Chapter 4 Environmental Impact Assessment

4.1 Sources of Environmental Impact

4.1.1 During Construction

Sources of environmental impact which could be caused by the proposed plan can be divided into four components as follows:

- Operation of heavy equipment
- Dredging
- Construction of structures
- Transportation of construction materials

4.1.2 After Construction

After construction there may be impacts caused by the erection of structures as protection against high tides and wave overtopping. The impacts depend on type, size and location of the structures.

4.1.3 Identification of Environmental Impact

A project impact matrix that covers the possible impacts on environmental elements during and after construction is shown in Table 4.1.1.

Table 4.1.1 Environmental Impact Matrix for the Proposed Project

	Environmental Element → / Project Component and Project Area ↓	Socio-economic Environment: Land Use	Coastal Use	Traffic	Infrastructure	Community stability	Migrant population	Fishery	Employment	Public health	Cultural values	Recreation	Aesthetics	Physical and Natural Environment: Slope stability	Coastal hydrology	Sea water quality	Ground water use	Ground water quality	Air quality	Noise	Vibration	Terrestrial biota	Marine biota
During Construction	Operation of heavy equipment			-2									-1						-1	-3	-3		-1
	Demolition of existing structures		-2	-1				-1		-1		-1	-2		-2				-1				-1
	Dredging/Excavation		-2					-2							-2								-3
	Construction of structures		-2	-1				-1				-2	-2		-1								-1
	Transportation of construction materials			-1															-1	-2	-1		
After Construction	West coast	+2		+1	+3	+2				+1			+1	+2									-1
	East coast – Reclaimed area	+3	-2		+2					+1		-2* / +1*	+1		-2								-3
	East coast – Artificial beach	+2	+2									+2	+1										-2
	South coast	+1	+2	+2																			
	North coast																						

* Upper figure in column : Aquatic Sports
Lower figure in column : Outdoor sports, Football etc.

Environmental Impact Rate

-3 Significant negative impact
-2 Moderately negative impact
-1 Negligible negative impact

+3 Significant positive impact
+2 Moderately positive impact
+1 Negligible positive impact

4.2 Forecast and Evaluation of Environmental Impact of the Proposed Plan

4.2.1 During Construction

During the construction period, impacts caused by the proposed project will not be serious for the environment, because, the 'working period is short, and the construction of structures will be carried out in sections.

4.2.2 After Construction

Results of the environmental study after construction are shown in Fig. 4.2.1 and described as follows.

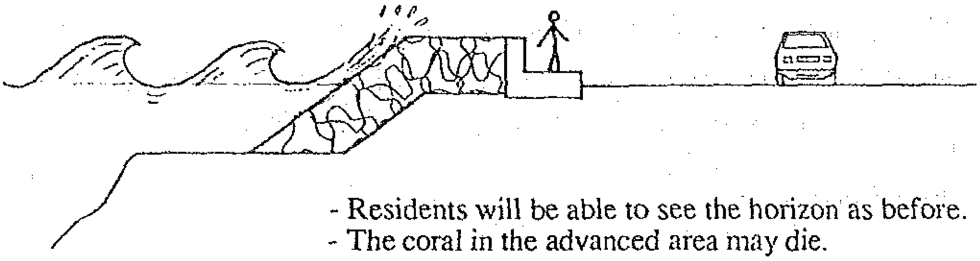
- West Coast
  Proposed structures on the west coast will not receive serious impact.

- East Coast
  Marine life in the reclaimed area will be influenced after construction. However, impacts to the other environmental elements will not be serious. In terms of the human activities, new recreational facilities are being planned in the project, including the artificial beach and reclaimed area so that residents can enjoy sports and other activities as before.

- South Coast
  Proposed structures on the south coast will not change from existing structures. Therefore, the south coast area will not be influenced after construction.

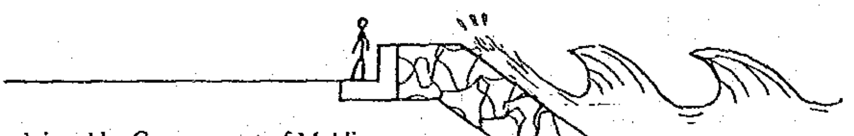
- North Coast
  Type of proposed structures are similar to existing structures. Therefore, the north coast area will not be influenced after construction.

WEST COAST



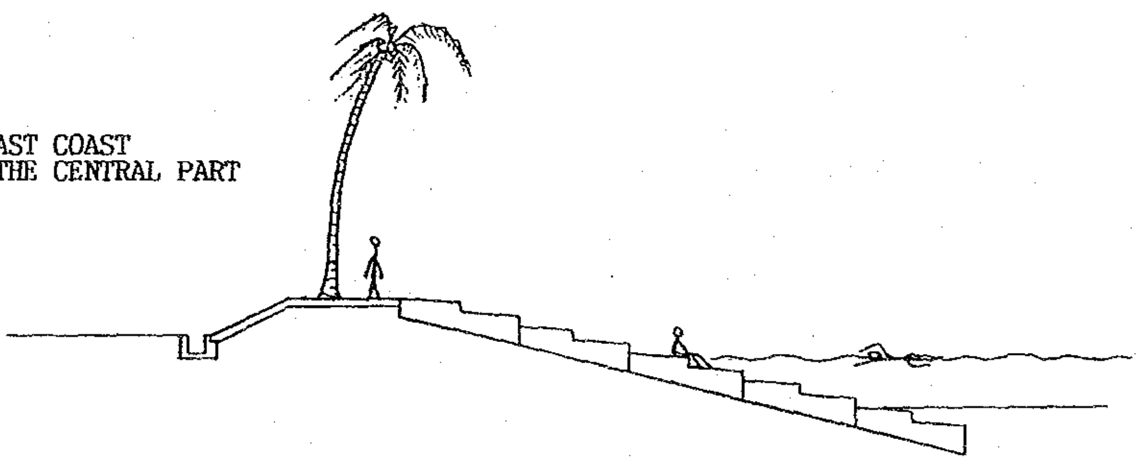
- Residents will be able to see the horizon as before.
- The coral in the advanced area may die.

EAST COAST
THE NOUTHERN PART



- Maldive's government has a "Sport and Recreation Development Plan" for the reclaimed area.
- Reclaimed area will vanish after the reclamation.

EAST COAST
THE CENTRAL PART



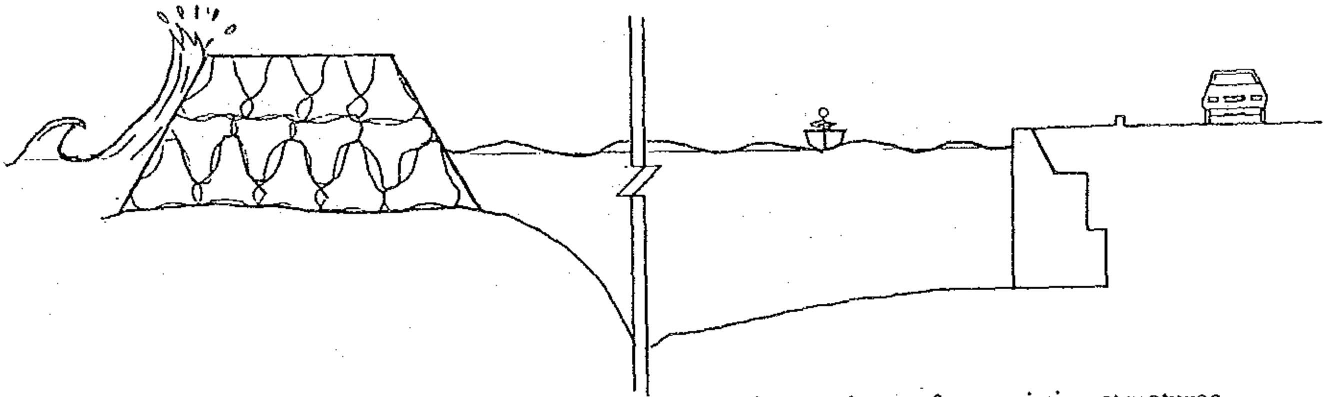
- Step type seawall in the southern part can be enjoyed by swimme

Figure 4.2.1 Proposed Structures in Male' Island (1)

EAST COAST
THE SOUTHERN PART

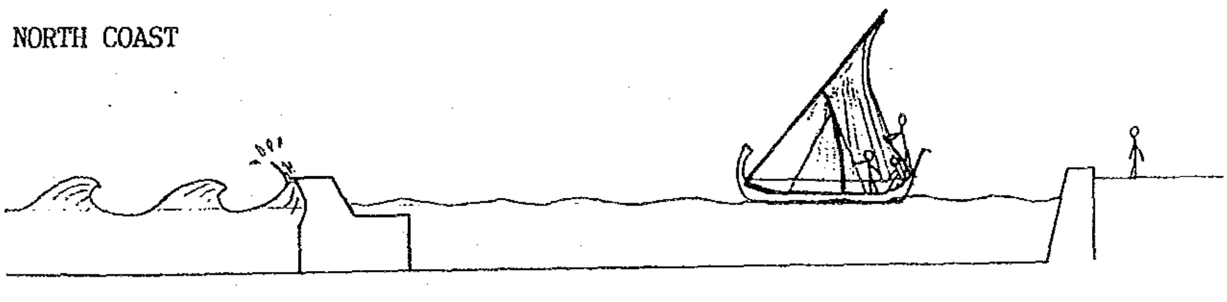
- This area can continue to be used for surfing as before.

SOUTH COAST



- Proposed structures will not change from existing structures.

NORTH COAST



- Proposed structures are similar to existing structures.

Figure 4.2.1 Proposed Structures in Male' Island (2)

Chapter 5. Organization and Management

5.1 Routine Business & Emergency Operation

The scope of this study covers both daily routine business and emergency operations of the Ministry of Public Works & Labour (MPWL).

Two aspects of operations, i.e., daily routine business and emergency operation at the time of disaster (see para 5.4.3) have to be covered by a set of organizations. The first may further be divided into three sections. They are maintenance and repair work of the seashore protecting structures (see para 5.3), recording of oceanographic data (see para 5.4.1), and public relations to the citizens (see para 5.4.2).

The MPWL is holding the sole responsibility for carrying this project through to execution and conducting daily maintenance work of the structures after the completion of the project. Its routine business also includes collection of oceanographic data and public relations activities, the perspective of which requires broader framework than the MPWL itself. It is, therefore, assumed that the gist of the matter beyond this scope of work should be described for the better understanding of the position in which the MPWL will be placed in relation to the total organizational framework we propose.

5.2 Management Policy on the Seashore Protection

5.2.1 Principle behind the Policy

The nation's backbone lies in the sea. People identify with it; yet the nuance of the people's perception towards the sea has been varying, especially in the context of the national policy or political guidelines.

<u>Change in People's Perception of the Sea</u>

(1) Economic → (2) Environmental → (3) Socio-Psychological

5.2.2 National Commission for the Protection of the Environment

National Commission for the Protection of the Environment (NCPE) was established in the MPE on 19 June 1989 to oversee all the aspects of activities of the seashore management and to make pertinent decisions. It is an extension of the disaster committee which was formed soon after the 1987 disaster. Table 5.2.1 gives an idea how the member organizations participate in the activities.

Participation of four Ward Development Committees (WDC) of Male' Island in the activities of public relations and emergency operation is very important.

Table 5.2.1 National Commission for the Protection of Environment

Four Activities	Planning Body	Executing Body
1. Maintenance & Repair (of seashore protecting structures) design criteria, renovation plan, maintenance & repair	OPPD; MPWL; MM	HD*, MPWL
2. Data Collection & Analysis overall policy making, data collection, processing, analysis	MPE;	ERU*, MPE; DM; PWD, MPWL
3. Public Relations (PR) national identity formation PR of the committee's activity education-at school & away from school	MPE; DIB*; ME* WDC	VOM; TM; DIB ME; WDC
4. System of Emergency Operation emergency operation training & practice	MDNS*; WDC	see Fig. 5.4.1

*

HD : Harbour Division
ERU : Environment Research Unit
DIB : Department of Information & Broadcasting
ME : Ministry of Education
MDNS : Ministry of Defence & National Security

5.3 Maintenance and Repair System

The HD of the MPWL is to be in charge of all aspects of maintenance and repair works of the system.

5.4 Managerial Countermeasures against Coastal Disaster

5.4.1 Oceanographic Observations

Continuous and regular recording is one of the most important elements of observation, the PWD's responsibility is to take good care of the under-water gauges.

5.4.2 Public Relations

The ultimate purpose of PR activity is to let the citizens understand the nature of the sea in its totality through promoting the idea of maintaining the shore protecting structures, which is the mainstay of safeguarding the citizens' life.

5.4.3 Emergency Operation System

The HQ headed by the minister of MDNS will be established instantly in the NCPE when disaster takes place, and the HQ staff will be notified to assemble through emergency communication network.

A sample diagram of the emergency communication channel between the HQ and each operating body is shown in Fig. 5.4.1.

The HQ is manned by the emergency brigade of MDNS assisted by an engineering corps with necessary equipment, besides members of the CSD and duty officers dispatched from each operating ministry.

Preparation of disaster operation in normal times involves formation of residents' voluntary emergency brigade under each WDC. They will get regular training. Training manual will be prepared by the CSD and instructors will be provided by the emergency brigade, MDNS.

HQ →	DIB:	VOM, TM
HQ →	WDC	
HQ →	MM:	PWD, CSD*
HQ →	MPWL:	HD, PWD
HQ →	DPT*:	DHIRAAGU (telephone company)
HQ →	Public Utilities:	MEB*, MWSSPU*
HQ →	The Central Hospital:	Emergency Unit

*

CSD:	Community Service Department
DPT:	Department of Posts & Telecom
MEB:	Maldives Electricity Board
MWSSPU:	Male' Water Supply & Sewage Project Unit

Figure 5.4.1 An Emergency Communication Network

Chapter 6. Project Appraisal

6.1 Introduction

In this chapter, firstly, the quantitative and descriptive appraisals of the project are carried out from the benefits and costs point of view (see para 6.2); after which, the project is assessed more comprehensively by using the Disaster Prevention Appraisal Index (DPAI), which was proposed by Prof. Y. Kawata of Kyoto University in 1990 (see para 6.3).

6.2 Costs and Benefits Aspect of the Project

6.2.1 Economic Internal Rate of Return (EIRR)

1) Construction Cost (1992 Price)

West Coast	US$10,328,156
East Coast	US$13,632,487
South Coast	US$17,057,963
North Coast	US$10,403,567

2) Project Benefit

Project benefit will be calculated from a definite integral of Damage Probability Curve (D-P Curve) between the return period of the scale of disaster that the project is designed to counter and that of one, which is equivalent to an yearly benefit (YB).

The magnitude of the tidal wave assaulted on Apr. 10. 1987 can be regarded as the one with the return period of 100 year.

The tidal wave of April 10, 1987 caused Male' island to be burdened with an estimated damage cost of MRf. 29,348,621 (1987 price), (see Table 6.2.1). This is a part of the direct damage costs (Direct 1). We have enumerated two more types of the direct costs, which are not included in the above list. They are the damages which were caused to the residences and small shops in the inundated area (Direct 2), and the one to the household goods kept in the houses (Direct 3).

We estimate loss of positive earning opportunity as a type of indirect loss.

3) EIRR

EIRR of the Project is calculated at 30 % (without construction cost of North Coast) and 24 % (including North Coast).

6.3 Disaster Prevention Potential

6.3.1 DPAI

In this section we shall assess the project in terms of its contribution to the increase of disaster prevention potential of the population living in Male' Island as a whole.

Kawata (KY) has found that the probability of encountering a disaster in a region (P) can be explained by an average lifespan of its population, and that "soft ware" aspects of the potential can be represented by the average lifespan. Then, he has introduced two equations; P and combined potential of both "soft and hard ware" countermeasures (Pd).

$$P1 = 1 - P = (1 - 1/T)^{T1} \text{ ------------------------------ (1)}$$

T_1: average lifespan, T: return period (year)

$$Pd = 1/[1 + \exp\{-(\alpha + \beta P_1 + \gamma P_2)\}] \text{ ------- (2)}$$

where:

- P_1 : probability of non-encountering of disaster; see (1)
- P_2 : average lifespan (ALS)/the limit of lifespan (=120 set by KY)
- α : corresponds to change in hydrological Phenomena

He standardizes the relationship by giving 100 to the most dangerous situation, and 0 to the safest; then he gets:

$$DPAI = 433 \times (0.731 - Pd)$$

The ALS of the Maldives has been increasing rapidly in recent years.

A gain by the execution of this Project at the time when the ALS will be 70, which will come sometime in late 90s, will be 25 points in terms of the DPAI, and will reach DPAI 43.

The DPAIs of many developing countries are above ca.70, those of the NICS between 70 and 50, and most developed countries below 50.

6.3.2 Maximum Risk of Life (RL) at the Time of Disaster

1) RL

KY got an equation on maximum risk of life:

$RL = 10^{-0.036T1-0.471}$ (T1 < ca.60)

T1: ALS of the country concerned at the time of disaster

When T1 > ca.60, RL reduces dramatically, and reaches in the order of 10^{-5} at a level of T1 = 70.

2) R : Disaster Amplification Factor

The number of deaths (Np) can be calculated by the equation:

$Np = \alpha 1 * RL * PO * R$ ($\alpha 1 * R = 1$ in ordinary cases)

Legend: PO = Population
R: Disaster Amplification Factor of cities with high population density (PD). R = PD of the city concerned/PD of the country concerned.

KY has discovered a phenomenon of phase transition in which Np increases suddenly, i.e., $\alpha 1 * R > 1$, when R = 15 ~ 20.

In actual situation, at the time of 1987 disaster, though, only two persons died of cholera, i.e., RL = 4 x 10^{-5}. This is even far less than Np (= 1500:1990) and RL is at the level of ALS = ca.70. This extreme low risk of life gives proof that the island has been lucky enough never to have been devastated by any severe cyclones or earthquakes. Islanders' another anxiety lies in global warming. If the CO_2 conference of this year's diagnosis is correct, the sea-level rise will be up to 65 cm by 2100. Though this is basically rather an argument of purely mathematical nature*, the seawalls which would be provided by the project would surely mitigate the effect of rise of the sea levels and lessen the citizens worry, mentally as well as physically, for sometime to come.

* 65 cm rise in 108 years (1992 to 2100) means 0.6 cm rise per year. So 50 years after the construction of seawalls, ie, at the end of their useful life, the sea may rise 30 cm from the present level. Meanwhile the structure would counter the high tide of Hs at 3.0 m at present, therefore, if might protect citizens from that of 2.7 m at the end of their useful life; the height still corresponds to the probability of 1/100 according to the Sri Lankan Oceanographic Institute.

Chapter 7. Implementation Programme

7.1 Implementing Priority

As stated in Chapter 3, the first priority for construction of shore protection facilities will be given to the west, east, south and north coasts in this order.

Construction sequence will be set-up as shown in Fig. 7.1.1.

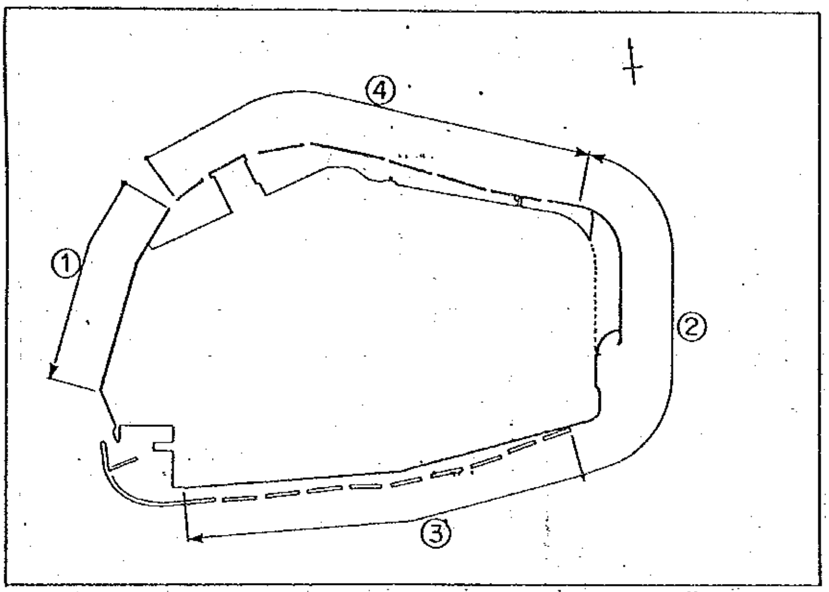


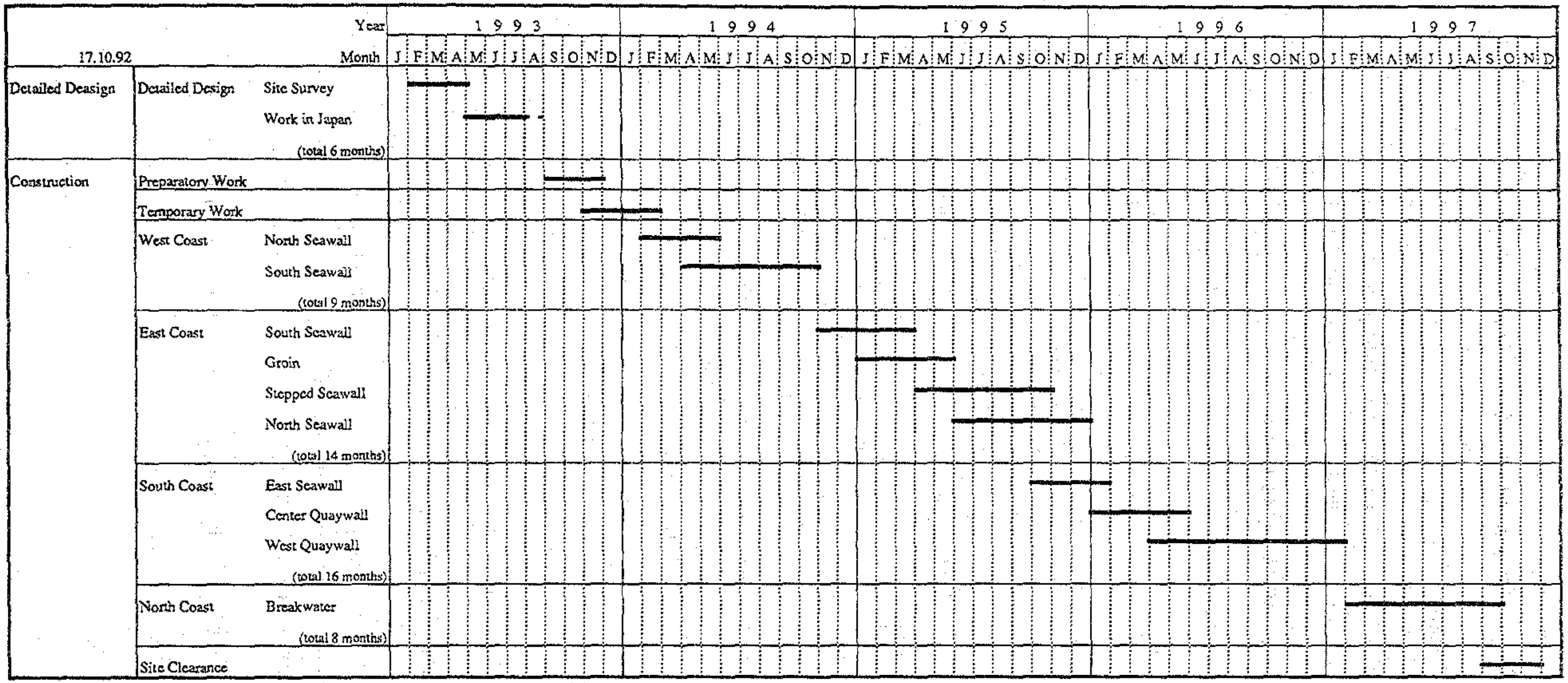
Figure 7.1.1 Construction Sequence by Priority

7.2 Construction Schedule

The construction schedule is prepared taking into consideration the five-year phase programme including the detailed design, preparation of tender documents and construction work.

The Table 7.1.1 shows the proposed construction schedule based on the construction sequence.

Table 7.1.1 Construction Schedule



Note: It is assumed that the Project will start at the beginning of February, 1993.

Chapter 8. Conclusion and Recommendations

8.1 Conclusion

(1) Necessity of Shore Protection

Maldives consists of 1,190 coral islands of which only 202 islands are inhabited. Each island is surrounded by a shallow lagoon which is enclosed by a coral reef providing protection from the hazards of the sea. Maldives, however, has experienced many inundation disasters by waves since the 1980s. For example, extremely high tides accompanied by high waves attacked Male' Island in April 1987 and caused serious damages on seawall and private houses resulting in flooding on the low lying coastal areas and in the outbreak of epidemic disease by standing waters.

With the increase of population in Male' Island, the shallow reef flat has been required to be reclaimed of the nearby reef edge in order to compensate for the shortage of space for houses, roads, public facilities and so on. The shorter the width of shallow reef flat becomes, the stronger the wave force appears in exerting damage to the land side including the rise of sea level due to wave run-up. The reclaimed land will consequently suffer disasters from storms and the reclaimed area of Male' Island has actually experienced inundations several times since 1987.

In Addition, the present seawall made of coral stones covered with thin concrete layer, is not adequate in both the strength of structure and the crown elevation of seawall to withstand wave forces.

Therefore, in order to ensure safe livelihood for the residents the construction plan of an appropriate seawall is urgently required on all coasts of Male' Island.

(2) Shore Protection Plan

Based on the results of field investigations as to environment, topography, geology, meteorology, oceanography and existing protection facilities, shore protection plans are proposed for each coast taking into account the requirements from the Government of Maldives, the technical suitability by hydraulic model tests, and the ease and economy of construction works. Moreover, the high priority for construction works is given to the west, east, south and north coasts in this order from their urgency against wave attacks.

The shore protection works for each coast are proposed as follows:

1) West Coast;
   - armor block mound type seawall,

2) East Coast;
   - armor block mound type seawall on the south and north part of this coast,
   - step type seawall on the middle part of this coast,

3) South Coast;
   - concrete block type vertical quaywall,

4) North Coast;
   - concrete block type breakwater.

Considering the process of construction works, it will take a total of five years to complete the above proposed seawalls on all coasts of Male' Island.

The construction of the proposed protection works is considered adequate to prevent extremely strong storm waves from overtopping into the hinterland area, and to promote the economic and social activities of the local residents.

(3) Environmental Impacts

Environmental impacts were examined with regard to socio-economic, physical and natural elements in each stage of during and after construction. In both stages impacts caused by the proposed plans are thought to not be serious to the environment.

8.2 Recommendations

In order to construct countermeasure works smoothly and effectively, and to acquire semi-permanent functions of shore protection facilities, the following recommendations are proposed:

(1) A next stage of detailed design for construction works succeeding the seawall project be initiated as early as possible;

(2) More civil engineers of MPWL who are responsible for carrying out this project be encouraged to study abroad coastal engineering and to establish a maintenance and repair system for the shore protection facilities as well as to obtain the knowledge of various coastal phenomena such as wave, current, tide, sea level rise and so on;

(3) Acquisition of enough space be kept for construction works such as a site base for heavy equipment, stock yard for material and armor blocks and other requirements;

(4) The seawall construction on the northern part of east coast be conducted in coordinating well with the reclamation plan which will be prepared and implemented by the Government of Maldives (the volume of reclamation material is estimated at approximately 92,000 m^3);

(5) A patrol inspection after construction be emphasized to observe wave height, wave run-up height and overtopping at high wave attacks in order to grasp actual effects on the seawall and to assist in dealing with shore protection problems in other islands of Maldives;

(6) A submerged permeable breakwater, which is beyond the scope of this seawall project, is preferable to be set between the existing detached breakwaters on the south coast at its necessary position in order to obtain harbor calmness for safe anchorage of small boats. Construction of this submerged permeable breakwater will not prevent the exchange of the seawater in the channel into the open sea;

(7) The proposed seawall position should not be changed seaward because the crown elevation of seawall and the weight of armor blocks are determined to meet wave forces around Male' Island.

Appendix: List of Personnels Concerned

(1) Maldivian Government

Hon. Abdulla KAMALUDEEN	(MPWL) :	Minister
Mr. Mohamed SHIHAB	(MOFA) :	Director of External Resources
Mr. Abdulla MASEEH	(MOFA) :	Assistant Under-Secretary
Mr. Ibrahim MANIKU	(MPWL) :	Director of Public Works
Mr. Wang ZHENG-DE	(MPWL) :	Coastal & Harbor Engineering Advisor
Mr. Quirico F. ORENCIA	(MPWL) :	Civil Engineer
Mr. Ragheb Ahmed KHALAF	(MPWL) :	Civil Engineer
Mr. Mohamed SAEED	(MPE) :	Director, Programme
Mr. Hussain SHIHAB	(MPE) :	Director of Environment Affairs
Mr. Mohamed ALI	(MPE) :	Deputy Director, Environmental Research
Mr. Mohamed HUNAIF	(MPE) :	Assistant Director, Physical Planning
Mr. Hamdoon A. HAMEED	(MPE) :	Director, Projects
Mr. Mahjoob SHUJAU	(MM) :	Civil Engineer
Mr. Abdulla SALEEM	(MM) :	Under-Secretary
Mr. Mohamed SHAFEEGU	(OPPD) :	Director
Mr. Ali HAIDAR	(OPPD) :	Senior Planner

(2) Counterparts

Mr. Ahmed ASHRAF	(MPWL) :	Assistant Under-Secretary, Overall Management
Ms. Fathmath RASHEED	(MPWL) :	Architect Trainee, Soil Investigation Facility Design Environmental Analysis
Mr. Ajwad SHAKEEL	(MPWL) :	Civil Engineer Trainee, Wave Observation Topo/Hydrographic Survey Coastal Analysis

(3) JICA Advisory Committee

Dr. Takaaki UDA	(MOC) :	Chairman
Mr. Hisaaki EMON	(MOC) :	Member
Mr. Masanori SETA	(MOC) :	Member

(4) JICA Study Team

Dr. Tamio ONO	(INA)	:	Team Leader till March 1992
Mr. Hiroshi SAKURAMOTO	(INA)	:	Team Leader from May 1992
Mr. Kazuo UNOKI	(INA)	:	Shore Protection Planning
Mr. Tsuyoshi NAGAYOSHI	(INA)	:	Oceanographic Observation
Mr. Yoji TERAZU	(INA)	:	Geological and Geophysical Survey
Mr. Masakazu IKEHARA	(PCI)	:	Hydrographic Survey
Mr. Naoshi HIGA	(INA)	:	Topographic Survey
Mr. Sadao ORISHIMO	(PCI)	:	Structural Design
Mr. Katsuhiko TAKAHASHI	(PCI)	:	Cost Estimate/Construction Planning
Mr. Akinori SATO	(PCI)	:	Environmental Analysis
Mr. Fumiaki ONODA	(PCI)	:	Institutional/Managerial Evaluation

INA : INA CORPORATION

PCI : PACIFIC CONSULTANTS INTERNATIONAL

JICA