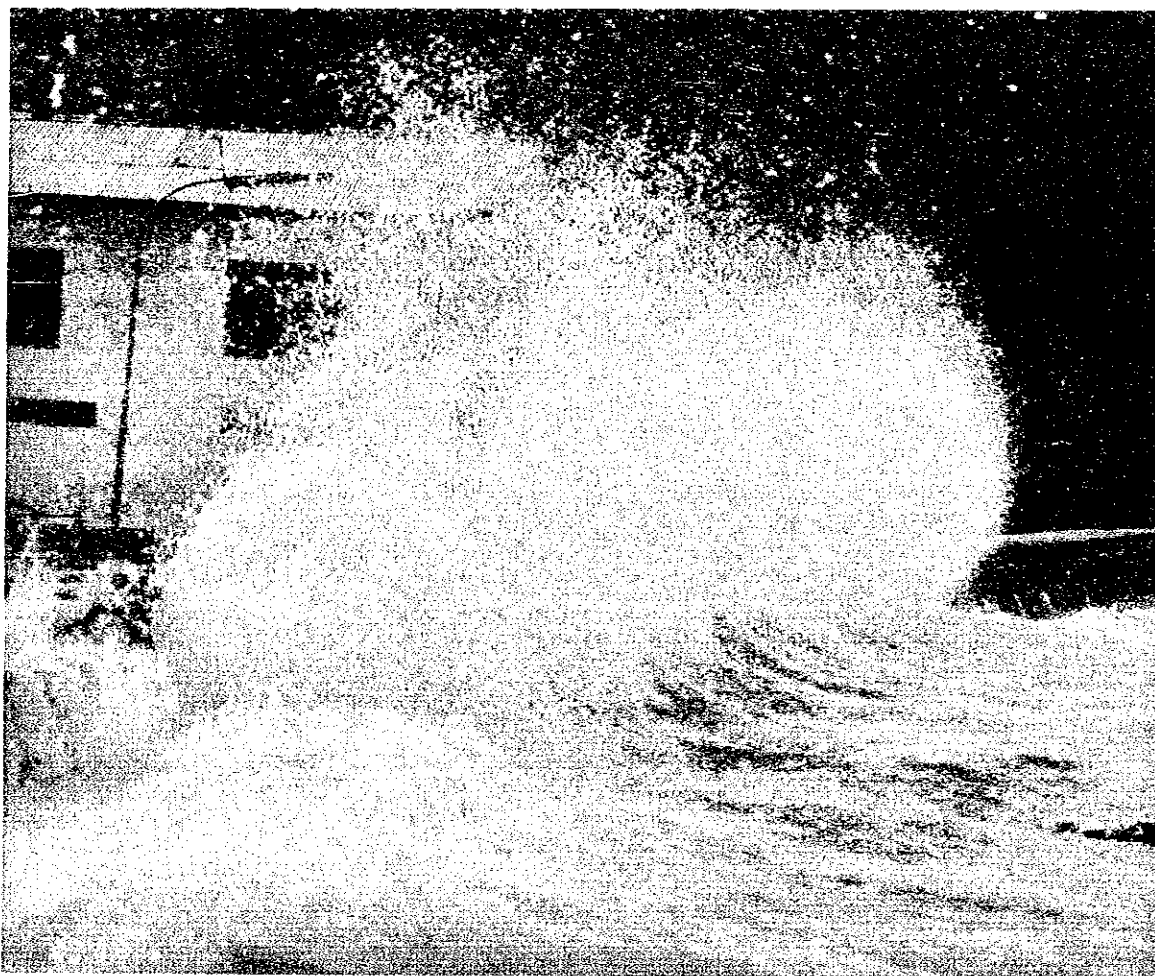


**THE DEVELOPMENT STUDY
ON
THE SEAWALL CONSTRUCTION PROJECT
FOR
MALE' ISLAND IN THE REPUBLIC OF MALDIVES**

MAIN REPORT I



DECEMBER 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

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**THE DEVELOPMENT STUDY
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PREFACE

In response to a request from the Government of the Republic of Maldives, the Government of Japan decided to conduct a development study on the Seawall Construction Project for Male' Island and entrusted the study to the Japan International Cooperation Agency (JICA).

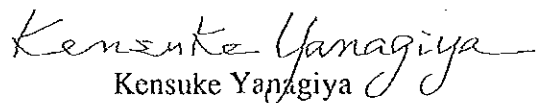
JICA sent to Maldives a study team headed by Mr. Hiroshi Sakuramoto, INA Cooperation, 3 times between September 1991 and October 1992.

The team held discussions with the officials concerned of the Government of Maldives, and conducted field Survey 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 Republic of Maldives for their close cooperation extended to the team.

December 1992


Kensuke Yanagiya

President

Japan International Cooperation Agency

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MALDIVES

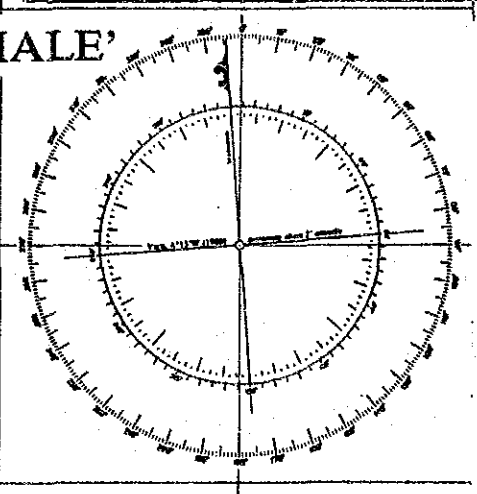
ISLANDS

MALE'

LOCATION MAP (1)

Scale 1:3,473,000

0 50 100 km



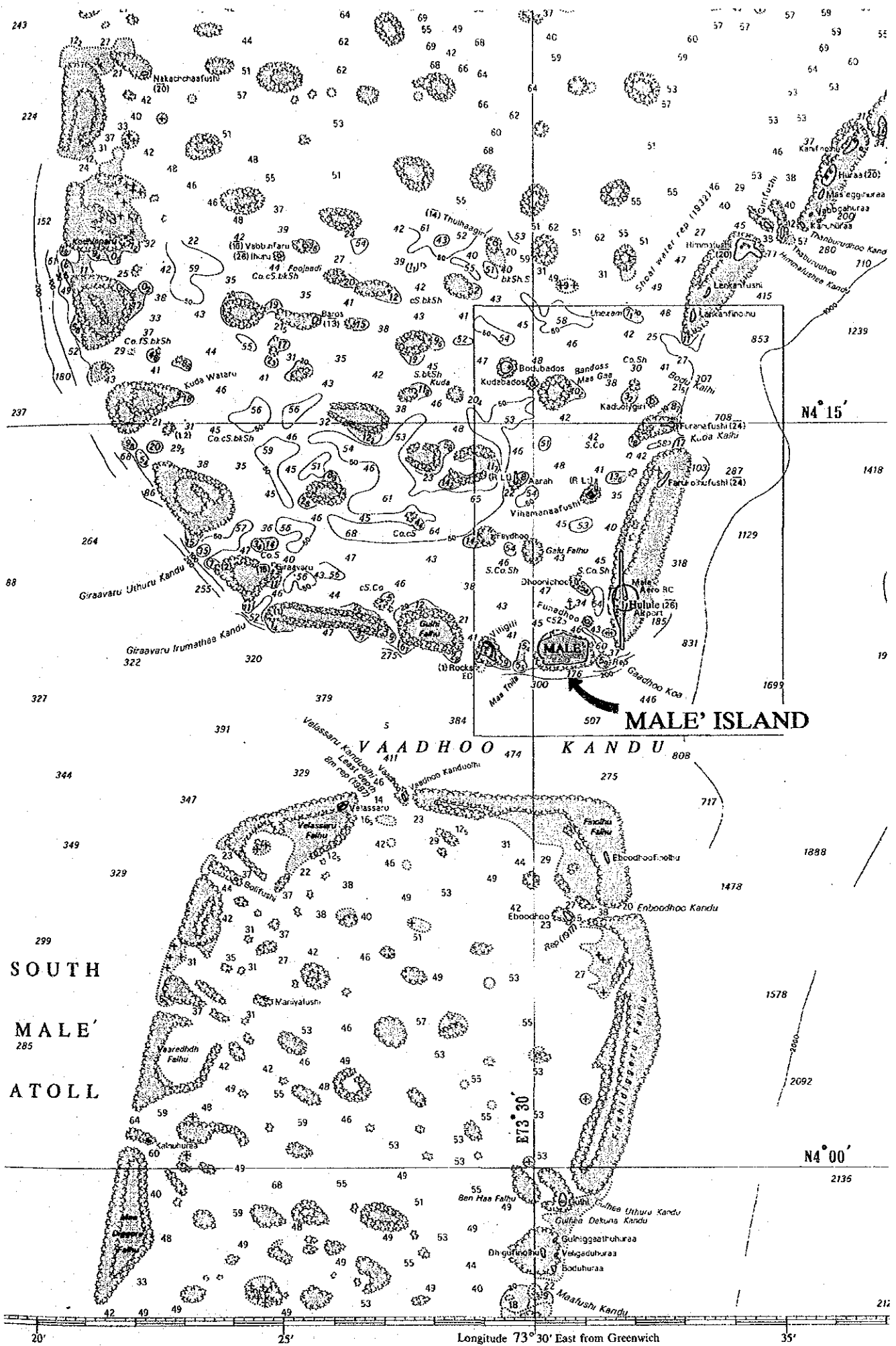
EQUATORIAL CHANNEL

(See chart No. 708)

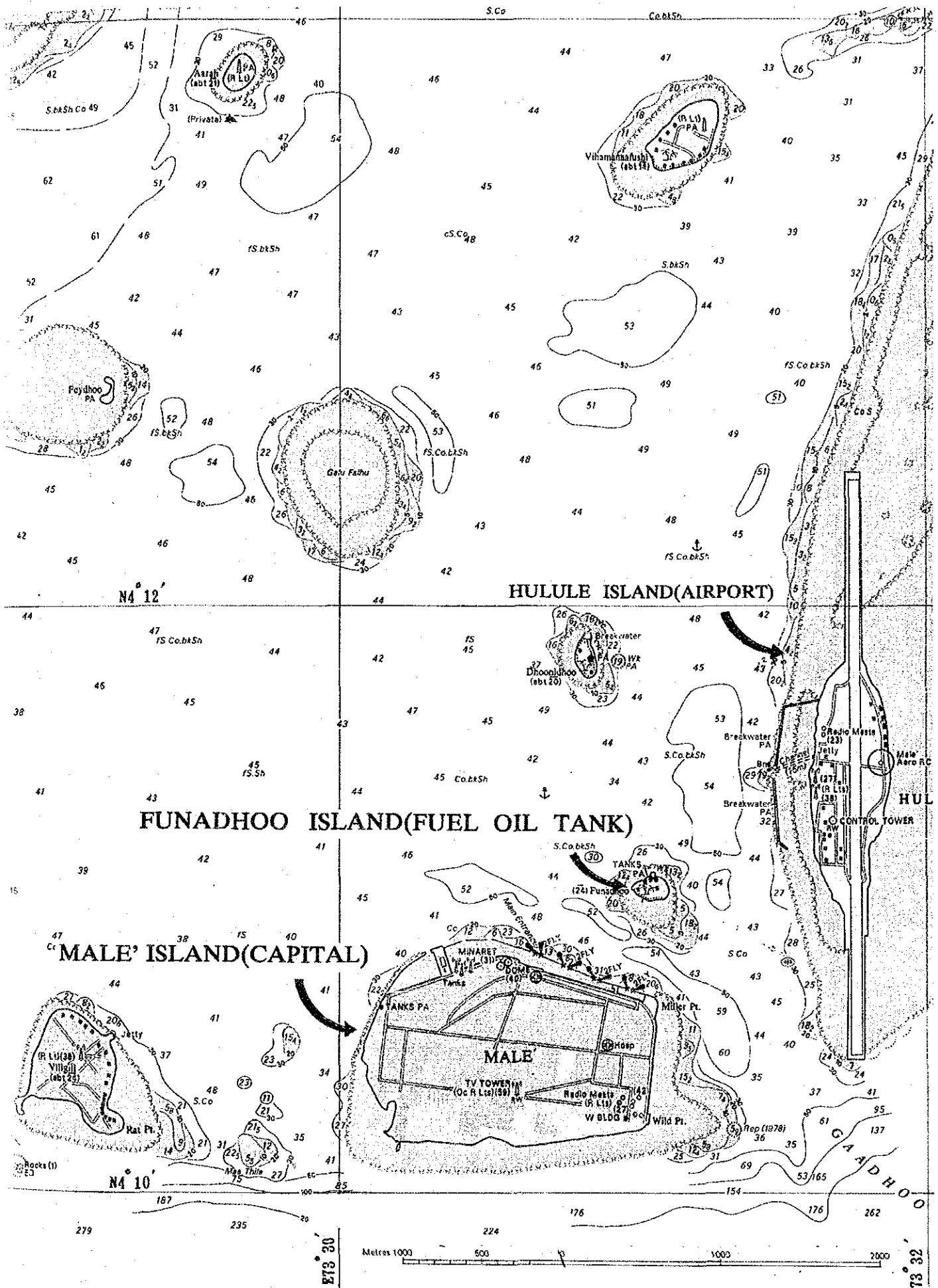
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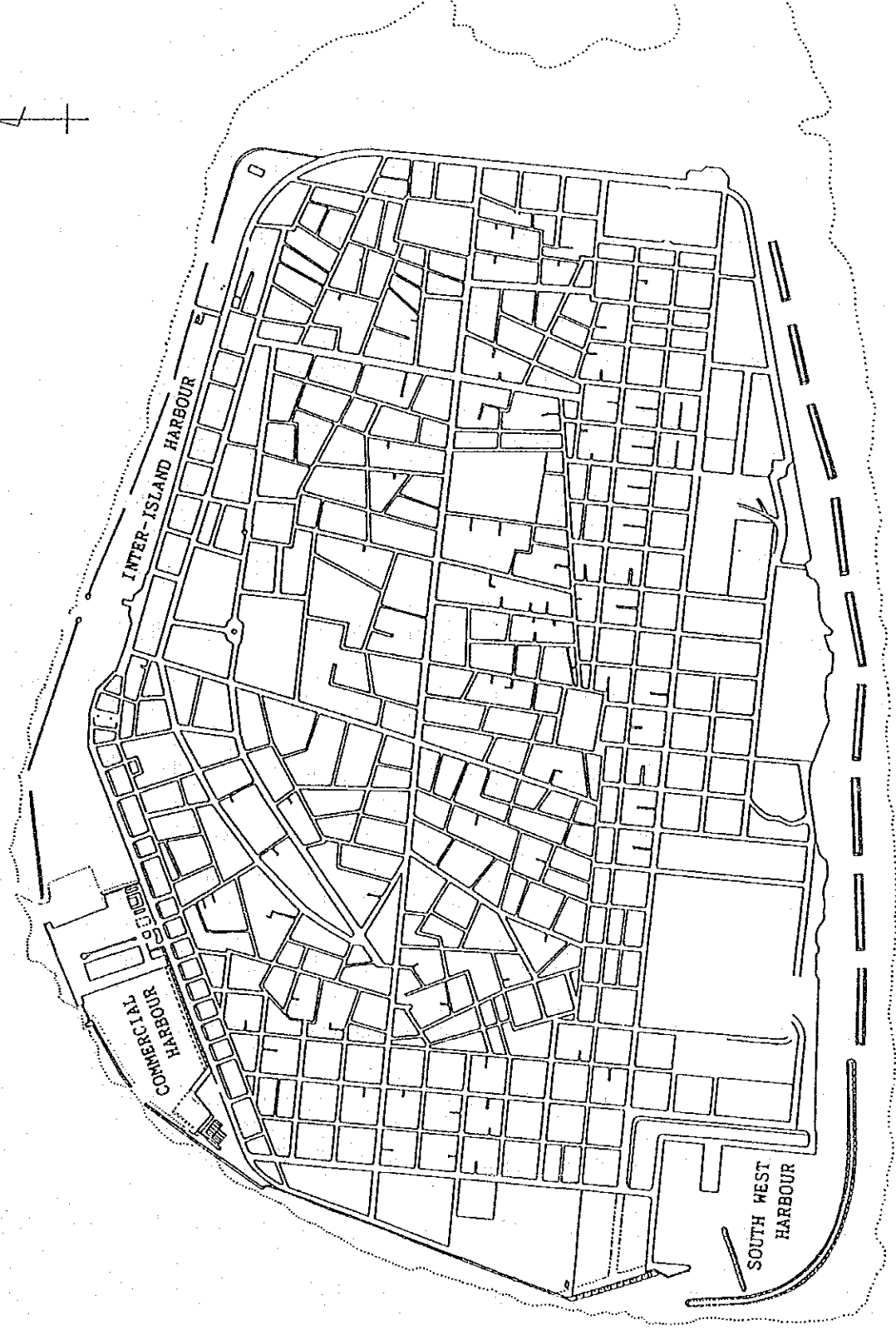
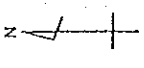
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LOCATION MAP (2)



LOCATION MAP (3)



LOCATION MAP (4)

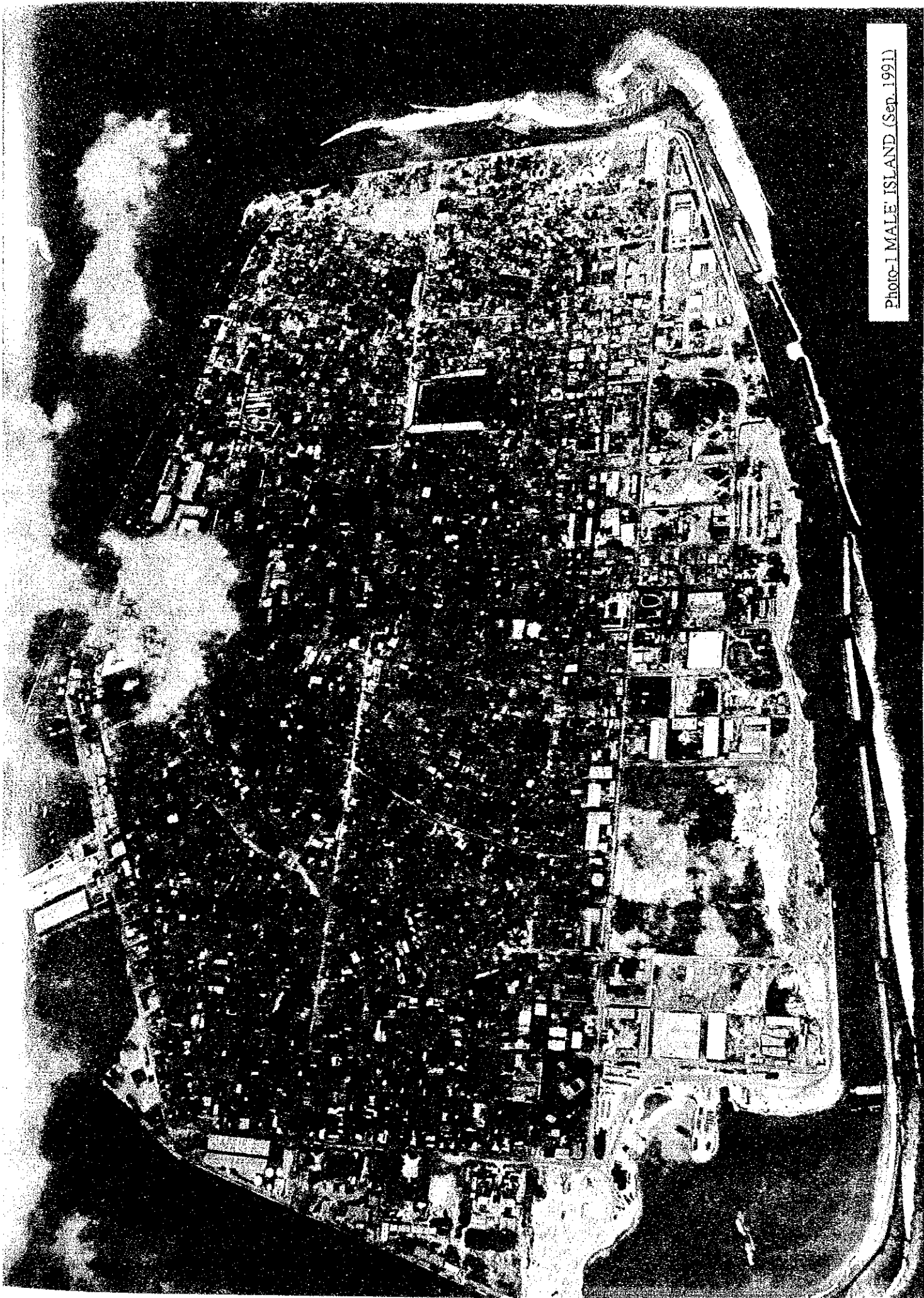


PHOTO-1 MALE ISLAND (Sep. 1991)



Photo-2 SOUTH AND EAST COAST (Sep. 1991)
The southern part of the east coast is the only location in Malé where sea bathing, swimming and surfing are practised by the local people.

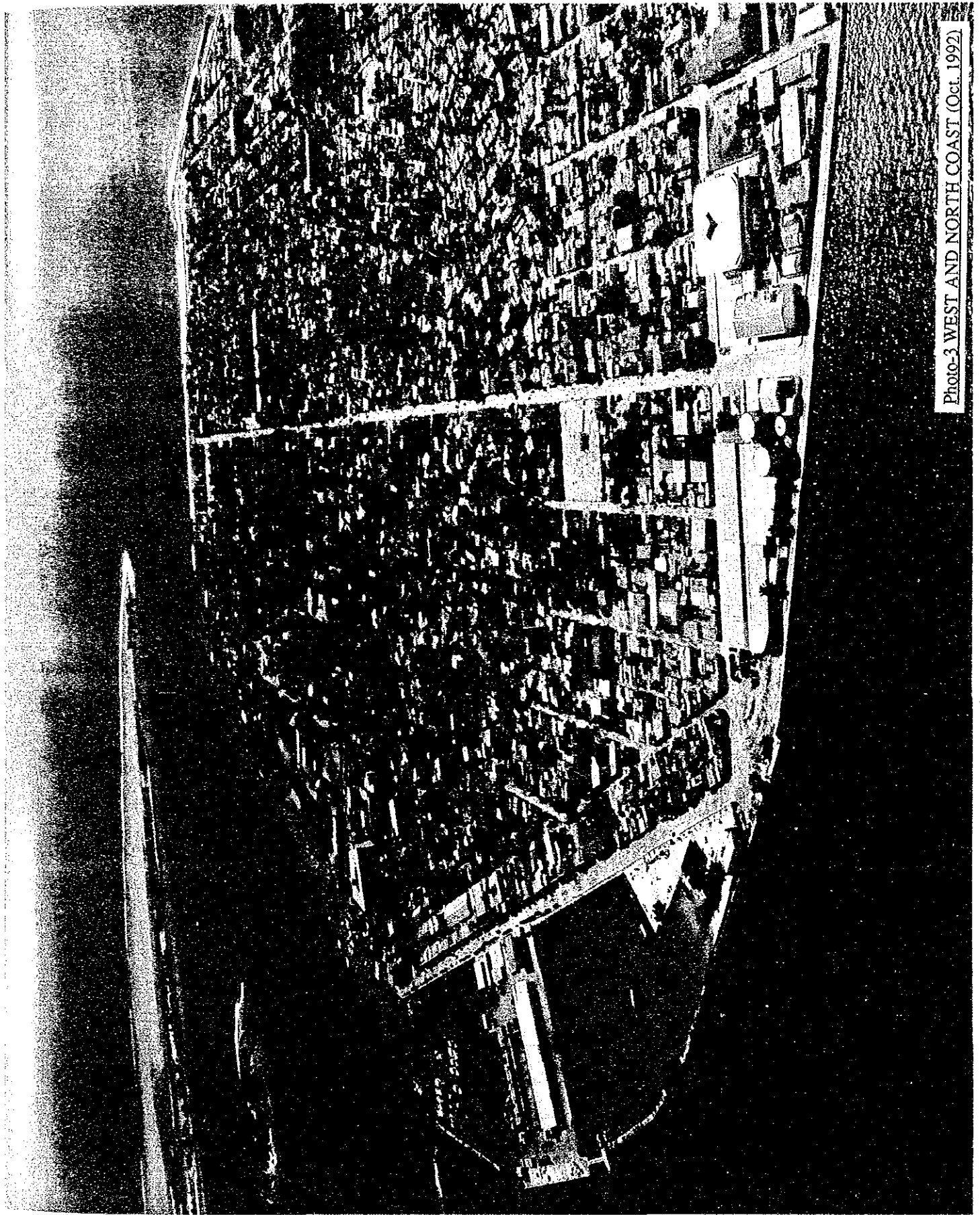


Photo-3 WEST AND NORTH COAST (Oct. 1992)



Photo-4 EAST COAST (Sep. 1991)

Although coral reef is the most ideal breakwaters, the Government plans to reclaim this coast to provide construction of swimming pool.

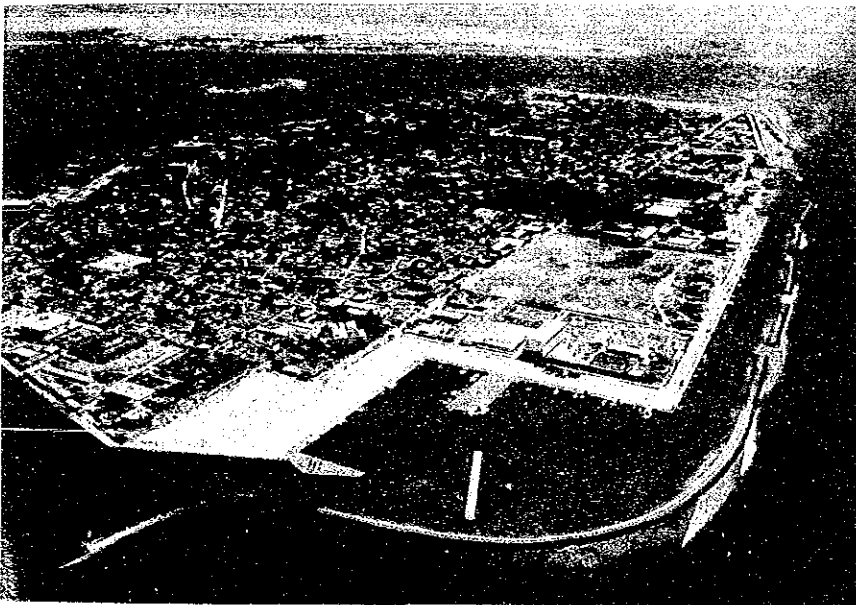


Photo-5 SOUTH COAST (Sep. 1992)

The detached breakwaters were completed in 1990. Along the coast, quaywalls for inter-island boats are planned.

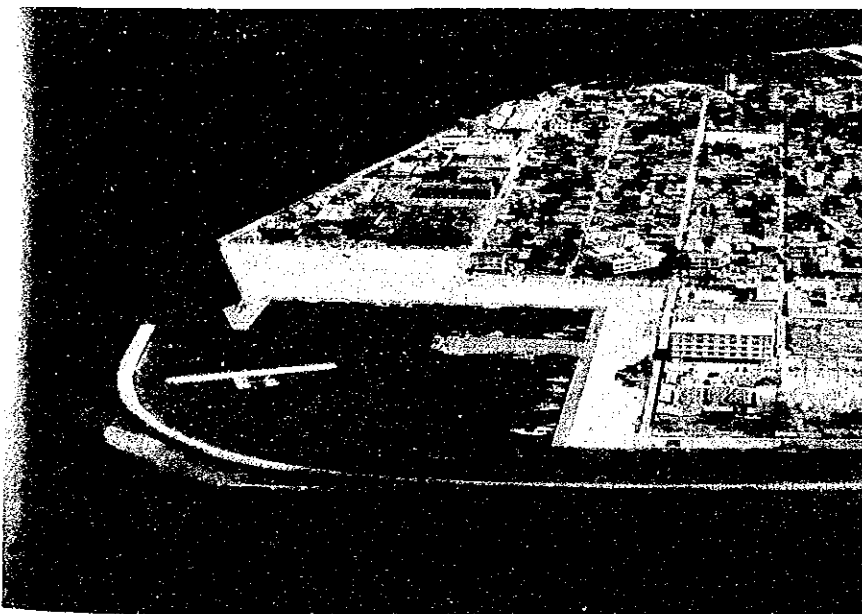


Photo-6 SOUTH-WEST HARBOUR(Oct. 1992)

Inter-island harbour was completed in November 1992.

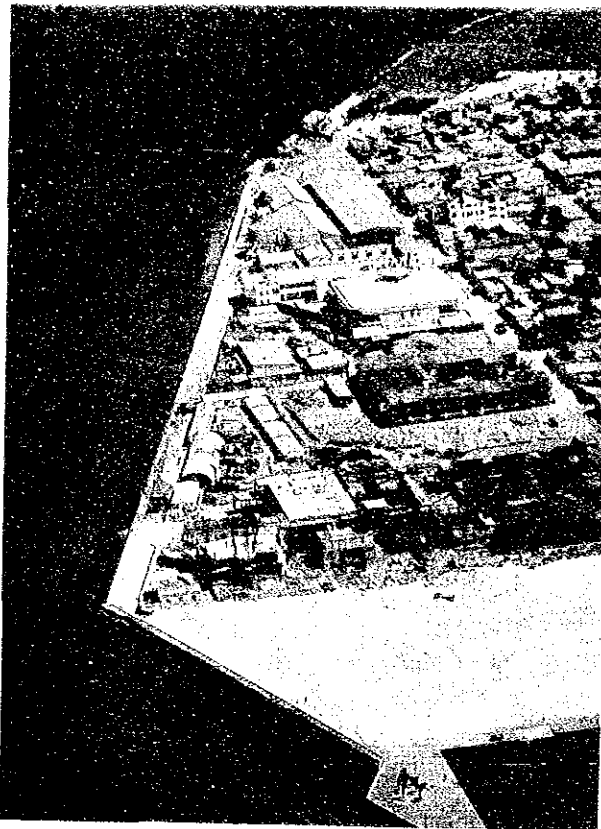
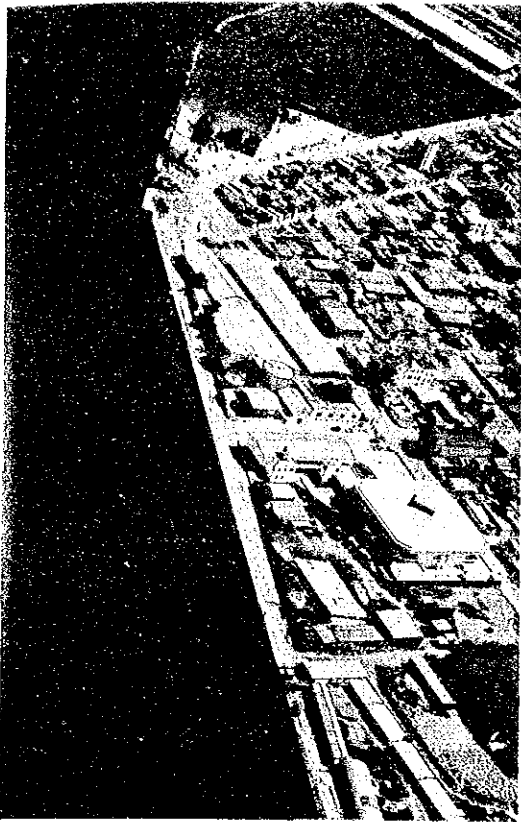


Photo-7 WEST COAST (Oct. 1992)

There are many important public facilities such as hospital, school and education center very close to the seawalls. The Government plans to expand Marine Drive to connect two harbours.

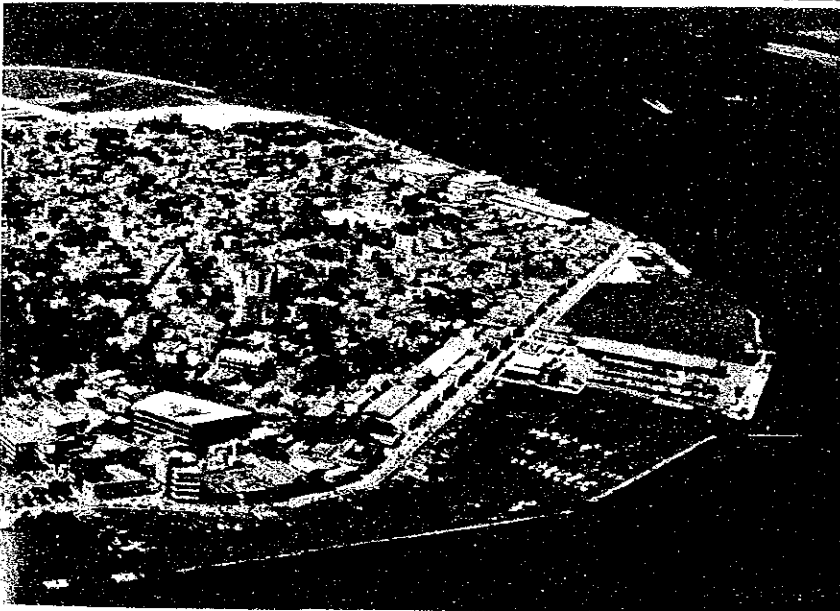


Photo-8 NORTH COAST (Oct. 1992)

Commercial harbour and Inter-island harbour are congested with dhonis, fishing boats and pleasure boats.

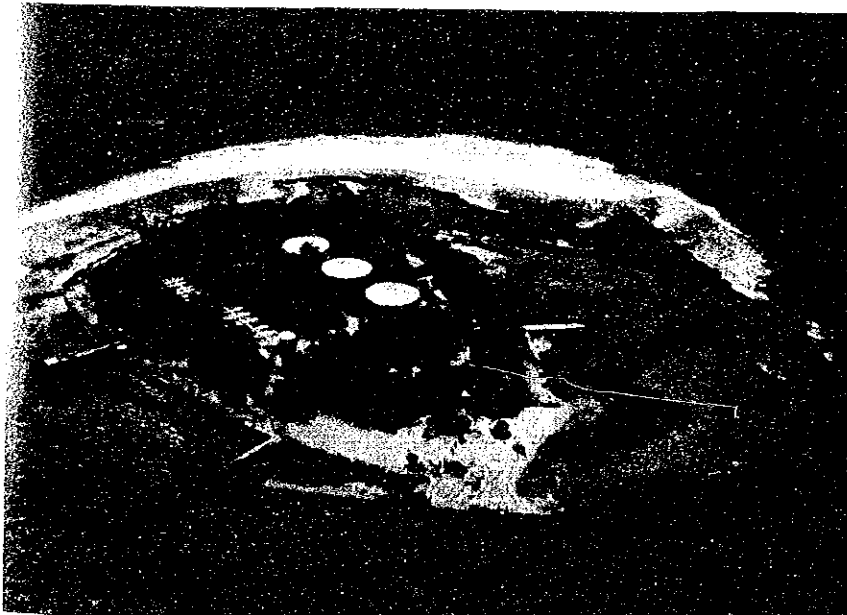


Photo-9 FUNADHOO ISLAND (Sep. 1991)

Three tanks of 1800 mt capacity are installed and utilized as fuel storage for Male' and other islands.

Fuel oil is transported to Male' everyday by small tankers.

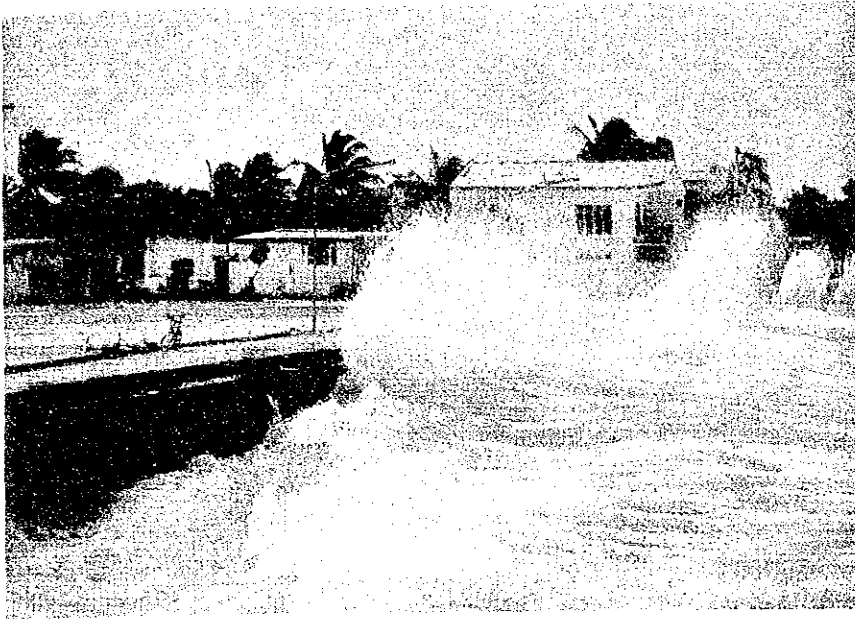


Photo-10 EAST COAST (Jul. 1992)

Wave overtopping occurs very often at the south part of east coast seawall.



Photo-11 SOUTH COAST (Sep. 1991)

Detached breakwaters were constructed on the reef edge of the south coast after the 1987 high tide disaster.



Photo-12 WEST COAST (Sep. 1991)

The existing seawalls are constructed very close to reef edge. There is no room to expand the road seaward although the road is planned to be expanded.

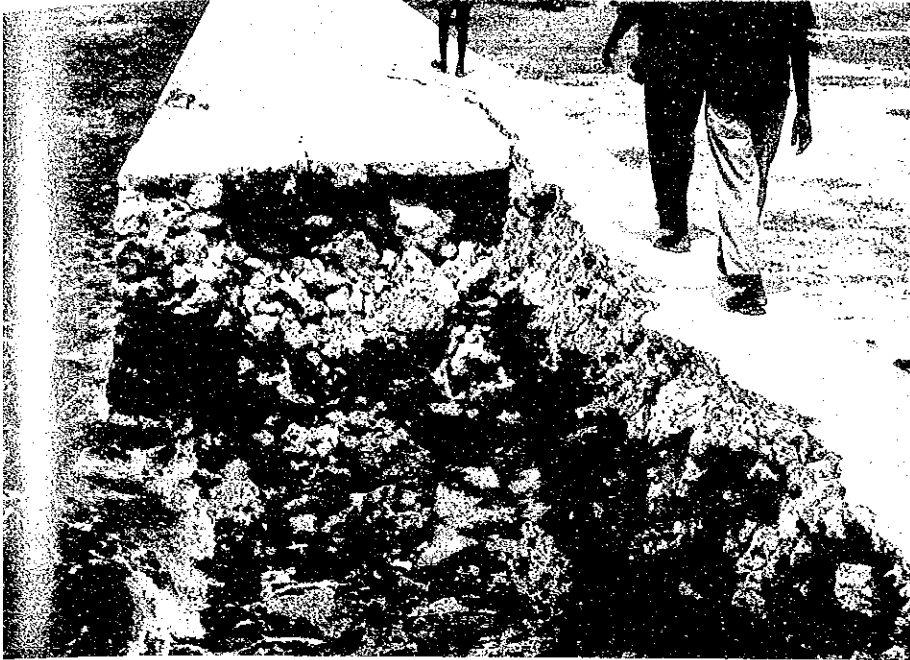


Photo-13 EXISTING SEAWALL
STRUCTURE (Sep. 1991)

The structure is of coral rocks of 10 to 20 cm in dia. piled with its surface mortared or plastered.



Photo-14 SHEET PILING SEAWALLS (Sep. 1991)

New sheet piling seawalls are being substituted for the old seawalls along north coast.

Composition of the Report

This report consists of six volumes as follows;

- ① Summary Report : Summary
- ② Main Report I : Report for Male'
- ③ Main Report II : Report for Funadhoo
- ④ Supporting Report : Supplementary Study Report
- ⑤ Supporting Data I : Topo/Hydrographic Maps
- ⑥ Supporting Data II : Oceanographic Survey Data



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I. Abbreviations of Institutions

ADB	Asian Development Bank
DANIDA	Danish International Development Agency
DIB	Department of Information and Broadcasting
DM	Department of Meteorology
ERU	Environment Research Unit
FAO	Food and Agriculture Organization of the United Nations
GOM	Government of Maldives
HD	Harbour Division
IDA	International Development Association
IDB	Islamic Development Bank
IFAD	International Fund for Agricultural Development
IMF	International Monetary Fund
JICA	Japan International Cooperation Agency
MDNS	Ministry of Defence and National Security
ME	Ministry of Education
MM	Male' Municipality
MOC	Ministry of Construction of Japan
MOFA	Ministry of Foreign Affairs
MPE	Ministry of Planning and Environment
MPWL	Ministry of Public Works and Labour
NCPE	National Commission of the Protection of the Environment
OPPD	Office of Physical Planning and Design
PWD	Public Works Division
SAARC	South Asian Association for Regional Cooperation
TM	Television Maldives
UN	The United Nations
VOM	Voice of Maldives
WDC	Ward Development Committee

II. Other Abbreviations

CPI	Consumer Price Index
D.L.	Datum Line
dB	decibel
EIRR	Economic Internal Rate of Return
GDP	Gross Domestic Product
JIS	Japanese Industrial Standard
Jpn ¥	Japanese Yen
MRf	Maldivian Rufiyaa
MW	Mega Watt
PR	Public Relations
sq. km	square kilometer
sq. m	square meter
TTS	Telegraphic Transfer Sale
US \$	US Dollar

Chapter 1. Background of the Study

1.1 History and Purpose of the Study

1.1.1 History

Any serious damage caused by extremely high tides may not have been recorded before 1986 in the Republic of Maldives, but thereafter high tides occurred three times and caused considerable damage in April 1987 and in June and September 1988.

From 10th to 15th April 1987, extremely high tides occurred in Male' and its surrounding islands and caused damage to seawalls, private houses, airport facilities, etc. The total loss caused by this high tide was estimated at about US\$ 5 million concentrated along the heavily populated south coast area of Male' Island and at the international airport in Hulule Island. When high tides occur in Male' Island, flood waters continue to remain for considerably long periods, mainly because the island is flat and low lying and has no adequate drainage system. In 1987, due to flooding for a long period of time coupled with high temperatures, an epidemic of diarrhea broke out.

Immediately after the flood disaster in 1987, the Government of the Republic of Maldives requested the Japanese Government for an investigation on damages caused by the extremely high tides. The Japanese Government dispatched an urgent mission to study the flood disaster for 9 days from 24th April, 1987. The mission surveyed the damaged sites and recommended an urgent construction plan of a detached breakwater in order to protect the southern coast of Male' Island from intrusion of big swells. Following the recommendation, the Government of the Republic of Maldives requested the Government of Japan for grant aid to implement this Project, and the Japan International Cooperation Agency (JICA) had a basic design study mission to work in the field for 23 days from 30th July 1987. Based on the plan studied by JICA, the detached breakwaters were constructed and completed in 1990 along the southern coast as an urgent means against extremely high tides.

During the construction of the detached breakwaters in 1988, high tides, which were smaller in scale than the ones in April 1987, occurred and flooded the area along the southern coast of Male'. However, the damage by high tides were minimized by preventing flood water intrusion by constructing a temporary stop water sand bag mound of approximately 0.5 m high and 4 m wide across the road in the southern

area of the island. Furthermore, the sand bag mound was moved to the shoreline of a reclamation area to prevent wave overtopping. These emergency works were carried out by bulldozers owned by a Japanese construction company working on the detached breakwater project.

Although the urgent construction of the detached breakwaters has been completed, a further development study on the Seawall Construction Project is required in order to protect the Male' Island from any extremely high tides. In response to the request of the Government of Maldives, JICA dispatched a preliminary study team headed by Dr. Takaaki Uda, Head of Coastal Engineering Division, Public Works Research Institute of the Ministry of Construction, to Maldives from January 22 to February 2, 1991 and the Scope of Works for the Study was concluded.

1.1.2 Purpose

The southern and western areas of Male' Island comprise reclaimed land with its ground level almost the same as the spring high water level. Along the west and east coasts, seawalls were constructed, but they do not properly meet technical requirements against high tides and wave overtopping. The north seawall, generally used as berthing facilities for dhoni and pleasure boats, is sheltered from wind waves generated in the atoll by breakwaters, but the crown height of the seawall is not high enough and was overflowed in the 1988 high tide.

The land area of Male' is less than 2 km² and accommodates about 26 % of the nation's total population of 213,215 (in 1990). In recent years, the population has shown a large migration into the capital forming an extremely high population density in Male'. Therefore, in order to ensure a safe livelihood for the residents of Male' Island, the development study of the improvement of the seawall in Male' Island is urgently required.

The Study objectives are to make topographic/hydrographic survey, oceanographic survey, soil investigations and other necessary investigations and formulate the construction plan of the seawall, and to perform technology transfer to the Maldivian counterpart personnel.

1.2 Description of the Project Site

1.2.1 Project Site

According to the "Information 1 and 3" published in 1991 by the Department of Information & Broadcasting of the Government of Maldives, the country and the capital island are briefly introduced as follows:

(1) Maldives

a) Introduction

The Republic of Maldives is an archipelago of 1,190 small coral islands, out of which 200 are inhabited. The islands are formed into 26 natural atolls but for easy administration, they are divided into 19 administrative units or "atoll". The nearest neighbouring countries are India and Sri Lanka, situated about 600 and 670 km to the North and East respectively.

b) Physical Features

Every atoll of the archipelago is enclosed by a coral reef that has several deep, natural channels serving as entry points. Likewise, a protective coral reef and, in addition, a shallow lagoon surrounds each island.

The islands are very small and low-lying with many being no more than two meters above sea level. Common features are tall coconut palms, white sandy beaches and crystal clear lagoons.

There are no hills, mountains or rivers in the Maldives.

c) Area

The total area including land and sea is about 90,000 sq.km. The length of the archipelago is 823 km while it is 130 km at its greatest width.

d) People

Archaeological finds reveal that the islands were inhabited as early as 1500 BC. However, it is believed that the first settlers in these island were Aryan immigrants who came here around 500 BC. Today, Maldivians are a mixed race.

e) Population

The 1990 census puts the population at 213,215 out of which about 48.5 % are women. It is expected that the figure would rise to 288,800 by the year 2000. Population by atoll and labour force by sub-sector are as indicated in Table 1.2.1 and 1.2.2 respectively.

Table 1.2.1 Population by Atoll, 1985 in 1990

Locality	1985	1990
Republic	180,088	213,215
Male'	45,874	55,130
Atolls	134,214	158,085
North Thiladhunmathi	9,899	12,031
South Thiladhunmathi	10,850	12,890
North Miladhunmadulu	7,509	9,022
South Miladhunmadulu	6,864	8,437
North Maalhosmadulu	9,416	11,303
South Maalhosmadulu	6,982	7,716
Faadhippolhu	6,414	7,725
Male' Atoll	8,734	10,133
Ari Atoll	7,861	9,793
Felidhu Atoll	1,419	1,697
Mulakatholhu	3,490	4,186
North Nilandhe Atoll	2,148	2,614
South Nilandhe Atoll	3,568	4,199
Kolhumadulu	6,949	8,189
Hadhdhunmathi	7,212	9,101
North Huvadhu Atoll	6,054	7,295
South Huvadhu Atoll	8,905	10,417
Foammulah	4,983	6,160
Addu Atoll	14,957	15,177

Source: National Development Plan 1991 - 1993 Vol. 1 Table 2.1

Table 1.2.2 Labour Force by Sub-Sector, 1985 and 1990

Sector	1985			1990			% change		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Agriculture	1,673	1,336	3,009	1,438	1,181	2,619	-14	-12	-13
Fishing	12,170	264	12,434	11,181	317	11,498	-8	20	-08
Quarrying	604	39	643	482	14	491	-20	-64	-23
Manufacturing	5,116	6,443	11,559	4,259	4,182	8,441	-17	-35	-27
Utilities	500	4	504	409	36	445	-18	800	-12
Construction	2,528	35	2,563	3,109	42	3,151	23	20	23
Wholesale/retail	5,129	305	5,434	8,332	552	8,884	62	81	63
Transport/ communications	3,212	115	3,327	5,024	297	5,321	56	158	60
Financial services	366	52	418	869	189	1,058	137	263	153
Comm/social/ personal services	8,157	2,274	10,431	8,132	3,716	11,848	0.3	63	14
Total	39,455	10,867	50,322	43,235	10,526	53,756	201.3	1,294	2

Source: National Development Plan 1991 - 1993 Vol. 1 Table 2.6

f) Religion

Maldives is a 100 % Sunni Moslem country. Islam is the religion of the State and the backbone of society.

g) Language

Throughout the Maldives, Dhivehi, a language which belongs to the Indo-Iranian group of languages is spoken. Its present script, introduced in the late 16th century, is written from right to left and is unique, being the only language of the Maldives. The language also shows a strong Arabic influence.

h) Climate

The climate, which is determined by two monsoons, is warm and humid. The rainy south-west monsoon begins during April and continues until October, while the generally fine north-east monsoon prevails from December to March. The average annual rainfall is 1948.2 mm and the mean daily maximum temperature is 30.4 °C while the daily minimum is 25.7 °C.

i) Fauna and Flora and Marine Life

The protective coral reef surrounding every island is not only a submerged underwater garden or a diver's paradise but also home to hundreds of species of multi-coloured tropical fish, countless shapes and sizes of coral and shells.

In the Maldives, there is no room for thick jungles. Trees of food value include breadfruit, banana, mango, screwpine, casava, sweet potato, and millet. Coconut palm is the most common.

The fauna and flora of Maldives is very similar to those found in the tropical island ecosystem. Very few terrestrial fauna are represented while the majority of tropical fauna, that can survive the island conditions, do exist.

j) Political History

The Maldives has been an independent state throughout its known history, except for a brief period of 15 years in the 16th century. It became a British Protectorate in 1887 and remained so until 26 July, 1965, when independence was proclaimed. The independent Maldives reverted from a Sultanate to Republic on 11th November, 1968. There is no party system in the country.

k) Constitution

The first written constitution of the Maldives was proclaimed in 1932. But a deeper study of the system of government administration shows that there have been long standing unwritten, constitutional principles in the form of time-honoured customs. The present constitution was proclaimed in 1968.

l) The President

The President is the Head of State and the Chief Executive. He is nominated by the Citizens' Majlis and elected by a public referendum for a renewable term of five years. He is also the Commander-in-Chief of the armed forces and the supreme authority entrusted with the protection of the religion in the country.

m) The Cabinet

The Cabinet comprises the President, Vice President, Ministers with portfolios and the Attorney General. The President appoints and terminates ministers, who may or may not be a member of Parliament.

n) Citizen' Majlis

The Citizens' Majlis (Parliament) elected for a five-year term, is the legislative body. The Majlis consists of forty-eight members, two from each atoll and Male', and eight nominated by the President.

o) The Economy

The economy is based on three principal activities, fishing, tourism and shipping. Poor soil and limited availability of cultivable land limit agriculture. Traditional industry consists of local boat-building, handicraft such as mat-weaving, jewellery-making and lacquer work. Export-oriented industries include tuna fish canning, and manufacture of garments.

At present the major trade partners include U.S.A., Thailand, Sri Lanka, Japan, Germany, Canada and Singapore.

Gross Domestic Product and Physical Indicators of Production are as indicated in Table 1.2.3 and 1.2.4 respectively.

Table 1.2.3 Gross Domestic Product, 1987 - 90
(in million Rufiyaa at 1985 constant price)

Sector	1987	1988	1989	1990
Gross Domestic Product (GDP)	709.668	771.554	843.180	970.319
Agriculture	77.909	79.856	82.252	87.130
Fisheries	116.543	124.118	132.670	147.554
Coral and Sand Mining	13.193	13.984	14.893	17.891
Construction	58.066	63.872	70.515	83.900
Manufacturing + Electricity	39.655	43.621	48.201	55.625
Distribution	115.487	128.768	144.092	166.829
Transport	37.106	40.817	45.021	56.958
Tourism	122.402	133.907	147.297	177.797
Real Estate	30.899	33.680	36.880	40.615
Services	37.861	42.934	49.160	55.600
Government Administration	60.547	65.997	72.200	80.420

* Newly revised figures adjusted to production changes in the two leading sectors and changes in prices.

Source: National Development Plan 1991 - 1993 Vol. 1 Table 3.1

Table 1.2.4 Physical Indicators of Production, 1987 - 90

ITEM	UNIT	1987	1988	1989	1990
Fish Catch	000 M/T	56.9	71.7	71.2	76.4
No. of Mechanized Boats	UNITS	1334	1425	1481	1491
Tourist Arrival	000	131.4	155.8	158.5	195.2
Vacation Tourists	000	118.7	140.2	145.1	179.6
Bed Capacity	000	6.2	7.1	7.6	7.6
Utilization Capacity	%	50.9	61.1	53.7	60.3
Shipping Fleet	UNIT	18	19	20	20

Source: National Development Plan 1991 - 1993 Vol. 1 Table 3.3

p) Transport

The common mode of inter-island transport is by locally built boats known as "Dhoni". Although there is a regular ferry service between the islands, one would often come across boats leaving Male' to most of the islands.

Air Maldives operates domestic flights to two of the Southern and one of the Northern atolls. Male' International Airport on the island of Hulhule handles international air traffic.

q) Communication

The Satellite Earth Station in Male' provides direct dialling telephones, telex as well as facsimile services to any part of the world. However, inter-atoll communication is primary through HF transceivers. In several islands VHF and UHF telephones are also used.

r) International Relations

The Maldives is a member of U.N. and most of its specialized agencies, Commonwealth, OIC, the Non-Aligned Movement and SAARC. Presently the Maldives has diplomatic relations with over one hundred countries. The country also enjoys membership in international financial institutions such as World Bank, IMF, ADB, IFAD, IDA and IDB.

(2) Male', the Capital of the Maldives

a) General

Male' is just one island in a multitude of islands making up the Male' Atoll. Throughout its known history, Male' (Pronounced Maaley) has been the political, business as well as cultural center of the country.

Situated north of the center of the island chain that makes up the Maldives, the island of Male' is approximately one and a half square kilometers in area and houses a population of 55,130 (census in 1990). In addition to its permanent population, Male' also has a floating population of several thousands who arrive from other atolls to sell their products, do their shopping and to receive medical treatment. People from other islands send their children to either Government or private schools in Male' for education.

The climate of Male' is warm and humid. The average daily temperature varies between 30.4 °C and 25.7 °C. The monthly rainfall averages 162.3 mm. Light cotton clothing is preferred. Visitors are expected to respect the local practice of propriety in dress while in Male'.

Male' is divided into four wards or districts; Henveiru, Galolhu, Machchangolhi and Maafannu. Henveiru occupies the whole of north eastern side and Maafannu the north west. Galolhu and Machchangolhi, the two smaller wards are situated in the center and south of the island.

A reclamation project carried out recently in the shallow waters within the western and southern reefs has added almost half of its original size to the island.

Although most resorts and tourist facilities are on nearby islands, Male' too has its share of hotels and guest houses. Nasandhura Palace Hotel is a governmentally operated hotel, while Hotel Alia is a privately operated hotel. And there are a large number of guest houses managed by private parties.

Staying in Male' is further facilitated by the services available from both the Government and private sectors. These include international telephone, telex and cable services provided by the Dhiraagu Private Ltd. (formerly Cable and Wireless) and medical services are provided by Central Hospital and Male' Health Center. Furthermore, there are several private medical clinics. Embassies, High Commissions and Consulates including those from the State of

Palestine, India, Pakistan, Sri Lanka and the United States reside in Male'. For those in the mood for reading research, there are a few libraries in Male' including the National Library. Banking facilities are available through several banks such as Bank of Maldives Ltd., State Bank of India, Habib Bank Ltd., and Bank of Ceylon.

b) Transportation

Male', being quite a small island, there is no place one cannot walk. In fact, it takes about 20 minutes to walk the length of the island. However, bicycle is the commonly favoured mode of transport. Other vehicles including motor cycles, vans, lorries and cars are rapidly increasing too. Taxi services, which can be contacted by phone, are operated by several private companies.

Going out of Male', whether to the International Airport or any other place, means using sea transportation; generally by a local ferry boats known as Dhoni. Most of these are anchored in the Male' inner harbour-the breakwater enclosed area lying to the North of the island. Sections of the water front are allocated for various purposes such as ferrying outbound passengers, unloading local products, and fish landings. An official jetty situated on the same water front, faces the Islamic Center.

The inner harbour is separated from outer harbour by a coral stone breakwater, first built between 1620-1648. Although there are no physical boundaries marking the outer harbour used for international shipping it lies generally in the sea enclosed within three nearby islands, Funadhoo, Dhoonidhoo and Villingili.

All ocean-going vessels are anchored in the outer harbour and the cargo is ferried by towed lighters to the newly built wharf in Male' Viyafaari Ban'dharu which also houses Male' Customs.

1.2.2 Related Development Plans

(1) National Development Plan (1991-1993)

a) Development Objectives

The Government accepts that the ultimate goal of all development must be to achieve a sustained improvement in the human condition. This improvement must encompass advances in both the material and non-material status of the Maldivian people, and find expression in increased incomes with reduced

disparities, better housing, improved access to quality health and education services, and more and diverse opportunities for recreation. No less important, progress must result in improvements in the less quantifiable aspects of improved levels of well-being, rooted in respect for social and cultural values, conservation of the environment and the existence of a stable and harmonious society.

The main objectives have been formulated for the period 1991-93. These objectives are to:

- (i) secure improvements in the living standards and quality of life of all Maldives;
- (ii) ensure that the benefits of development are shared more equitably among the population; and
- (iii) achieve greater self-reliance, which is essential for future growth.

b) Priorities for Development

While these objectives will serve to guide the nation's development over the next three years, the formulation of strategies require their translation into specific priorities. In formulating these priorities, the Government has made a detailed review of the performance of past policies and plans, and identified some 30 priorities for the Plan period. While some of these priorities are multisectoral in character, they can be approximately grouped under five main headings:

- economic management and development;
- infrastructure development;
- social development;
- institutional development; and
- the environment.

i) Priorities for Economic Management and Development

- To maintain a credible and prudent macro-economic and fiscal policy.
- To diversify the Government's revenue base.
- To maintain the competitive edge of Maldives in fisheries, and increase the importance of the sector in absolute terms.
- To maintain the country's international comparative advantage in tourism;
- To diversify the economy and increase productivity, emphasizing, where appropriate, non labour-intensive activities and technologies.
- To accelerate the process of atoll and island development.
- To increase the participation of women in economic activities.

- To create the financial and legal conditions required to promote foreign investment.
- To foster an indigenous capacity for scientific research and technological innovation.

ii) Priorities for Infrastructure Development

- To improve and expand the infrastructure required for the development of transport and communication links with the outside world.
- To improve and expand inter-atoll and inter-regional transport and communication services.
- To strengthen coastal defences in areas of high vulnerability on both Male' and the atolls.
- To provide the essential infrastructure on atolls and islands required to foster social and economic development.

iii) Priorities for Social Development

- To accelerate human resource development and skill formation.
- To improve access to, and the quality of, educational facilities and services.
- To improve the delivery and quality of services in the health sector.
- To expand access to potable water and environmentally sound systems of sanitation and waste disposal.
- To reduce the rate of population growth.
- To secure improvements in the distribution of income.
- To continue programmes aimed at improving the quality of the built environment on Male', with improved coordination of decentralization programmes.
- To ensure that development programmes and projects both in respect to cultural and spiritual values, and contribute to enhancing the quality of life and well-being of the population.
- To promote awareness pertaining to preservation of the nation's cultural heritage with particular emphasis on youth.

iv) Priorities for Institutional Development

- To accelerate programme of establishing the legal and judicial infrastructure required to enable the private sector to contribute fully to the nation's development.
- To improve the efficiency and performance of the civil service, by introducing further programmes of training, reform and reorganization.
- To consolidate the process of strengthening the social and political institutions required for a democratic, just and harmonious society.

- To establish new financial institutions required to accelerate the process of social and economic development, and ensure the availability of development finance.
- To strengthen machinery for the management and coordination of external assistance, so as to ensure that assistance is matched more effectively to priority programmes and projects.

v) Priorities for the Environment

- To ensure that all development programmes and activities are fully consistent with sound and prudent management and conservation of the environment and natural resources.
- To ensure that environmental impact assessments are prepared for all major capital investment projects, in both the public and private sector.
- To monitor carefully both global warming and impending sea-level rise, and assess their implications for the future of Maldives.

c) Main Strategy for Development Programmes for Male'

Male' will continue to demand a large share of the nation's development resources during the Plan period. Programmes will be implemented aimed at reducing overcrowding, and improving the overall quality of life in a "built" environment. The neighbouring island of Villingili will be developed as a satellite of Male', and steps will be taken to identify and develop additional islands that can serve the same purpose.

Important programmes planned for Male' include the further improvement of the system of water supply, with a new desalination plant powered by the waste heat from new electricity generating sets, and the improvement of garbage collection and sewage facilities, the latter including the construction of a treatment works. Road paving that provides for the recharging of the island's greatly depleted freshwater lens will remain a priority, drawing upon the positive experience gained during the previous Plan period. Increased attention will be given to improving the quality of the housing stock, increasing the availability of affordable accommodation to low-income groups, and the provision of sports and recreation facilities.

Important programmes and projects to develop infrastructure will include further strengthening of the island's coastal defences, improving the commercial port, and completing the inter-atoll harbor. Planned projects in Male' of national importance include the construction of a 200-bed hospital, a Centre for Social

Education, a national sports complex and several training institutions. A site has also been reserved for the construction of a new building for the Citizens' Majlis.

(2) Related Regional Development Plan

a) Male' Land Reclamation Projects

The Project was launched in April 1979 and was completed in July 1986. This project aimed at creating 59.7 ha of land area in the shallow flat reef over the southern and western sides of Male' Island to provide land for housing, schools, a new hospital, a power plant, a harbour for inter-island transport, a sports complex and other public facilities. The total land area of Male' Island before this project was measured at about 108 ha. By 1979, a land area of 14.9 ha was reclaimed. Out of this reclaimed land, 22 % has already been handed over to new home-owners and the concerned governmental departments. The total volume of soil required for this project amounts at about 850,000 m³ and was to be met by dredged material mainly from the port development site on the northern side of the island. The construction equipment for this project included two cutter suction dredgers of 12 inch suction pipe each, 4 excavators and 5 tipper lorries. The land area reclaimed and yearly project costs incurred are shown in Tables 1.2.5 and Fig. 1.2.1.

Table 1.2.5 Land Reclamation Project

Year	Area Reclaimed (ha.)	Cost (000 Rf.)
1979	0.2	2,212
1980	13.6	4,464
1981	8.4	6,941
1982	8.4	5,259
1983	12.5	8,754
1984	1.3	6,643
1985	7.4	7,429
1986	7.9	n.a.
	59.7	41,702

Source: DPWL (1985)

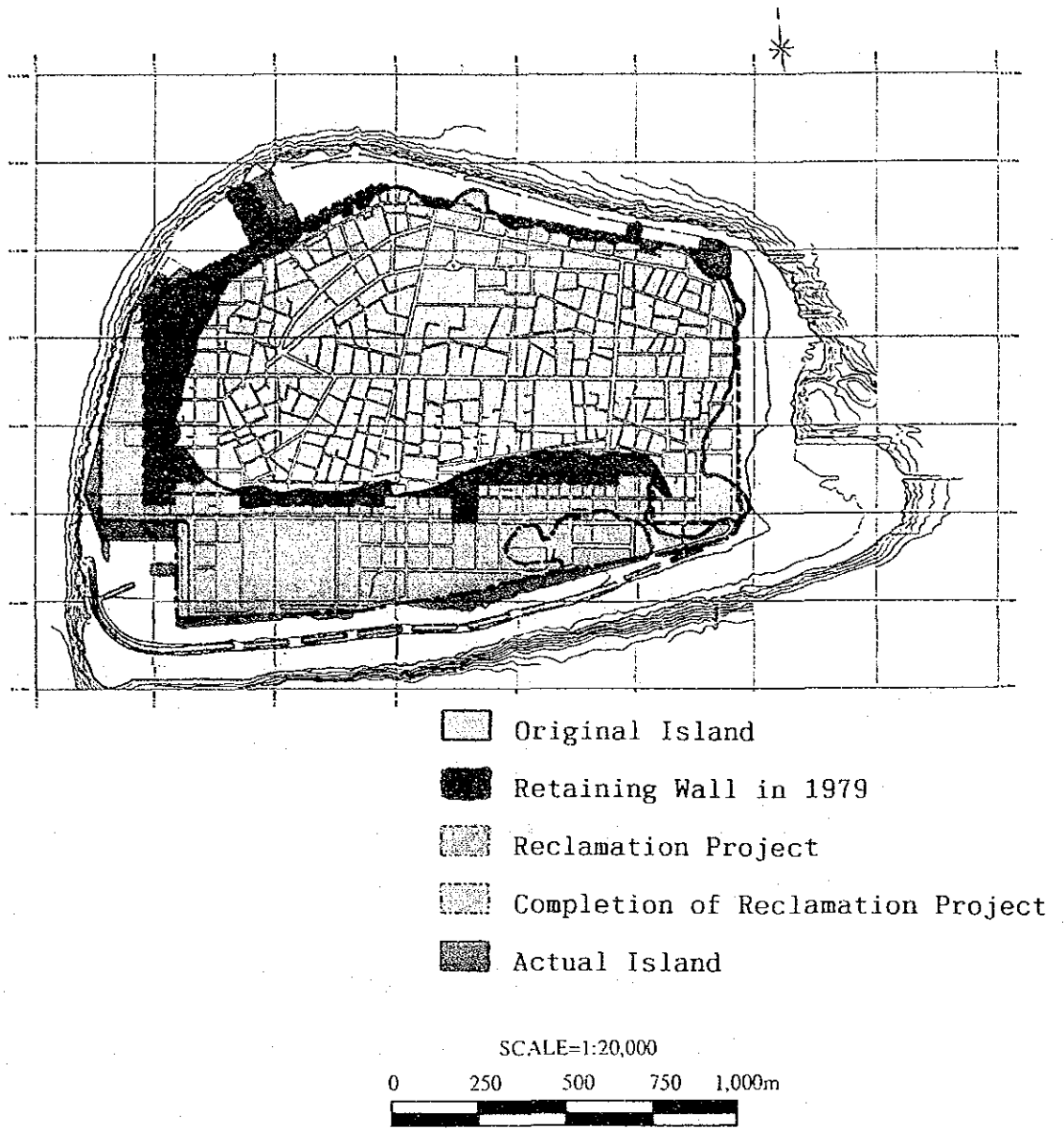


Figure 1.2.1 Progress of Land Reclamation

(3) Port Development for Inter-island Transport and Fishing Boats

The northern shore of the island is bounded by a series of harbour basins serving inter-island diesel boats, open dhonis, Government and private launches, tourist boats and cargo lighters. The latter are operated from the Commercial Basin situated in the north-west corner of the island and are used to unload cargo from ships anchored in the roadsteads just north of the island. One of the Project objectives is to alleviate the congested conditions in these various harbour basins by the construction of a new harbour serving inter-island boats and fishing boats in the south-west corner of the island.

The construction works of the project, financed by ADB UNCDF and OPEC, were started in March 1991 and scheduled to be completed in October 1992. The main works consist of the following:

Section A - Commercial Harbour

- earthworks and paving of an enlarged port area of about 15,800 sq.m,
- construction of a workshop and other buildings totalling about 900 sq.m,
- rehabilitation of the 160 meter long existing lighterage berth,
- rehabilitation of existing pavement of about 7,500 sq.m,
- construction of a 97 meter long temporary lighterage quay,
- dredging to 3.5 m depth as required in the existing lighterage basin, relocation of basin entrance and refurbishment of existing seawalls

Section B - Vessel Repair Yard

- earthworks for an area of about 5,500 sq.m,
- construction of a slipway for barges and dhonis,
- construction of a railway, cradle and winch system for barges and tugboats, and
- construction of a 45 meters long fitting-out berth with paved quay frontage

Section C - South-West Harbour

- construction of a new 480 m long SW breakwater,
- construction of the west revetment and spur breakwater
- construction of new quay walls totalling 651 m in length
- dredging to an average depth of 3.5 m,
- earthworks for hinterland areas of about 27,000 sq.m, and
- paving of 7,800 sq.m for inter-island cargo handling.

(4) Garbage Collection and Dumping Plan

The Government plans to provide a temporary dumping site for garbage collected from Male' Island along the south coast, and to transport the garbage to another island (designated as garbage island) by barges. To implement this Project, the Government constructed a new ramp for garbage barges in a part of the South-West harbor.

(5) Power Plant Project

The project, completed in June 1991, includes construction of 4MW diesel power generator in addition to the existing 4.8 MW generator with an ADB loan to meet increasing demand for electricity in Male'. The project site was located at the southeastern reef edge. The generator was installed 2 m above the existing ground level in order to protect the facilities from flooding expected in this area. Waste heat is supplied to the desalination plant. Since the power plant was constructed very close to the seawall, the wave overtopping there should be carefully examined.

(6) Water Supply and Sewage Development Project

The project includes construction of the networks of water supply and sewage to reduce the incidence of water-borne diseases and infant mortality. The project started in 1985 and was completed in 1988 except for the area not reclaimed yet. Sewage from 9 divided areas is pumped out off the reef edge by 27 to 47 liter/sec pumps. Drinking water is supplied from a desalination plant in emergency cases in the dry season from January to March through hydrants installed along the city streets.

(7) Desalination Plant Project

There are three desalination plants near the shore line as listed below. The existing sea water intake pipelines intersect the seawall and should be taken into consideration in designing the seawall.

- Danida I 200 m³/day
- Danida II 600 m³/day
- French 200 m³/day

(8) Center for Social Education

The prime objective of the Project is to construct facilities to be the center of various educational activities other than school education aimed at enhancing human resources development in Maldives. At the center, the development of physical education, the

development of manpower through vocational training, and the dissemination of health and hygiene information will be carried out as a part of the social education programme.

The Project by the Japanese Government Grant Aid was completed in March 1992. Since the project facilities, comprising the following, are located very close to the western coast, improvement works to the existing seawall are very urgently required.

Multi-Purpose Hall

- Central Hall (980 seats)	900 m ²
- Stage	110 m ²
- Lobby	66 m ²
- Storage	43 m ²
- Project Room	19 m ²
- Toilet	68 m ²
- Hallway, Gallery, Stair, etc.	871 m ²

Total Floor Area 2,077 m²

Classroom and Administration Building

- Instructors Room, etc.	66 m ²
- Administration Office	76 m ²
- Meeting Room	18 m ²
- Three Classrooms (30 seats per room)	153 m ²
- Workshop 1 (30 seats)	109 m ²
- Workshop 2 (40 seats)	119 m ²
- Seminar Room (100 seats)	198 m ²
- Toilets	105 m ²
- Preparation Rooms (4)	129 m ²
- Hallway, Gallery, Stair, etc.	459 m ²

Total Floor Area 1,444 m²

(9) Indira Gandhi Memorial Hospital

The hospital complex, providing 200 beds, will have an approximate area of 17,000 sq.m comprising hospital area of 13,000 sq.m and residential area of 4,000 sq.m. The total complex will be built on an approximately two acres site.

The hospital will be made up of the following major groups:

- Ambulatory Care
- Diagnostics
- Emergency Department
- Operations Department
- Intensive Care Unit
- Intermediate Care Nursing Units
- Hospital Services
- Engineering Services
- Administration and Staff Areas
- Public Amenities

The construction will be completed in September 1992 by Grant Aid of the Government of India.

(10) Expansion of Marine Drive

In order to meet increasing traffic volume after the completion of new south-west inter island harbour, the Government plans to widen the existing Marine Drive road along the western coast from 25 feet to 35 feet. Since a part of the existing western seawall is constructed on the extreme edge of the coral reef and there is no space to extend the road, careful attention should be paid when new seawalls are planned.

(11) Swimming Pool

The Government is desirous of promoting swimming amongst the public because of the maritime nature of the country. It is for this reason and also to train swimmers to participate in both national and international events that a swimming pool is planned for Male'. The site for the swimming pool is planned to be provided on new-reclaimed land on the east coast.

Chapter 2. Results of Site Investigations

2.1 General

In order to collect data and information on environmental conditions, topography, geology, meteorology, oceanography and shore protection facilities, the Study Team conducted site investigations in Male' and Funadhoo Islands from September 5 to December 20, 1991 and from May 17 to May 29, 1992. Wave and Current observation in oceanographic survey, however, has continued during the one year from September, 1991 to August, 1992 by using an automatic wave and current gage installed at the southern east offshore sea bottom in Male' island. Environmental conditions were investigated on items concerning socio-economic and natural environment. Topographic and hydrographic surveys were conducted covering the areas 50 meters landward and 100 meters seaward from the edge of coral reef. Geological investigations were conducted by three boring tests on soil condition and material tests on coral rocks and coral sand. Meteorological information was summarized statistically using data obtained from 1986 to 1990 at Hulule island by the Weather Center. An oceanographic survey was conducted by using pressure type wave gage and electromagnetic current meter at Male' island. The present shore protection facilities were investigated from the following points of view; (a) type of structure, strength, degree of deterioration and construction method; (b) function to protect flooding; (c) relation to the port facilities; (d) utilization of shore; and (e) operation and maintenance.

2.2 Environmental Conditions

2.2.1 Socio-economic Environment

Socio-economic and natural environmental conditions of Male' island are shown in this section. Environmental detailed conditions are described in the "Supporting Report".

(1) Population

The total population of the Maldives in 1990 was 213,215 and the annual exponential population growth has been over 3 % since 1965 (Ministry of Planning and Environment). The population growth is shown in Fig. 2.2.1.

The population of Male' island accounts for 26 % of the total of the Maldives, or 55,130. The population of Male' is increasing 1 - 17 % in the annual exponential population growth rate since 1965. The population density in Male' is 30,627 people/km².

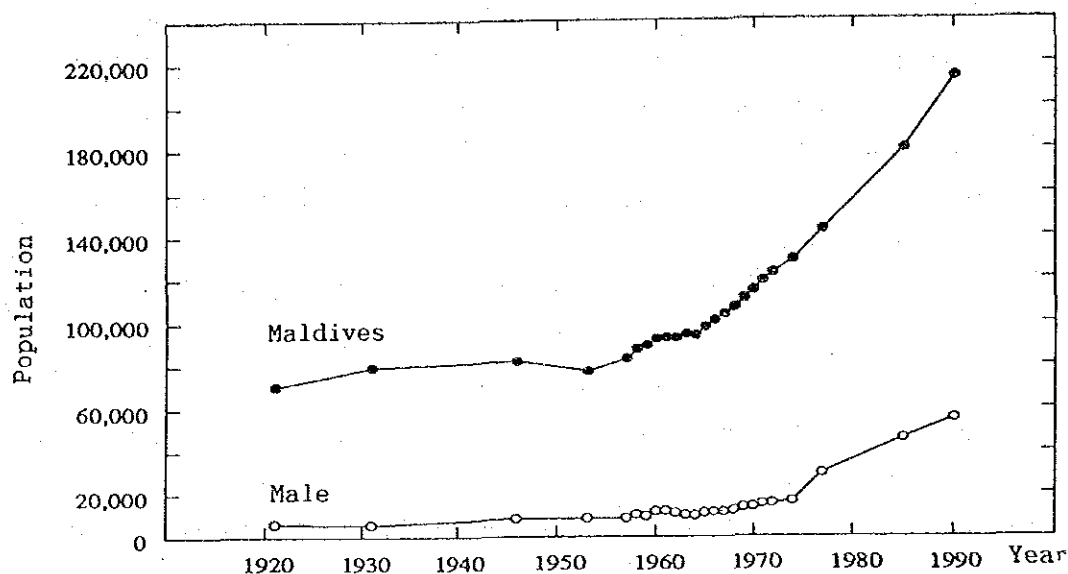


Figure 2.2.1 Growth of Population, 1920 - 1990
(by Ministry of Planning and Environment)

(2) Land Use

Land use on Male' island is shown in Table 2.2.1 and Fig. 2.2.2. Male' island has an area of approximately 1.8 km². Residential and small shop areas account for 57 % of total area of Male'. Most government warehouse and project sites are distributed in the south of Male'. There are commercial areas in the northwest and in the center of Male'.

Table 2.2.1 Land Use in Male', 1991

Area Category	*Area (km ²)	(%)
Residential/Small Shops	1.000	57.0
Commercial Area	0.142	8.1
Government Office	0.059	3.4
Government Warehouse/Project Sites	0.284	16.2
Public Utilities	0.095	5.4
Educational Area	0.046	2.6
Recreation/Park	0.128	7.3
Total	1.754	100

* Area includes roads.

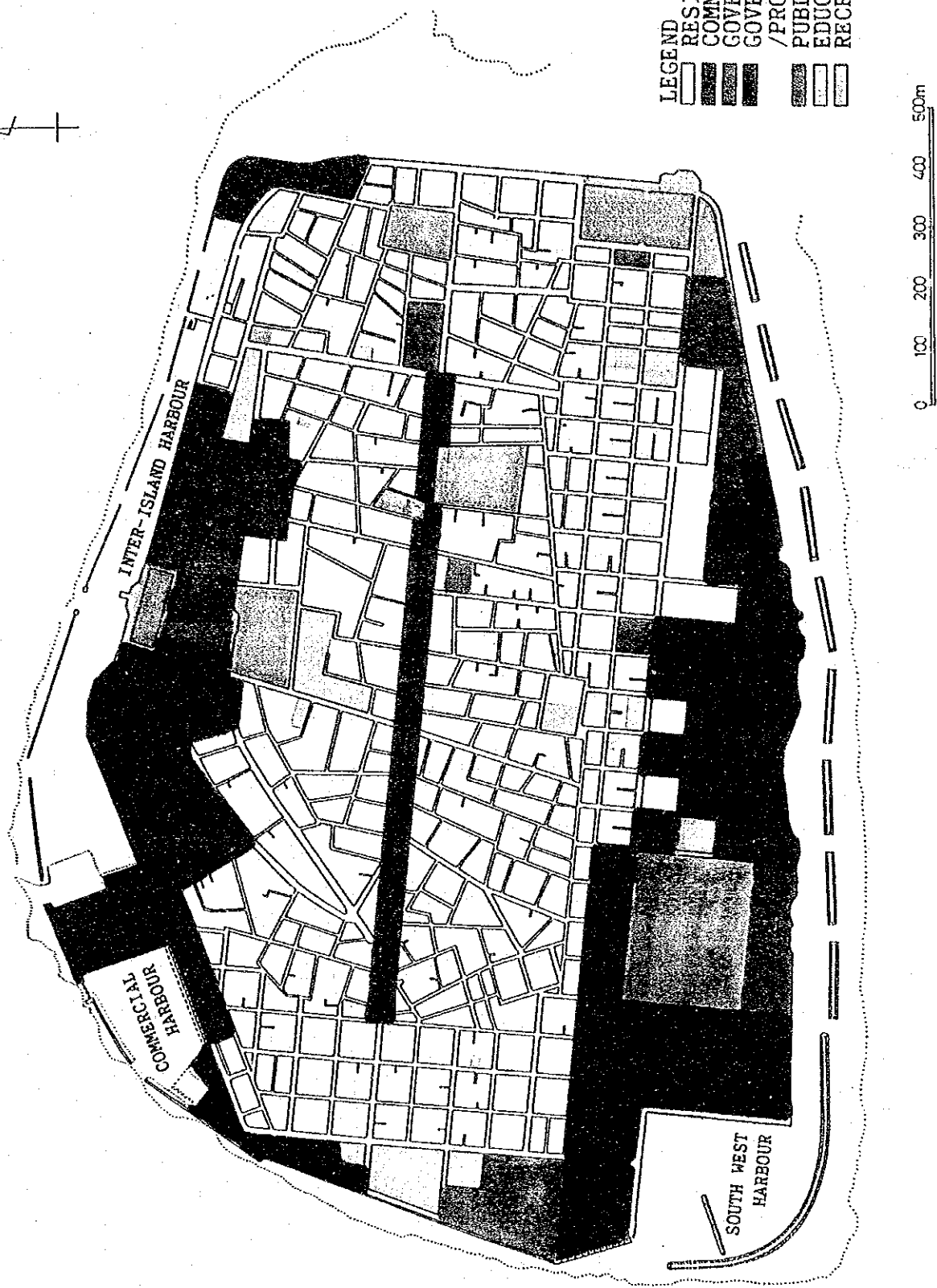
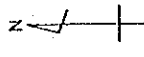


Figure 2.2.2 Land Use Map

(3) Coastal Use

a) Present Situation

The protective structures of coastal disaster and coastal use map in Male' at present are shown in Fig. 2.2.3.

Male' is surrounded by Seawalls and detached breakwaters. The Commercial Harbour and the Inter-Island Harbour are in the north of Male'. The Inter-Island Harbour is used by many dhonis for anchorage. Southwest Harbour in the south is completed in August 1992.

The coast of Male' island is used for six sewage discharge lines, for intake and outlet of desalination plants both DANIDA and French Plant, and for cooling water for power stations.

The shoreline of Male' is used as recreation area for residents. The southeast of Male' is also popular with young people, as this area is the only place on Male' island where surfing is possible.

b) The Future Plans

Maldives government has some development plans for the future on Male'. These development plans are shown in Fig. 2.2.4 and are as follows:

- Commercial Harbour Project (completed)
- Southwest Harbour Project (completed)
- Sports and Recreational Development Plan
- Indira Gandhi Memorial Hospital in the West of Male' sponsored by the Indian Government (under construction)
- Widening of Marine Drive (under construction)
- Secondary Private School (Male' English School)
- Collection Site for Transport of Solid Waste
- Swimming Pool (of Olympic standards)

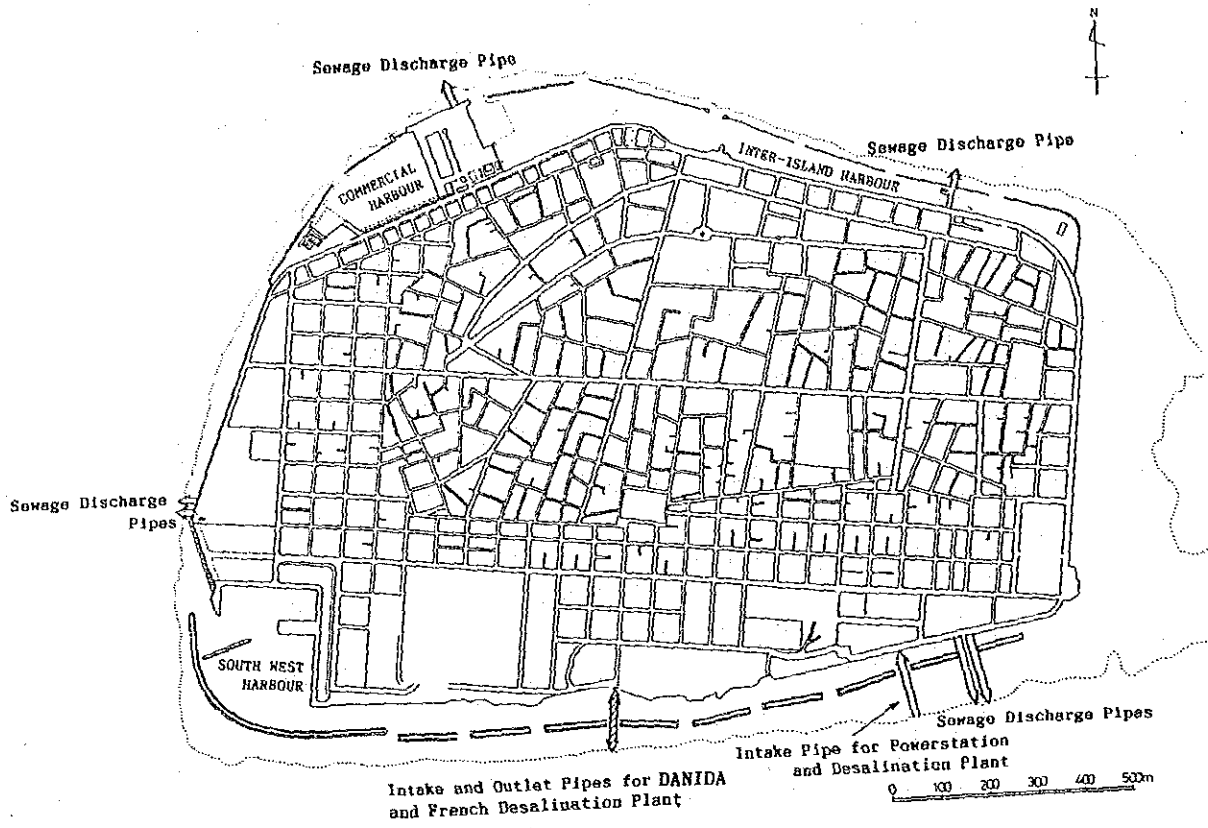


Figure 2.2.3 Coastal Use Map at Present

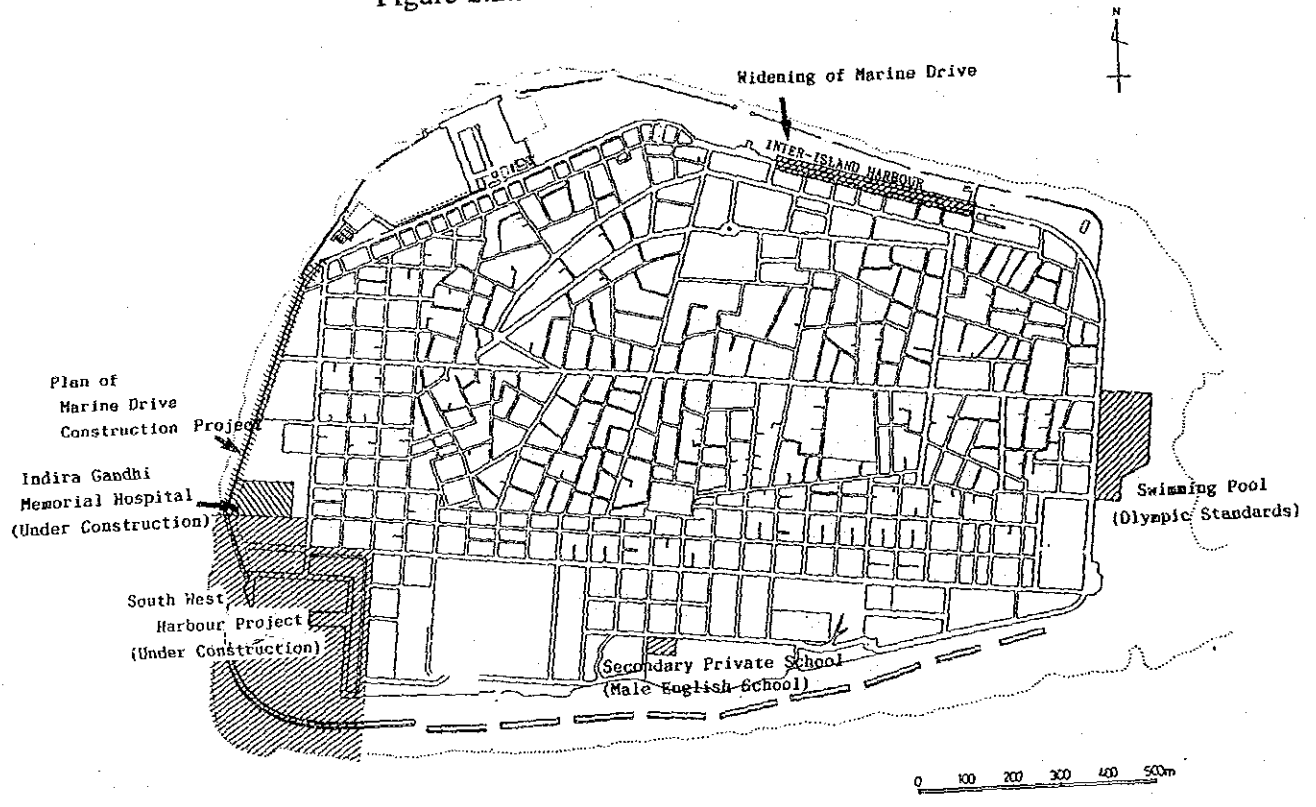


Figure 2.2.4 Coastal Use Map in Future

(4) Transportation

a) Land Transportation

The total length of roads in Male' is about 48 km. The main road is Majeedhee Magu which is located in the center. There is a ring road on the beach side named Marine Drive. Marine Drive passes through the north, the east, and a part of south Male' on the shoreline.

b) Sea Transportation

The Maldives has a variety of vessels such as dhonis, mechanized yacht dhonis, baththeli and launches. However, the most popular sea transportation is the dhonis. The dhonis are also used for inter-island transport. Many dhonis anchor in the Inter-island Harbour in the north of Male'. Harbours in Male' are described in "(5) Infrastructure".

(5) Infrastructure

There are harbours, power stations, water supply system, hospitals, and roads in Male' island. Infrastructure concerning the Seawall Project is described as follows:

Harbours

There are two harbours which are located in north Male' at present. The commercial Harbour to be used by large scale vessels is being constructed at present. "Dhonis" for inter island transport use the Inter-Island Harbour. The third harbour which is named Southwest Harbour is being constructed in southwest Male'.

Shore Protection Facilities

Male' island is surrounded by seawall and detached breakwater. These structures are shown in Fig. 2.7.1.

Sewage

In Male', there is no sewage treatment system. Sewage is discharged directly into the sea from 6 outfalls by 9 pumping stations. Location of discharge points are shown in Fig. 2.2.3.

(7) Landscape

Landscape photographs of coastal area are shown in Photo 2.2.1.

a) East Side

Marine Drive passes through the east side of Male'. There is a seawall 0.9 m above the road. Reef edge and the horizon can be seen from the road side. In the south of the east side, there is a public park, which is used as a recreation area for residents.

b) South Side

Residents can access the shore line only on the east of the south side. There is a seawall which is 0.8 m above the road. Detached breakwaters are made up of tetrapods installed over the seawall. These tetrapods hinder visibility of the sea. However, the horizon can be seen between detached breakwaters from the road. It can also be seen above detached breakwaters from the seawall.

c) West Side

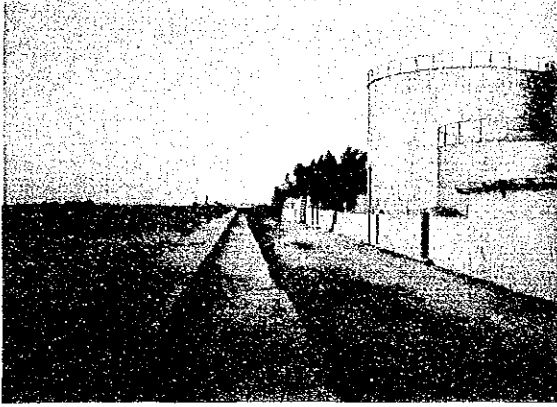
Marine Drive passes through the north of the west side, the sea can be seen from Marine Drive over the 1.4 m high seawall.

d) North Side

In the north side of Male', there are breakwaters over the seawall. The area between the breakwaters and the seawall is used by some vessels for anchorage.

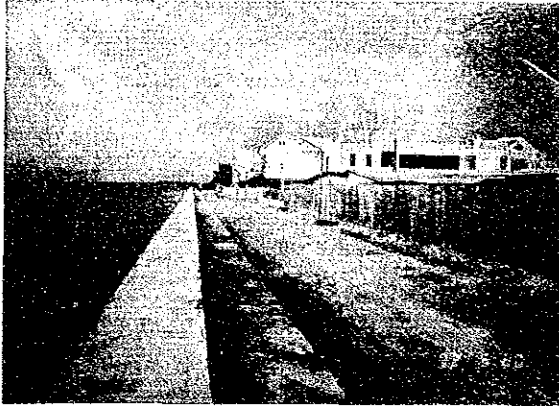
In the center of the north side of Male', there is a park for residents and tourists where people come to relax in the evening.

West Coast



The northern part of the west coast:
A northward view from the warehouse of State Trading Organization. There is not so much traffic volume on the road at present.

After construction of proposed seawall, transportation volume will increase and this road named Marine Drive.



The southern part of the west coast:
The existing structures is broken in some parts and wave overtopping occurs often at present.

The front of the site for the construction of Indira Gandhi Memorial Hospital surrounding with walls and Social Education Center (the white building).

East Coast



The northern part of the east coast:
Marine Drive passes along the beach. A coral reef view from the road.

Reef flat along the shoreline will be reclaimed about 100 m wide by Maldivian Government.

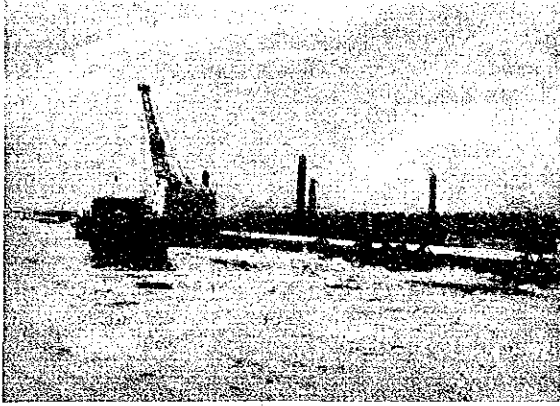


The southern part of the east coast:
There is a recreational area for the residents, and young people enjoy surfing.

Artificial beach will be constructed in this area by the Seawall Project.

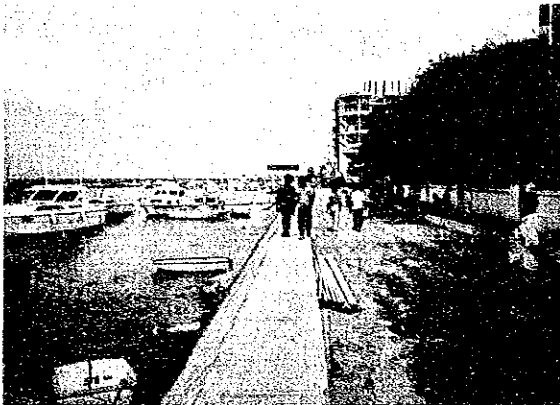
Photo 2.2.1 Landscape of Male' Island (1)

South Coast



The horizon can be seen between the detached breakwaters. The quaywall is being constructed. This area was used before to dispose of solid waste.

North Coast



The eastern part of the north coast: There are some offices and markets in front Inter Island Harbour. There are many traditional fishing boats and freighters. Ministry of Public works and Labour is constructing quaywall on the north coast.



The western part of the north coast: There are government offices and small shops, and dhonis and small boats come into Inter Island Harbour.

