Negombo, Mount Lavinia and so on.

2) Highland Resorts

The gently sloping mountains lie in the center of Sri Lanka. The main attractions in this region are tea plantations, mountain scenery, waterfalls and the refreshing climate. The main attraction is the hill resort of Nuwara Eliya, which provides facilities for golf and also trout fishing and mountain recreation.

3) Wildlife National Parks

There are four wildlife national parks in Sri Lanka. A wide variety of wild animals and birds are protected by the parks. Tourist can observe the animals as they drive by in their vehicles.

4) Ancient Relics

Historical cultural relics going back to the 5th century B.C. are carefully protected. In particular, relics exist at Anuradhapura, Sigiriya and Polonnaruwa.

5) Gem Shopping

Sri Lanka has long been known as the land of gems. Though rubies are quite rare, blue sapphires which have taken the place of rubies are known as the king of Sri Lankan gems. Besides rubies and sapphires, the gem grounds also carry cat's eyes, spinels, topaz, garnets, amethysts, zircons and a variety of other valuable stones.

(3) Characteristics of the Southern Province

The Southern Coast abounds with areas of scenic and recreational value as well as places of archaeological, historical and cultural significance.

In particular, there are many hotels on the coast from Colombo to Galle. Marine and beach resorts are the most significant tourism resources on the South Coast for foreign tourists. According to data from 1989, the total number of foreign tourist nights in the South Coast was about 30% of those for the whole country, and that of rooms of accommodations in the South Coast was also about 30%. Therefore, the South Coast plays a very important role in tourism. But, in the eastern region from Galle, the accommodations are not adequate in either quantity or quality.

3-3 Infrastructure

3-3-1 Transportation

(1) Railways

The main characteristics of the Southern Coastal Line are as follows:

Gauge:	Broad Gauge(5'-6', 1.676 mm)
Route:	Colombo Fort to Matara
Length:	156,818 m
Radius of Sharpest Curve:	201.2 m
Pulling Gradient:	0.76%
Tunnel:	1. (Near Galle)
Track:	(Double-Fort to Panadura)
	(Single-Panadura to Matara)

The limitations on the length of trains are as follows:

Fort to Panadura:	No limitations as such, except in the case of passenger trains, where the length of platform will be the deciding factor.
Wadduwa to Matara:	From Wadduwa to Aluthgama the shortest loop is 817 feet (249m) at Beruwela. From Galle the loops are sufficiently long, 736 feet (224m) at Gintota being the shortest. From Galle to Matara the position is almost the same as between Aluthgama and Galle.

The gross load of any wagon, i.e, Tare + Contents, must not exceed the following:

* 4-Wheeled Wagons - 20 tons.
* 8-Wheeled Bogie Wagons - 66 tons.
* 12-Wheeled Bogie Wagons - 75 tons.

(The maximum permissible axle load is 16.5 tons.)

Generally speaking, many parts of the track are in poor condition and that is the reason for uncomfortable rides, slow speed and so on.

(2) Road

The main roads in the Southern Province comprise four (4) routes as follows:

A 2:	Colombo - Galle - Matara - Hambantota - Wellawaya	310 km
A17:	Galle - Akuressa - Madampe	140 km
A18:	Pelmadulla - Nonagama	80 km
A24:	Matara - Akuressa	20 km

Of these, A2 is the most important road and the volume of traffic is heavy. Next comes the A1, connected with Kandy, and then the A3, connected with Puttalam. Appendix I-3-7 shows traffic volume, which is more than 10,000 vehicles a day in Colombo and its outskirts, 5,000-10,000 between Colombo and Kalutara, 3,000-5,000 between Kalutara and around Bentota and 1,000-3,000 in other parts.

According to the Report titled "Sri Lanka Transport Sector Planning Study", 5% of the total length is rather rough riding and 17% is very rough riding for road conditions, even on the A class roads.

The condition of the section between Colombo and Galle of the A2 road is as follows:

*Colombo - Moratuwa	4 lanes
*Moratuwa - Panadura	Under construction for expansion 4 lanes
*Panadura - Galle	2 lanes

There are many inconveniences described hereunder:

- Almost all parts have no pedestrian walkways or pavements.
- There are some sections which have no shoulder or are very close to dwelling houses.
- There are several parts with narrow width, especially where

bridges are concerned.

- There are always pedestrians, bicycles, bullock-carts mixed with the traffic on the road.
- There is no centre line.

It can be said that there are many obstacles for large vehicles like lorries to pass this road considering the present conditions mentioned above.

3-3-2 Water and Energy

(1) Water

Water resources are divided into two categories: surface water and groundwater. Surface water consists of rivers, streams, lakes, marshes, reservoirs and ponds. The National Water Supply and Drainage Board (NWSDB) manages a supply of surface water and the Water Resources Board controls groundwater.

The supply of water is a very important in Sri Lanka from the industrial and living points of view. In order to improve the water supply system, the Mahaweli Development Programme was planned and has been carried out.

According to a recent survey done by the NWSDB, there are sufficient resources of water in the Southern Province. There are no schemes for providing water for industrial purposes. Water for large-scale industry could be provided from existing major water supply schemes only if there is excess capacity in these schemes at present.

The existing water supply schemes in the following areas will be rehabilitated with foreign assistance in the near future. They are Matara, Weligama, Hikkaduwa, Galle, Tangalle, Hambantota, Ranna and Hungama.

(2) Energy

There are 18 power stations in Sri Lanka. And there are 25 grid stations where transmission lines are brought in for the

purpose of stepping down the voltage to an intermediate level (33 KV), and for distribution to wide local areas. Presently the electricity generation is sufficient to meet the national demand, which includes electricity for householders, industries and commercial establishments (shopping complexes, hotels etc).

However, the Southern Province has no power station. It has one (1) grid station whose capacity is sufficient for supplying electricity to the province.

Appendix I-3-8 shows the summary of electric energy:

3-4 General description of Galle City

3-4-1 Topographic Condition

Galle City is divided into three zones: the western zone, the middle zone and the eastern zone.

The western zone is made up of Galle Fort, which is surrounded by walls made of granite. The fort, whose area within the walls is around 35 ha, jetties into the sea. The front of the Fort is a rocky shore and there are some places, more than 200 meters off the shore, where rocks crop up on the sea surface.

The middle zone is almost flat, except for one hill which is located just behind the center of Galle City. Galle Port is located in the middle zone. The Port area is composed of both the original land area, which has plenty of rocks, and the reclaimed land area. On the western side of the port, there are reefs, around 100 meters off the beach, where waves break. There are breakwaters made of rocks which protect the port from waves. All shores are sandy beach except for the port area.

The eastern zone is a comparatively high Hill whose name is Rumassala. The south-eastern side of this hill faces the outside of Galle Bay and has a very beautiful beach. The western side of the hill is rocky and very steep. There are no flat areas on the hill. Almost all the shoreline of the eastern zone is rocky.

Topographic conditions in water area are mentioned in Chapter 4.

3-4-2 Land Use

In the western zone (the Fort area), there are many buildings which are historical and archaeological. Some people live there, but the many functions directly related to the daily life of the people take place in the city center, outside the Fort. There is a special regulation governing the cultural properties of the Fort and the people can't even rebuild their own houses within it. There is an old port which has small jetties at the outlet of the Fort. It is still used as a pilot station and the pilot boat is moored there.

The center of middle zone has an administrative area, a business area, a commercial area and a residential area along the road. Generally speaking, the land side of the road is a residential area which is located on a comparatively high level and behind these areas there are paddy fields. Tea and rubber plantations are located in the inland area, i.e., paddy fields are located in the lower part of the inland area and plantations of tea and rubber are located at a somewhat higher inland area. The western part of the middle zone is the center of Galle City, which has a town hall, a post office, a railway station, a bus terminal, markets, etc. The Port of Galle is located in the center of this zone. There is a cement factory in the eastern part of this zone, but at the same time there are some less-utilized areas along the coast. The beaches next to the old port are used for small fishing boats to anchor in the western part of the middle zone.

The eastern zone is a hill which is used only for housing. For instance, the Harbour Inn, which is owned by the Sri Lanka Ports Authority, is located in the center of the hill. As this hill is rocky, the SLPA has used some sections of it for rock excavations which were necessary for the construction works.

3-4-3 Roads and Rivers

In the middle zone, there is a two-lane paved road. This road is somewhat narrow just behind Galle Port. In the Fort itself, there is a network of roads forming a square pattern. However, these roads are also very narrow. In the eastern zone, there is only a narrow unpaved road on the hill leading to the watering point.

There are two river mouths in Galle Bay. The river, the Mora-goda Ela, empties into the Galle Port basin, and the other, the Lunuvila Ela, empties into Galle Bay on the eastern side. Although the mouths of both rivers are around 20 meters wide, there is not much flux from then.

With regard to the railway, it runs around 500 meters behind the main road in the middle zone. Galle station is located in the middle zone.

4 NATURAL CONDITIONS OF COASTAL AREA ADJACENT TO GALLE PORT

4-1 Natural Characteristics of Southwestern Region of Sri Lanka

Chapter 1 - General Description of Sri Lanka - of this report provides an overview of the natural conditions of the country. This section outlines the natural characteristics of the Southwest Region of the country and compares them with the general features of other parts of the country.

4-1-1 Topography

Sri Lanka is divided topographically into four distinct regions: the Central Highlands ranging in elevation from 1,000 to 2,500 m; the relatively gently sloping Northern Lowlands; and the rather steep Southwest and Southeast regions.

The Southwest Region is well watered and has a topography characterized by elongated parallel ridges which are asymmetrical, that is, gently sloping toward the east and steep on the seaward side (west). The pattern of streams is similar to trelliswork and thus the system of drainage is called rectangular.

4-1-2 Soils

In Sri Lanka, the soils are grouped broadly into reddish brown earths, red-yellow podzolic soils and other soils. With the exception of the Southwest Region consisting of red-yellow podzolic soils, all the other regions are composed of reddish brown earths and other soil groups.

The red-yellow podzolic soils are well-drained, reddish to yellowish, moderately fine-textured and strongly acid soils formed on less steep slopes of mountainous terrain suitable for tea and plantation forestry serving as adequate erosion control measures.

4-1-3 Mean Temperature

The annual mean temperature in the lowlands is about 27°C with the mean daily range of 7°C to 3°C. Generally, the mean temperature tends to be higher in the northern part of the country. In the Southwest Region,

the mean temperature is about 1°C lower than that in the other parts of the country during the southwest monsoon period, the mean daily variations being as small as 3°C. Obviously, the annual rainfall pattern (Refer to 4-1-5 Annual Rainfall) of this region may influence these temperature characteristics.

4-1-4 Winds

Sri Lanka comes under the influence of the two monsoon systems in accordance with the formation of the Siberian High during the northern hemisphere winter, the formation of the Mascarene High during the southern hemisphere winter and the seasonal oscillation of the Equatorial Trough of low pressure. From December to February when the Equatorial Trough of low pressure is to the south of the island, Sri Lanka is under the influence of the northeast monsoon winds (Northeast Trades). From May to September when the Equatorial Trough is to the north, the Southeast Trades from the southern hemisphere cross the equator and sweep across Sri Lanka as the southwest monsoon winds. During this period relatively strong winds blow in nearly all parts of the country.

In March - April and October - November, in the coastal areas mild winds blow from the sea to land (sea breeze) during the day, while mild winds blow from land to the sea (land breeze) during the night.

The main tracks of depressions and storms run on the northern sea or across the northern part of Sri Lanka and seldom pass through the southern region. The more they veer toward the south, the less they become in energy. For this reason, they usually have a minor impact on the vicinity of Galle Port.

4-1-5 Annual Rainfall

The annual amount of rainfall in the Southwest Region is much larger than the annual mean value of 1,500 mm in the northern part of the country. In the inner part of this region, in particular, the annual rainfall runs as much as 4,000 to 5,000 mm and is concentrated in the periods immediately before and after the southwest monsoon season.

4-1-6 Tides

The spring tidal range in Galle Port is 54.2 cm as against 59.0 cm in Colombo Port. The time difference in tide in relation to Colombo Port is +15 minutes. The ratio of tidal ranges between the two ports is 0.92.

4-1-7 Waves

Field wave data available at Colombo Port and Galle Port since 1980 indicate that wave heights in Galle are generally about 40 cm higher than at colombo.

The greater wave height in Galle Port presumably is attributable to swells of 1.0 to 1.5 m in height and about 15 sec in period which come from S to SSW directions all year round, while in Colombo Port, located on the west coast of the country, the swells presumably are attenuated due to refraction and diffraction caused when they advance almost parallel to the coastline of the port.

4-2 Meteorology

Field observation records obtined by the Galle Observatory of the Department of Meteorology (located at lat. N 06°02' and long. E 80°13')during the last 10 years have been analyzed to compile the necessary meteorological data noted below.

4-2-1 Winds

Location of Observation: Premises of Galle Observatory
Instrument Used: 3-cup type anemometer (manufactured by Casella)
Height of Instrument: 6 m above the ground level which is 20 m above the Mean Sea Level)

At the observatory, mean wind speeds in knots from three-minute wind runs and eight wind directions were recorded manually by the observer every day at three-hour intervals from 0530 to 2030 hours (six times a day).

During the 1980-89 period, the field wind observations by the Galle Observatory of the Department of Meteorology were carried out at three different locations, and the observation records obtained are largely incomplete except 1986 to 1988.

For this reason, wind data covering the 3-year period noted were selected for the purposes of analysis on grounds that these data are derived from the same location and are relatively complete.

Frequencies of wind speed occurrence by direction have been compiled for the wet and dry seasons from the field data obtained four times during the daytime. The data derived from the field observations made once each in the morning and in the evening are not used, since they are largely incomplete.

The prevailing wind direction is SW in the two monsoon seasons and this direction accounts for 56.6% of all wind directions observed all year round and as high as 69.2% during the southwest monsoon months. (See Appendix I-4-1 and I-4-2.)

Strong winds with speeds in excess of 20 knots have occurred in the southwest monsoon season only with a frequency of no more than 0.2%. Annual frequencies of winds with speeds of over 10 knots and over 20 knots in the Ports of Galle and Colombo are compared below.

	Over 10 knots	Over 20 knots
Galle Port	10.5%	0.1%
Colombo Port	38.0%	1.0%

Note: Observation at Colombo Port

Location of Observation: Pilot station, Southwest Breakwater in the Port of Colombo

Instrument Used : Electric anemograph (Self-recording type)

Height of Instrument : 17.6 m above sea level

Period of Observation : From April 1979 to March 1980 and From December 1982 to November 1984

4-2-2 Temperature

The highest mean maximum daily temperature of 30.9°C is registered in March and April and the lowest value of 28.4°C in August. The lowest mean minimum daily temperature in each month vary moderately from 23.2°C to 25.7°C and the insignificant variations are comparable to those seen in the highest daily temperature.

The daily differences between the maximum and minimum temperatures are about 3.0° to 7.0°C with the annual average difference of 5.0°C. The widest daily difference between the extremes is seen in February and March.

Appendix I-4-3 gives the mean, maximum and minimum values of temperature and humidity during the 10-year period from January 1980 to December 1989.

4-2-3 Humidity

Humidity is 80% during the daytime, but increases to 88.6% at night. In monthly terms, daytime humidity is 72.8% in February and increases to 85% in August with a variation of 12%, while nighttime humidity varies from 86% in February to 91.3% in December with a variation of no more than 5%.

4-2-4 Rainfall

The annual total amount of rainfall ranges from about 1,550 to 2,560 mm with an annual mean value of 2,154.3 mm.

Viewed seasonally, rainfall is concentrated in April-June and September-November, that is, the periods immediately preceding and following the southwest monsoon season. These six months account for as much as 68% of the total annual amount of rainfall.

The maximum average monthly value of 304.1 mm has been registered in November as against the lowest average value of 50.7 mm in February. The largest daily amount of rainfall recorded during the 1980-89 period is 192.1 mm.

The average annual number of rainy days is 174 days (approx. 48%) and the number varies from 14-20 days/month during the southwest monsoon season and periods immediately before and after it to 5-11 days/month during the northeast monsoon season.

Appendix I-4-4 presents monthly rainfall data and annual mean values covering the 1980-89 period.

4-3 Oceanography

4-3-1 Waves

An adequate knowledge of the characteristics of waves attacking the port (wave height, period and direction and frequency distribution of wave occurrence) is prerequisite for the study and especially for the evaluation of the breakwater layout plans and the sheltering effects of the breakwater structures. Further, the determination of the design waves for the breakwaters demands long-term wave observation records or substitute results obtained by calculations.

For these reasons, the data from the wave observations being carried out by the Lanka Hydraulic Institute, Ltd. for the Sri Lanka Port Authority and similar field observations being undertaken by the Coast Conservation Department with German technical cooperation were analyzed: The positions of the two wave meters installed are shown on Appendix I-4-5.

Details of the field observations undertaken by the two different groups are as follows:

i) Lanka Hydraulic Institute, Ltd.

Location of Observation:	Close to Bell Buoy installed off Galle Bay
Water Depth:	23 m below Chart Datum Level
Instrument Used:	Waverider Buoy
	(Manufactured by Datawell)
Period of Observation:	From 1984 to 1990
Duration of Recording:	20 minutes every three hours
Items Observed:	Wave height and period

ii) Coast Conservation Department

Location of Observation:	Approx. 8 km south off Galle Bay
Water Depth:	68 m below Chart Datumum Level
Instrument Used:	Directional Wave Buoy
	(Manufactured by Datawell)
Period of Observation:	From February 1989 to date
Recording Duration:	30 minutes every three hours
Items Observed:	Wave height, period and direction

(1) Results of Observations by Lanka Hydraulic Institute

The frequency distributions of wave heights and periods according to season are compiled from the field wave data covering the period from May 1984 to September 1990. (See Appendix I-4-6 and I-4-7)

Wave heights with a 50% excess probability show the smallest value of 0.9 m during the northeast monsoon season spanning the December-February period, while they attain the maximum value of nearly 1.7 m during the southwest monsoon period extending from May to September. Wave heights of a 5% excess probability are about 1.2 m during the northeast monsoon season and 2.3 m during the southwest monsoon period.

Seasonal variations in wave period are less conspicuous than those of wave height and the most frequent period ranges from 5 to 7 sec in the four seasons, accounting for nearly 60 to 70 % of the whole spectrum of wave period observed in Galle Port.

(2) Results of Observations by Coastal Conservation Department

At the first field survey, the field wave data available at the Coast Conservation Department are limited and the observation records obtained from the Department cover only a 13-month period. These data are classified into swells, wind waves and overall waves. Field data analyzed cover the period from March 1989 to February 1990.

At the third field survey in May 1991, we were just able to obtain the wave data observed from March 1990 to February 1991 and some results of the analyses. According to these results, the waves during the first year are slightly larger than those during the second year. However, the characteristics of waves during two years are almost similar. Appendix I-4-8 and I-4-9 present some of these results.

The swell and wind wave characteristics according to monsoon seasons on the basis of the CCD data are as follows.

1) Swells

From the wave height frequency distributions according to wave directions for the northeast and southwest monsoon, intermediate

seasons and the whole year (See Appendix I-4-10 and Fig. 4-3-1), the swell directions are substantially constant at SSE to SSW throughout the year. However, certain swells from W to SW directions are observed during the southwest monsoon season. The most frequent direction is south with a 63.2% frequency of occurrence, followed by SSW with 28.5%.

A maximum wave height of 2.89 m has occurred during the southwest monsoon period and swells of 1.0 m and 2.0 m or over in height occur with a frequency of 88% and 8.5%, respectively, during the southwest monsoon. Wave height attains its minimum value during the northeast monsoons and swells with a height of over 0.5 m attack the port throughout the year.

The correlation between wave heights and periods is almost non-existent with nearly 90% of the swells showing a period of 10 to 16 sec. (See Appendix I-4-11 for the frequency distribution of significant wave heights and periods of swells.)

2) Wind Waves

Fig. 4-3-2 and Appendix I-4-12 present wave height frequency distributions of wind waves during the four seasons according to directions.

From these tables and figures, it can be seen that the influences of wind waves are most significant during the southwest monsoon season with wind waves of 1.5 m or more in height generated with a frequency of nearly 50%. Wind wave heights of 2.5 m or more have occurred with a 0.5% frequency and the maximum value of 4.22 m observed in August 1989.

The most frequent wind wave directions are WSW and W with a combined frequency of 83.7%.

During the northeast monsoon, northeast wind waves are blocked by the main island, providing the calmest waters in the neghborhood of Galle Port. Wind waves in excess of 1.0 m in height occur with a frequency of only 19.3% and they range in direction from SE to ESE. They come around the southernmost tip of the island.

In regard to the frequencies of occurrence of wind wave heights and periods (Appendix I-4-13), there exists a good correlation

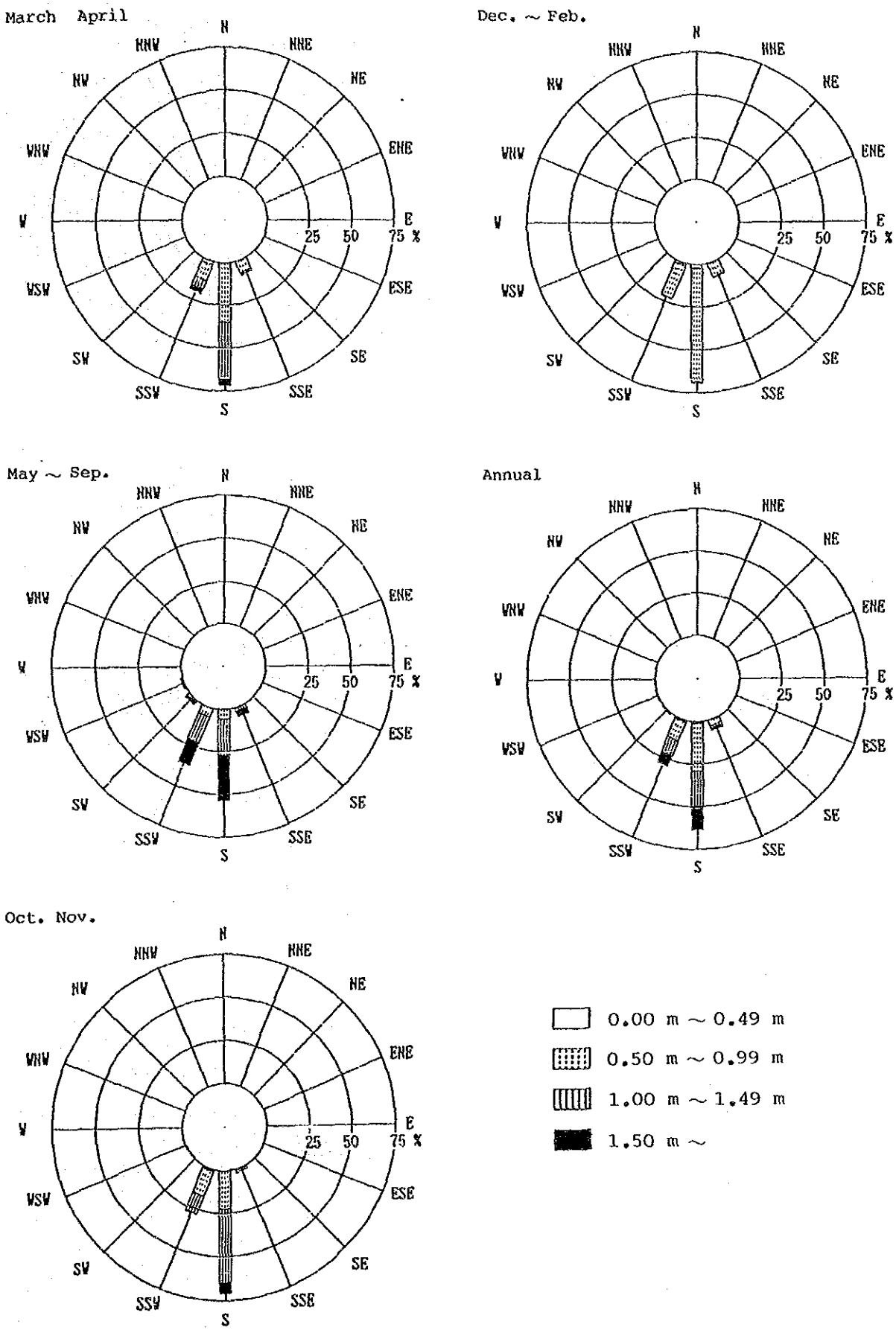

Fig. 4-3-1 Distribution of Significant Wave Height and Direction (Swell)

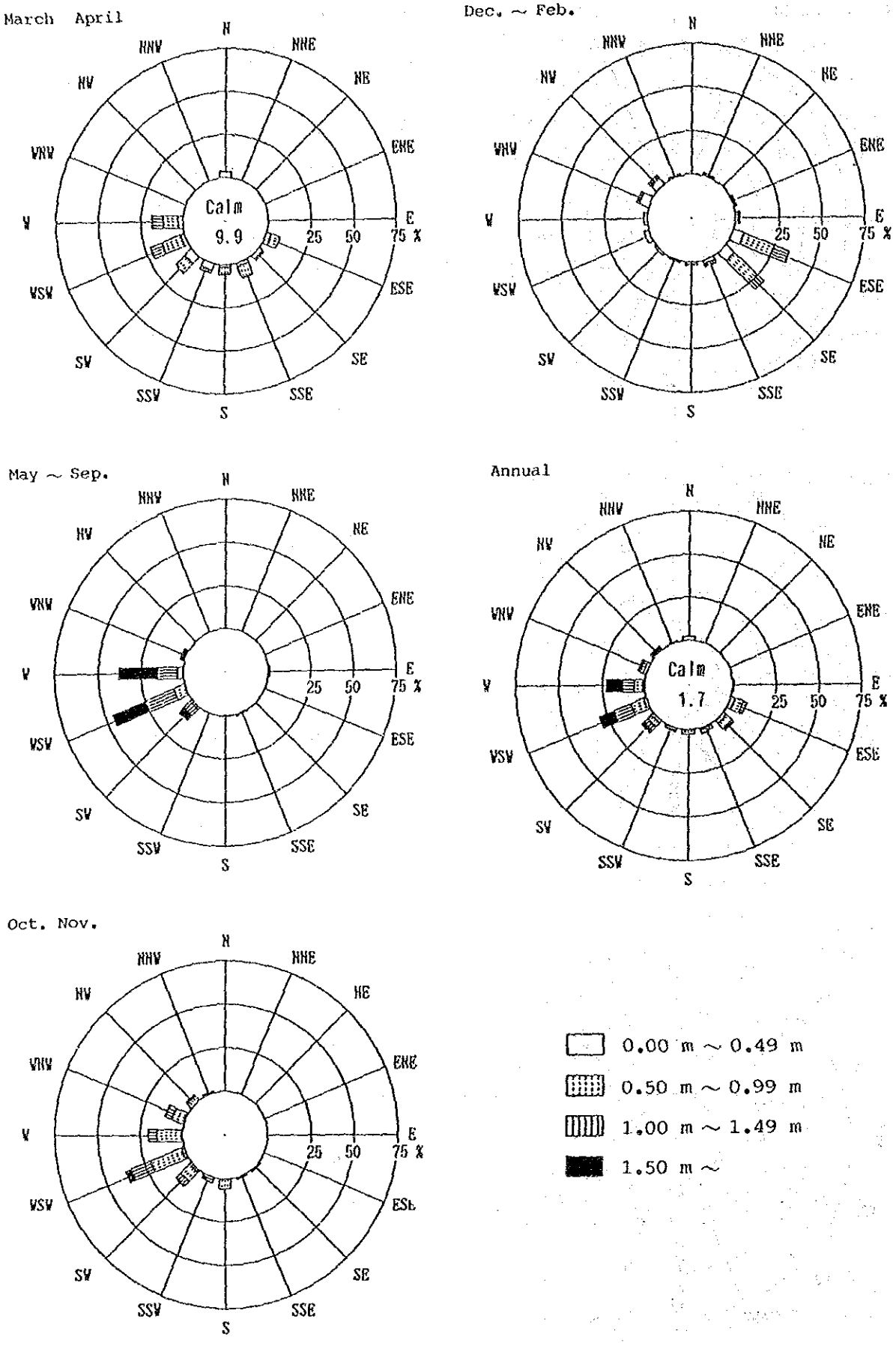

Fig. 4-3-2 Distribution of Significant Wave Height and Direction (Wind Wave)

between the wave heights and periods unlike in the case of swells and the wave period tend to increase with growing wave heights. The waves with a 50% frequency of occurrence have a period of less than 5.8 sec as compared with less than 7.0 sec for the waves generated with a 80% frequency.

3) Overall Wave

Fig. 4-3-3 and Appendix I-4-14 present frequency distributions of overall wave height (swells and wind waves combined) occurrence all year round as classified by directions. It can be seen that the wave heights of 1.0 m, 1.5 m and 2.5 m or more occur with a frequency of 81.6%, 51.8% and 9.2%, respectively. In terms of wave directions SSW and SW have a combined frequency of 50.2% and SSE to WSW 90.5%.

The maximum overall wave height of 4.28 m composed of the swell of 0.73 m and the wind of 4.22 m was observed in August 1989.

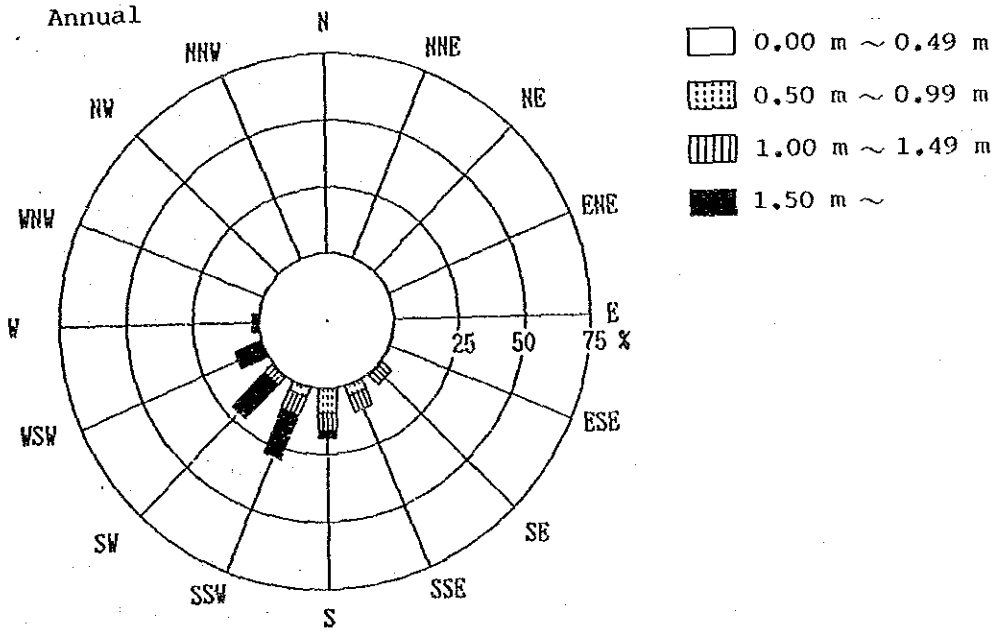

Fig. 4-3-3 Distribution of Significant Wave Height and Direction (Overall Wave)

(3) Relationship between Wave Height Values Observed during Field Observations by Two Different Organizations

There are certain differences between the wave data derived from the field observations carried out by the Lanka Hydraulic Institute, Ltd. and the Coast Conservation Department. These differences are attributable primarily to the different locations of wave meter installation and differing observation methods employed. Attempts were made to establish a correlation between the wave heights observed at the same hours during a one-year period.

The correlation can be determined by the following expression:

$H_1 = 1.2539h_2 + 0.2304$ $\quad r = 0.8157$

H_1 = Overall wave height at location of observations by Coast Conservation Department (m)

H_2 = Wave height at location of observations by Lanka Hydraulic Institute, Ltd. (m)

r = Coefficient of correlation

In the above expression, the value of H_1 is about 30% greater than that of H_2 when the values of H_2 are 1.0 m to 3.0 m. This presumably is ascribable to the different locations of wave meter installation. However, wave refraction, diffraction and shoaling deformations cannot adequately account for the difference between the values of H_1 and H_2 in the expression. This difference may be attributable to the different types of wave meter used by the two organizations in their respective field observations. (Refer to Part II 4-6-3 Study of Calmness Table 4-6-1 Wave Deformation)

(4) Analysis of Extreme Waves with Given Return Periods

Analysis of extreme waves with specific return periods in Galle Port has been undertaken on the basis of the available field wave data and cyclone tracks recorded in the past. The results of the analysis are discussed below in some detail.

1) Waves with Given Return Periods

With respect to waves with a height of 2.7 m or more selected from the field data spanning the 1984-90 period, the values of H_1 were determined from the correlation equations for the two observation points noted in Section (3) above.

The calculation results are tabulated below:

Date	Observed	June 1984	June 1984	Oct. 1984	July 1985	Aug. 1986	Aug. 1986
Wave height(H_1)		3.6 m	3.7 m	3.7 m	4.6 m	4.2 m	3.7 m
Date	Observed	Sept.1986	Sept.1988	May 1989	Aug. 1989	June 1990	
Wave Height(H_1)		3.9 m	4.0 m	3.5 m	4.3 m	3.9 m	

Fig. 4-3-4 and Table 4-3-1 present the probability wave heights obtained by Gumbel-Weibull's extreme statistic method with respect to the 11 sets of wave height values tabulted above. The calculations used a total of 4.5 effective statistical years with the southwest monsoon months of May to September taken as an effective statistic year.

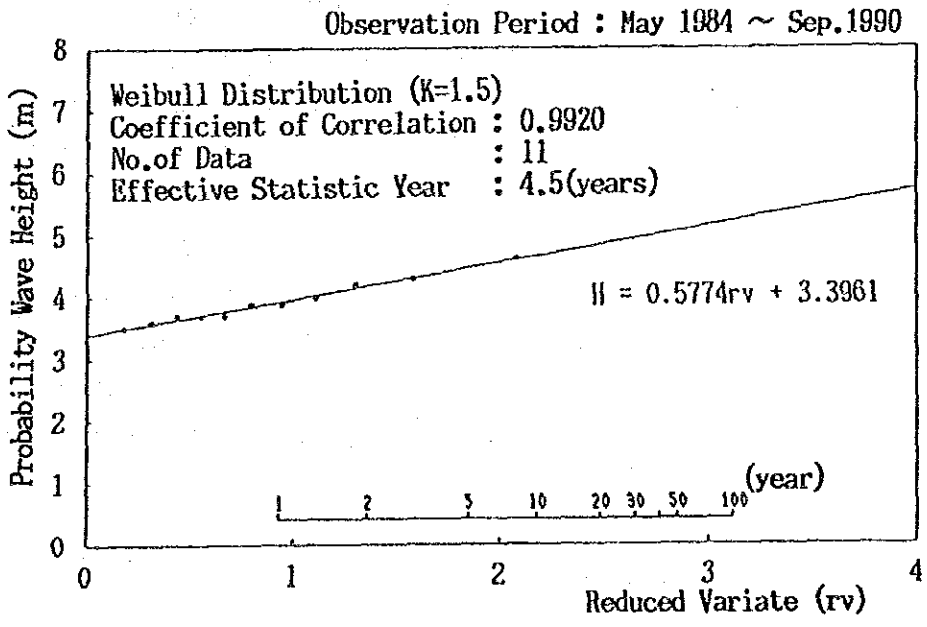

Fig. 4-3-4 Probability of Significant Wave Height

Table 4-3-1 Probability of Significant Wave Height

Return Period (year)	Non-exceeding Probability	Reduced Variate (rv)	Wave Height (m)	Wave Period (sec)
50	0.99182	2.8478	5.0	8.5
40	0.98977	2.7590	5.0	8.4
30	0.98636	2.6423	4.9	8.4
20	0.97955	2.4732	4.8	8.4
10	0.95909	2.1699	4.6	8.3
5	0.91818	1.8436	4.5	8.3
2	0.79545	1.3605	4.2	8.2
1	0.59091	0.9279	3.9	8.1

2) Analysis of High Waves Based on Past Cyclone Data

Depressions generated in the southern part of the Bay of Bengal normally advance westward and then veer northwest to northward on the north sea of Sri Lanka, developing into storms and cyclones. Thus Galle Port, located in the southwest of the island, is seldom stricken by cyclones.

According to the Indian Daily Weather Map, during the cyclone that hit Sri Lanka in November 1978 and May 1979, the greatest influence on different parts of the country in several decades, winds on the southern sea of Sri Lanka blew at a mean speed of 35 to 40 knots at the highest. The waves generated by the cyclone was estimated to be 5 to 6 m in height and 9.0 to 9.5 sec in period. The estimation assumed a wind duration of 20 to 25 hours.

3) Analysis of Design Wave for Galle Port

The probability wave discussed in Section 1) above has an estimated height of 5.0 m based on an assumed return period of 40 to

50 years. Taking the relatively short observation period into account for the probability wave estimation, it is necessary to consider an additional height to 5.0 m.

Taking into consideration the effects of cyclones as discussed in Section 2) above, a height of 5.5 m and a period of 9.5 sec have been taken for the design wave for the purpose of this study.

The design wave characteristics thus determined will have to be reviewed at the detailed design stage in the light of additional field wave data which may be made available after this study.

4-3-2 Tidal Levels

The Indian Tide Table shows the following four main tidal constituents in Galle Port:

M_2	S_2	K_1	O_1
16.1 cm	11.0 cm	5.1cm	1.4cm

From these tidal constituents the tidal levels required for design purposes have been determined as follows:

H.W.O.S.T.(≒ H.W.L.)	0.607 m	(0.6 m)
M.S.L.	0.336	
L.W.O.S.T.(≒ L.W.L.)	0.065	(0.1 m)
D.L.	0.00	

Note: Values in brackets are based on the chart.

The work datum level (W.D.L.) currently in use at Galle Port for construction purpose is 0.43 m below the Mean Sea Level (M.S.L.),or about 10 cm lower than the calculated datum level noted above.

H.W.O.S.T.	0.607 m	0.701 m
(≒H.W.L.)		
M.S.L.	0.336	0.43
L.W.O.S.T.	0.065	0.159
(≒L.W.L.)		
D.L.	0.000	
W.D.L.		0.000

4-3-3 Tidal Current

(1) Observation Records

Location of Observation: Close to Datawell Waverider Buoy
Instrument Used: Marsh McBirney 2-D Electromagnetic Current Meter
Period of Observation: From June 1990 to September 1990
Recording Duration: 8 minutes every six hours

(2) Frequency Distribution of Current Speed According to Current Direction

The frequency distributions of current speeds according to current directions are presented in Appendix I-4-15 and I-4-16.

The maximum current speed observed during June-September 1990 is 20.3 cm/sec. Current speeds of less than 10 cm/sec account for 71.2% of all the observations made. Thus it may safely be said that the current speeds in the vicinity of Galle Port are very insignificant.

The currents are distributed in nearly all directions, but the WNW to WSW and E to SE directions, which are more or less parallel to the coastline, are more frequent.

4-3-4 General Features of Coastline and Sand Drift

Galle Bay, located at the southwestern tip of Sri Lanka, is oval-shaped and measures about 2.5 km southeast to northwest and about 1.5 km northeast to southwest and 1.8 km wide at the bay entrance. A plain continental shelf, formed at a depth of about 70 m, extends nearly 20 km offshore.

The bay entrance opens to southwest and is dotted with reefs. On the west of the bay is located the Fort Area which rests on reefs and virtually forms a headland and the east side is surrounded by cliffs which also form a headland (Rumassala Hill).

Outside the bay the sea bottom slopes very gently on both the east and the west and the coastline forms beaches of fine sand.

The sea area abutting on the Fort Area on the west is enclosed by foreshore rocks (exposed at ebb tide) over a distance of about 150 m offshore. Off these foreshore rocks the waters are generally shallow, but the depth varies widely and the bottom is scattered with reefs.

The existing facilities of Galle Port were completed in the center of the bay in 1971. Beaches of fine sand are formed on both sides of the port and in front of the beaches the seabed slopes rather gently at 1/50 to 1/100 and this area forms a surf zone about 100 m wide. Dredging data for the harbour basin indicate that the seabed is scattered with rolling stones.

On the east of the bay the coastline extending from Rumassala Hill is backed by cliffs about 15 to 20 m high and the shoreline is formed by rocks and gravels. In front of the shoreline the water is deeper than on the west and scattered with fewer reefs.

Data available at the Coast Conservation Department show that the southwestern coasts of Sri Lanka are eroded at an annual rate of about 30 cm. The prevailing wave direction is south to west and the coastlines in the vicinity of Galle Bay run in a NW direction on the west and in an ESE direction on the east. Judging from these facts, the sand drift is presumed to branch off into the easterly and westerly directions in the neighborhood of the bay. The sand drift into the bay is intercepted by the east and west headlands.

Waves advancing toward the bay are either intercepted or broken by scattered reefs at the bay mouth, dispersing in the bay as diffracted waves

and then gradually broken in the gently sloping surf zone. In consequence, the sand drift inside the bay is presumably limited in volume and the shoreline remains virtually unchanged. The front of the revetment for a coastal road built by filling up part of the west coastline area of Galle Port in 1968 is partly eroded. Obviously, this erosion has been caused by a scour in the revetment base and the resulting sucking-out backfill material behind the steep revetment structure as the consequence of its constrution on the gently sloping natural beach.

Two small rivers with a total drainage area of nearly 50 km^2, namely, the Moragoda and Lunuvila, discharge into Galle Bay. They have a gently inclined bed and their mouths are completely closed in times of droughts. For these reasons, the sediment discharge into the bay is considered to be very limited, which is evidenced by the fact that the water depths of the inner and outer harbours have remained virtually constant since the completion of dredging work in 1984.

4-4 Site Investigation

4-4-1 General

The purpose of the site investigation is to obtain information on topographical features of the land and seabed, the submarine geology and subsoils.

The investigation was carried out between the middle of October and the middle of November 1990.

4-4-2 Components of Investigation

The investigation comprised the following activities:

a) Topographical Survey
b) Hydrographical Survey
c) Seismic Prospecting
d) Soil Investigation

The scope of the investigation is shown in Table 4-4-1 and Fig. 4-4-1.

Table 4-4-1 Scope of Site Investigation

Component	Scope
1 Topographical Survey	Area: approximately 8 square kilometers
2 Hydrographical Survey	Area: whole of Galle Bay Spacing of survey line: 50 meters Total line lengths: 90 kilometers
3 Seismic Prospecting	-ditto-
4 Soil Investigation	Number of borings: 9 points in Galle Bay

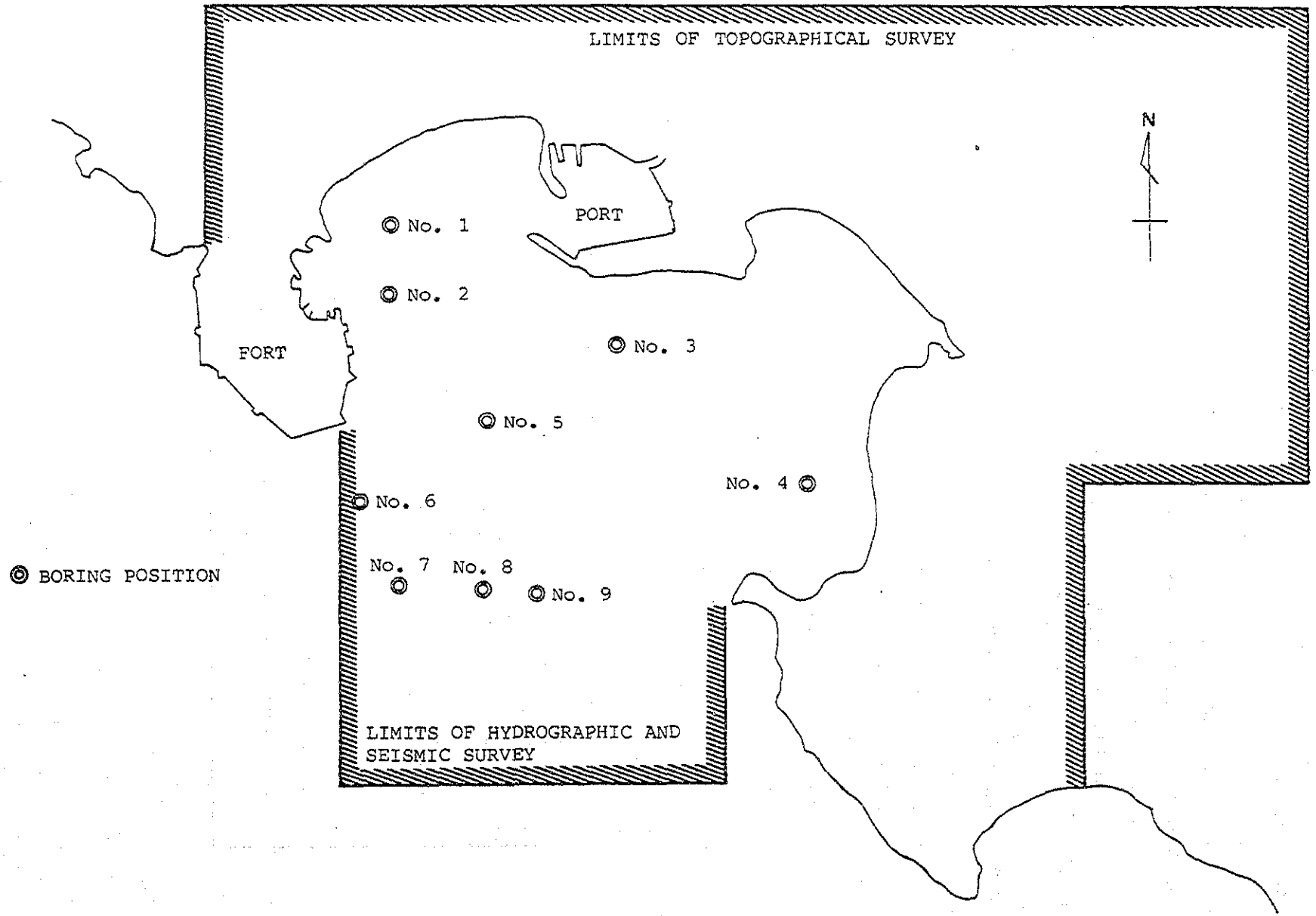

Fig. 4-4-1 Location Map

4-4-3 Method of Investigation

(1) Topographical Survey

The basic map for the work was prepared from the following maps:

a) Admiralty chart: No. 819
b) City maps of Galle: 40 sheets
c) Aerial photographs: taken in 1983 and 1988

Investigation was carried out using the Town Assessment Survey maps for Galle (scale 1:792) to update the basic map covering the Galle Municipal Area. All carriageways, public offices, playgrounds and other main structures were identified and marked on these maps in the field.

(2) Hydrographical Survey

The control points were established around Galle Bay by traversing. The traverse lines were connected to the known points which have National Coordinates (Table 4-4-2).

The leveling was performed from the existing Bench Mark near the circuit bungalow of the SLPA to the end of the main quay to establish a Temporary Bench Mark (T.B.M.). The tide gauge was installed at a sheltered point at the end of the main quay. The zero point of the gauge was adjusted to the Work Datum Level (Low Water Ordinary Spring Tide), which is 0.43 meters below the Mean Sea Level.

The hydrographical survey was carried out using an echo sounder to determine the topographical features of seabed.

The survey lines were spaced 50 meters apart from north to south.

The survey boat was guided along the survey lines with a theodolite and the location of the survey boat was fixed as the intersection of two theodolites.

A narrow-beam transducer of Ratheon DE719B Echosounder with 200 KHz frequency was installed on the boat.

The echosounder was calibrated by the bar-check method. Daily bar-checks were made before and after the work to ensure sounding

accuracy.

Water depths were read every 50 meters along the survey lines.

Table 4-4-2 Coordinates of Control Points

Unit: m

Name of points	Northing	Easting
Watering Point '78	91,382.50	140,405.48
Tong Joo '90	92,169.42	140,959.52
Marine Drive '78	93,408.66	139,149.43
Utrecht '78	92,041.64	138,651.57
Gibbet Island '78	92,730.33	139,815.40
Flagstaff Mark	92,563.70	138,633.34
Lighthouse	92,058.40	138,631.09
Clock Tower	92,661.60	138,160.16
All Saint's	92,378.02	138,409.65
Closenburg	92,708.87	140,318.14
Breakwater end	92,879.04	139,464.35

(3) Seismic Prospecting

The submarine geological survey was carried by the seismic prospecting method using a sub-bottom profiler (Type SP3) simultaneously with the sounding.

This equipment consisted essentially of a transmitter, receiver-recorder, transmitting transducer, receiving transducer and stabilized power unit.

The sound source of the sub-bottom profiler consisted of a magneto-strictive oscillation transducer which generated mainly acoustical elastic pulses of 1 to 9 KHz. The primary energy of the transmitter was 36 joules.

This profiler records continuously and automatically the geological structure just below it as a cross section. On recording, patterns of light and dark shades corresponding to the strength of the reflected signals from the bottom layers were indicated as cross section.

Analysis and interpretation of the records were made as follows:

a) Geologic information was obtained from the reflected signals.

b) The geologic strata were classified on the basis of the characteristics records.

c) The depth of a reflective horizon was determined and geologic profiles were built by adjusting the tidal level, draft of the survey boat and other pertinent factors on the assumption that the transmitting velocity in water and layer is equal to 1,500 m/sec.

$D=\frac{1}{2}VT$ (m)

V(m/s): average transmitting velocity in water and layer (1,500 m/sec)

T(second): time of the sonic wave from start to return

d) By reference to the geological information, geological maps, report and drilling data for the land and inshore areas surveyed, attempts were made to establish the relation between the records and the actual geologic strata and interpret them geologically.

(4) Soil Investigation

a) Boring Rig

Soil borings were made using a boring rig supplied by the SLPA.

The boring rig was moved by a crawler crane fixed on a steel flat water barge for positioning at the desired boring points.

The drilling machine, pump and other equipment were placed on a wooden platform (Fig. 4-4-2).

b) Determination of Boring Point

Nine borings were undertaken at the sites of the wharf, access channel, breakwater and other proposed port facilities.

Each boring point was determined by measuring the angles with a theodolite from traverse points after placing the boring rig.

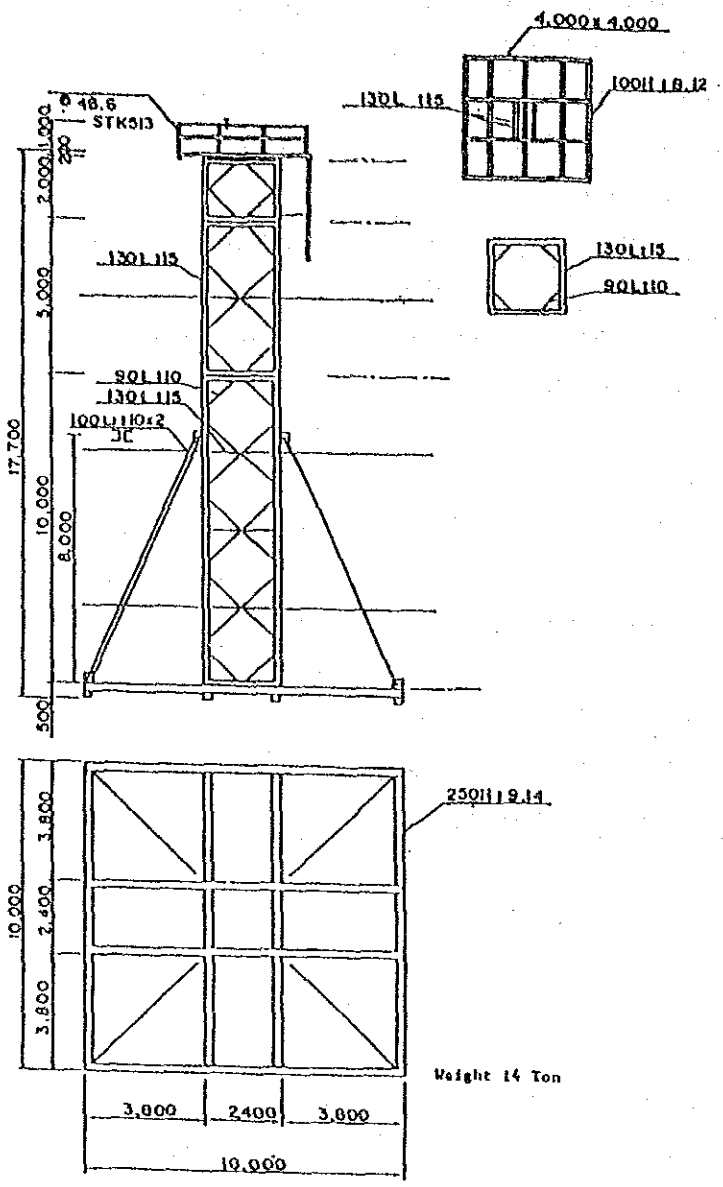

Fig. 4-4-2 SLPA's Boring Rig

c) Drilling

For drilling operations a skid-mounted, hydraulically-operated Rotary Drilling Machine was utilized.

Boreholes in the overburden layer were drilled by the wash boring method using NX/NW (76mmø) casings. Under this method a high pressure piston pump introduced sea water into the casings via 'B' size rods to extract cuttings and sediments.

Standard Penetration Tests were carried out in the bore holes at an interval of 1 m in principle. This enabled a 50 mm diameter SPT split tube sampler to collect disturbed samples in the overburden layer.

The standard split tube sampler was driven into the strata to a depth of 30 cm using a 63.5 kg hammer falling freely through 760 mm. In the standard penetration test, an automatically opening and closing latch released the hammer on reaching the specified falling height of 760 mm. The number of blows required to thrust the standard sampler into a thickness of 30 cm is called the 'N' Value.

In cohesive clay horizons, undisturbed samples were collected by hydraulically pressing a thin-walled 60 mm diameter copper tube into the strata. Where an appreciable quantity of Sand was present in the clay, undisturbed sampling by this technique was impossible. As noted in the Logs, highly saturated organic clay samples could not be obtained by this method. Below the overburden layer the weathered rock horizons were drilled with a tungsten carbide-tipped starting bit, and cuttings recovered by water pressure.

In the bedrock formations, core drilling was conducted using 'N' size diamond bits and double tube core barres to enable core samples to be taken continuously. In this way 54 mm diameter rock cores were recovered from the bed rock.

The soil types encountered were visually classified from the samples and mud water recovered from the tube samplers.

The characteristics of the rock core samples were analysed.

The annexed borehole logs indicate the classification of the soil types encountered along the depth of the bore hole and their 'N' values.

For the depth measurements from the drilling platform, the tide variations were taken into account in determining the WDL (Work Datum Level).